KAUNAS UNIVERSITY OF TECHNOLOGY

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UNIVERSITY EDUCATIONAL ENVIRONMENTS ENABLING STUDENTS TO LEARN PROBLEM SOLVING (IN ENGLISH AS A FOREIGN LANGUAGE COURSE)

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List of Abbreviations

PBL	Problem-based learning
FL	Foreign language
HE	Higher education
CLT	Communicative language teaching
CPS	Collaborative problem solving
IPS	Individual problem solving
FL	Foreign language
IDZ	Intermental Development Zone
ZPD	Zone of Proximal Development
EMI	English Medium Instruction
CEFR	The Common European Framework of Reference for Languages
PISA	The Programme for International Student Assessment

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Definitions of Key Terms

Cognitive skills for solving ill-structured problems comprise *devising problem representation* (understanding the situation described in the problem, including managing additional information and setting goals), *developing solutions* (considering all possible solutions), *making justifications for developed solutions* and *selecting solutions* (justifying and comparing solutions), and *monitoring and evaluating* (problem solving processes and progress made) (adapted from Sinott, 1989; Voss & Post, 1988; Voss et al., 1991, as cited in Ge & Land, 2004).

Collaboration is "the activity of working together towards a common goal" (Hesse et al., 2015, p. 38).

Collaborative problem solving involves "approaching a problem responsively by working together and exchanging ideas" (Hesse et al., 2015, p. 38).

Communicative language teaching is an approach to teaching and learning foreign languages through the involvement of students in meaning-focused and realistic communicative tasks (Harmer, 2015a).

Cooperation means "an agreed division of labour" (Hesse et al., 2015, p. 38).

Educational environments are dynamic spaces of information for learning and performance that are intentionally developed and controlled by an educator and determined by educational aims, relevant content, methods and aids, also including other objects and people in the same environment that somehow affect a learner, educational information and the ways it reaches a learner (Juceviciene et al., 2010).

Foreign language learning according to action-oriented approach means that language learners are engaged in purposeful communication by performing open-ended and authentic tasks that have both linguistic and non-linguistic goals. The motivation to communicate is enhanced through having a genuine purpose which is "a task to be accomplished, a problem to be resolved, an obligation to be fulfilled, or an objective to be achieved" (CEFR, 2001, p. 10).

Ill-structured problems (also called ill-defined) are "those that we encounter in everyday life, in which one or several aspects of the situation is not well specified, the goals are unclear, and there is insufficient information to solve them" (Ge & Land, 2004, p. 5, as cited in Ertmer et al., 2008). They are multidisciplinary in nature, may have multiple solutions or no solution at all (Jonassen, 2011a).

Problem solving (as a competency/skill/knowledge) is a bundle of skills, knowledge and abilities that are required to deal effectively with complex non-routine situations in different domains (Funke et al., 2018, p. 41).

Problem solving (as a process) is an activity in which a learner perceives a discrepancy between a current state and a desired goal state, recognises that this discrepancy does not have an obvious or routine solution, and subsequently tries to act upon the given situation in order to reach the goal state (Griffin & Care, 2014).

Simply speaking, problem solving is a process of searching through the problem space to find one's way from the initial to the goal state.

Problem exists when "an individual has a particular goal, but doesn't know how to achieve it" (Duncker, 1945, as cited in Csapó & Funke, 2017, p. 62).

Skill is referred broadly "to what a person knows, understands and can do" (European Commission, 2016, p. 2).

Social skills for collaborative problem solving comprise *participation* (readiness and willingness to share thoughts and information and being part in the stages of problem solving), *perspective taking* (seeing problems through the eyes of other problem solvers, solving a problem in collaboration and understanding the perspectives of others), and *social regulation* (self-evaluating, negotiating, initiative, and taking responsibility) (Hesse et al., 2015).

Well-structured problems "present all of the information needed to solve the problems in the problem representation; they require the application of a limited number of regular and circumscribed rules and principles that are organized in a predictive and prescriptive way; possess correct, convergent answers; and have a preferred, prescribed solution process" (Wood, 1983, as cited in Jonassen, 2011a, p. 6).

Abstract. Meeting the increased complexity and volatility of the world, higher education institutions should equip students with a broad set of skills with problem solving indicated as one of the essential 21st century skills. Students should be prepared to solve ill-structured problems that are most common in real life. Such problems include unknown elements, are not self-contained (do not have all the necessary information to solve within themselves), may have multiple answers or no answer at all, require the integration of several content domains and therefore are interdisciplinary in their nature (Jonassen, 2011). A number of researchers and practitioners (e.g., Cho et al., 2015; Csapó & Funke, 2017; Greiff at al., 2013; Luckin et al., 2017; Siddiq & Scherer, 2017; Tawfik & Jonassen, 2013) agree that learning to solve ill-structured problems should be integrated into various subjects across university studies.

The current study is not about the application of problem based learning, which is a very popular and widely researched practice across a range of disciplines (e.g., Savin-Baden, 2000; Cho et al., 2015; Guerra & de Graaff, 2015; Li, 2013, etc.). Generally, PBL is known as a content-based method where the major focus of which is mastering a subject in the context of solving problems; however, the current study is about learning to solve ill-structured problems and the development of problem-solving skills in learners by integrating such practice into foreign language studies.

Modern views on foreign language learning (see, for example, *Common European Framework of Reference for Languages: Learning, Teaching, Assessment*, 2017) are about the importance of learning by doing and completing open-ended, meaningful and purposeful tasks that have both linguistic and non-linguistic goals. In practice, it can be implemented by relating learning to real world language use and engaging students in ill-structured problem solving.

Unfortunately, there are just few studies (e.g., Anthony 2011; Anthony & Kadir, 2012; Caspary & Boothe, 2017; Doghonadze & Gorgiladze, 2008; Du & Kirkebæk 2012; Mathews-Aydinli, 2007) discussing the coupling of foreign language learning and learning to solve ill-structured problems, which are usually illustrated with short theoretical assumptions or narrow empirically researched aspects. There is no systematic view joining both theory and practice of how to ensure the development of problem-solving skills integrated into foreign language studies. Thus, the main research problem of the thesis is:

What should university educational environments be to enable students to learn problem solving (in foreign language studies)?

Research object: university educational environments enabling students to learn problem solving (in foreign language studies).

Research aim: to substantiate university educational environments enabling students to learn problem solving (in foreign language studies).

Research objectives:

1. To provide a theoretical rationale of university educational environments enabling students to learn problem solving (in foreign language studies).

2. To substantiate the research methodology for revealing the usability of the model of educational environments enabling students to learn problem solving in the university foreign language study practice.

3. To empirically assess the usability of the model of educational environments enabling students to learn problem solving in the case of a specific university foreign language course.

The research was based on the following theories and conceptions: situated learning (Lave & Wenger, 1991), learning by doing (Dewey, 1938), socio-cultural constructivism (Vygotsky, 1978), collaborative problem solving (Hesse et al., 2015) and empowering educational environments (Jucevičienė et al., 2010).

The study started with a literature review, according to which the theoretical model of educational enablement of students' learning to solve problems in foreign language studies was created. The same Model was applied for three study groups studying at X university. Data was collected about the process of how students were learning, what results were achieved and how factors of educational environments influenced their learning.

The empirical research methodology was based on a qualitative multiple-case study. The study utilized three data collection methods: observation, semi-structured interviews and document analysis.

Structure of the dissertation. The introduction contains the background of the problem with the statement of the problem, purpose of the study, conceptual framework, research methodology, significance of the study, definitions of the key terms and organization of the study. Chapter 1 presents the literature review as a theoretical rationale of university educational environments of foreign language studies to learn problem solving, which ended with a theoretical model to be implemented and assessed in the empirical part. Chapter 2 includes the research methodology of the study, including data collection methods, data analysis procedures, methods applied and trustworthiness of the study. Chapter 3 contains the empirical assessment of educational environments of students learning to solve problems as they were implemented in the university study module *English (for C1 level)*. The results are presented from each case separately and then followed by cross-case synthesis of findings. The chapter ends with a discussion. The final chapters are conclusions and recommendations. The list of references is presented at the end of the research.

Research results and theoretical novelty. The model of educational environments, which was not only theoretically validated but also practically implemented, proved to be effective in enabling students to learn problem solving. In each group, students demonstrated the necessary social (collaborative aspect of problem solving – managing other people including oneself) and cognitive (managing the task of problem solving) skills, as well as increased understanding and experience of collaborative problem solving. The current study adds to the knowledge in the field of education by theoretically substantiating and empirically testing the model that enables students to learn ill-structured problem solving integrated into foreign language studies. The research makes a more specific contribution to the knowledge base on how to design, implement and assess such educational environments. The designed model could be used by all instructional designers of educational environments that consider the development of problem-solving skills as one of the main outcomes of learning.

INTRODUCTION

Background of the problem. Karl Popper (1999) states that "All life is problem solving" (p. 99) meaning that every day people are confronted with myriads of uncertain situations for which no resolutions are immediately known. Problem solving is considered one of the most important topics in the human cognition (Cho et al., 2015; Funke, 2013; Goldstone & Pizlo, 2009, Jonassen, 2011a; Jonassen, 2011b; Jonassen & Hung, 2008). Therefore, research on problem solving has become a dominant theme in both psychology and education. The broad field of research usually includes three overlapping topics: understanding human problem solving, learning to solve problems and learning in the context of problems, with the latter gaining increased popularity in education.

Traditionally, the major focus of formal education has been on domain-specific knowledge acquisition; however, domain-specific knowledge alone is not sufficient in ensuring the students' capability to apply it in solving real-life problems. As stated by Csapó and Funke (2017), "success in life and work is no longer mainly about reproducing content knowledge, but about extrapolating from what we know and applying that knowledge in novel situations" (p. 3). In real life, nobody will be given portions of information and asked to memorize it with the assessment following of how well it can be reproduced in an unchanged context. Disciplinary knowledge will probably remain necessary; however, much of it is quickly forgotten and becomes obsolete in most disciplines. An impressive fact is, for example, an estimate that nearly 50 percent of subject knowledge acquired during the first year of a typical four-year technical degree, the student becomes outdated; even by the time that the student graduates (World Economic Forum, 2016).

The European Commission is arguing that formal education can no longer restrict its mission to easily operationalized learning goals and should be responsible for equipping everyone with a broad range of skills (European Commission, 2016). Therefore, it has been stressed that education should not only care about domain-specific skills but also integrate the development of additional important skills necessary for personal growth and career-readiness.

Major changes in the job market call for revising the way we think about career-readiness. As explained by Griffin and Care (2016), routine repetitive tasks have become automated, therefore freeing people for doing non-routine tasks that require more complex sets of skills. Work environments have already become technologically rich, problems are most commonly ill-defined and people usually work in teams, often multidisciplinary to deal with them. The focus has already switched onto individual skills and characteristics, rather than on narrow occupational titles. Therefore, it has become vital to possess certain particular skills sets that can be successfully applied across a variety of occupational activities and contexts. The increasing necessity to teach these skills requires reimagining the goals of education in general.

Rapid social, technological and economic development makes the world increasingly volatile and uncertain. It is apparent that many of the future jobs do not even exist yet. This leaves us with a crucial question: what are these skills that students will need in the future in order to be better prepared for the workforce of tomorrow.

The issue of such skills has been the subject of both educational and job market policy makers for over a decade. Consequently, a new term has emerged, labelling a set of skills to be most important in modern societies, called 21st century skills, which are indicated to be the desired outcomes of education (Csapó & Funke, 2017). Lists of such skills usually include communication, creativity, innovation, collaboration, information and communications technology literacy, critical thinking and problem solving, with the latter being included in all major frameworks (e.g., P21 Framework for 21st Century Learning or Assessment & Teaching of the 21st Century Skills). It is usually coupled with critical thinking, as it is the foundation of this skill.

Employers also indicate problem solving and critical thinking to be the most desirable skills in employees. For instance, after studying the global workforce at large and interviewing the industry leaders, an education expert, Tony Wagner (as cited in Bidshahri, 2017) identified seven survival skills of the future: 1) critical thinking and problem solving, 2) collaboration across networks and leading by influence, 3) agility and adaptability, 4) initiative and entrepreneurship, 5) effective oral and written communication, 6) assessing and analyzing information, and 7) curiosity and imagination. Brewer (2014) notes that today's employers do not just require work experience but they are also interested in "softer skills" like problem solving and creativity. According to the Future of Jobs report (World Economic Forum, 2016), the complex problem solving skill is in demand as the number one skill across various industries, which is also predicted to be in the same demand in 2020. As Schwab (2016) observes, the fourth industrial revolution is already drastically changing the way we work, live and relate to each other, including the need of the knowledge and skills for the future. He also predicts that the most desirable skills will be complex problem solving (on the top of the list), social and systems skills and these are far more important than physical abilities or content skills. According to Strauss (2017), the findings on workplace success from Google confirm the fact that STEM subjects (science, technology, engineering and maths) are less important than such abilities as to think critically, problem solve, work with others and be a lifelong learner. There is already a ceasing trend on college application essays "What I want to be …." across America, which proves the fact that "hard skills" become less important than soft skills (Strauss, 2017). Similarly, the findings from The Hamilton Project, an economic think-tank, are that non-cognitive skills (e.g., communication, capability to lead a team and being able to work with others) are becoming increasingly important, not only for success at work but also for educational performance (Gray, 2017). The project also provides four main reasons non-cognitive skills are crucial: modern jobs rely more on non-cognitive skills than it did in the past, the salaries of those with more advanced non-cognitive skills are higher, these people are more likely to get full time employment and, finally, those with fewer non-cognitive skills are usually more often left behind (Gray, 2017).

As problems become more complex, problem solving has been increasingly done by teams instead of individuals working alone (Greiff et al., 2014). In education, the value of knowledge is depreciating rapidly "towards a world in which the enriching power of collaborative problem-solving activities is increasing" (Csapó & Funke, 2017, p. 4) and, therefore, collective intelligence has become more appreciated. Findings from researchers at Massachusetts Institute of Technology confirm that collective intelligence of a group is much greater than the maximum intelligence of the smartest group member (Malone, 2018). Therefore, students should be prepared “for a world in which many people need to collaborate with people of diverse cultural origins, and appreciate different ideas, perspectives and values; a world in which people need to decide how to trust and collaborate across such differences” (Csapó & Funke, 2017, p. 3). In this way, social interactions become essential while learning to solve problems and it is therefore collaborative problem solving that needs additional research.

Since problem solving is indicated as one of the essential 21st century and career readiness skills, it is apparent that learners need to become more proficient in problem solving. Therefore, many educational researchers agree that the development of this skill should be incorporated in every curriculum and diverse subjects (Cho et al., 2015; Csapó & Funke, 2017; Greiff at al., 2013; Halpern, 2014; Hassan et al., 2012; Jonassen, 2011a; Knowlton, 2003; Luckin et al., 2017; Rybold, 2010; Siddiq & Scherer, 2017; Tawfik & Jonassen, 2013). In this way, the bridge between the skills required in real life and the skills developed in higher education can be reduced. Consequently, educational large-scale assessments have already included the assessments of problem-solving abilities (e.g., Programme for International Student Assessment (PISA); Assessment and Teaching of 21st Century Skills (AT21S); The OECD Survey of Adult Skills (PIAAC)).

Statement of the problem. As it concerns the skill of problem solving in particular, a number of researchers and practitioners agree that universities do not prepare students for this adequately and higher education graduates are not good enough at problem solving (Csapó & Funke, 2017; Keeling & Hersh, 2011; Luckin et al., 2017; Sellingo, 2017). The European Commission concludes that “many young people leave education and training without being sufficiently prepared to enter the labour market” (European Commission, 2016, p. 4). Similarly, Csapó and Funke (2017) observe that although the development of the most important 21-st century skills is frequently declared among educational goals, it remains just a slogan in the majority of cases. A recent conclusion from a group of experts that took part in the research on collaborative problem solving at the University College London is that the link between the research (which stresses the importance of the development of this skill) and practical actions is very poor and, therefore, more support for the implementation of this initiative is necessary (Luckin et al., 2017). After reviewing 80 examples of collaborative problem solving practice, the findings reported was that there were very few examples in higher education of addressed this skill more explicitly.

In formal education, the skill of problem solving can be developed in various ways. The increasing amount of research on problem solving usually includes four different groups of methods that contribute to the development of this skill: direct development of problem-solving skills, content-based methods, enhanced instruction and others (Csapó & Funke, 2017). Among them, the method that has been most prominent and most widely researched is problem-based learning (hereafter PBL), which places the major emphasis on disciplinary content knowledge acquisition in the context of problem solving. The current research focuses on the application of enhanced instruction in educational environments designed for the main purpose – so that students enhance problem-solving skills.

An important concern is about what types of problems should be taught to be solved in formal education. A number of researchers (e.g. Walker et al., 2015; Jonassen, 2011a; Jonassen & Hung, 2008; Hung et al., 2008; Hung, 2011; Walker et al., 2015) agree that students should learn how to solve ill-structured problems because these are the problems which are more commonly encountered in professional lives and everyday practice. However, well-structured problems are the ones that still dominate in formal education. They are the type of problems when, for example, an individual is given portions of content knowledge during the semester and then its memorization and application is tested during the exam. In most cases, such problems are not complex because they can be solved by the application of a limited number of rules and procedures, they usually possess correct and convergent answers and have preferred and prescribed solution processes (Wood, 1983, as cited in Jonassen, 2011a). On the other hand, ill-structured problems include one or more problem elements that are unknown, are not self-contained and multidisciplinary in nature, have multiple solutions or no solution at all (Jonassen, 2011a).

If the development of the most important 21-st century skills is indicated to be included in every curriculum, foreign language modules could not be the exception. For higher education institutions, it is not enough to develop foreign language proficiency in a foreign language course or, simply speaking, nor taking care of learners learning foreign languages solely. Higher education is expected to support and facilitate the development of citizens ready to live and work successfully in an increasingly complex and unpredictable world and, therefore, foreign language courses should also have an emphasis on the development of additional skills necessary for personal growth. Learning how to solve problems can be coupled with the learning of a foreign language (hereafter FL). This is what the new face of a university FL course can be, serving as an answer for those practitioners and researchers that criticize it for being a "light-thinking" subject instead of "rich-thinking" and for too much focus on learning about language rather than with or through language, and also indicate the need to re-envision FL education (e.g., Cammarata et al., 2016).

Many researchers and practitioners (e.g., Jonassen, 2012; Spector et al., 2013; Wang et al., 2016) agree that learning with real-world problems or in problem-oriented contexts is more effective at all levels of education. Learning in such contexts may ensure both better domain knowledge acquisition and the development of non-cognitive and cognitive skills involved in learning to solve problems. However, organizing such learning remains challenging and difficult because of the lack of both practical methods and scientific research on how to improve problem-solving skills (Cho et al., 2015, Csapó & Funke, 2017; Jonassen, 2011a; Mayer & Wittrock, 2006; Wang et al., 2016; Siddiq & Scherer, 2017).

Furthermore, there is too little research on how the development of problem-solving skills can be integrated into FL studies. There were only some attempts to integrate the development of these skills through the use of PBL (e.g., Anthony 2011;

Anthony & Kadir, 2012; Du & Kirkebæk 2012; Doghonadze & Gorgiladze, 2008; Caspary & Boothe, 2017; Ciuciulkiene, 2003; Coffin, 2014; Larsson, 2012; Lin, 2017; Mathews-Aydinli, 2007) as one of the ways to develop this skill. However, this very idea is also under researched and seldom experimented (Anthony, 2011; Coffin, 2014; Larsson, 2001; Li, 2013; Otham et al., 2013). In addition, no studies were found that investigated the question on how enhanced instruction contributing to the development of problem-solving skills and different from PBL can be integrated into foreign language studies. Although a limited number of the scientific attempts to describe this phenomenon have already proved it to be a suitable and effective approach for foreign language teaching and have had positive effects on acquiring additional skills, it still needs more thorough investigation and substantiation (Anthony, 2011; Coffin, 2014; Larsson, 2001; Li, 2013; Otham et al., 2013).

A number of scholars and practitioners within the field (e.g., Cammarata et al., 2016; Martel, 2016; Ryshina-Pankova, 2016) point to the necessity to reform FL education. It is criticised for being highly conservative; as merely focusing on the idea that learning to master a language means acquisition of its forms and structures. FL education is frequently considered as a light-thinking subject with a mere emphasis on repetition and recall, with traditional skill-focused and grammar driven curricular structures (Cammarata et al., 2016). Taking this minimalist and limited understanding of the nature of language, higher education fails to ensure enough quantity and quality of true higher learning, and not helping students to become qualitatively different people ready to think critically and creatively, solve problems, accept responsibility and comprehend complex issues. Focusing only on the students' linguistic repertoires is not the direction for the FL curricular. Instead, FL classrooms should change into intellectually stimulating environments where both cognitive and linguistic growth is coupled.

Furthermore, merging FL learning with learning to solve real-life problems is in line with the recommendations expressed in The Common European Framework of Reference for Languages (CEFR, 2018) and includes the major emphasis on an action-oriented approach for learning languages. Accordingly, learners should be involved in performing real life open-ended tasks requiring extensive and purposeful communication allowing them to improve mediation strategies (facilitation of communication and understanding among group members). Mediation activities are indicated to be central when learning languages (CEFR, 2018).

Although the need to develop problem-solving skills is widely acknowledged, there is too little research on how to design such complex educational environments where learners are educationally enabled to develop this skill in formal education, including university educational environments of foreign language studies. Thus, the main research problem can be formulated in the following question: **What should university educational environments be to enable students to learn problem solving (in foreign language studies)?**

This descriptive qualitative multiple-case study was done in order to investigate the complex educational phenomenon of university educational environments of foreign languages studies enabling students to learn problem solving (to develop problem-solving skills) implemented in the study practice. The study offered a snapshot of three cases, followed by a comparison across these cases (cross-case analysis) both to determine similarities and differences, as well as to draw conclusions based on cross-case findings. To answer the main research problem of what university educational environments of foreign language studies should be that enable students to learn problem solving, the study started with the literature review and ended with the theoretical model of educational enablement of students' learning to solve problems in foreign language studies. The goal of the empirical research was to validate the model by implementing it in a specific university foreign language course.

Research object:

University educational environments enabling students to learn problem solving (in foreign language studies).

Research aim:

To substantiate university educational environments enabling students to learn problem solving (in foreign language studies).

Research objectives:

1. To provide a theoretical rationale of university educational environments enabling students to learn problem solving (in foreign language studies).

2. To substantiate the research methodology for revealing the usability of the model of educational environments enabling students to learn problem solving in the university foreign language study practice.

3. To empirically assess the usability of the model of educational environments enabling students to learn problem solving in the case of a specific university foreign language course.

Conceptual framework. The research was based on the following theories and conceptions:

• **Situated learning** (Lave & Wenger, 1991) is an important contemporary learning theory according to which "learning is most effective when it is embedded in authentic tasks that are anchored in everyday contexts" (Hung et al., 2008, p. 488). According to this view, learning to solve problems should be achieved not while learning how to solve problems but by involving students into real life problem solving experience.

• **Learning by doing** (Dewey, 1938) by accepting it as a more suitable way of learning when learners are engaged in purposeful and meaningful communication, by completing authentic tasks having both linguistic and non-linguistic goals.

• **Social constructivism** (Vygotsky, 1978) emphasizing the collaborative nature of learning, which is also essential for learning to solve problems. The methodological worldview held for this study is also social constructivism, according to which truth is constructed and manifold; knowledge, meaning and facts are context-based and produced by the interactions between the informants and the researcher, which is congruent with the characteristics of qualitative research (Creswell, 2009).

• Move from individual to **collaborative learning**. Contemporary constructivist, sociocultural and situated conceptions of learning stress the view that learning is a socio-dialogical process (Jonassen & Land, 2012). Relying on social aspects these conceptions offer, when learners construct knowledge within a community, it inevitably provides more motivational meaning, more confidence and opportunities to learn from each other. A number of advantages of learning collaboratively have been widely discussed in educational literature (e.g., Juceviciene & Valineviciene, 2015; Vizgirdaite, 2013).

• **Collaborative problem solving**. Collaborative problem solving has been studied in the current research, since this is the type of problem solving that is more necessary for students to be prepared for future work environment (Hesse et al., 2015).

• The development of the **empowering educational environment** is emphasized (Juceviciene et al., 2010; Juceviciene, 2013; Lipinskiene, 2002).

Research methodology and the nature of the study. To explore and describe the complex phenomenon of students' learning to solve problems in three groups in university educational environments of foreign languages studies. A case study was seen as a suitable approach, given the desire to understand how learners learn to solve problems, how factors of the developed educational environments enable them to learn problem solving and what results are achieved. The position taken was that of a practitioner-researcher according to which understanding on how to better develop educational environments came only from those researchers that are working within and not outside a class (Cochran-Smith & Lytle, 2009).

The current case study was grounded on the qualitative research method, which allows in-depth understanding of students' learning to solve problems. It was carried in the university module *English (for C1 level)* and involved more than a single case, it used a multiple-case design. Being conducted simultaneously, across all three cases, it aimed to assess the usability of the model on students' educational enablement of learning to solve problems in a foreign language studies course. It was expected that the evidence obtained from more than a single case would be more compelling and enhance the generalizability of the research.

To ensure internal validity, triangulation was used by employing multiple methods and multiple sources of data. Data was collected by asking students during semi-structured interviews at the end of the study, by observing and then analysing data from the researcher's notes and reviewing documents created by the participants during the study.

Qualitative data obtained from observations, semi structured interviews and outcome documents were analysed using directed content analysis (Hsieh & Shannon, 2005). In it, data analysis starts with the initial codes obtained from the literature review, which are later supplemented with the new categories and subcategories from the data which cannot be coded (Hsieh & Shannon, 2005). The findings obtained using this approach were expected to support or contradict evidence from the literature review, which was presented by showing codes with exemplars and by offering descriptive evidence.

The logical structure of the study is: 1) literature review according to which the model of educational environments enabling students to learn problem solving was designed, 2) selection of cases and design of data collection, 3) conducting the empirical investigation across all three cases simultaneously, 4) presenting the results from each case, and 5) drawing the conclusions based on cross-case findings.

Theoretical novelty. The current study adds to the field of education by theoretically substantiating and empirically testing the model of educational environments that enables students to learn problem solving. The research makes a contribution to the knowledge base on how to design, implement and assess such educational environments in higher education.

Being implemented in foreign language studies, it additionally supplements the overall body of research on what a modern face of foreign language studies in higher education could be, especially for those institutions that aim for long-term outcomes in their students. The research supports the possibility of integrating the development of domain-general problem-solving skills into the field of foreign language education and adds to the research done in this area. Foreign language educators may benefit from this research by acquiring new ideas on how to develop a more robust and advanced educational environment that couple both learning of foreign languages and the development of the most important 21st century skills. Also, they can further develop ideas on how to embed language instruction in the context of content more meaningful to students, which is claimed to be more effective in foreign language education and belongs to one of the increasing trends in foreign language education (e.g., see Cammarata et al., 2016). It is usually implemented by using the practice of content and language integrated learning, known as CLIL. The focus of this approach is both on language learning and domain-specific knowledge acquisition, whereas in educational environments, enabling students to learn problem solving the focus might be on language (learning it in a more meaningful way than traditionally) and the development of problem-solving skills, with the decreased focus on learning content in comparison to content and language integrated learning. It may serve as an answer to what foreign language educational reform should be about, how foreign language education should be transformed, especially for those learners that seek higher levels of foreign language proficiency. Furthermore, this way of learning is in line with the modern ideas on foreign language education, encouraging higher educational organisations to focus on an action-oriented approach and mediation activities.

Practical relevance. Since the development of problem-solving skills is suggested to be included into every domain-specific curriculum, the designed model could be useful for all instructional designers that consider the development of problem-solving skills as one of the main aims. This research could also add to the PBL research area in suggesting ways on how to enhance the development of this important skill. The current research focuses on collaborative ill-structured problem solving, namely, the aspects that are vital in PBL contexts. Considering the prevalence of problem solving in our daily lives, this research might be also useful for everyone that is interested in the ways to develop this skill. In conclusion, this study is intended to give educational stakeholders a better understanding of how to design modern educational environments. The main aim was to develop theoretical insights and practical solutions simultaneously on how collaborative problem-solving skills can be enhanced in formal education.

Structure of the study. Introduction contains the background of the problem with the statement of the problem, purpose of the study, conceptual framework, research methodology, nature of the study, its significance, definitions of the key terms and organization of the study. Chapter 1 presents the literature review as the theoretical rationale of university educational environments of foreign language studies to learn problem solving, which ends with the theoretical model to be implemented and assessed empirically. Chapter 2 discusses the research methodology of the study, data collection methods and its analysis procedures as well as trustworthiness. Chapter 3 contains the empirical assessment of educational environments of students learning to solve problems as they were implemented in the university study module *English (for C1 level)*, where results are presented from each case separately and then followed by cross-case synthesis of findings. The chapter ends with a discussion. The final chapters are conclusions and recommendations.

CHAPTER 1: THEORETICAL RATIONALE OF UNIVERSITY EDUCATIONAL ENVIRONMENTS ENABLING STUDENTS TO LEARN PROBLEM SOLVING IN FOREIGN LANGUAGE STUDIES

1.1 Approaches to problems and their solving

The first goal of this chapter is to overview the essence of problems. The second goal is to briefly overview the research on human problem solving by presenting the most prominent theories and models. The third goal is to discuss cognitive and non-cognitive processes, as well as the types of knowledge involved in problem solving. The chapter ends with a discussion of various types of problem solving and capabilities included into it.

1.1.1 The essence of problems

The goal of this section is to overview the essence of problems by analyzing their definitions, anatomical parts, types, external and internal characteristics.

A well-known definition of a problem is given by the Gestalt psychologist Karl Duncker (1945) in his classic work *On Problem Solving*:

> A problem arises when a living creature has a goal but does not know how this goal is to be reached. Whenever one cannot go from the given situation to the desired situation simply by action, then there has to be recourse to thinking. Such thinking has the task of devising some action, which may mediate between the existing and desired situations. (p. 1)

Scientists from the cognitive psychology field, Eysenck and Keane (2005), also state that "a problem only exists when someone lacks the relevant knowledge to produce an immediate solution" (p. 434). Dunbar (1998) reiterates that "a problem exists when a goal must be achieved and the solution is not immediately obvious" (p. 289). Psychologists treat a problem as "a gap or barrier between where you are and want to be" (Halpern, 2014, p. 452). Thus, the definitions imply that a problem exists when someone wants to move from here (the initial state) to there (the desired goal state) but currently lacks knowledge and possible solution paths are not immediately known or blocked by barriers.

In their classic work *Human Problem Solving*, Newel and Simon (1972), proposed the following basic anatomical parts of a problem: initial state, goal state, solution paths, problem space and givens, which brings more clarity in the terminology of problem solving. Problem space includes all possible solution paths from the initial state to the goal state. A problem solver passes through intermediate problem states on the way from the initial state to the goal state. The givens are knowledge needed to reach the goal, which can be divided into explicitly stated and implicitly assumed (Halpern, 2014). Barriers or obstacles stand in the way of achieving a goal. They mean the lack of knowledge either on the means necessary to solve the problem or lack of concreteness in understanding the goal state (Dorner, 1976, as cited in Fischer et al., 2012).

Similarly, Dunbar (1998) lists four components of a problem: 1) initial state (state of knowledge at the start of problem solving process), 2) goal state (the goal to achieve), 3) actions or operations (used to achieve the goal state), and 4) task environment (the problem solver is working in). Solving a problem means searching through the problem space to find the best path to the goal state (Newel & Simon, 1972).

Applying the terminology discussed, the anatomy of an ill-structured problem is shown schematically in Figure 1 below.

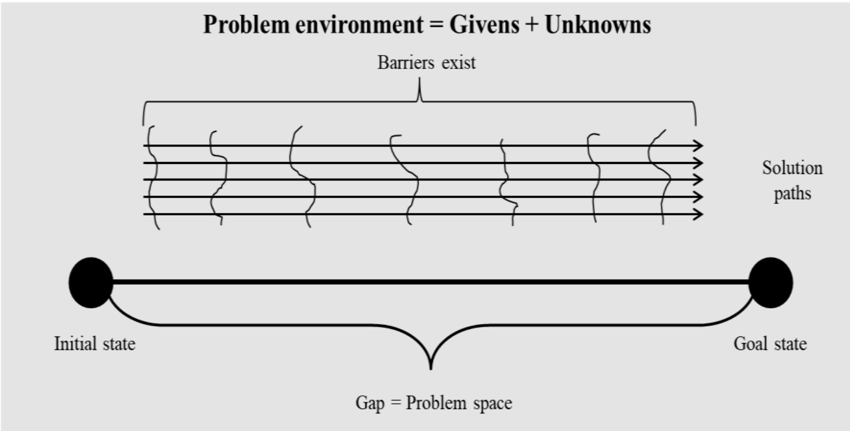

Figure 1. The anatomy of an ill-structured problem

Newel and Simon (1972, as cited in Fisher et al., 2012) explain that human problem solving starts with the construction of the internal representation of a problem space (understanding the possible states of a problem), then continues with the search for a method to reach the desired goal state. When the chosen method does not allow reaching the desired goal state, new methods are searched or possible problem states are reconsidered. However, Funke et al. (2018) observe that this explanation is too simplistic and is only applicable to well-structured problems because it does not address the aspects that are typical to complex problem solving, such as dynamicity and complexity of problems as well as non-cognitive factors affecting problem solvers themselves.

Both external and internal factors of problems can be distinguished. As explained by Jonassen (2011a, 2011b), external factors are those related to the problem as it exists in the world and internal ones are related to how individuals conceptualize and resolve them or to problem solvers. According to Jonassen (2011a), there are six **external characteristics of problems**: 1) *structuredness*, 2) *situatedness* (context), 3) *complexity*, 4) *dynamicity*, 5) *transparency*, and 6) *domain specificity* (see Figure 2).

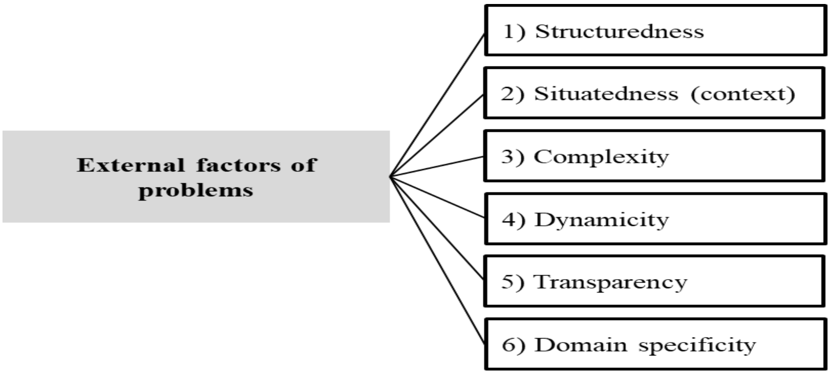

Figure 2. External factors of problems (adapted from Jonassen, 2011a)

Firstly, problems vary in the amount of the structure they provide. As indicated by researchers (Dunbar, 1998; Foshay & Kirkley, 1998; Jonassen, 2011a; Hong, 1998; Newell & Simon, 1972;), the continuum between *well-structured* and *ill-structured* problems based on their **structuredness** is the most common classification of problems.

Well-structured ←————→ **Ill-structured**

Figure 3. The continuum of problems according to their structure (Jonassen, 2011a; Foshay & Kirkley, 1998; Hong, 1998; Newell & Simon, 1972; Dunbar, 1998)

However, researchers (Jonassen, 2011a; R. J. Sternberg & K. Stenberg, 2012) point out that structuredness is not a dichotomous variable and only represents a continuum, which means that not every time problems can be assigned as to belonging to one or another end of this continuum and be divided into two discrete classes with clear boundaries between them. In addition, Simon (1973, as cited in Hong, 1998) notes that whether a problem is well-structured or ill-structured depends not only on the problem itself but also on an individual's solving ability and his/her available knowledge. Therefore, what may be counted as a problem for one person does not always mean a problem for the other (Eysenck & Keane, 2005). For instance, some difficult mathematical calculation that is usually a problem for most people may not be a problem for somebody with relevant expertise in that domain. Thus, whether a particular question is a problem or not, as well as what kind of problem it is depends on the problem solver. This means that any judgement about a problem should imply both its external and internal characteristics.

To define well-structured problems, Wood (1983, as cited in Jonassen, 2011a) explains that they "present all of the information needed to solve the problems in the problem representation; they require the application of a limited number of regular or circumscribed rules and principles that are organized in either a predictive or prescriptive way" (p. 6). In addition, these problems "possess correct and convergent answers; and have a preferred, prescribed solution processes" (Wood, 1983, as cited in Jonassen, 2011a, p.6). As defined by Jonassen (2011a), they "consist of a well-defined initial state, a known goal state, and a constrained set of logical operators" (p. 6). Kirkley (2003) explain that well-structured problems always use the same step-by-step solution, their solution strategies are usually easily predictable, they have convergent answers (one right answer) and a problem statement includes all information necessary for its solution. Well-structured problems are most common in formal education and typically found at the end of a textbook chapter or during examinations. For instance, typical examples of such problems are most mathematics and mathematics-related problems that require the application of a formula or questions that students have to answer after reading a chapter in a coursebook or consulting domain-specific material presented in the slides of a lecturer.

On the other hand, ill-structured problems are the most commonly encountered in everyday life and work. They contain "one or more of the problem elements are unknown or not known with any degree of confidence" (Wood, 1983, as cited in Jonassen, 2011a, p. 7), which means that they are not self-contained in comparison to well-structured problems. These problems have solutions that are not predictable or convergent (no one right answer); they usually require the integration of several content domains and therefore are interdisciplinary in their nature (Jonassen, 2011a). They may have multiple solutions and paths to them as well as no solutions at all (Kitchner, 1983, as cited in Jonassen, 2011a). Hong (1998) also confirms that ill-structured problems are more frequent in human experience and may have multiple solution processes and solutions. Such problems may have multiple criteria to evaluate solutions and are less frequent in classrooms because of them being more difficult and time consuming (Collins et al., 2016). An example of such kind of problem is a workplace engineering problem.

Table 1 summarizes the discussed differences of problems as they concern the first external factor of problems - structuredness.

Table 1. Differences between well-structured and ill-structured problems

1) Structuredness	Well-structured problems	Ill-structured problems
Initial state	Well-defined	Ill-defined (because one or more of the problem states are unknown)
Goal state	Goal state is known (have correct and convergent answers)	Goals are vaguely defined (have no correct and convergent answers; may have multiple solutions or no solution at all)
Solution paths	Clear paths to solution (constrained set of logical operations towards the goal)	No clear paths to solution; may have multiple solution paths
Givens	Contain all of the information needed to solve	Not self-contained; there is insufficient information to solve them

Furthermore, taking into account the terminology used in the classification of problems, according to their structure, the researchers (Ertmer et al., 2008; Jonassen, 2011a; Mažeikienė & Lenkauskaitė, 2011; R. J. Sternberg & K. Stenberg, 2012) indicate that ill-structured problems are synonymous to ill-defined as well as well-structured problems to well-defined. For the present thesis, the same view is taken.

Secondly, **situatedness** (context) of a problem is related to the context in which it is embedded or the situation described in the problem. While well-defined problems are more abstract and not embedded in any meaningful context, ill-structured problems are more context dependant and defined by everyday and workplace situations (Jonassen, 2011a). For instance, ill-structured problems may be so context-dependant as not to have meaning outside the authentic situation in which they occur (Jonassen, 2011a). Clearly, because of this aspect, ill-structured problems should be more difficult to be solved.

Thirdly, as it concerns the **complexity** of problems, it is "a function of external factors, such as the number of issues, functions, or variables involved in the problem; the number of interactions among them; and the predictability of the behaviour of those issues, functions or variables" (Jonassen, 2011a, p. 9). The number of components, their interactions and consistency in the problem that allow to decide about the complexity of a problem. Obviously, the more components are represented in a problem, the more difficult it is to solve. Ill-structured problems tend to be more complex because of having more variables and well-structured tend to be simpler because they have a constrained set of variables. However, this is not always true because sometimes an ill-structured problem can be very simple, for example, which shoes to wear. On the other hand, chess is a very complex but well-structured problem.

The views of researchers diverge, as some of them equate ill-structured problems with complex problems (e.g., Shin & Song, 2016) while the rest support the idea that complexity of a problem is not equal to its structuredness (e.g., Jonassen & Hung, 2008; Jonassen, 2011a). To support this, Jonassen and Hung (2008) place problems on two crossing continuums both between complex and simple problems as well as between well-structured and ill-structured problems.

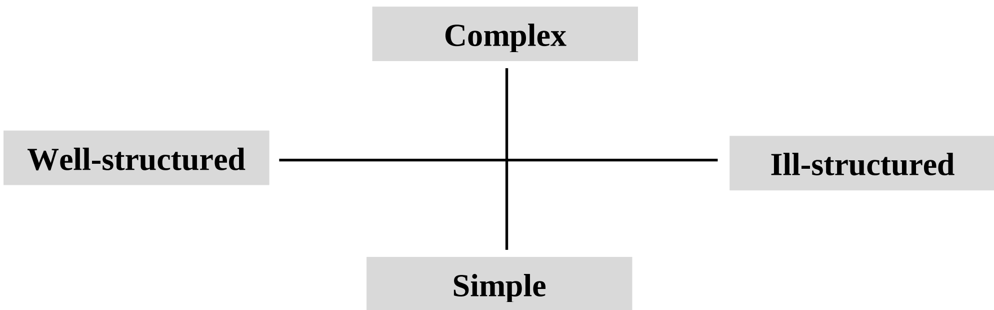

Figure 4. Two crossing continuums of problems according to their structure and simplicity (adapted from Jonassen & Hung, 2008)

In the terminology used by Jonassen (2011a), complexity of a problem is just an external function (dependant only on a problem itself) whereas a number of researchers (see below) warn about the necessity to take into account both external and internal (related to a problem solver) factors when judging about complexity of a problem and its solution. For instance, Funke (2003, as cited in Fisher et al., 2012, p.20) defines complex problems as "involving multiple goals, as many possible actions that could be considered, each associated with several different and uncertain consequences, in environments that may change dynamically and independent of the problem solvers' action". Fisher et al. (2013, p. 22) define complex problem solving "as a kind of problem solving, with the problem itself (the structure of (a) the external problem representation and/or (b) the mental representation of the problem), or the process of its solution having to be formalized as a set of many highly interrelated elements, i.e., complex system". Jonassen and Hung (2008) explain that the degree of a problem complexity can be judged considering four parameters:

1) the breadth of knowledge required (how much knowledge a problem solver needs to solve the problem),

2) the difficulty level of concepts involved (whether learners are able to grasp and apply concepts involved in solving one particular problem),

3) the skills and knowledge levels required to solve it (intricacy of problem-solving procedures – the length of solution path), and

4) the degree of nonlinearity of the relations among the variables included in the problem space (the number and complexity of relations that need to be processed).

Taking into account the following parameters, Table 2 below summarizes the differences between simple and complex problems.

Table 2. The relationship between the complexity of a problem and the parameters determining it (adapted from Jonassen & Hung, 2008)

Parameters	Simple problems	Complex problems
Breadth of knowledge required	Less amount of knowledge and information required	Require big amount of knowledge and information
Difficulty level of concepts involved	Concepts involved in solving a problem are easy to grasp and apply	Concepts involved in solving a problem are difficult to grasp and apply
Intricacy of problem-solving procedures	Less number of steps to be executed in solution paths with less complex tasks and procedures in these steps	Bigger number of steps to be executed in solution paths with more complex tasks and procedures in these steps
Relational complexity	Less complex relations requiring less processing load	More complex relations requiring more processing load

Fourthly, **dynamicity** of a problem is related to any change of its variables over time (Jonassen, 2011a). While well-structured problems tend to be more static, ill-structured ones tend to be more dynamic.

Fifthly, **transparency** is how many unknowns are in the problem space (Jonassen & Hung, 2008). Ill-structured problem usually have a larger number of unknowns in comparison to well-structured problems.

Sixthly, **domain specificity** can be explained by the fact that some problems require cognitive strategies which are specific to one or another domain (Mayer, 1992; Sternberg & Frensch, 1991, as cited in Jonassen 2011a). Hence, learners in different domains develop reasoning skills that require forms of logic specific to these domains.

For instance, students of psychology and medicine perform better on statistical, methodological, and conditional reasoning problems than students in law and chemistry (Jonassen, 2011a).

The relationships between the type of a problem according to its structure and external characteristics are summarized in Table 3, which is the continuation of Table 1; where structuredness (number one in the list of external characteristics) is already presented.

Table 3. The relationships between the type of a problem according to its structure and external characteristics (adapted from Jonassen, 2011a; Jonassen & Hung, 2008)

External characteristics of problems	Well-structured problems	Ill-structured problems
2) Situatedness (context) (situation described in the problem)	Tend to be more abstract and not embedded in any meaningful context	Tend to be more embedded in and defined by everyday or workplace situations
3) Complexity (how components (issues, functions, variable) are represented implicitly or explicitly in the problem, how they interact, and how consistently they behave)	Tend to be simpler because they have a constrained set of variables or factors	Tend to be more complex because they have more variables
4) Dynamicity (whether relationship among variables (conditions or context) change over time)	Tend to be more static	Tend to be more dynamic
5) Transparency (unknowns in the problem space)	Tend to have less unknowns	Tend to have more unknowns
6) Domain specificity (belonging to a specific domain)	No direct relationship between structuredness and domain specificity exists	No direct relationship between structuredness and domain specificity exists

Regarding **internal factors of problems**, they are related to each individual and not to the problem itself. As Jonassen (2011a) explains, these factors are the cognitive styles, reasoning abilities, levels of domain knowledge, breadths of knowledge required to solve the problem and the attainment levels of students solving problems. In addition, such important factors as interest, motivation and creativity also belong to these characteristics. Hence, individual cognitive, social and personality differences are internal factors influencing problem solving. Internal characteristics of problems are summarized in Figure 5 below.

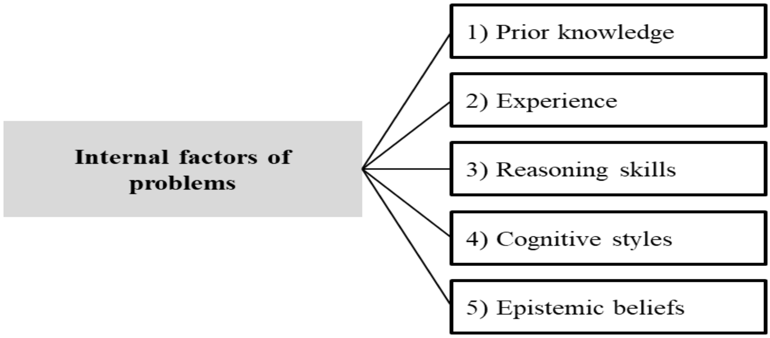

Figure 5. Internal factors of problems (adapted from Jonassen, 2011a)

To sum up, a problem occurs when a person has a goal but does not know how to achieve it immediately, therefore does not know how to move from the initial to the goal state because of lacking the necessary knowledge for that. The anatomy of a problem includes the following components: initial state, goal state, solution paths, barriers, problem space and givens. The factors that define problems can be distinguished into external and internal ones. External factors are related to the problem itself as it exists in the world and include: 1) structuredness (structure of a problem), 2) situatedness (context) (situation described in a problem), 3) complexity (the number of variables and relationships among them), 4) dynamicity (change over time), 5) transparency (number of unknowns in a problem space), and 6) domain specificity (how much of domain-specific skills and knowledge are required). Internal factors are related to a problem solver and include their cognitive styles, reasoning abilities, the amount of domain knowledge, interest, motivation and creativity, which are individual cognitive, social and personality differences.

The two most common types of problems are well-structured and ill-structured. Well-structured problems contain all information needed to solve them, have correct and convergent answers, as well as constrained paths to a solution. Ill-structured problems, on the other hand, do not contain all information necessary to solve them, goal states are vaguely defined, and they possess multiple solutions paths and solutions or no solution at all. Whether a problem is well-structured or ill-structured is dependent not only on a problem itself (internal factors) but also on a problem solver (external factors).

Placing problems on a continuum from simple to complex problems is another most common classification of problems. Although ill-structured problems are usually complex, complexity of a problem cannot be equated only to its structuredness. All three elements – the problem itself (its external characteristics), its understanding (representation) and solution processes have to be complex, which means containing many highly interrelated elements that make its system complex. In addition, whether a problem is simple or complex is dependent not only on a problem itself (internal factors) but also on a problem solver (external factors.)

For this thesis, *problem* is approached as a question or an issue that is uncertain and so must be examined and possible answers and solutions searched for. It should have three main components: 1) an initial state that is perceived as requiring a resolution, 2) a desired goal state (it can be one solution or many solutions of a problem) and 3) a lack of knowledge of how to immediately move from 1) into 2). The conception of a problem cannot be restricted to something negative only.

1.1.2 Problem-solving theories and models

This chapter aims to give a chronological overview of the research on human problem solving by explaining the most salient aspects in it.

Early attempts – analysis of individual mental processes during complex problem solving. Early attempts to understand problem solving were made by psychologists, such as Oswald Külpe, Karl Bühler, and Otto Selz, who analysed the mental processes during complex reasoning and problem solving (Dunbar, 1998). For instance, in the late 1890s, Kulpe invented "the method of 'systematic experimental introspection', a technique that required extensive retrospective reports from trained subjects about their perceived internal processes during their problem solving activities while working on complex intellectual tasks" (Funke, 2013, p. 2). Such initiatives to understand and explain human problem solving were referred to as the analysis of higher cognitive processes (Funke, 2013; Dunbar, 1998).

Behaviorist approach – trial and error for problem solving. Later, with the appearance of the learning theory of behaviorism, the analysis of problem solving as of higher cognitive processes was diminishing. To understand problem solving, behaviourists did not look at what happened in the human mind but analysed it as a situation, stimulus and response. The term *trial and error* was introduced by C.Lloyd Morgan in 1894, who analysed his dog's behaviour during the process of problem solving. Another notable behaviourist Edward Thorndike experimented with cats, also trying to explain problem solving. He placed hungry cats inside a box and the food was placed outside the box so that cats could see it. In order to get out, the cats had to pull a lever and they showed a random behaviour until they were able to do that by chance. This problem solving is another example of trial and error which involves trying randomly and unsystematically again and again without requiring any specific knowledge, it is time consuming and monotonous. It is a kind of problem solving that is typical to children (e.g., trying to fit the shapes into the holes) and, of course, not suitable for solving complex problems.

Gestalt approach – emphasis on the need to create new representation of a problem that may provoke an insight. In the 1940s and 1950s the Gestalt psychologists continued research on complex problem solving. The main idea behind this theory was that problem solving requires mental restructuring – creation of a new representation (how someone views, interprets, and organizes the given information) which is accompanied by the insight experience (also called "aha" moment or illumination) (Ohlsson, 1992). The Gestalt psychologists divided problem solving into 4 stages: 1) preparation, 2) incubation, 3) insight, and 4) verification (Dunbar, 1998). According to Halpern (2014), incubation is the period of time when an individual is not actively thinking about a problem but during which a solution may emerge unexpectedly. This sudden understanding that you already know the solution is called *insight* (Ohlsson, 1992). This suggests the idea of timing-out from a problem that can result in the sudden solution.

Dunbar (1998) provides a famous example of Karl Dunker's radiation problem, in which it was asked to destroy a stomach tumour without destroying the surrounding tissue. If high intensity rays were applied to destroy the tumour, they would have the same effect on the healthy tissue around it as well. The solution of the problem was that instead of using a single high-intensity ray, doctors found the way to apply several low-intensity rays at once from different directions. As a result, each ray could not do harm along its path and the effects of them summed in the place of the tumour; thus achieving the effect of high-intensity. In such complex problems, an individual had to discover a crucial element and after it was discovered all the other elements fell into place and the problem was solved. These were called insight problems, because of problem solving occurring with a flash of insight.

Related to insight, *functional fixedness* is a more interesting phenomenon that Gestalt psychologists were trying to explain. They stated that human perception first identifies the whole of anything and only then tries to understand smaller individual components of it. According to Duncker (1935, as cited in Ohlsson, 1992), this is the main reason why people see things for their common use only. For instance, a fan is first seen as a device for hair drying and not as a device suitable for blowing leaves from the pavement in autumn. If overcoming functional fixedness, it can be one of the useful ways of thinking when solving problems and improving creativity.

General problem-solving models/ Cognitive approach/ Information-processing models – attempts to suggest general problem-solving approaches. After the Gestalt movement, in times of Cognitive Revolution around 1950s, a search for general problem solving models that can be used to solve various types of problems started. Researchers understood that in everyday life most problems do not involve the element of insight. General problem solving models assume that all problems, regardless of their type, are solved in almost the same way; yielding to similar results and, therefore, these decontextualized problem-solving skills can be utilized in any situation (Foshay & Kirkley, 1998; Funke, 2013; Jonassen, 2011a).

From the information-processing perspective, Wood (1983, as cited in Jonassen, 2011a) explains that a problem may have multiple initial states, goal states and paths. The process of solving a problem means "finding a path through the problem space that starts with initial states travelling along paths that satisfy the path constrains and ends in the goal state" (Jonassen, 2011a, p. 2). The problem space is like the sum of all its possible states and operations needed in the path to the goal state. Thus, problem solving is the search in this space by undergoing a sequence of processes in order to solve the problem. Information processing models highlight two main processes when solving problems – understanding and search processes (Jonassen, 1997).

Among the popular information-processing models, two models of classic General Problem Solver (Newell & Simon, 1972, as cited in Jonassen, 2011a) and the IDEAL problem solver (Bransford & Stein, 1984, as cited in Jonassen, 2011a) can be mentioned. By publishing their classic book *Human Problem Solving* in 1972, Allen Newell and Herbert Simon were considered the revivers of the research on problem solving (Novick & Bassok, 2005). Whereas the Gestalt psychologists emphasized the importance of new problem representations, Newel and Simon emphasized the step-by-step process of searching for a solution path in a problem space from its initial to the goal state. As explained by Ohlsson (1992), a classic problem that has commonly been used to analyse problem solving is the Tower of Hanoi puzzle. In it, an individual is given a board with three rods on it with three disks of decreasing size placed on the leftmost rod (the initial state). The solution that has to be achieved is to place all the disks on the rightmost rod with the two restrictions that only one disk has to be moved at a time and a larger disk is not allowed to be placed on a smaller one. All possible problem states consist of 27 states that are connected by the movement of just one disc. This problem can be solved in different ways when searching for a path to the goal state through the problem space. Problem solvers need to search for the right processes to solve this problem. The general purpose strategy to solve this puzzle is means-ends analysis, during which people select subgoals (goals of subproblems into which a problem is broken down) and use them to progress toward the goal of a problem (Halpern, 2014).

The second example of a general problem-solving approach is the IDEAL problem solver that "describes problem solving as a uniform process of *i*dentifying potential problems, *d*efining and representing the problem, *e*xploring possible strategies, *a*cting on those strategies, and *l*ooking back and evaluating the effects of those activities" (Jonassen, 2011a, p. 3).

Although general problem-solving models have been used for teaching problem solving, they are frequently criticized for being not suitable to solve all types of problems, especially more complex or ill-structured (Dorner & Funke, 2017; Fischer et al., 2013; Foshay & Kirkley, 1998). For example, Jonassen (2011a) and Ohlsson (2012) conclude that problem solving is not a uniform process and such information processing models are inadequate for solving all problems. In addition, a number of scholars (e.g., Ericsson & Smith, 1991; Ifenthaler et al., 2011; Jonassen, 2011a) came to the conclusion that context is the most essential feature and problem solving should be seen as a situational or context-bound process, which is not taken into account in the case of general problem-solving models. Thus, the application of such models should be seen as limited for learning to solve problems.

Towards currently dominating ideas – collaborative complex problem solving. Two new directions of problem solving were the move from well-structured problems to complex problem solving (usually ill-structured problem solving) and focus on collaborative problem solving. Researchers (e.g., Dorner & Funke, 2017; Fischer et al., 2013; Foshay & Kirkley, 1998) agree that problem solving is a complex mental activity focusing on realistic, dynamic, complex and ill-defined problems. Accordingly, cognitive research led to more sophisticated models of problem solving that included "a complex set of cognitive, behavioral and attitudinal components" (Kirkley, 2003, p. 4). The understanding changed from approaching problem solving as a purely cognitive activity into the one that also involves motivational and affective factors (Funke, 2010; Funke et al., 2018). It broadened with the inclusion of such non-cognitive factors, such as frustration (negative emotions), motivation, tenacy, perseverance or trustworthiness (Funke et al., 2018). Jonassen and Tessmer (1996, as cited in Kirkley, 2003) list confidence, anxiety, persistence, effort and knowledge about self among such motivational and attitudinal factors important to the problem solving process. Therefore, a number of authors (e.g., Cho et al., 2015; Csapó & Funke, 2017; Jonassen, 2011a; Mayer & Wittrock, 2006; Wang et al., 2016) came to the conclusion that starting from about the 1970's, complex problem solving has become the emerging area in problem solving research.

In addition, complex problem solving has started to be included among main outcomes of learning in contemporary educational contexts. Therefore, it has received the increased interest in educational large-scale assessments (e.g., Programme for International Student Assessment (PISA); Assessment and Teaching of 21st Century Skills (ATC21S) and the OECD Survey of Adult Skills (PIAAC)) (Funke, 2013). The most prominent and the largest (over 70 participating countries) of these is the Programme for International Student Assessment (hereafter PISA) run by the OECD (Organization for Economic Cooperation and Development), which has evaluated the skills and knowledge of fifteen-year-old students worldwide from 2000. The assessment of problem solving was included in PISA 2003, PISA 2012 and PISA 2015. While the earlier versions of PISA 2003 and PISA 2012 focused on the assessment of individual problem-solving skills, PISA 2015 assessed collaborative problem-solving skills. PISA has probably been the most influential factor causing the increase in interest on problem solving and changes in its understanding.

To sum up, until about the 1970's the research on problem solving had two main traditions: 1) emphasis on the representation of knowledge and creation of new representations or mental models of the problem (as in Gestalt approach) and 2) emphasis on the concept of working in a problem space – a process of generating solutions (as in information-processing models). Still, many current views on problem solving have their roots in these two main traditions. What unified both earlier traditions was the type of problems (usually they were static and well-defined) used for research and the analysis of problem solving as an individual cognitive process. Considering a wider perspective beyond of mere understanding of human problem solving but also learning to solve problems, Gestalt's approach can be useful when advising problem solvers to create new representations of a problem or merge multiple representations into one shared understanding. On the other hand, information-processing approaches can be useful in teaching strategies or procedural ways for problem solving.

Later, with the start of approaching problem solving as a more complex process, the focus shifted on more complex and ill-defined problems. In addition, it was assumed that not only cognitive processes are involved in human problem solving but also motivational and affective. Researchers started to highlight the importance of contextual factors. With the emergence of understanding of learning as a socio-dialogical process, the research area also started to include collaborative problem solving, which is the focus of the current thesis.

1.1.3 Cognitive, non-cognitive aspects and types of knowledge necessary for problem solving

In the research on the development of problem-solving skills, researchers usually focus on cognitive and non-cognitive aspects related to problem solving, as well as different types of knowledge required for problem solving. Therefore, the following chapter dwells on the discussion of these aspects, irrespective of the type of a problem, in order to identify teachable/ learnable problem-solving aspects. It also includes the discussion on the definitions of the terms closely related to problem solving.

Problem solving vs thinking, intelligence, reasoning, decision making, critical thinking and creative thinking. Problem solving is closely related to other terms, such as thinking, intelligence, reasoning, decision making, critical thinking and creative thinking. A helpful way to distinguish among these terms could be thinking about the outcomes each of them may produce.

First, problem solving is often used interchangeably with thinking (Mayer & Wittrock, 2006; Robertson, 2001). However, Mayer and Wittrock (2006) make a finer distinction between the two terms – thinking refers to a broader concept that includes both directed cognitive processing (e.g., problem solving) and undirected ones (e.g., daydreaming). In this respect, problem solving may be regarded as a directed subset of thinking. Second, it cannot be equated with intelligence, since problem solving is characterised by some domain or situation specificity (Fleischer et al., 2017). Third, creative thinking, reasoning, decision making and critical thinking may be regarded as the constituent parts of problem solving. Creative thinking is commonly defined as thinking that is novel. Decision making is indicated as the most frequent form of problem solving or one of its constituent parts (Jonassen, 2011a). Reasoning is simply knowing "what follows what" (Halpern, 2014, p. 175). The ability to reason well is central in the definitions of critical thinking. Critical thinking can be defined as "thinking that is purposeful, reasoned, and goal directed – the kind of thinking involved in solving problems, formulating interferences, calculating likelihoods, and making decisions, when the thinker is using skills that are thoughtful and effective for the particular context and type of thinking task" (Halpern, 2014, p. 8). On the other hand, noncritical thinking is a simple "recall of information (e.g., listing the capitals of countries) or the failure to consider evidence that might support a conclusion that you do not like" (Halpern, 2014, p. 9). Critical thinking is the central part of problem solving and these skills usually come together. They are both listed next to each other in all major frameworks of the most important 21st century skills (Häkkinen et al., 2017). Accordingly, the components usually agreed to be necessary for critical thinking are also important for problem-solving skills. For example, Ventura et al. (2017) list the following components: analysing trustworthiness of information sources, looking for evidence and thus seeking justification, determining the power of an argument, recognizing biases, among others.

Problem solving – process, skill, competency, ability or expertise. Problem solving can be approached as a process (e.g., Mayer & Wittrock, 1996; Newel & Simon, 1972), skill (e.g., Hesse et al., 2015) or competency (e.g., Funke et al., 2018) without any exclusions of seeing it as an ability or expertise.

Considering problem solving as a process, it can be defined as "cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver" (Mayer & Wittrock, 1996, p. 47). Accordingly, Mayer and Wittrock (1996) list four main characteristics of problem solving: 1) it is cognitive because it occurs within the problem solver's cognitive system; 2) can be seen as a process because of the involvement in knowledge representation and manipulation, 3) it is directed because a problem solver has a goal, and 4) it is personal because it involves individual knowledge and skills. The above listed characteristics can be supplemented with the idea that problem solving can also be collaborative – involving collective knowledge and skills (for the terms of crowdsourcing, collective intelligence and the differences between individual and collaborative problem solving see Chapter 1.1.4). In addition, according to more modern views of problem solving, it is also a non-cognitive process involving such non-cognitive factors, as motivation or frustration, among others.

As stated by Funke et al. (2018) when seeing problem solving as a skill, it implies that a problem solver needs to learn how to apply some particular strategies. Referring to problem solving as a competency, it implies that it can change through training (Funke et al., 2018). Problem solving can be also approached as a competence which is more static or as an expertise which is the endpoint in the development of problem-solving skills (Funke et al., 2018). The position taken in this thesis is that problem solving is both a process and a skill comprised of a number of skills, competencies, knowledge and abilities. This view is congruent to Funke et al.'s (2018) explanation that "problem solving is a bundle of skills, knowledge and abilities that are required to deal effectively with complex non-routine situations in different domains" (p. 41). Accordingly, problem solving can be divided into three broad categories:

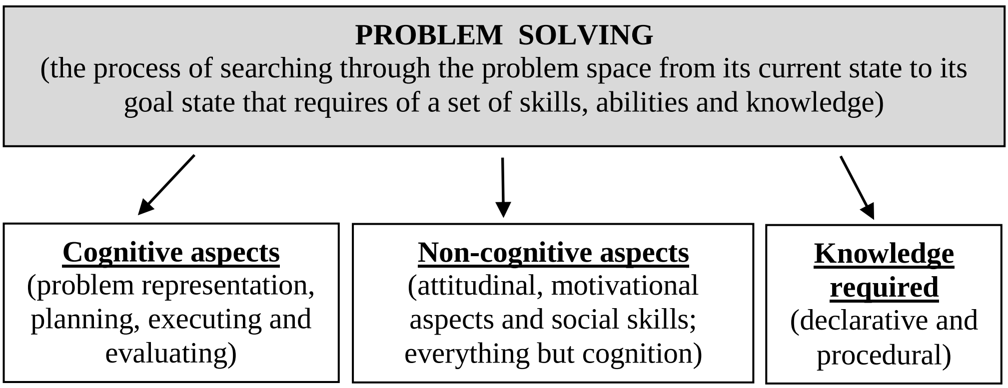

Figure 6. Aspects of problem solving

The following figure demonstrates that problem solving is a complex phenomenon. The remainder of the chapter is devoted to explaining each group separately in order to facilitate understanding of what constituent parts of problem solving can be teachable and assessed.

Cognitive aspects of problem solving process. Firstly, Mayer and Wittrock (2006) divide cognitive processes comprising problem into the stages of *representing*, *planning/ monitoring*, *executing* and *self-regulating*. According to the authors, the first cognitive process of representing means the process of constructing a cognitive representation of the problem - converting an externally presented problem into internal mental representation. During it, a problem solver seeks to understand the problem from its initial state to the goal state, including all possible paths, or, simply speaking, attempts to clarify the situation described in the problem. Researchers (Jonassen, 2011a; Robertson, 2001) also refer to this process as the creation of a mental model, mental representation, problem space or problem schema of the problem. Robertson (2001) explains that a helpful problem representation is the first and most important factor for successful problem solving, which means thinking about a problem situation and having a dynamic model of it in one's head. Any mental representation of a problem has to include at least some ideas of what a person can do in order to move from the initial state to the goal state. It depends on the knowledge that a problem solver has and the way this knowledge is organized (Robertson, 2001). In cases where this representation is complete (enough knowledge and clear situation), no problem exists. As outlined previously, a problem only occurs when an individual lacks knowledge and does not immediately know how to move from the initial to the goal state. In addition, Ge and Land (2003) state that problem representation includes the identification of the major facts causing the problem, its constraints and the recognition of divergent views on the problem. Robertson (2017) observes that the cases when problem solvers are mistaken about the problems' constraints can be improved by creating new representations. Halpern (2014) also agree that finding a different way of representing a problem is helpful. What should be concluded is that problem representation is the first and most important aspect for successful problem solving.

As Mayer and Wittrock (2006) explain it, the process of planning includes devising and monitoring a plan or a method for solving a problem, for example, breaking a problem into parts. Planning may already involve the development of solutions. Generated solutions should be supported by arguments, viable and persuasive (Jonassen, 1997). They should be evaluated and examined against other alternatives (Ge & Land, 2003). Monitoring of the problem solving means considering the suitability and effectiveness of the solution plans or methods (Mayer & Wittrock, 2006). Hesse et al. (2015) explain that it is necessary for the modification of plans and thus including problem solvers in a cyclical problem solving performance. The stage of executing means carrying out planned operations, for example, making arithmetic calculations to solve a problem. During self-regulating, problem solvers consider the effectiveness of cognitive processing during problem solving and adjusts it accordingly. Davidson et al. (1994, as cited in Fleischer et al., 2017) explain that self-regulation involves ensuring that the processes of problem solving is suitably planned, monitored and evaluated, as well as modified if necessary. Ge and Land (2003) note that monitoring and evaluating is necessary throughout all the processes of problem solving.

Secondly, the ATC21S project has developed a more modern and inclusive framework of skills that are necessary for collaborative problem solving (hereafter CPS). It is not restricted to just cognitive skills and divides all the necessary skills into two broad classes: social skills (constituting collaborative part of problem solving and related to managing group members) and cognitive skills (constituting the part of problem-solving skills and related to managing the problem at hand). As defined by

Hesse et al. (2015), cognitive skills can be grouped into planning, executing and monitoring, learning as well as flexibility, which fall into two broad groups: task regulation and learning and knowledge building. Task regulation comprises of four aspects of planning: problem analysis, goal setting, resource management and complexity. It also comprises executing and monitoring processes: information collection and systematicity. Learning and knowledge building include learning during group interaction or because of group interaction, which leads to knowledge building. The table below provides the explanations of each constituent element belonging to the cognitive skill class.

Table 4. Cognitive skills in collaborative problem solving (adapted from Hesse et al., 2015, pp. 47-48)

Cognitive skill class	*Element*	*Indicator*
Task regulation (aspects of planning and then monitoring and executing)	**Problem analysis**	Analyses and describes a problem in familiar language
	Goal setting	Sets a clear goal for a task
	Resource management	Manages resources or people to complete the task
	Flexibility and ambiguity	Accepts ambiguous situations
	Information collection	Explores and understands elements of the task
	Systematicity	Implements possible solutions to a problem and monitors progress
Learning and knowledge building	**Relationships (Represents and formulates)**	Identifies connections and patterns between and among element of knowledge
	Rules: "If…, then"	Uses understanding of cause and effect to develop a plan
	Hypothesis "What if …" (Reflects and monitors)	Adopts reasoning or course of action as information or circumstances change

Thirdly, after reviewing a number of researchers, PISA 2015 (2017) summarizes the cognitive components of individual problem solving into "understanding and representing the problem content, applying problem-solving strategies, and applying self-regulation and metacognitive processes to monitor progress towards the goal" (p. 135).

Fourthly, PISA 2015 (2017) presents a similar classification of four cognitive processes typical to individual problem solving as:

1. exploring and understanding (understanding problem situation from the available information and uncovering additional information),
2. representing and formulating (selecting, organizing and integrating information with the prior knowledge),
3. planning and executing (planning comprises clarification of the goal of the problem, setting of subgoals and devising a plan to reach the goal state; executing the devised plan), and

4. monitoring and reflecting (monitoring steps in the plan and reflecting on possible solutions and assumptions).

Fifthly, an alternative view to the cognitive processes in problem solving is proposed by Halpern (2014) who talks about three stages:

- preparation or familiarization (understanding the nature of the problem, the desired goal/s and the given at hand,
- production (the production of the solution paths),
- judgement or evaluation (evaluating the solution paths so as to choose the best one).

To sum up the classifications provided, it is evident that the cognitive aspects fall into four main cyclical processes of problem solving.

1. Understanding (understanding the problem situation),
2. Planning (devising a plan to reach the goal state),
3. Doing (executing the devised plan),
4. Looking back (evaluating every step that was already taken).

This does not mean that each process is followed by one another in the provided order. In addition, it is important to note that the discussed classification of the cognitive aspects can be applied both to individual and collaborative problem solving.

Non-cognitive aspects. Again, as it concerns non-cognitive aspects, it is important to note that some of them are typical to both individual and CPS, while some of them should be taken into account only when considering collaboration. While cognitive skills are about the problem that needs to be solved, all the other aspects may be considered as non-cognitive.

More specifically, Kirkley (2003) suggests taking into account two important aspects: attitudinal (confidence, anxiety, effort, persistence and knowledge about self) and motivational (learners have to want to solve a problem). These ideas are congruent to what Jonassen (2011a) calls internal factors of problems, which are related to each individual and not the problem itself. Among these characteristics, various cognitive styles, reasoning ability, the level of domain knowledge, prior knowledge to solve similar problems, breadth of knowledge required to solve the problem, the attainment level of solving problems, interest, problem solver's personality traits, his or her motivation and creativity (individual cognitive, social and personality differences) are listed (Jonassen, 2011a). Funke et al. (2018) state that non-cognitive aspects include: 1) motivation, perseverance, tenacity, trustworthiness, personality traits; 2) social-regulation; and 3) social skills. For example, frustration because of barriers between the problem's current state and its goal state show a connection between emotions and cognition (Funke et al., 2018). Isen et al. (1987, as cited in Funke et al., 2018) observe that positive affect enhances creative problem solving.

According to Gray (2017), non-cognitive skills can be termed as soft skills and they are related to abilities/ capabilities to communicate, being able to work with others, knowing how to lead a team and even related to self-motivation. Gray supports the idea that despite the fact that these skills usually depend on each personality, they can be taught as well.

Furthermore, modern insights about non-cognitive aspects come from neuroeducation (also known as educational neuroscience), which is one of the emerging interdisciplinary fields joining together the ideas of educators and neuroscientists and providing a more objective understanding of learning. The new findings of the human brain should also be taken into account when developing educational environments. For example, Bidshahri (2017) presents useful key findings related to emotions and group work. She states that negative emotions, such as stress or fear, may have negative effects on the learning process, while emotions related to passion or awe may have a positive effect. Also, the brain functions positively if a learner is in a supportive group that increase his/her determination and continued effort, as well as resilience to setbacks (Bidshahri, 2017).

Social skills (collaborative aspect of problem solving). This is about managing participants (including a problem solver himself or herself) and are applicable for most collaborative tasks. As referred in the framework developed in the ATC21S project (Hesse et al., 2015), social skills fall into three groups of participation, perspective taking and social regulation, which additionally can be subdivided into smaller elements. Participation in a collaborative task refers to a problem solvers' engagement with the task and the extent to which they contribute to the solution process of the problem. Also, it includes the ways students act and interact to complete the task. Perspective taking stands for the quality of interaction among students during and indicates the ability to understand the perspective of others, be able to recognize different sources of information and others as sources of information. Social regulation includes such activities as negotiating, self-evaluating, taking responsibility and initiative. The table below lists these skills altogether, including their explanations and indicators.

Table 5. Social skills in collaborative problem solving (adapted from Hesse et al., 2015, p. 43)

Social skills	*Element*	*Indicator*
Participation (quantity of participation)	**Action**	Activity within environment
	Interaction	Interacting with, prompting and responding to the contributions of others
	Task completion/ perseverance	Undertaking and completing a task or part of a task individually
Perspective taking (quality of interaction)	**Adaptive responsiveness**	Ignoring, accepting, or adapting contributions of others
	Audience awareness (Mutual modelling)	Awareness of how to adapt behavior to increase suitability for others
Social regulation (acting properly on group diversity)	**Negotiation**	Achieving a resolution or reaching compromise
	Self-evaluation (Metamemory)	Recognizing own strengths and weaknesses
	Transactive memory	Recognizing strengths and weaknesses of others
	Responsibility initiative	Assuming responsibility for ensuring parts of task are completed by the group

Knowledge required for problem solving. First, problem solving is bound to new knowledge required to solve a particular problem and, second, to prior knowledge of a problem solver. Considering the prior knowledge, researchers (Eysenck, 2004; Eysenck & Keane, 2005; Funke et al., 2018; Robertson, 2001) distinguish between knowledge-lean (little prior knowledge is needed to solve such problems) and knowledge-rich problems (considerable amount of prior knowledge is necessary) or even knowledge-free problems (no previous knowledge is required). Also, the type of problem (whether it is well-structured or ill-structured) is dependent on the amount of prior knowledge of a problem solver. For instance, to answer a simple question of what the result of six plus nine is not a problem for an adult but it is a problem for a child who might lack such knowledge. In order to minimize the negative effects related to the lack of prior knowledge, researchers usually prefer knowledge-lean tasks (Funke et al., 2018).

Problem solving requires various types of knowledge. According to Mayer and Wittrock (2006), problem-solving processes depend on five different kinds of knowledge: 1) factual knowledge, 2) conceptual knowledge, 3) procedural knowledge, 4) strategic knowledge, beliefs and 5) metacognitive knowledge. Resnick (1983, as cited in Fleischer et al., 2017) classifies knowledge into the knowledge of concepts, procedures and conditions. Furthermore, Gagne (1985, as cited in Kirkley, 2003) distinguishes between two distinct types of knowledge – declarative (knowing facts -“what”, concepts – “that” and “why”-principles, content-specific or factual knowledge within a discipline) and procedural (knowing “how”). Similarly, both Shin and Song (2016) as well as Csapó and Funke (2017) distinguish between knowledge of concepts (“knowing that”) and knowledge of procedures (“knowing how”). Table 6 provides a summary on the types of knowledge.

Table 6. Types of knowledge necessary in the process of problem solving (adapted from Byram & Hu, 2013; Csapó & Funke, 2017; Resnick, 1983, as cited in Fleischer et al., 2017; Gagne, 1985, as cited in Kirkley, 2003; Mayer & Wittrock, 2006; Shin & Song, 2016)

Broad type of knowledge	***More specific type of knowledge***	***Examples***
DECLARATIVE (knowledge of concepts) **(WHAT, THAT, WHY)**	**Factual knowledge** (knowledge of facts, awareness of what situation is and how it affects the problem)	there are 100 cents in a euro
	Conceptual knowledge (knowledge of concepts, includes knowledge of categories, principles, and models; content-specific or factual knowledge within a discipline)	why hot air rises
PROCEDURAL (knowledge of procedures) **(HOW/WHEN/WHY)**	**Procedural knowledge** (knowledge of operations how to do something)	how to change nouns from singular to plural form
	Strategic knowledge (knowledge of general methods or general problem-solving strategies, knowledge of conditions under which specific operations are to be applied fit between procedural and contextual knowledge)	how to break a problem into parts or how to summarize an article

	Metacognitive knowledge (awareness and control of one's own cognitive processing)	knowing that you are not good at choosing a problem solving strategy

Both declarative and procedural types of knowledge are interrelated and necessary for the understanding and solution process of a problem. In addition, the amount of knowledge a problem solver has affects various aspects of problem solving. For example, it might affect the speed (whether additional time needs to be spent for searching new information) or motivation of a problem solver. Moreover, too difficult a problem may discourage learners (Jonassen & Hung, 2008; Jonassen, 2011a).

Since problem solving is usually a context-bound process requiring domain specific knowledge (e.g., Ericsson & Smith, 1991; Jonassen, 2011a), a number of researchers support the view that it is an ineffective practice to teach problem solving separately (just procedural knowledge) without the supportive declarative knowledge. Kirkley (2003) states that problem solving cannot be taught without its integration with the rest of the curriculum or work environment as a "content-free" thinking skill. Jonassen (2011a) also holds the view that "students cannot learn how to solve problems by learning about problem solving" (p. 100). On the other hand, it is also stated that it is erroneous to teach only declarative (content-specific or factual knowledge within a discipline) knowledge, since it does not ensure that learners will be able to solve problems in the domain.

General problem-solving strategies are indicated as a form of strategic knowledge (e.g., Fleischer et al., 2017; Halpern, 2014). Although no single strategic choice can guarantee suitable solutions every time (Halpern, 2014), they can help to search for relevant information, create alternative problem representation, identify subgoals or choose among alternative decisions. For instance, Halpern (2014) lists the following general problem-solving strategies that can be used to solve problems (both well-structured and ill-structured):

- **Means-end analysis** (splitting the problem into smaller problems (subproblems), formulating goals or subgoals for each and then applying operations to reduce the distance between the nearest subgoal and the problem solver's current stage; the strategy is suitable for complex problems),
- **Working backwards** (opposite to means-end analysis (also called forward-looking strategy); using operations to move from the goal to the current or initial state),
- **Generalization and specialization** (considering a problem as an example of a larger class (generalization – considering the problem from a broad perspective) or considering it as a special case (specialization – considering the problem from a narrow perspective); using tree diagrams as the most compatible form for problem representation; these strategies are also suitable for complex problems),
- **Random search** (searching among possible solution paths in a random way),

- **Trial-and-error** (searching all possible solution paths from the initial to the goal state systematically; suitable in the situations when there are not many possible solution paths),
- **Rules** (establishing underlying principles like in most mathematic and physical science problems),
- **Hints** (giving additional information during the process of solving a problem),
- **Split-half method** (continually selecting a point that is halfway between the present state and the goal as a systematic way for guessing solutions),
- **Brainstorming** (generating possible wild and imaginative solutions either individually or as a group; for better results having first individual (a silent phase) and then as a group brainstorming),
- **Contradiction** (considering opposite desirable qualities),
- **Analogies and metaphors** (noting similarities between two or more problems while simultaneously recognizing that there are also differences).

While some of these strategies seem to be simple and easily applied, the rest probably need some kind of longer training and practicing. Practice of solving many problems and thus applying various strategies many times is said to be the best way to become an expert problem solver (Jonassen, 2011a; Halpern, 2014).

Metacognitive knowledge. As discussed among cognitive aspects previously, a number of researchers agree that looking back and thinking about all problem solving processes is crucial, both while solving and learning to solve problems. In educational literature it is commonly understood as thinking about thinking that allows learners to take charge of their own learning. According to Davidson and Sternberg (1998, as cited in Jonassen, 2011a) thinking about one's own problem solving activities is a characteristic of a good problem solver in comparison to a poor one. Serra and Metcalfe (2009) state that metacognition involves one or more of the following cognitive processes: knowledge of the process, monitoring and control of it. According to the authors, whenever these processes are optimized, this can improve the performance of the target cognition, including learning. Therefore, educators should seek to train learners to better engage in metacognitive thinking. For example, metacognitive knowledge about the task in turn affects monitoring and control. Monitoring is also related to the cognitive process in which a group or an individual is engaged. Metacognitive knowledge and monitoring then determine control, which, for example, may result in the groups' decision to allocate time differently (to give more time for some particular problem solving process) or choose another problem solving strategy after seeing that the already applied one does not provide the desirable outcomes.

Winne and Hadwin (1998, as cited in Serra and Metcalfe, 2009) conclude that those students who have more metacognitive knowledge (know more about how learning occurs and how to study) learn much better in comparison to those that have less metacognitive knowledge. Consequently, if students know more about problem solving and about how it occurs (have more metacognitive knowledge of it), it is possible that they show better performance during problem solving. As a result, this can augment further problem solving activities.

Davidson, Deuser and Sternberg (1994, as cited in Jonassen, 2011a) provide the following classification of the metacognitive processes during problem solving:

1. identification and definition of the problem (clarification of what kind of problem it is);
2. mental representation of the problem (developing mental model of problem);
3. planning of a solution procedure (especially when problem is novel and complex, weighing costs and benefits);
4. evaluation of performance (evaluating mental representation of problem).

The presented classification indicates that problem solvers should be thinking about their thinking of the problem itself, its solution process and their own behaviour. In the case where it is collaborative problem solving, they should be thinking about the behaviour of the whole group as well. To enhance problem solvers' metacognition, educators should be fostering learners' understanding about this process and devising suitable ways to monitor and regulate it. For the current study, various types of scaffoldings as methods to support metacognition will be discussed in Chapter 1.3.4 on various types of scaffoldings during problem solving (e.g., question forms, expert advice, instructional dashboard, etc.).

Issues and skills related to both declarative and procedural knowledge generation, reduction and application. The first prerequisite for a problem to exist is the lack of knowledge to solve it and this is exactly what makes it a problem. Therefore, problem solving is usually new knowledge generation and application. More specifically, problem solving may include two broad aspects consisting of recalling of prior knowledge and its application and new knowledge generation (either individually or collaboratively) and its application.

Both declarative and procedural knowledge is necessary when analysing and defining problems, planning and finding solutions for them, as well as evaluating the whole process of problem solving. However, as noted by Fischer et al. (2012), "as large amounts of knowledge may overcharge human processing capabilities, a most important aspect of coping with complexity is information reduction". According to Klauer's (1993, as cited in Fisher et al., 2012) empirical findings, capacity overload and thus information reduction is more related to declarative knowledge and not to procedural knowledge while solving problems. The suggested ways to cope with this issue include conceptual segmentation, chunking and distinguishing between relevant and irrelevant features (Fisher et al., 2012). These information reduction issues can be more easily coped with when individuals are not alone solving the problem, i.e. in cases of CPS. On the other hand, collaborative context may also increase the amount of information (information overload) generated during problem solving.

In her book *Thought and knowledge: An introduction to critical thinking* (appropriate for use as a textbook in problem solving and critical thinking courses), Halpern (2014) proposed an exhaustive list of strategies that can be applied to knowledge memorization, generation and application (see pp. 561-592). Her ideas may be helpful when coping with the issues related to both declarative and procedural knowledge. For example, the strategies to enhance memory are using advanced organizers for collecting and organizing information, practising the recall of information, using some hints (for example, images, keywords, first letters) for internal memory. The strategies to enhance creative thinking are brainstorming; so as more ideas could be generated, encouraging learners not to be afraid of taking risk or evaluating something along the predetermined dimensions, among others.

To sum up the chapter, there are three broad groups of aspects related to problem solving: cognitive, non-cognitive and knowledge for problem solving. Cognitive aspects are about the problem at hand and are made of two broad parts: representation of the problem (trying to understand it) and its solution, which involves finding strategies to move from the initial state to the goal state of a problem (focus on the process/procedure). More specifically, there are four major cognitive processes comprising problem solving, irrespective of the type of a problem (well-structured or ill-structured): 1) understanding (trying to understand the situation described in the problem and possible paths from its initial to the goal state), 2) planning/ monitoring (devising and monitoring a plan/ a method for solving a problem), 3) doing (carrying out planned operations), and 4) looking back and evaluating (monitoring and evaluating the processes of problem solving).

Non-cognitive aspects include everything but cognition. They comprise affective and motivational aspects (whether a problem solver wants to solve a problem or not), individual traits that may affect problem solving and social skills that are critical for problem solving in the collaborative context. Social skills include participation (quantity of it), perspective taking (quality of interaction among group members) and social-regulation (acting properly on group diversity to benefit from it).

Two broad types of knowledge required for problem solving are: 1) declarative (knowledge of concepts, knowing that, what and why) and procedural (knowledge of procedures, knowing how, when and why). It is necessary when analysing and defining problems, planning and finding solutions for them, and evaluating all processes of problem solving.

In conclusion, teachable/ learnable aspects during problem solving can be divided into two broad groups: the ones that support problem understanding and the ones that support thinking processes in the search of its solution/s. When designing educational environments enabling learners to learn problem solving, it is necessary to improve problem solvers' cognition and make non-cognitive aspects have a more positive effect on problem solving. To serve these purposes, various forms of scaffoldings are discussed in Chapter 1.3.4.

1.1.4 Various forms of problem solving

The goal of this chapter is to overview various forms of problem solving commonly discussed in the research on problem solving. A more thorough analysis of ill-structured and collaborative problem solving (including problematic aspects related to these two forms) is present, since these are the forms for which educational environments were designed. The chapter also includes the terminology and types of assessment of problem solving as has been used in the most prominent large-scale assessments (specifically, the Programme for International Student Assessment, hereafter PISA).

As already outlined, problem solving is the process of searching through the problem space to find one's way from the initial to the goal state, which requires a number of skills, abilities and both declarative and procedural knowledge. In the broad topic of problem solving, researchers are usually not unanimous and use various labels to describe it from either the psychological or educational point of view:

1. **analytic vs dynamic problem solving (also called complex or interactive)** (e.g., Csapó & Molnar, 2017; Fisher et al., 2012; Fleischer et al., 2017),
2. **domain-specific vs domain-general problem solving** (also called subject-specific vs cross-curricular) (e.g., Csapó and Funke, 2017; Fleischer et al., 2017; Greiff et al., 2014; Jonassen, 2011a),
3. **problem kind - specific problem solving** (e.g., Jonassen, 2011a),
4. **well-structured vs ill-structured problem solving** (e.g., Collins et al., 2016; Ge, 2010; Ge & Land, 2003; Jonassen, 1997),
5. **individual vs collaborative problem solving** (e.g., Csapó & Funke, 2017).

The list can be further supplemented with social problem solving, creative problem solving, everyday problem solving, etc.; however, these types are less common.

Terminology, definitions and assessment of problem solving used in PISA. With the increasing tendency to see problem solving as one of the major outcomes of education, the largest-scale assessments have already included the assessment of problem solving abilities (for instance, the Programme for International Student Assessment (PISA), Assessment and Teaching of 21st Century Skills (ATC21S) or the OECD Survey of Adult Skills (PIAAC)). The most prominent and the largest of them with over 70 countries participating is PISA, run by the Organization for Economic Cooperation and Development (hereafter OECD). It evaluates the skills and knowledge of fifteen-year-old students worldwide from 2000. Since it can be predicted that more and more basis and terminology in problem solving research will be consistent with how it is referred in PISA, its terminology, definitions and assessment are discussed in more details.

In PISA 2003, when problem solving was first in focus, it was treated as the static form of problem solving assessed by paper-pencil-tasks. The focus was on testing domain-specific problem-solving skills with the inclusion of problems from science, mathematics, literature, and commerce (Greiff et al., 2013). The types of problems included were decision making, system analysis and design, and troubleshooting. Although referred as problem solving in its broadest sense, Greiff et al. (2013) explain that this type of problem solving should be termed analytical problem solving, since all needed information to solve the given problem is available at the beginning. In addition, the following version of PISA used the assessment that took into account only cognitive dimensions of problem solving, which is a too limited understanding of problem solving.

Later, in PISA 2012, the focus from analytical problem solving switched to a more general and less domain-bound problem solving by using computer-based tests to test the ability to solve problems in simulated environments. Again, although officially referred to as problem solving, the inclusion of computer administered interactive problems makes this type of problem solving into Interactive Problems Solving (Greiff et al., 2013).

Whereas the idea of PISA 2003 was the assessment of reproduction of domain-based knowledge, the current version marked the move to the cross-curricular nature of assessment (OECD, 2012). Thus, the focus changed to a more general and content-free problem solving with the reduced need for expert knowledge. However, the same as in PISA 2003, problem-solving skills were tested with individuals working alone.

CPS is indicated to be a “critical and necessary skill used in education and in the workforce” (PISA 2015, 2017). Therefore, the focus shifted onto CPS with individuals joining their understandings and efforts to work together (PISA 2015, 2017). Probably, the major reason to include the assessment of collaboration was the increasing popularity of project-based and inquiry-oriented learning and the emerging trends to develop this skill in educational systems (Greiff et al., 2013). As noted by Greiff et al. (2013), PISA 2015 extended the cognitive emphasis on the social aspects of problem solving, such as interaction and communication by connecting problem solving with the research area of collaborative learning. “Vygotsky’s view that there is an inherent social nature to any type of learning or problem solving” (Lee & Smaroginsky, 2000, as cited in Greiff et al., 2013, p. 81) was acknowledged. In addition, the necessity to test not only individual complex problem solving but also communication and collaboration was admitted. Whereas PISA 2003 and PISA 2012 tested cognitive processes involved in problem solving, assessment of non-cognitive skills (social and collaborative skills) was additionally added in PISA 2015 and it was the first empirical evidence that these skills may be measured (Greiff et al., 2013). In PISA 2015 (2017), the problem solving process is indicated to involve the same four individual cognitive processes as in PISA 2012, however, the assessment of three core collaborative problem solving competencies was added: 1) establishing and maintaining of shared understanding, 2) taking appropriate action to solve the problem, and 3) establishing and maintaining team organization (PISA 2015, 2017).

Analytic vs dynamic (also called complex or interactive) problem solving. According to PISA terminology, analytical problem solving is when “all the information needed to solve the problem is explicitly stated or can be inferred; it can thus be seen as the reasoned application of existing knowledge” (Fleischer et al., 2017, p. 35). As explained by Funke et al. (2018) analytical problem solving is suitable for well-defined problems (like textbook problems). In PISA 2003, successful analytical problem solving includes the following steps: “1) understand; 2) characterise; 3) represent the problem; 4) solve the problem; 5) reflect; and 6) communicate the problem solution” (Fleischer et al., 2017, p. 36). As explained previously, general problem solving models (also called information-processing models) consisting simply of representing (understanding) processes and search processes are suitable to solve well-structured problems.

On the other hand, dynamic problem solving is used synonymously with interactive problem solving and complex problem solving in the research on problem solving (Fisher et al., 2012; Fleischer et al., 2017). What differentiates dynamic problem solving from the analytical one is that “most of the information needed to solve the problem has to be generated in an explorative interaction with the problem situation" (Fleischer et al., 2017, p. 35). Funke (1991, as cited in Fleischer et al., 2017) defines dynamic problems as having "a high number of interrelated variables (complexity), a lack of transparency regarding the causal structure and sometimes several, partly conflicting, goals and subgoals" (p. 35). As outlined in Chapter 1.1.1, complex problem solving is when the problem itself, its representation and solution are all complex and resembles a complex system (Fisher et al., 2013). Funke et al. (2018) note that complex problem solving is about complex problems that usually have none-transparent, dynamically changing and complex given states, goal states and barriers that make their solution processes more complex.

Domain-specific vs domain-general problem solving (also called subject-specific vs cross-curricular) problem solving. Domain-specific problem solving is highly dependent on domain-specific knowledge, while the domain-general one is independent of that. In the case of domain-specific problem solving, insufficient domain-specific prior knowledge of problem solvers is indicated to be among the main barriers in the process of problem solving (Csapó & Funke, 2017). Alternatively, the greater domain-specific knowledge, the better and quicker problem-solving behaviour can be expected (Csapó & Funke, 2017; Fischer et al., 2012; Jonassen 2011a). For example, Fischer et al. (2012) conclude that experts in certain domain knowledge have a better working memory, are able to judge problems according to their deep features, have better semantic memory, are usually faster and more precise, as well as having better metacognitive abilities.

However, the amount of prior knowledge required is just one of the internal factors (related to problem solver) of problems. Jonassen (2011a) also reminds that it is not just the domain that may influence problem solving and points to different contexts that may have an impact on problem solving. For instance, doctors solving the same problem in a rich country are working in a very different context in comparison to those working in poor countries, which makes the same problem less dependent on domain-specific knowledge but more on the context of the country.

Problem kind-specific problem solving. Jonassen (2011a), a prolific researcher on learning to solve problems, represented the developmental theory of problem solving and suggested problem kind-specific logics for solving problems. Jonassen formulated a typology, including eleven kinds of problems that range from logic problems to dilemmas. The typology also includes decision-making problems, which are indicated to be the most common form of problems (Jonassen, 2011a). The researcher analysed various instructional approaches for dealing with different kinds of problems because they are not equivalent, either in content, form, or process and, therefore, his thinking diverges from the attempts to approach problem solving as a uniform process. For example, the process of solving design problems (which are greatly domain and context specific) consists of "articulating the problem space, specifying functional requirements, applying prior knowledge, analysing constraints, selecting a solution, constructing a model or artefact, and optimizing the solution" (Jonassen, 2011a, p. 18). It also includes reading some special design literature, such as architectural design, product design, engineering design and instructional design (Jonassen, 2011a). Until now, researchers have been following the tradition of dividing problems into the kinds as proposed by Jonassen (e.g., Tawfik & Jonassen, 2013).

Well-structured vs ill-structured problem solving. Although in the history of problem solving research there have been attempts to offer general problem solving approaches assuming that they may be applied for all types of problems (for the discussion on these aspects, see Chapter 1.1.2), problems are not the same and, therefore, the processes of their solving are different. As summarized in Chapter 1.1.1, well-structured problems have a well-defined initial state, known goal state, correct and convergent answers, constrained set of logical operations towards the goal or clear path to solution (usually the same step-by-step solution), and contain all of the information needed to solve them. In contrast, ill-structured problems have an ill-defined initial state (because one or more of the problem states are unknown or not known with any degree of confidence), goals that are vaguely defined, no correct and convergent answers, multiple solutions (also called divergent solutions) or no solution at all and no clear paths to solution or multiple solution paths. In addition, these problems are not self-contained (with insufficient information to solve them). Thus, this array of differences clearly indicates the need for different problem-solving processes. In addition, it is wrong to assume, as it has been for a long time among researchers, that learning to solve well-structured problems transfers positively to solving ill-structured problems (Choi & Lee, 2009; Foshay & Gibbons, 2005). This additionally points to the necessity not to limit formal education to the practice of solving well-structured problems.

As a consequence of the above listed inherent characteristics of well-structured problems (they are simple in most cases, see Chapter 1.1.1), their solution process is usually defined as simple and easy (e.g., Eseryel et al., 2013; Foshay & Kirkley, 1998; Funke, 2010; Jonassen, 2011a; Jonassen, 1997). As explained by Jonassen (2011a), even mental representation, which is the most important process when solving problems, is easily identifiable. To solve well-structured problems, general problem solving models (also called information-processing models) are considered to be sufficient. For example, Gick (1980, 1986, as cited in Jonassen, 2011a) offered a simplified model of the problem-solving process "including the processes of constructing a problem representation, searching for solutions, and implementing and monitoring solutions" (p.3).

However, solving ill-structured problems (as already explained in Chapter 1.1.1, ill-structured problems are usually complex problems) is a more challenging activity because they have many variables and a high degree of interconnectivity among them (e.g., Eseryel et al., 2013; Funke 2010; Jonassen 2011a). In the research on ill-structured problem solving, researchers (Choi & Lee, 2009; Voss & Post 1988; Voss et al. 1991; see review in Ge & Land 2003; 2004) agree that this usually involves four broad cognitive processes:

(a) problem representation,

(b) development of solutions,

(c) evaluating solutions, making justifications and constructing arguments,

(d) monitoring and evaluating the problem-solving process.

More specifically, Jonassen (1997) considered ill-structured problem solving as a design process (opposite to systematic search of solutions typical to well-structured problem solving) and explained it in the following summarized way:

Step 1

A problem solver needs to analyze problem space and its contextual constraints (the processes of deciding whether a problem really exists, representing the problem (constructing the problem space containing all possible states of it), examining its context, possible causes as well as the constraints and reflecting critically on what is known about problem domain);

Step 2

He or she needs to identify and clarify alternative options, positions, and perspectives (the process of constructing multiple problem spaces after taking into account alternative views or perspectives on the problem);

Step 3

Generating possible solutions (the process of generating solutions according to different problem representations);

Step 4

Assessing the viability of alternative solutions by constructing arguments and articulating personal beliefs (the processes of selecting the most viable, defensible, and having the most convincing argument solutions, as well as selecting the best course of solution);

Step 5

Monitoring the problem space and solution options (the process of deciding if the solution works);

Step 6

Implementing and monitoring the solution (the processes of implementing the solution and evaluating its effectiveness and suitability);

Step 7

Adapting the solution (be willing to adapt the solution or solutions if necessary).

From the stages listed, it is evident that they can be undergone either by individuals solving a problem alone or groups of problem solvers.

Difficulties related to ill-structured problem solving (related to managing the task of ill-structured problem solving) can be grouped into two broad categories. First, these difficulties may arise because of the complex nature of ill-structured problems themselves (related their external characteristics discussed in Chapter 1.1.1.). Second, they may arise because of problem solvers themselves (internal characteristics of problems) and social context of problem solving.

Ill-structured problems are usually complex, which means that the problem itself is complex and, therefore, its understanding and solution are complex. As explained by Eseryel et al. (2013), difficulties may arise because only part of problem variables can be observed directly, problem solvers are usually imposed with time pressure and the problem solving situation is dynamic, which does not allow to predict the consequences of the steps. In addition, difficulties may occur because of the fact that such problems may have multiple goals or solutions or no solution at all. Accordingly, complex solution processes of ill-structured problems are complex and dynamic systems that include more steps and more sophisticated solution paths.

Secondly, problems related to problem solvers themselves are usually because of the lack of either declarative or procedural knowledge or lack of motivation. For example, new information collection and its management can be problematic because students' cognitive skills for effective information are underdeveloped. As noted by Frerejean et al. (2016), although students are able to find information and offer solutions, the quality of these processes may be insufficient; meaning that they still lack "advanced search strategies and the ability to critically scrutinize information sources" (p. 90). In addition, problem solvers may have difficulties in constructing arguments and causal reasoning, which are essential capabilities when solving ill-structured problems (Jonassen, 2011a; Tawfik & Jonassen, 2013). Hesse et al. (2015) also note that some problem solvers are incapable of deciding what information is required to solve complex problems. At some stages, where brainstorming is applicable, Halpern (2014) recommends starting with individual brainstorming and only then continue with sharing ideas in the group.

Solving an ill-structured problem is a difficult task involving implicit processes. Therefore, whenever such tasks are incorporated in formal education, educators should think of the ways to facilitate them. For example, Hesse et al. (2015) suggest coordinating steps of CPS by using verbal or non-verbal observable signals; also, by externalising the processes of problem solving. After analysing different types of interventions and the impact of student achievement, Hattie (2009, as cited in Luckin et al., 2017) concluded that making learning and teaching visible was the key feature influencing learning outcomes. Thus, it can be concluded that making the process of ill-structured problem solving visible can facilitate the solution process for these type of problems.

Individual problem solving (IPS) vs Collaborative problem solving (CPS). IPS processes defined in PISA 2012 framework comprise: "*exploring and understanding; representing and formulating; planning and executing;* and *monitoring and reflecting*" (PISA 2015, 2017, p. 136). As an individual undergoes these cognitive processes alone, problem solving is based on his/her individual understanding (what I think, feel, know and understand as an individual) and may be called inferential (based on inference – opinion that a problem solver forms is based on the information that he or she has as an individual) (Griffin & Care, 2016). On the other hand, CPS additionally has social or collaborative aspects of problem solving.

As already discussed, the focus on CPS and collective intelligence and communication has increased with work environments starting to include increasingly complex problems requiring the solutions that cannot be the outcomes of individuals working alone. Collaboration is listed among critical competences that students need to be equipped with in order to be prepared to work in groups effectively and apply problem-solving skills (Griffin & Care, 2016; Lai et al., 2017).

In educational literature, a number of definitions for CPS exist. In general, collaboration means "the activity of working together towards a common goal" (Hesse et al., 2015, p. 38). CPS means "approaching a problem responsively by working together and exchanging ideas" (Hesse et al., 2015, p. 38). As explained by Roschelle and Teasley (1995, as cited in PISA 2015, 2017, p. 3), collaboration is "co-ordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem". Hesse et al. (2015) summarize that CPS can be characterized by joint activities, when more than one individual takes a number of steps towards transforming a present state into a goal state that they desire. CPS is about communicating, organising a team, managing a conflict, managing progress and building consensus (PISA 2015, 2017). Funke et al. (2018) define CPS as "a complex activity with closely intertwined cognitive, social and self-regulatory aspects" (p. 49). After summarizing a number of views on CPS, Frensch and Funke (1995, as cited in Funke et al., 2018) state that a problem solver has to engage in a number of complex activities in order to overcome barriers from the given state to the goal state, which are usually dynamic, complex and largely none-transparent. These activities require not just some particular knowledge but are also related to a person's emotional, cognitive and personal abilities.

In CPS, everything is more complex because of many problem solvers undergoing the same problem solving process synchronously. Accordingly, the effectiveness of CPS is dependent on the group's ability to exchange ideas and work together. CPS is comprised of the sum of individuals' cognitive processing that engages in both cognitive and social processes and collective knowledge (both declarative and procedural) that a group shares. While IPS is based on individual understanding and efforts, in CPS everything becomes evidence-based and observable (what we do – other people can see, what we say – other people can hear, what we write – other people can read, what we make/ produce – other people can see) (Griffin & Care, 2016). IPS is a more cognitive process, however, CPS is a more communicative one, which is highly dependent on the social skills of group members. Griffin and Care (2016) summarize that CPS is more difficult than IPS because it involves interaction, exchange of ideas, negotiated agreements, shared identification of the problem and is a dynamic process.

In CPS, shared goal should be differentiated from the type of goal that is pursued in cases of cooperation. Hesse et al. (2015) note that cooperation is about an activity when learners are simply dividing labour and usually work in parallel and in this manner do not make the full use of group's potential. In addition, this process does not engage learners into using and developing the whole set of social skills that are required for real collaboration when working together. In CPS, learners are expected to "jointly orchestrate their activities in order to address a particular task or problem. The activities from learners are inextricably intertwined, contributions by learners mutually build upon each other, and one learner's actions might be taken up or completed by another" (Hesse et al., 2015, p. 38). As Lai et al. (2017) points out, cooperation might be an effective way to achieve the group's aim by dividing tasks, letting them complete independently and putting them in one piece at the end, but it does not entail coordination, effective interaction and working together. Thus, collaboration cannot be equated with cooperation.

Although social interaction is the primary condition for CPS, it alone is inadequate. Problem solvers should engage in organized attempts towards the shared goals, reach agreements and pooling knowledge, efforts and skills to reach solutions

(PISA 2015, 2017). Shared understanding is the main feature that distinguishes CPS from IPS. It can be defined as the "constructing a common ground (. . .) through communication and interaction" (PISA 2015, 2017, p. 135). More specifically, shared understanding involves the creation of "shared representation of the meaning of the problem, understanding each individual's role, understanding the abilities and perspectives of group members, mutual tracking of the transfer of information and feedback among group members, and mutual monitoring of progress towards the solution" (PISA 2015, 2017, p. 135). As defined by Halpern (2014), seeking consensus "does not mean caving in to majority opinion, and it does not mean forcing others to agree with you. It is a disposition that allows individuals to accept what is good or true about alternative position" (pp. 24-25).

As summarized in PISA 2015 (2017), the necessary attributes of CPS are:

- engagement of two or more members,
- collaboration (engagement of all members towards a shared goal and not mere division of tasks as in cooperation,
- effective communication (sharing the right information and reporting what actions have to be taken),
- shared understanding of the task (considering the perspectives of all team members, tracking the knowledge of others, and building as well monitoring a shared understanding of the progress made on the task),
- effective team organisation (assigning and understanding roles, adapting the activity or organisation so it achieves its goals),
- attempts to solve a problem by sharing understanding and effort to come to a solution (collaborative actions while trying to reach a solution).

Hesse et al. (2015) note that CPS includes communication (that should go beyond simple exchange of ideas), which alone is not sufficient, and, therefore, should also include collaboration (working together) and responsiveness (thoughtful and active participation). They remind that problem solvers should be ready to participate, ready for mutual understanding and management of interpersonal conflicts.

The subskills of collaboration listed in the framework of the Partnership for 21st Century Learning are (P21) are the following: working effectively and respectfully with diverse teams, exercising flexibility; assuming shared responsibility, making necessary compromises to accomplish common goals and valuing individual contributions (P21 Framework for 21st Century Learning). An important idea added is the attitude component, meaning that without a positive attitude an individual will not be collaborating as expected. After analysing various frameworks, including collaboration, Lai et al. (2017) summarize that collaboration requires interpersonal communication (using supportive and open communication), negotiation (performance management, goal setting, planning and task coordination), conflict resolution (being able to distinguish between constructive versus destructive conflict and apply conflict-resolution strategies), and task management.

CPS "is not a uniform process but a complex, coordinated activity between two or more individuals. Consequently, efficient problem solving does not rely on a uniform skill but rather a set of distinguishable subskills which are deployed in accordance with situational needs" (Hesse et al., 2015, p. 41). For instance, some groups tend to start with making decisions and only then seeking evidence for them, the others start with attempts to find evidence and only then converge on decisions (Hastie & Pennington, 1991, as cited in Hesse et al., 2015). Groups also use different social decision schemes like “majority wins”, “truth wins”, or “plurality wins” (Laughlin & Ellis, 1986, as cited in Hesse et al., 2015). This means that a typical procedure of CPS cannot be informed by research.

Processes typical to IPS (problem identification, problem representation, planning, executing, monitoring) can be applied when describing CPS, however, CPS requires more diverse additional cognitive and social skills to ensure shared understanding, information and knowledge flow, maintaining an effective team organisation and performing co-ordinated actions in order to solve the problem in a team (PISA 2015, 2017). As explained in PISA 2015 (2017), CPS can be influenced by the problem itself, the medium of the task, the team composition and the overall background context of the problem-solving process. Thus, the efficiency and effectiveness of CPS is dependent on a set of variables: social and cognitive skills, motivational, emotional and situational variables. What is most important, it involves two or more problem solvers working together, which means that the set of variables may at least double because no person is the same.

Advantages of CPS over IPS. There are a number of advantages of CPS over IPS. In general, a number of researchers came to the conclusion that the outcomes of a team solving the problem are usually greater than the sum of the outcomes from individual members (PISA 2015, 2017). More specifically, CPS is indicated to be advantageous over individual, since it allows for: 1) an effective division of labour, 2) the incorporation of information from multiple sources of knowledge, perspectives, and experiences, and 3) enhanced creativity and quality of solutions stimulated by ideas of other group members (PISA 2015, 2017, p. 132). As explained by Griffin & Care (2016), CPS is evidence-based, which means that it incorporates information from more sources and includes more diverse perspectives and experiences. Häkkinen et al. (2004) state that CPS allows for better problem representation in comparison to an individual working alone. Ge and Land (2003) also indicate that peer interaction allows learners to build upon each other’s expertise and ideas to develop solutions and provide multiple perspectives. Jonassen (1997) also observes that group work creates conditions where learners are able to identify alternative views on the problem. CPS is an activity where students develop critical thinking, communication, problem solving and collaboration (Griffin & Care, 2016).

CPS is a way for learners to engage in such an inquiry cycle that is called “reflective discourse” by Zee and Minstrell (1997). During this type of discourse, group members engage into a series of questioning exchanges. As the authors state, this helps “students better articulate their beliefs and conceptions; and student/student exchanges involve one student trying to understand the thinking of another” (p. 209). Clearly, it is a type of discourse necessary to develop shared understanding and benefits from each other’s expertise. More ideas on the type of discourse or talk among problems solver as a powerful linguistic scaffolding is present in Chapter 1.3.3.

Although problem solving is considered to be one of the most difficult forms of human activities and higher-order thinking, CPS may be considered as a way of solving problems with reduced cognitive load because of many group members working on the same problem. At the same time the fact that a group has more perspectives and more information on the same problem seems to be making it a more complicated task. As stated by Hesse et al. (2015), CPS is suitable for complex problems, also for problems that require specific expertise. Thus, IPS, as compared to CPS, may result in a narrow understanding of the problem at hand and a limited range of thinking strategies that prevent learners from reaching higher levels of learning how to solve problems and opportunities to evaluate a problem situation from different perspectives.

Assuming the fact that writing a research article is an ill-structured problem that requires solving, a typical example of collaborative ill-structured problem solving is interdisciplinary research among scientists that is already proved to result in higher citation indices than the ones written by the scientists working alone (PISA 2015, 2017). With the expansion of user-generated media and social media, knowledge production and problem solving that relies on multiple individuals has already become commonplace. The practice of crowdsourcing among members of the online community allows gathering insights from people of different backgrounds and expertise and ensures the production of more advanced and original artefacts and ideas. For example, ideaCONNECTION https://www.ideaconnection.com/ is a website where people of diverse domains, skill sets and talents are working in teams to produce innovative solutions, which is also a way to earn money. As more communication is moving online, another example could be the platform for rational debates called Kialo https://www.kialo.com/. It employs the form of "pros and cons" type online debates and is a suitable tool for the development of critical thinking and consequently problem solving. One more example is the initiation of the organisation Apps for Good https://www.appsforgood.org/ which offers space where learners work collaboratively to develop apps for solving social problems.

Group formation (group size, its formation principles, group composition according to gender and ability level and assignments into roles) is an important aspect when considering CPS. Concerning group size, Lai et al. (2017) reviewed a number of research articles and concluded that "there is likely not a 'best' group size for group performance, but it depends on the goal of the task and the type of work to be accomplished" (p. 16). Regarding group formation principles (either instructor assigns them or they are self-selected), the evidence that comes from research is that the groups formed by instructors showed a lower level of satisfaction (Oakley et al., 2007, as cited in Lai et al., 2017). Additionally, gender and ability level, an important finding is presented by Webb (1991, as cited in Lai et al. 2017), according to which groups are suggested to be formed while balancing gender as much as possible and grouping individuals with mixed abilities. With regard to the collaborative learning culture, including the assessment of collaborative efforts, Siddiq and Scherer (2017) note that the most optimal procedure for assigning learners into groups still remains an open question. The authors indicate random selection and selection according to maximum variation criteria as two additional types apart from the self-selection principle.

Assignment of roles. Assigning students to roles is known to facilitate the learning process. The research results reviewed by Lai et al. (2017) confirm the fact that role assignment is beneficial in the learning process, since students can become more active, responsible and interested. For example, based on desirable behaviour, students may be given the roles of source searchers, theoreticians, summarizes, moderators or starters (De Wever et al., 2008, as cited in Lai et al., 2017). In addition, assignment of roles can be done according to the functions desired, for example, dividing group members into a project planner, communicator, editor or data collector (Strijbos et al., 2004).

Difficulties related to CPS (collaborative aspect of problem solving). One broad category of problems typical to CPS are problems related to social skills or, simply speaking, about managing group members. Overall, a number of researchers conclude that learners lack the skill of collaboration in general and are not prepared for collaborative learning contexts (e.g., Jucevicíene & Vizgirdaite, 2012; Lai et al., 2017). Jucevicíene and Vizgirdaite (2012) analysed how student collaborative learning can be empowered. As the authors explain, collaborative learning can be approached either as a method to learn and do a task (e.g., learners collaborate on the same project) or as a goal in itself (learning to learn collaboratively). They state that simply asking learners to collaborate will not produce the desired outcome every time because some learners may simply lack collaborative learning competence and, therefore, additional time should be spent to teach them how to learn collaboratively (Jucevicíene & Vizgirdaite, 2012). For instance, Cohen (1994, as cited in Jucevicíene & Vizgirdaite, 2012) observes that students tend to participate unequally. Ge and Land (2003) also note that group members tend to cooperate and divide their work depending on each student's expertise, especially when the time for the tasks is ending. Steiner (1972, as cited in Hesse et al., 2015) talks about process losses that can be caused by the lack of motivation among group members. This can also be caused by the fact that not all group members share information, are not properly monitoring and evaluating their activities and progress (Hesse et al., 2015). As noted by Hesse et al. (2015), groups may be lacking the quantity of participation, externalisation of thoughts and sharing information. Ge and Land (2003) report about possible off-task chatting and joking in cases of CPS. When summarizing the typical characteristics of Generation Z, Targamadze (2005), observes that this generation is unwilling to work in groups or tends to get distracted frequently. While acknowledged as the most important condition for successful CPS, effective communication cannot be guaranteed if some of the group members are resistant to participating in speaking activities. The phenomenon of reticence may have various causes, which were thoroughly discussed in Chapter 1.2.2.

All the mentioned problems may impede the creation of shared understanding. Häkkinen et al. (2004) state that in cases when it remains incomplete, some group members might threaten the continuation of interaction because it requires additional time and effort to re-construct shared understanding. Hesse et al. (2015) also note that some problem solvers are incapable of considering future or alternative problem states after new information is added and thus consider and focus only on the current state of the problem and information required. Funke et al. (2018) indicate that CPS may result in coordination losses, miscommunication and potential goal conflicts.

Hinsz et al. (1997, as cited in Hesse et al., 2015) note that groups usually do not use the potential of diversity fully, for example, information that is very different is frequently disregarded by group members. Another potential difficulty for CPS could be the dominating power of minority perspectives over the majority ones (Wood et la., 1994, as cited in Hesse et al., 2015). Sardamalia (2002, as cited in Hesse et al., 2015) points to the cases when group members do not fully acknowledge collaborative responsibility, which may lead to a complete failure of a collaborative task.

Problem solving is a process of coping barriers that are in the way to its solution. It happens frequently that whenever some problem solvers meet these barriers they simply withdraw from the solution process and it is the case of intolerance for ambiguity (Norton, 1975, as cited in Hesse et al., 2015). Thus, tolerance for ambiguity should be addressed in the communication of group members. This aspect can be additionally explained by the educator.

One more common problem typical to CPS is the unsuitable type of talk among problem solvers. If talk does not resemble what is typical to exploratory talk, but just typifies cumulative and/or disputational one, learning outcomes may not be satisfactory (Mercer, 2009). For a thorough discussion on this aspect, see Chapter 1.3.3. Considering this long list of problems, it is evident that collaboration among problem solvers is a complex phenomenon.

Teaching collaboration. Morgeson et al., 2005 (as cited in Lai et al., 2017) conclude that team success is more dependent on group member's collaboration skills (such as goal setting, conflict resolution, performance management or planning) than their personality characteristics. For Highes and Jones (2011, as cited in Lai et al., 2017), the way group members interact is even more important than the quality of the end product. However, collaboration is not a skill that students can learn on their own by simple involvement in the group work (Lai et al., 2017). The evidence that comes from research suggests that learners lack collaboration skills and any attempt to train them how to collaborate may increase the effectiveness of collaborative learning and make the learning environment more acceptable for learners (e.g., Juceviciene & Vizgirdaite, 2012; Lai et al., 2017; Prichard et al., 2006).

Lai et al. (2017) argue that there should be explicit teaching of collaboration by applying deliberate noticing of what is being done incorrectly and how it can be improved by receiving feedback on it. They summarize numerous explicit techniques suitable for the enhancement of collaborative skills, such as explaining to students why the skill is important, encouraging group members to share the task and the responsibility fairly, learning to disagree appropriately, teaching to resolve conflicts or providing checklists of good behaviours. It can be also achieved by using direct instruction in declarative collaboration strategies and knowledge, by analysing worked examples or using scripted prompts (Lai et al., 2017).

Considering the above mentioned, Table 7 provides the summary of ideas related to both major types of problem solving that could be applied when developing educational environments to enable students to learn problem solving.

Table 7. Summary of the aspects pertinent to CPS and ill-structured problem solving

	COLLABORATIVE PROBLEM SOLVING	ILL-STRUCTURED PROBLEM SOLVING
DEFINITION	Searching of two or more group members through a problem space from its current state to goal state in the CPS manner.	Searching through a problem space from its current state to goal state in the manner that is typical to ill-structured problem solving.
CHARACTERISTICS	1) effective engagement into the process where a group works towards a shared goal synchronously, 2) sharing understanding (pooling individual knowledge together) by additionally constructing new collective knowledge, 3) effective team organisation (assigning and understanding roles, adapting the activity or organisation so it achieves its goals).	1) devising problem representation, development of solutions, making justifications and constructing arguments, monitoring and evaluating the whole problem-solving procedure, 2) considering the characteristics inherent to ill-structured problems: no well-defined initial state, vaguely defined goals, no convergent answers, may have many solutions possible or no solution at all, multiple paths from the initial state to the goal state may exist.
DIFFICULTIES	*Problems related to collaborative aspect:* lack of skill of collaboration in general, not equal participation, ineffective information sharing, process losses, lack of agreements about shared goal/s, not friendly perspective taking, problems of impasses (when group members cannot agree), incomplete shared understanding, inability to assume collaborative responsibility, communication anxiety, lack of exploratory type of talk among problem solvers.	*Problems related to the complex nature of ill-structured problems:* ill-defined initial state (some hidden elements in the definition of a problem), vaguely defined goals, no correct and convergent solutions, multiple solutions or no solution at all, no clear paths to solutions, or multiple solution paths. *Problems related to a problem solver:* lack of interest and motivation, lack of declarative knowledge (factual and conceptual) and procedural knowledge (knowledge of procedures, strategic knowledge and metacognitive knowledge), difficulties related to causal reasoning and argumentation.
IMPLICATIONS FOR DESIGNING EDUCATIONAL ENVIRONMENTS	Educators should form educational aims of encouraging, supporting and facilitating the creation of supportive and collaborative learning environment. They should aim to develop such an educational environment where 1) participation is far beyond simple communication (there should be action, interaction and perseverance of each group member), 2) exploratory type of discourse dominates, and 3) effective perspective taking is present.	Educators should form educational aims to 1) motivate learners so that they want to solve problems, 2) help throughout all processes of ill-structured problem solving: representing (understanding the problem), generating and evaluating solutions, carrying out their plans (if this is included in the main goals of the procedure) and monitoring and evaluating the process, 3) help gather and process additional necessary information, and 4) coordinate and externalise the processes of problem solving in order to make them easier and visible.

To sum up the chapter, researchers in the problem solving domain are not unanimous in the use of terminology. There are different forms of problem solving discussed both in educational and psychological literature: 1) analytic vs dynamic (also called complex or interactive) problem solving, 2) domain-specific vs domain-general problem solving (also called subject-specific vs cross-curricular), 3) problem kind - specific problem solving, 4) well-structured vs ill-structured problem solving and 5) individual vs collaborative problem solving.

PISA is one of the most significant large-scale assessments that includes problem solving and explains terminology as it specifically relates to the area of problem solving. All three versions of it (PISA 2003, PISA 2012 and PISA 2015) included slightly different understandings and assessments of problem solving. What unites all versions is the targeted cognitive processes of problem solving (knowledge acquisition and application). What is different is the move from the mere assessment of domain-specific capabilities in PISA 2003 to the assessment of domain-unspecific (cross-curricular) problem solving in both PISA 2012 and 2015. The last two versions also included the assessment of non-cognitive skills: affective in PISA 2012 and collaborative aspect within problem solving in PISA 2015.

The most common type of problem solving is ill-structured problem solving, which is the type of problem solving where the problem itself, its understanding and solution processes are complex. Both the representation and the solution process of such problems is difficult because these problems usually have unclear goals, least constrained solution strategies, multiple solutions or no solution at all. The process requires both declarative (factual and conceptual) and procedural knowledge (knowledge of procedures, strategic knowledge and metacognitive knowledge). Ill-structured problem solving is also context-dependant.

Researchers agree that problem solvers undergo four major processes: problem representation, development of solutions, making justifications and constructing arguments, monitoring and evaluating problem-solving process. During problem representation (also called as the creation of a mental model, mental representation, problem space or problem schema), problem solvers try to clarify the situation described in the problem. They examine its context, possible causes and constraints; reflect critically on what is already known and what additional information is required. Development of solutions is the process when multiple solutions are constructed based on various problem representations. During the process of making justifications and constructing arguments, problem solvers assess the viability of alternative solutions and select the most viable, defensible, and having the most convincing arguments, as well as the best paths to the solution. The process can continue with implementing the solution and evaluating its suitability, which, if necessary, can be refined. Monitoring and evaluating of the problem-solving process or considering its effectiveness should be present throughout all the process.

Problems related to ill-structured problem solving can be grouped into the problems pertinent to the complex nature of ill-structured problems themselves and problems related to problem solvers (e.g., lack of interest and motivation or either declarative or procedural knowledge).

Problem solving can be approached either as an individual or as a collaborative process. What differentiates CPS from IPS is the engagement of two or more members in the problem solving process and the creation of shared understanding (of the problem itself, the goal group tries to achieve and the very process of the task of solving the problem). All this can be achieved by collaboration, effective communication and contributions of each group member to effective team organisation. CPS is advantageous over IPS since it incorporates multiple sources of knowledge, perspectives and experiences, which can result in a higher quality of output in terms of problem solution and serves as a valuable practice for improving collaborative skills.

While both CPS and IPS share the same class of cognitive skills (problem representation, planning, monitoring and self-regulating), CPS adds the second class of the required skills – social skills (also called collaborative aspect of problem solving). They consist of participation (engagement with the task and the extent to which a problem solver solves the problem, the ways he or she acts and interacts to complete the task), perspective taking (understanding the perspectives of others, being able to recognize different sources of information and others as sources of information) and social regulation (negotiating, self-evaluating, taking responsibility and showing initiative).

The most common problems that learners may face in CPS are the lack of skill of collaboration in general, ineffective information sharing, process losses, lack of agreement about shared goal/s, not friendly perspective taking, problems of impasses, incomplete shared understanding or inability to assume collaborative responsibility.

1.2 Learning to solve problems in the context of foreign language learning in higher education

The major goal of this chapter is to add and analyse the dimension of learning a foreign language while solving problems. First, the chapter presents the overview of the situation in higher education concerning the European policies related to foreign language learning and teaching. Second, the goal is to overview action-oriented or process-oriented conceptualization of FL learning, which is the basis for educational environments of foreign language studies that include learning to solve problems.

1.2.1 Studies of foreign languages in higher education

This chapter aims to briefly review the situation in higher education (hereafter HE) concerning the European policies related to foreign language learning and teaching.

The European HE area has faced a number of challenges set by demands for change, internalization and mobility. In this context, students and all of the academic community members’ multilingual competence has been considered of central importance. For this reason, formal practices, specific directives, action plans and projects have been set up by the European Commission, scientific committees and various networks in order to give directions for learning foreign languages (hereafter FL) in HE. While maintaining their autonomous status in allowing to implement separate institutional language policies, the institutions of HE are still required to operate within the policy frameworks devised to regulate learning of FL. Thus, it is necessary to briefly review the most significant EU initiatives and regulations concerning HE language policies.

In 1989, the Council of Europe issued *The Common European Framework of Reference for Languages: Learning, Teaching and Assessment* (CEFR), which aimed "to overcome the barriers to communication among professionals working in the field of modern languages arising from the different educational systems in Europe" (Council of Europe, 2001, p. 1). It was a major step in providing "a common basis for the elaboration of language syllabuses, curriculum guidelines, examinations, textbooks, etc. across Europe" (Council of Europe, 2001, p. 1). Serving as a 'descriptive' document instead of 'prescriptive' one (Piccardo, 2014), it allowed FL educators to adjust teaching, learning and assessment of all FLs in Europe within all levels of education. Starting from 2001, the CEFR has been widely used as the European standard to plan the intended learning outcomes and to grade learners' language proficiency by using a set of six Common Reference levels (A1, A2, B1, B2, C1, C2), which until now brings clarity in the area of FL education. The most recent updates to the CEFR were introduced in September 2017. Two major refinements were the updates in the 2001 scales (C-level, pre-A1 and A1 enrichments) and the development of new scales for mediation. Most importantly, the document clearly indicates the need for an action-oriented approach in FL teaching/learning, which is discussed in more detail in the subsequent chapter.

In 1999, the Bologna Declaration signed by 29 European Ministers aimed at reforming HE towards an overall convergence in Europe. In the document, the main idea clearly stated was to take "full respect of the diversity of cultures, languages, national education systems and of University autonomy – to consolidate the European area of higher education" (Confederation of EU Rectors' Conferences, 2000, p. 8). Among all objectives agreed, the Bologna Declaration indicated the need for students' mobility within the network of the European universities. Accordingly, it was acknowledged that knowledge of FLs plays an important role in students' academic lives and therefore learning of FLs in HE institutions has to be promoted.

In 2002, a well-known "Barcelona objective" was agreed by the European Union heads of states and governments, which highlighted the need that every European citizen should be able to communicate in 2 languages other than their mother tongue (Presidency conclusions, 2016).

Later, the Directorate General for Education and Culture of the European Commission proposed the Action Plan 2004-2006 for "Promoting Language Learning and Linguistic Diversity", the main objectives of which were to "make sure that everyone can speak two languages as well as their mother tongue, (. . .) improve the quality of language teaching (. . .), and create a more language-friendly environment in Europe" (European Commission, 2004, p. 3). HE institutions were indicated to be the key players in the promotion of societal linguistic diversity and individual multilingualism (European Commission, 2004). Thus, educational institutions were recommended to encourage their students to study abroad for at least one term, preferably in FLs.

In 2004, the European Network for the Promotion of Language Learning Among all Undergraduates (ENLU) project was launched. The key aim of the project was to set up "a trans-European network of higher education institutions (…) which share the vision of the generalisation of language learning among all undergraduates and of language diversification and which are determined to create conditions – policies, resources, strategic partnerships" (ENLU Documents, 2004, p. 2). It stressed the importance for the continuation of language learning by all students in HE and provided recommendations of how it can be achieved. The concrete measures proposed were "the provision of language courses accompanying other disciplines; the provision of supplementary learning, including self-instruction, facilities; the teaching of portions of courses through the medium of Community foreign languages; the use of postgraduate students from other Member States as teaching assistants; the provision of a wide range of languages, including lesser-used and lesser-taught languages" (ENLU Documents, 2004, p. 1). The principal outcome of ENLU was to launch a permanent network of HELP (Higher Education Language Policy) to ensure the development of university-wide language learning and teaching policies.

In 2011, the European Language Council (CEL/ELC) expressed serious concerns about the situation with HE language policy, especially in times when English has taken the role of a lingua franca and lingua academia. It was stated that while European universities were facing new linguistic challenges resulting from EU enlargement, globalisation, increased intra-European mobility and migration as well as the internationalisation of HE, the decrease in language provision in a number of countries was observed (European Language Council, 2013). It was suggested that each university should have its own specific language policy adapted to their institution's mission and context. Consequently, the European Language Council offered to prepare defining referencing points to deal with the pertinent new challenges that HE institutions may want to consider when developing and revising their own language policies. Indicating language proficiency as a key qualification for mobility and employability, the recommendations included the ideas on ensuring language provision continuity for students in HE. In Europe, it was the University of Jyvaskyla (Finland) to be the first to announce its institutional language policy. It can be found at https://www.jyu.fi/hallinto/strategia/en/university-of-jyvaskyla-language-policy-2012.

In 2012, the first European survey on language competences was carried out to find out the levels of competences both in the first and second FLs (European Parliamentary Research Service, 2016). The findings were that in the 1st FL the level of an independent user (B1+B2) was achieved by 42 percent of respondents and only 25 percent of them had this level in the 2nd FL. As it concerns the level of basic user (the beginning level), 14 percent of respondents did not have it for the 1st FL and 25 percent for the 2nd FL. These numbers clearly indicated the need to expand FL education.

In 2014-2015, the European Language Council developed the memorandum on the role of Languages in the European Higher Education Area (The Role of Languages, 2015). Stressing that individual and societal multilingualism should be a political goal of Europe, the document aimed to "identify key linguistic and intercultural skills and competences that would be considered essential for European graduates and their employability; and recommend actions to be taken in order to ensure that students at European HEIs are given the opportunity to develop these skills and competences in the course of their studies" (The Role of Languages, 2015, p. 2).

The memorandum indicated that English Medium Instruction (hereafter EMI) programmes occupied a very special position in HE institutions with an increase of more than 1,000 percent in Europe. This marked a significant shift in the FL learning/teaching area. Currently, a great number of European HE institutions opt for offering master's programmes in English. This is one of the appealing ways to attract international students and at the same time learners are expected to improve their L2 or L3 language proficiency. This trend is probably one of the major causes why the provision of FLs as separate academic subjects or teaching FLs in a more explicit way decreased, especially of the English language. In addition, as explained by Pinto and Araújo e Sá (2016), HE institutions are usually operating on the basis of the culture that is based on utility and, thus, playing the pragmatic role in education. In this sense, learning FLs, except English, is probably considered as time consuming and not providing immediate results that can be rapidly applicable in labour markets. However, in order for learners to improve their language proficiency in the course of their studies, the formal practice of EMI is not sufficient, since these capabilities need to be explicitly trained (The Role of Languages, 2015). Content and Language Integrated Learning (hereafter CLIL), which involves the balanced and concurrent teaching of both content and language, was offered as one of the alternatives.

The major conclusion of the memorandum was that no HE institution "can take it for granted that students have the language and intercultural communication skills and competences taught in the national or local school system" (The Role of Languages, 2015, p. 7). Therefore, they were recommended to evaluate their students' language and communication skills and make provisions so that they have opportunities to develop them further in HE. Thus, language learning in the course of studies is concluded to be an essential part of non-language programmes and should be indicated as one of the intended learning outcomes of HE.

Furthermore, "Education and Training 2020", which is a new strategic framework for European cooperation in education and training, identifies language learning as a priority and communication in FLs as one of the eight competences necessary to improve the quality and efficiency of education and training (Language Policy, 2016). In order to enhance employability and mobility, language skills are also indicated to be crucial in the "Agenda for new skills and jobs" and "Youth on the move" initiatives (Language Policy, 2016).

With regard to FLs, there is no doubt that English is the most popular language. Although it is difficult to count, it is believed that speakers of English as a second or additional language outnumber native speakers four or even five times (Harmer, 2015a). If earlier there was an attempt to determine whether British English or American English was an appropriate model for learners, nowadays the majority of non-native speakers speak the kind of English that is called English as a lingua franca (Harmer, 2015a). It has already become the language of the Internet, science and business. Harmer (2015a) even calls everyone a second language (ESL) student because of the fact that the Internet is an English speaking country. Witnessing the increasing popularity of working from home, no doubt English will remain among the top languages to learn.

From this short overview, it is evident that a number of European policies concerning FL teaching/learning in HE have been highlighting the key role of HE institutions in the promotion of learning FLs and linguistic diversity in order to prepare students both for academic and professional contexts. In this respect, HE institutions should not reduce or should not even decrease the provision of learning languages while applying different forms.

1.2.2 Foreign language learning as a process in educational environments, including problem solving learning

The chapter overviews process-oriented or action-oriented conceptualization of FL learning, which can be considered as the basis for educational environments enabling students to learn problem solving, i.e. where students' learning of a FL is coupled with learning to solve problems and language learning occurs in the context of solving ill-structured problems.

In FL education, many fundamental questions exist: Is explicit FL instruction more effective than an implicit one? What successful FL learning looks like? Which approach, method, procedure or technique is the best? As stated by an EFL legend Harmer (2015a), research does not provide direct answers to the questions like these and some answers are even either contradictory or controversial. Richards and Renandya (2002) also conclude that research "almost always yields findings that are subject to interpretation rather than giving conclusive evidence" (p.11). For example, Canale and Swain (1980) report about numerous studies that diverge in providing conclusions whether emphasis on getting one's meaning across (as in communicative language teaching) is better than the development of grammatical accuracy.

It has become commonplace to distinguish between language learning and acquisition. Acquisition is the form of language mastering like young children acquire their first language through a subconscious process without being aware of grammatical rules. Language acquisition may also refer to the second language. According to the American linguist Stephen Krashen's (1984, as cited in Harmer, 2015a) theory of second language acquisition, meaningful interaction or comprehensible input (best in the anxiety free environment) is enough for language acquisition to occur. Learners participate in natural communication and in this way acquire language in a subconscious way. On the other hand, learning a language entails formal instruction and is a more conscious process during which learners gain knowledge of language (e.g., its grammar), for example, through FL lessons. Currently, both acquisition in a subconscious way (implicit form) and learning in more deliberate ways (explicit form) coexist in FL education.

There have been many different approaches and methods to FL learning with a varying degree of mind consciousness and explicitness of learning involved. The earliest methods, such as the grammar-translation method, direct method and audiolingualism, focus on repetition of forms, memorization and reading of texts. These approaches are typical examples of explicit language teaching and represent product approaches, which "are grounded on behaviourist principles and relate language teaching to linguistic form, discrete linguistics skills and habit formation.

They claim that language consists of parts, which should be learned and mastered separately in a graded manner" (Turuk, 2008, p. 253). The goal of learning is grammatical or lexical competence and, therefore, knowledge of language is equated with the proficiency in that FL. However, Chomsky (1959, as cited in Harmer, 2015a) criticizes such behaviourism-rooted approaches by providing the argument that humans are able to say such new things that they have not heard before. This proves that language learning cannot be seen just as the result of endless repetition (habit formation according to behaviourist theories) but also involves some kind of mental processing of the input that occurs in human minds (Harmer, 2015a).

As a reaction against product approaches, process approaches appeared in the 1960s and 1970s. They can be grounded on sociocultural theory and Vygotsky's ideas. Process approaches do not emphasize what learners need to know but focus on what they need to experience (Scott, 1996). Instead of focusing on product or object words like output, input, grammar or test scores (to measure proficiency) and learning about language, they treat FL learning as a process or activity (van Lier, 2007).

In the 1970s and early 1980s, the appearance of a communicative approach (also called communicative language teaching, hereafter CLT) in an example and shift in the understanding of FL learning from cognitive to socio-cognitive process occurred. CLT is based on the idea that communication and interaction among learners is both the way of learning and the goal of the learning process. It marked "a shift away from a focus on how language was formed (grammar and vocabulary, etc.) to an emphasis on what language was used for" (Harmer, 2015a, p. 57). Canale and Swain (1980) define CLT as a method that focuses on communicative functions (e.g., apologizing, inviting, promising, describing) that learners need to know. Thus, the method is a move from the main focus on developing grammatically correct sentences to learning on how to use a FL in a variety of contexts and for various functions, which, undoubtedly, can be seen as more practical and closer to real world language use.

According to Harmer (2015a), CLT is opposite to earlier traditional teaching procedures, where explicit language teaching dominated. To illustrate the differences between these two, the 'communication continuum' can be considered (see Figure 7).

Non-communicative activities (traditional learning and teaching procedures)	↔	**Communicative activities (CLT)**
• no communicative desire		• a desire to communicate
• no communicative purpose		• a communicative purpose
• form not content		• content not form
• one language item only		• variety of language
• teacher intervention		• no teacher intervention
• materials control		• no materials control

Figure 7. The communication continuum (Harmer, 2015a, p. 58)

While CLT is at one end of the language learning spectrum, traditional earlier approaches are at the opposite one. In the case of CLT, communicative activities are in the centre of the learning process, where language may be seen as taking care of itself (Allwright, as cited in Harmer, 2015b). Accordingly, learners are involved in meaning-focused and realistic communicative activities where the ability to use language for some purpose is more important than knowledge of the rules of grammar or vocabulary. Learners concentrate on the content instead of a particular language form and in this respect the use of language becomes more important than its usage. CLT represents a more implicit way of learning languages.

In addition, the appearance of CLT has greatly changed the role of a language teacher. If earlier methods were more structured, CLT gives both more freedom and responsibility. The role of a language teacher changes from master or possessor of knowledge to "the person who fosters, encourages, and orchestrates the work of the students, who are now referred to as 'learners' to reflect their new responsibility and autonomy in the process of acquiring language" (Piccardo, 2014, p. 13). Harmer (2015a) also indicates that CLT offers a richer menu of topics. Furthermore, Piccardo (2014) states that CLT is about authenticity of both resources and the situations during which language is practised. Authentic material means that language educators have to develop their own material according to the learners' needs and place learners into a natural context as much as it is possible. Inevitably, these ideas put forward new demands, not only on language educators but also on learners themselves.

Many researchers and practitioners have been arguing whether explicit or implicit (without any noticing of language aspects) FL learning is more beneficial and which intermediary position in the proposed continuum is better. As discussed previously, Krashen (1984, as cited in Harmer, 2015a) was one of those linguists who believed that for language acquisition to be successful it is enough to expose learners to much comprehensible input in a relaxed setting during a FL classroom, the same as for young children. However, Harmer (2015a) holds the view that while implicit language learning is applicable to child language acquisition, it is questionable whether comprehensible input is enough for FL learners in the later stages in their lives. He admits that "students will better understand and learn things if they pay attention to those things and focus on them" (p. 52). Thus, Harmer (2015a) argues that modern CLT should be a meaning-focused approach with the inclusion of an explicit focus on language study when it is appropriate and needed. He claims that just emphasizing activity and engaging learners into communicative tasks does not make the magic work every time because of leaving some learners with more cognitive needs floundering. For Griffiths (as cited in Harmer, 2015a), traditional methods could serve as complementary to communicative approaches and this is what reflects the most frequent modern reality, at least in education levels lower than tertiary education. Dörnyei (as cited in Harmer, 2015a) argues for a principled communicative approach, which also involves a focus on form and controlled practice, i.e. mix of both implicit and explicit language teaching. Similarly, Canale and Swain (1980) support the view that complete rejection of grammatical accuracy and learning a FL that mirrors parental teaching is suitable only for young learners. As it concerns adult learners, the authors provide three main reasons based on empirical findings why CLT should not exemplify the outreach side in the communicative continuum. First, learners' errors may be different in first and second language acquisition. Second, adult second language learners may not be ready or satisfied to put emphasis on meaning exclusively. Third, second language learners risk not developing grammatical accuracy if there is an emphasis on meaning only. As Canale and Swain

(1980) point out, grammatical inaccuracies may "tend to 'fossilize' – i.e. persist over time in spite of further language training" (p. 11). Consequently, in EFL education, there is "a fairly convincing consensus that having students focus explicitly on language forms will help them learn" (Harmer, 2015a, p. 43) and these two opposite ends continue to coexist (Harmer, 2015a; Kumar et al., 2013). The ideas expressed imply that at least some minimal language noticing initiated or minimal guided instruction by a language educator to gain explicit knowledge in the language development process is necessary for language learning to succeed. Thus, although earlier approaches are considered to be less practical and effective, some of their ideas cannot be completely rejected.

Concerning the same discussion, whether more explicit (or conscious) in comparison to implicit (or subconscious) language learning is better, Elliot (2012) reminds that everything a human does is always a cooperation between subconscious and conscious minds. According to him, 90 percent of our brain is devoted to the subconscious mind while the rest, 10 percent, to our conscious thought. The subconscious storage part (called memory) is able to hold much information and may enable a person to know 40 foreign languages (Elliot, 2012). However, it is the conscious mind that controls everything we do and takes from the subconscious department (Elliot, 2012). This implies the idea that a subconscious way of learning should amount to the conscious one.

Communicative competence is a broad term. According to Canale and Swain (1980), it is composed of grammatical competence, sociolinguistic competence, and strategic competence or communication strategies and the main goal of CLTis that a learner develops all of them. More specifically, grammatical competence is knowledge of the structures and rules of grammar as well as vocabulary. Sociolinguistic competence is about sociocultural rules of use, as well as rules of discourse, while strategic competence is about verbal and non-verbal communication strategies that can be used to compensate breakdowns in communication that may be caused either by insufficient competence or performance variables (Canale & Swain, 1980).

Action-oriented approach is a more overaching approach than CLT. As already mentioned, The Common European Framework of Reference for Languages: Learning, Teaching and Assessment (CEFR) is a major document providing recommendations on learning, teaching and assessing of FLs in Europe. Its ideas are grounded on sound research and evidence from the practice of language educators. The CEFR (2018) scheme advocates using various FL learning methods or approaches that are informed by sociocultural and socioconstructivist theories, including the action-oriented approach, task-based approach or the ecological approach. One of the critical ideas it suggests is the superiority of action-oriented approach over the communicative one (CEFR, 2001). Nevertheless, both approaches are complementing each other (Delibas & Gunday, 2016; Piccardo, 2014).

While in CLT, learning is organized around speech acts to learn some particular language functions, the central idea of the action-oriented approach is that speech acts occur in social contexts and, thus, this gives more meaning to these speech acts. The main methodological message of the action-oriented approach is "that language learning should be directed towards enabling learners to act in real-life-situations, expressing themselves and accomplishing tasks of different natures" (CEFR, 2018, p. 27). It means that language learning and teaching should be based on various authentic tasks that resemble real life activities.

More specifically, according to CEFR (2001), in the action-oriented approach users and learners of a language are "primarily as 'social agents', i.e. members of society who have tasks (not exclusively language-related) to accomplish in a given set of circumstances, in a specific environment and within a particular field of action" (p. 9).

They act as social agents to perform various actions that have goals other than just communicating or learning to communicate. They write not just because to convey their ideas in a written form, but, for instance, to convince someone to consider their application for a job. They speak not just to be able to speak in other languages, but, for instance, to share knowledge on the same problem while solving it in a collaborative manner. Thus, according to the action-oriented approach, learning a language comprises not only linguistic activities and goals but also non-linguistic ones.

While implementing the action-oriented approach, "learners' undivided physical, psychological, emotional and spiritual preconditions in the learning process as well as their inherent drive to be actively and wholeheartedly involved in relevant actions" (Finkbeiner, 2002, as cited in Byram & Hu, 2013, p. 292) are taken into account. Thus, this approach is related to learners' senses, bodies and hearts. Whenever someone learns a FL, his or her interests, feelings and motivational state are involved and this affective status is influencing learning in an implicit and subconscious way (Byram & Hu, 2013). Therefore, it can be deduced that any activity a FL learner is suggested by a language teacher, first of all, it should be motivational. To take an example, motivated problem solving involves meaningful information sharing and personal interest into the task, which may result in a more holistic experience and not just problem solving because of the fact someone asks to do it. Therefore, ways to enhance motivation to communicate might involve tasks having a genuine purpose, for example, some real-life problem to be solved or interesting project to be completed.

The action-oriented approach emphasizes the idea that learning a language does not happen in isolation, there are other people in the social context. As explained by Piccardo (2014), two types of interactions should be taken into account - among individuals as well as between the learner and the external context. The situated nature of tasks makes them dependent on various environmental factors. Thus, while CLT outlines just learning through communication and in communicative situations, the action-oriented approach adds two more dimensions – learning with others and in some specific situations or contexts, which in turn influence learning by providing some conditions or constraints. Accordingly, the action-oriented approach may be considered as a more overarching approach to language learning.

According to van Lier (2007), the action-oriented approach can be related to a number of other approaches that consider learning by doing or actions in the centre of learning. They are project-based, content-based, task-based, or any form of experiential learning. For example, the content-based approach emphasizes content, task-based approach emphasizes tasks and project-based focuses on projects. The listed approaches are not totally synonymous, but they share the idea that a learner is an active person and not the one that copies behaviour, just inputs or rote memorises facts (van Lier, 2007), as it was emphasized in earlier approaches. When such approaches are adopted, it becomes more important what learners say and do while undertaking various meaningful activities.

Most importantly, the CEFR's (2018) view is that the action-oriented approach allows a shift away from the type of syllabus that is based on a predetermined set of functions and language structures that a learner has to learn (still a dominant way to organize coursebooks for learning FLs) to organizing learning around real-life tasks and purposefully selected functions reflecting real world communicative needs. Thus, for example, if training for employment requires learners to be prepared to solve complex problems in a collaborative manner, the syllabus should be organized around functions on how to work collaboratively and interact to solve such type of problems.

According to CEFR (2018), real-life communicative situations require a range of competencies - general competencies (e.g., knowledge of the world, socio-cultural and intercultural competence or professional competence), communicative language competences (linguistic, sociolinguistic and pragmatic), and strategies (some general and some communicative language strategies). In this respect, the constituent parts of the overall language learners' proficiency prove the fact that learning a language cannot be restricted just to language outcomes. This also implies the fact that any task in an EFL classroom is about overall language proficiency: requires general and communicative language competences and allows to further develop them.

Furthermore, in CEFR (2018), a learner is seen as a mediator acting as an intermediary between interlocutors or the rest of the people communicating in the same social situation. Accordingly, although it was not stated explicitly in the 2001 version, the updated CEFR (2018) indicates **mediation to be the central activity in the action oriented approach**. In mediation, the role of a language learner is to convey or construct meaning so as to "create the space and conditions for communicating and/or learning, collaborating to construct new meaning, encouraging others to construct or understand new meaning, and passing on new information in an appropriate form" (CEFR, 2018, p. 98) or, simply speaking, facilitate communication and understanding among group members.

If earlier language learning was traditionally defined as the development of four skills (speaking, reading, writing and listening) and classification into proficiency was based on them, CEFR (2001) highlights four modes of communication: reception, production, interaction and mediation. The shift from four skills to modes of communication occurred because these categories better reflect the ways individuals use language and therefore every task they perform is easier situated within these modes. The examples of these modes are provided in the table below.

Table 8. CEFR categories for communicative language activities (CEFR, 2018, p. 31, italics in the original)

	RECEPTION	PRODUCTION	INTERACTION	MEDIATION
Creative, Interpersonal Language Use	e.g. Reading as a leisure activity	e.g. Sustained monologue: Describing experience	e.g. Conversation	Mediating communication
Transactional Language Use	e.g. Reading for information and argument	e.g. Sustained monologue: Giving information	e.g. Obtaining goods and services Information exchange	Mediating a text
Evaluative, Problem-solving Language Use	*(Merged with reading for information and arguments)*	e.g. Sustained monologue: Presenting a case	e.g. Discussion	Mediating concepts

The complicated relationships among the four modes or four categories of communicative language activities is presented in Figure 8 below. As explained in CEFR (2018), reception and production (either spoken or written) are about four traditional skills while interaction involves both and even more. Mediation involves all three: production, reception and interaction, which makes it the central goal while learning FLs (CEFR, 2018).

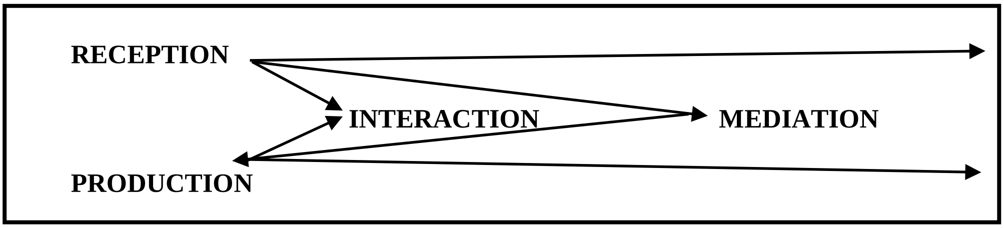

Figure 8. The relationship between reception, production, interaction and mediation (CEFR, 2018, p. 32)

The older version of CEFR (2001), limited the understanding of mediation to cross-linguistic mediation and the activities of interpretation or translation (passing on information in another language), for example, a paraphrase, summary or record to provide another person a (re)formulation of a source text which he or she does not or cannot access directly. In it, mediation was explained as the type of oral or written activity that makes "communication possible between persons who are unable, for whatever reason, to communicate with each other directly" (CEFR, 2001, p. 14).

On the other hand, the new version of CEFR (2018) emphasizes a wider and more modern view on mediation, which is one of the most important changes of the document. It defines mediation as "a social and cultural process of creating conditions for communication and cooperation, facing and hopefully defusing any delicate situations and tensions that may arise" (CEFR, 2018, p. 102), which means that a speaker who engages in mediation helps other participants in communicative situations. He or she is not concerned of the ways to express their own ideas but acts as an intermediary "between interlocutors who are unable to understand each other directly, normally (but not exclusively) speakers of other languages" (CEFR, 2001, p.

87). It is any action or procedure to remove barriers that stand in the way between two speakers and prevent them from understanding each other, effective sharing information and management of the collaborative environment.

In addition, the newest version of CEFR (2018) adopted Coste and Cavalli's classification of mediation where it is divided into two types. *Relational mediation* is defined as "the process of establishing and managing interpersonal relationships in order to create a positive, collaborative environment" (p. 159) and *cognitive mediation* as a complementing process "of facilitating access to knowledge and concepts, particularly when an individual may be unable to access this directly on his /her own, due perhaps to the novelty and unfamiliarity of the concepts and/or to a linguistic or cultural barrier" (p. 159). Relational mediation is, for example, an attempt to resolve disagreements when group members cannot agree on some issues. An example of cognitive mediation could be a case when learners help other learners who do not understand an unknown type of a chart or do not know meanings of the new words.

Usually, real life communication situations requires both relational mediation and cognitive mediation to coexist and, therefore, a more practical division is to divide mediation into three broad ways – mediating a text, concepts or communication (CEFR, 2018). More specifically, each of them may engage in:

Mediating a text

- Relaying specific information – in speech and in writing
- Explaining data (e.g., in graphs, diagrams, charts, etc.) – in speech and in writing
- Processing text – in speech and in writing
- Translating a written text – in speech and in writing
- Note-taking (lectures, seminars, meetings, etc.)
- Expressing a personal response to creative texts (including literature)
- Analysis and criticism of creative texts (including literature)

Mediating concepts

- Collaborating in a group
- Facilitating collaborative interaction with peers
- Collaborating to construct meaning
- Leading group work
- Managing interaction
- Encouraging conceptual talk

Mediating communication

- Facilitating the pluricultural space
- Acting as intermediary in informal situations (with friends and colleagues)
- Facilitating communication in delicate situations and disagreements (CEFR, 2018, p. 102).

Furthermore, CEFR (2018) lists two types of **mediation strategies** or techniques to facilitate understanding and clarify meaning. Specifically, these strategies consist of:

Strategies to explain a new concept:

- Linking to previous knowledge (e.g., by explaining new information with the help of comparisons),
- Adapting language (e.g., shifting in use of language, style or register; paraphrasing; explaining terminology), and
- Breaking down complicated information (e.g., presenting ideas as bullet points).

Strategies to simplify a text:

- Amplifying a dense text (e.g., paraphrasing in different ways, modifying style, giving examples)
- Streamlining a text (e.g., highlighting key information, excluding what is not relevant)

Therefore, according to CEFR (2018), the learner's ability to mediate is not just about being linguistically competent but also about being able to apply proper mediation strategies according to the given communicative context. These strategies allow learners "to shuttle between people, between texts, between types of discourse and between languages, depending on the mediation context" (p. 124).

According to the expanded vision of mediation, communication may be hindered by various reasons and not necessarily because of the fact that speakers speak different languages. There may be cases that learners speak the same language but simply their level of proficiency is different and barriers in their communication occur. Accordingly, the activity of mediation cannot be restricted within the same language but should be also understood as a form of communication help from one language into another (cross-linguistic mediation) and, therefore, the notion of mediation goes beyond language use in the field of foreign language education because it is also about facilitating communication in various fields (e.g., diplomacy, business). As already discussed, the future is likely to involve current learners in the situations where they will have to deal with complex problems while workings in teams with heterogeneous members. Heterogeneity means that group members may belong to different cultures, speak different languages or might be of different language proficiency. Here, mediation becomes indispensable.

Communication anxiety (reticence): one of the obstacles for the implementation of the action-based approach. In 1965, Gerald M. Philips introduced a very common problem of communication called either FL anxiety or reticence (Li & Liu, 2011). It is a phenomenon when learners are resistant to participating in speaking activities (either individual or group-based) during FL classes. More specifically, it is the feeling of "uneasiness, worry, nervousness and apprehension experienced by non-native speakers when learning or using a second or foreign language" (Li & Liu, 2011, p. 961). According to the authors, communication anxiety belongs to the most common FL usage related problems.

As it concerns the possible causes of being not able to actively and equally participate in communicative activities, Li and Liu (2011) provide general causes, causes for FL anxiety and specific causes. As the authors indicate, the list of general causes include such causes as low self-esteem, fear of being that others may laugh from the speaker's inaccuracy or communication apprehension (a clinical fear, fear of communicating in the presence of others). The latter reason is usually termed as glosophobia and indicated to be among the top fears in humans. Causes for FL anxiety can be divided into communication apprehension, test anxiety and negative evaluation (Li & Liu, 2011). Specific causes can be, for example, a culture-specific attitude to interpersonal relations. For instance, Chinese learners value collective over individual (Li & Liu, 2011).

Reticence is likely to have a detrimental effect on a student's confidence, levels of self-esteem and participation. Reticent learners are "perceived as less trustworthy, less competent, less socially and physically attractive, tenser, less composed and less dominant than their less reticent counterparts" (Li & Liu, 2011, p. 963). Also, the degree of reticence may be different, both in FL classes and in real life. No doubt, reticent students may not benefit from communicative activities and thus both teachers and peers have to think of ways of how to reduce this problem. Among the ways to solve reticence problems, Li and Liu (2011) mention teachers' attempts to encourage students to deal with shyness, various reward systems for staying active, attempt to find out problem/reasons of demotivation and efforts to increase motivation.

Mismatch of the underlying representations of language among problem solvers. Halpern (2014) introduces the problem of mismatches of the underlying representations of language among speakers of different language proficiency levels, which may also hinder successful communication in a FL language while learning to solve problems. As explained by Halpern (2014), speakers of any language select words they want to use and produce them. On the other hand, listeners use information in another's utterance and in this way thoughts are shared.

More specifically, language can be divided into two types of representations: the underlying representations or deep structure (refers to the meaning component of language that are thought a person wants to convey) and surface structure (refers to sounds of the verbal expression or written words) (Halpern, 2014). A person has a thought he or she intends to communicate to another person. This thought is private and known only to the sender (is still deep structure). The sender attempts to transform it using speech sounds or letters (in this way it becomes surface structure) and sends to the receiver so that he or she could reconstruct the intended meaning expressed by the sender (Halpern, 2014, p. 115). In cases when underlying representations constructed by the receiver match the underlying representations of the sender, communication is successful (Halpern, 2014). On the other hand, the more barriers in transforming thoughts into utterances (from deep structure to surface structure) and in getting from the surface structure back to the deep structure, the less successful communication occurs. The process is depicted in Figure 9 below.

Considering learners solving problems in teams, it can be anticipated that mismatches among speakers may arise because of the different levels of language proficiency or different knowledge of grammar and vocabulary. In such cases, learners may be using various mediation comprehension activities (cognitive mediation) for facilitating communication among group members.

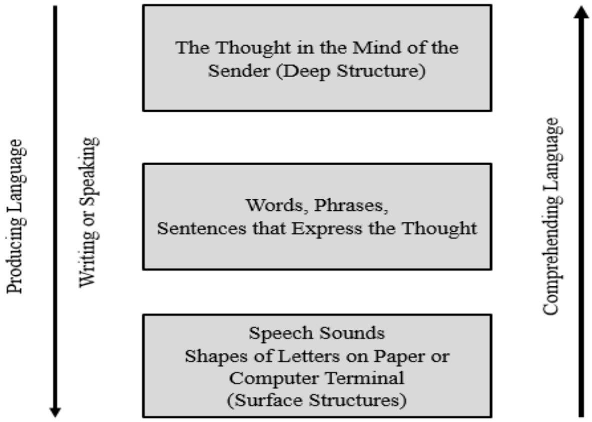

Figure 9. The problem of comprehension (Halpern, 2014, p. 115)

Implications for designing educational environments employing action-oriented approach. As it concerns the process of designing educational environments for learning FLs, the action-oriented approach requires some salient aspects to be adapted. First, educators should think of authentic, ill-structured (may have many answers) and purposeful collaborative tasks having both linguistic and non-linguistic goals (e.g., creating a joint poster, collaborative presentation or solving a problem) which are expected to involve learners into meaningful communication or interaction with each other. It is important to note that these activities may be undertaken by learners only in those cases when they are enough motivated. Second, FL educators should focus not only on the product aspects (grammar topics they cover, test scores they get or final artefacts of the tasks) but also on the process aspects (what learners do) and think about the ways the process could be facilitated. Language proficiency diversity could be addressed by, for example, introducing language learners to mediation strategies required to simplify a text or introduce a new concept. Third, the social aspect implies that a FL classroom becomes similar to a community of practice where learners share ideas, knowledge, skills and goals. Thus, educators should think of how to encourage a supportive and collaborative learning culture. For example, language learners can be involved in the repeated practice of collaboration by allowing additional time to reflect on the peculiarities of such processes. Table 9 below summarizes the discussed peculiarities of CPS in a FL.

Table 9. Summary of peculiarities of collaborative problem solving in a FL

	PROBLEM SOLVING IN A FOREIGN LANGUAGE
DEFINITIONS	Searching through a problem space from its current state to the goal state using a foreign language.
CHARACTERISTICS	1) development of communicative competence and all three aspects of it (linguistic, sociolinguistic and strategic). 2) participating in the central mode when learning a language – mediation (helping others in communicative situations).

DIFFICULTIES	*Problems related to using a FL as a working language:* barriers for successful communication because of mismatches of the underlying representations (thoughts to convey) between the sender and the receiver, communication anxiety (when the reason is the use of a FL as a working language).
IMPLICATIONS FOR DESIGNING EDUCATIONAL ENVIRONMENTS	Language educators should think of ill-structured, authentic and purposeful (thus involving in meaningful communication) tasks that include both linguistic goals and activities as well as non-linguistic ones. Considering FL learning as a process based on action-oriented approach, educators should seek to facilitate learners' interaction and mediation activities. They should help them while participating in relational mediation (the process of establishing and managing interpersonal relationships in order to create a positive, collaborative environment) and cognitive mediation (the process of facilitating access to knowledge and concepts, particularly when learners' language proficiency is different).

To sum up the chapter, there have been various approaches to FL learning and acquisition. Two broad types discussed are product approaches (the earlier ones) that can be equated with more explicit ways of language teaching and the more recent process-oriented approaches that typify more implicit ways of FL learning and acquisition. CLT has completely changed the understanding of language learning and teaching by placing learners themselves at the front of the learning process. The central idea of CLT is that students learn best when they communicate in real-life situations and in this way learning focuses not on learning about language (as in earlier methods) but how to use it for various purposes.

Similarly, according to a complimentary and more overarching action-oriented approach, language learning can occur while learners are engaged in purposeful actions and thus meaningful communication. In addition, this approach adds the dimensions of learning a language not in isolation but together with others, as well as learning in some specific contexts, which both influence learning. The action-oriented approach or learning by doing condition requires language educators to engage learners into purposeful and mirroring everyday life in authentic learning tasks. Namely, problem solving can be seen as the type that clearly reflects learning by doing or learning a FL in the context of solving problems, which allows learners to improve both the skill of problem solving and FL proficiency at the same time.

More importantly, problem solving in a FL involves learners in the most central mode of language usage – mediation and further development of it. By participating in mediating activities, learners further develop mediating strategies to facilitate understanding and communication among each other. This learning framework can be considered as the most advanced for FL education, since it allows learners to prepare for real life situations where they will need to collaborate and probably solve problems in diverse teams made up of group members having different language proficiency or even using different languages.

Language educators should take the stance of facilitators who encourage and support learning in a group. The vital implication for designing educational environments is that they should think of various scaffolds to facilitate relational mediation (the process of establishing and managing interpersonal relationships in order to create a positive, collaborative environment) and cognitive mediation (the process of facilitating access to knowledge and concepts, particularly when an individual may be unable to access this directly on his /her own).

1.3 Educational environments enabling students to learn problem solving

The main goal of the current section is to discuss and model educational environments that enable students to learn problem solving.

1.3.1 Theories of learning: from learners in isolation to dialogic learning

Learning theories is a useful background when analysing students' learning to solve problems and educational environment having such an educational goal in mind. The aim of the chapter is not to discuss all existing learning theories, as this is beyond the scope of the current thesis. Instead, a short glimpse is necessary into the ones indicating the transition from treating learners in isolation to approaching them learning collaboratively, as well as conceptualizing learning as a dialogue or conversation among learners.

Early well-known learning theories, such as behavioural and cognitive, focused on individuals learning in isolation. For instance, as already mentioned in the previous chapter, the representatives of behaviourism analyzed learning as a situation, stimulus and response. The learners responded to stimuli and formed associations between them, and this represented learning. The understanding of learning was limited to a change of behaviour, which brought about such reinforced practices as reward and punishment in education. Behaviorism favored direct instruction, which is suitable for teaching factual content but does not seem to be suitable for teaching higher order skills such as problem solving. Later, the cognitive learning theory provided internal and mentalistic explanations for the learning processes. Learners were believed to be constructing own meaning while exploring their environment. In the light of cognitive theory, as already explained, problem solving was understood as a search in the problem space to understand a sequence of processes that are carried out in order to solve the problem. Therefore, it resulted in various attempts to offer general-purpose strategies known as information processing approaches that can be applied to solve various types of problems.

Both learning theories paid little attention to the social context within which learning occurs. Dialogic power and the centrality of talk in the learning process were acknowledged only when social theories such as Vygotsky's social constructivism was introduced. According to this theory, meaning making is a social negotiation among people participating in the same activity. In Vygotsky's book *Thought and Language* (1930, translated into English in 1962), it was claimed that "using language to communicate helps in the development of new ways of thinking: what students learn from their 'inter-mental' experience (communication between minds through social interactions) shapes their 'intra-mental thinking' activity (the way they think as individuals)" (Hardman, 2010, p. 37). What was additionally stressed is that these are more capable people, such as parents or teachers, who influence the development of thinking in the ‘zone of proximal development’ (the zone between what a learner can do without assistance and what he or she can do with assistance of more knowledgeable) (Hardman, 2010). Vygotsky’s ideas were critical in starting to use a dialogue as a learning strategy because of approaching learning as a social-dialogical process (Jonassen & Land, 2012). That was similar to the ancient Socratic forms of education where learners were questioned and learning resembled a conversation.

Dialogue is seen as a powerful condition for learning, through which we share our understanding and modify it. A number of researchers and practitioners stress the fact that our ideas in isolation have no such great powers as if joint together. For example, Jonassen and Land (2012) state that:

> not only does knowledge exist in individual and socially negotiating minds, but it also exists in the discourse among individuals, the social relationships that bind them, the psychical artefacts that they use and produce, and the theories, models, and methods they use to produce them. (p. x)

Based on the social constructivism theories of Vygotsky and Piaget, Laurilland (2002) also describes complex learning as:

> a continuing iterative dialogue between teacher and student, which reveals the participants’ conceptions and the variations between them… There is no escape from the need for dialogue, no room for mere telling, nor for practice without description, nor for experimentation without reflection, nor for student action without feedback. (p. 71)

According to the newest learning theory of connectivism introduced by George Siemens, learning should go beyond traditional theories of learning of behaviorism, cognitvism as well as constructivism and technology should be seen as its core element (Scmidth et al., 2009). Technology adds a dimension of online dialogue and allows moving learners’ social interaction beyond the walls of a traditional classroom. In addition, new skills for the 21st century are that which are more procedural than factual, allowing communicating effectively and analyzing complex data (Murnane & Levy, 2004, as cited in Scmidth et al., 2009). Siemens (as cited in Scmidth et al., 2009) holds the view that factual knowledge is less important than learning how to use the networked connections between constantly changing specialized information. He argues that the “ability to learn what we need for tomorrow is more important than what we know today” (as cited in Scmidth et al., 2009, p. 5). In this framework, abundant technologies allow educators to organize learning in the form of a dialogue or conversation and make it more feasible and easier.

Technologies allow replacing face-to-face dialogue with an online one for the whole learning process or some parts of it. To compare online dialogue and face-to-face communication of learners, a number of online dialogue advantages can be identified. First, it may increase cognitive intensity. In a traditional classroom, only one learner can speak at a time and it is not possible to hear everybody, which makes it not clear whether all students are participating, listening or paying attention to the ideas being discussed by all members. Also, listening to only part of the learners may be boring for the rest learners. Those that are less voiced may be not involved. Thus, online dialogue produces multiple voices and increases the amount of engagement considering all participants of the course. Second, the nature of classroom discourse in the cases of online communication is different. When oral language is produced, it usually has much redundancy and is less formal. On the other hand, it becomes more formal and systematic with less redundancy observed during online discourse. In this sense, it can be considered as a move towards a more academic literacy that requires students to formulate and frame main ideas in shorter ways than in a spoken discourse.

Kalantzis and Cope (2016) also support the ideas of dialogic learning as well as other ones pertinent to reflective pedagogy. In their recent book, *E-Learning Ecologies*, they present the discussion about learning paradigms existing throughout the history of education and distinguish between two main pedagogical alternatives: didactic and reflexive pedagogies. First, the didactic mode of learning appeared in the late middle ages and became universal by the end of the nineteenth century. By the beginning of the twentieth century, the didactic pedagogy was started to be for being outdated and ineffective. The practical alternative was called "reflexive" pedagogy, since it represents "a revival of the dialogical, where the agency of the learner is at play in a dialectic between teacher and learner, the to-be-learned and the learning" (Kalantzis & Cope, 2016, p. 9). Table 10 summarizes the features of didactic pedagogy and reflexive learning, with the latter one representing more modern views in education.

Table 10. Main characteristics of didactic and reflexive pedagogies (adapted from Kalantzis & Cope, 2016)

Didactic Pedagogy	Reflexive Pedagogy
Balance of control with the instructor, transmission pedagogy, learner as knowledge consumers	Learners have equal responsibility to be in control of their learning, learners as knowledge producers
Focus on cognition, specifically long-term memory	Focus on the knowledge artefacts created by the learner and the processes of their making
Focus on the individual learner	Focus on the social sources of knowledge
Narrow range of knowledge activities: remembering facts, deducing the right answers	Wider repertoire of knowledge activities, including recognition of perspective, argument and a more dynamic and evolving understanding of the nature of knowledge

A similar debate on the aspects that distinguish didactic pedagogy from reflexive one is reflected in the article by Kirschner et al. (2006). The authors discuss the necessary level of guidance in instruction, the role of long-term memory in human cognition, and the necessity of content learning. Kirschner et al. (2006) define unguided or minimally guided instruction as a learning context where "learners, rather than being presented with essential information, must discover or construct essential information for themselves" (p. 75) and contrast it to direct guidance or instruction which is defined as "providing information that fully explains the concepts and procedures that students are required to learn" (p. 76). After reviewing a body of research, the authors found that learners, when dealing with novel information and complex learning, should be explicitly provided with guidance of what to do and how to do it. Thus, they argue in favor of guided instruction and state that minimally guided or unguided pedagogical approaches, such as constructivist, discovery, problem-based, experiential and inquiry-based, are ineffective or detrimental to learning because of the too heavy cognitive loads on the learners' working memory. In comparison, considering the need to guide instruction, Kalantzis and Cope (2016) state that learning should be guided whilst leaving space for freedom for learners themselves to construct their knowledge. What they suggest is that sources of knowledge are not monological but instead multimodal from a great variety of sources including the ones discovered by learners themselves.

In addition, Kirschner et al. (2006) define learning "as a change in long-term memory" (p. 76) and consider long-term memory as "the central, dominant structure of human cognition" (p. 76). Thus, according to Kirschner et al.'s view, instruction should aim to alter long-term memory. Kalantzis and Cope (2016) question the assigned importance for long-term memory alteration in instruction. They claim that nowadays long-term memory is not so important and it should not be emphasized in pedagogy. It will develop but it is "incidental and an inessential consequence of deep engagement in a discipline" (p. 12). In case facts or procedures cannot be remembered, they are always easily accessible, especially in times when learners are surrounded by ubiquitous personal digital devices as "cognitive prostheses" (Kalantzis & Cope, 2016, p. 12). Therefore, Kalantzis and Cope (2016) indicate that the measurable goals of learning should change from emphasizing cognition and long-term memory to epistemic artefact or knowledge representations in various documented forms. In cases the focus remains on long-term memory it means a focus on the individual learner and reflects the didactic pedagogy (Kalantzis & Cope, 2016).

To conclude, learning through a dialogue or conversation among learners is an essential condition for learning to solve problems. The form it may take can be both a face-to-face and an online one. Relying on the tenets of reflexive pedagogy, instruction should be guided but only to such a level that learners could take equal responsibility and be actively involved in their knowledge creation. At least minimal guidance is necessary because it is a form of complex learning. Emphasis should be placed on various knowledge artefacts and the processes of their making, as well as the ability to create and extend collaborative knowledge.

1.3.2 Different learning and teaching approaches contributing to the development of problem-solving skills

The goal of this chapter is to analyse various learning and teaching approaches contributing to the development of problem-solving skills in students. It starts with a brief review of what problems may be suitable while learning to solve problems.

In education, the discussion on problem solving usually involves the debate on what types of problems are more suitable for learners to be solved. The majority of researchers (Hung et al., 2008; Jonassen, 2011a; Jonassen & Hung, 2008; Hung, 2011; Walker et al., 2015) agree that problems suitable for problem-solving tasks should be ill-structured problems. Well-structured problems are the ones that are most common in formal education and typically found at the end of a textbook chapter and in examinations, contain all of the information needed to solve them, require the application of a limited number of rules and principles organized in either a predictive or prescriptive way, possess correct and convergent answers and have a preferred, prescribed solution processes (Wood, 1983, as cited in Jonassen, 2011a). On the other hand, ill-structured problems resemble problems that are met in real life and work, have one or more problem elements unknown, are not self-contained and multidisciplinary in nature, have multiple solutions or no solution at all (Jonassen, 2011a). More specifically, Jonassen and Hung (2008) specify that problems should be ill-structured but with a moderate degree of structuredness; complex to such a degree that motivates and engages students' interests; adapted to solvers' prior knowledge, cognitive development and readiness; authentic and related to students' future or potential workplaces. For a PBL setting, the authors offer problems that are moderately ill, structured (to such a degree that is near the median) and slightly above average in complexity, as reflected in Figure 10.

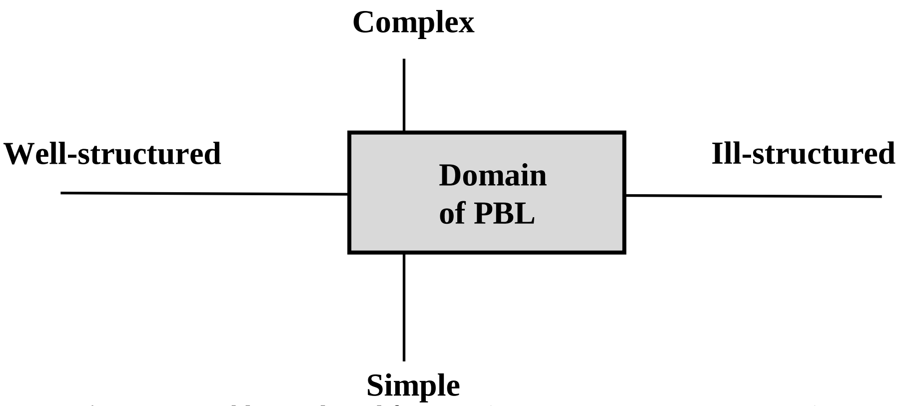

Figure 10. Problems advised for PBL (Jonassen & Hung, 2008, p. 16)

The types of problems used vary depending on the discipline. Jonassen and Hung (2008, as cited in Walker et al., 2015) state that students of medical schools usually solve diagnosis-solution problems, students of chemical engineering studies, architecture and engineering studies solve design problems, PBL in nursing and teacher education focus on diagnosis solution problems or a simpler version of design problems, decision making and policy analysis problems are common in business administration and leadership education, rule-using problems are usually solved by law schools and case analysis problems are offered to business graduates. When adapting PBL to foreign language education, clearly the problems that are common for studying science are not suitable. The solution here could be offering students to solve real life problems, which mirror their lives outside the classroom. Larsson

(2001) observes that it is important that problems are challenging, interesting and relevant to students' reality.

There has been a considerable body of empirical evidence that proves the fact that problem solving ability can be successfully improved (e.g., see Halpern, 2014). In formal education, this can be achieved by using various methods. Referring broadly to the improvement of critical thinking skills, Ennis (1989, as cited in Ventura et al., 2017) proposed a framework classifying various approaches. They can be also applied to problem solving because these skills are interrelated. According to this classification, problem solving can be taught by implicit, explicit or hybrid ways. The four methods are:

- General (like stand-alone critical thinking courses separated from any particular discipline without the integration of any subject-matter content),
- Infusion (explicit teaching of critical thinking placed in certain subject-matter within a discipline),
- Immersion (no explicit teaching of critical thinking with an expectation that students will naturally develop this skill),
- Mixed (a hybrid way when the general way is mixed with either infusion or immersion, students are taught explicitly for a limited period of time during a larger course in the discipline).

Another classification of educational methods contributing to the development of problem-solving skills was proposed by Csapó and Funke (2017) who put them into four groups: direct teaching, content-based methods, enhanced instruction and global approaches.

First, **direct teaching** is explicit teaching about problem solving and presenting learners with well-known general problem-solving or information-processing models, such as the classic General Problem Solver or the IDEAL problem solver, which were described in more detail in Chapter 1.1.2. In these cases, problem solving is taught without its integration with the rest of the curriculum or work environment, just as a "content-free" thinking skill (Kirkley, 2003). However, this approach is often criticized for being ineffective to teach problem solving because of providing procedural knowledge separately without supportive declarative and situated knowledge (e.g., Kirkley, 2003; Ifenthaler et al., 2011; Jonassen, 2011a; Ohlsson, 2012). Context is considered to be the essential feature in problem solving and, therefore, problem solving should be seen as a situational or context-bound process.
To support the inappropriateness of general problem-solving methods for solving ill-structured problems, Jonassen (2011a) argued that problem solving is not a uniform process and most problems require more complex processes than just indication of steps typical to all kinds of problems.

Second, **content-based methods** where learners both master a subject and improve general cognitive abilities are indicated to be producing better results (Csapó & Funke, 2017; Ventura et al., 2017). Among such, the method that is most prominent and most widely researched is problem-based learning (hereafter PBL), which places a major emphasis on disciplinary content knowledge acquisition in the context of problem solving. In PBL, learners learn by solving problems and in this way they are expected to develop problem-solving skills. The method dates back to the 1960s when McMaster University introduced it for medical education. Until now, PBL is widely applied in education, including HE (Barrett & Moore, 2012; Coffin, 2014; Jonassen, 2011a; Li, 2013; Savin-Baden, 2000). The method has already diverged from what it was when originally introduced and resulted in a number of variations; it ranges between institutional model used for the entire curriculum or can be integrated into a conventional one (Cho et al., 2015; Coffin, 2014; Li, 2013; Savin-Baden, 2000). In general, it has greatly changed the understanding of both teaching and learning and is considered among most important curricular inventions.

Apart from content knowledge acquisition, PBL is agreed to be developing a number of the essential twenty-first century skills, such as problem-solving, collaboration and self-directed learning, among others. A number of PBL researchers (e.g., Arts et al., 2006; 2008; Jonassen, 2011a; Hung, 2011; Hung et al., 2008) conclude that enhancement of problem-solving skills is one of the most important advantages of this approach. However, although this method is commonly expected to achieve it, there is not enough proof that PBL really contributes to the enhancement of problem-solving skills (Arts et al., 2006; Hassan et al., 2012; Hung, 2011; Yaqinuddin, 2013).

In educational practice, PBL can be implemented with a step-specific procedure, guiding the necessary steps or cognitive activities ensuring an effective problem-solving process rather than relying on intuitive problem-solving habits (Hung, 2013). In Table 11, two examples of famous PBL processes are provided.

Table 11. Examples of PBL processes

Seven Jump Approach used by Maastricht University (Scmidth & Moust, 2000, p. 23, as cited in Barrett & Moore, 2012, p. 12)	**A nine-step problem design process** (Hung, 2006, as cited in Hung et al., 2008, p. 498)
1. Clarify unknown terms and concepts in the problem description.	1. Set goals and objectives.
2. Define the problem: that is, list the phenomenon to be explained.	2. Conduct content/task analysis.
3. Analyse the problem: “brainstorm” – try to produce as many different explanations for the phenomenon as you can. Use prior knowledge and common sense.	3. Analyze context specification.
4. Criticise the explanations posed and try to produce a coherent description of the processes that, according to what you think, underlie the phenomenon.	4. Select/generate PBL problem.
5. Formulate learning issues for SDL (self-directed learning).	5. Conduct PBL problem affordance analysis.
6. Fill in the gaps of your knowledge through self-study.	6. Conduct correspondence analysis.

7. Share your findings with the group and try to integrate the knowledge acquired into a comprehensive explanation of phenomenon.	7. Conduct calibration processes.
	8. Construct reflection component.
	9. Examine inter-supporting relationships of 3C3R components.

While PBL is most typical for medicine studies, it is less known for humanities and social sciences. Moreover, the use of PBL for foreign language teaching and learning is under researched (Anthony, 2011; Coffin, 2014; Larsson, 2001; Li, 2013). Only a few scientific attempts to describe this phenomenon in the area of FL teaching (e.g., Anthony 2011; Anthony & Kadir, 2012; Ciuciulkiene, 2003; Coffin, 2014; Doghonadze & Gorgiladze, 2008; Du & Kirkebæk 2012; Larsson, 2012; Mathews-Aydinli, 2007) are known. However, the findings of the existing research prove that PBL can be a suitable and effective approach not just positively influencing learning of languages but also enhancing essential twenty-first century skills.

The third educational method to improve problem-solving skills is **enhanced instruction,** which is the integration of specific improvements or additional aspects in the instructional process (Csapó & Funke, 2017). Among such improvements, question prompts, the application of visualization for problem representation, expert modelling, metacognitive regulation or similar scaffoldings can be mentioned. A number of studies that included such additional aids have shown that training learners with some additional aids contribute significantly to the improvement of problem-solving performance. A more detailed discussion on these aspects is present in the next chapter.

Fourth, **global approaches** include various methods that are grounded on modern constructivist theories describing "learning as an interaction with the environment, with the teacher's role being to provide students with a stimulating physical and social environment and to guide their students through their own development process" (Csapó & Funke, 2017, p. 24). The educator's role is not just to observe the process of problem solving but to develop and guide learners through a suitable educational environment. Global approaches are concerned with the improvement of learners' motivation, interest and the overall quality of learning (Csapó & Funke, 2017). Among such methods, Csapó and Funke (2017) list "innovative learning environment" (from OECD initiatives), "powerful learning environments" (enhanced with ICT), various forms of group work, collaborative problem solving and inquiry-based science education.

Finally, **simple immersion into problem solving tasks** and expecting that students will naturally develop problem-solving skills, is said to be ineffective. For example, Ventura et al. (2017) support the view that simple immersion may not contribute to becoming better at problem solving because these tasks are complex. Jonassen (2011a) also warns that learners are not naturally skilled in problem solving, especially for solving ill-structured and complex problems. Similarly, Wang et al. (2016) conclude that learning in the context of problem-solving and learning to solve problems engages learners in complex implicit processes having multiple aspects, which should be made visible, especially for novices. These environments may generate too heavy cognitive loads on students and that is why they require special guidance (Kirschner et al., 2006).

To sum up, the various educational methods relevant to problem solving can be grouped into five major groups (see Table 12).

Table 12. Summary of different learning and teaching approaches (methods) contributing to the development of problem-solving skills

Educational method	Major focus of it	Examples	Drawbacks/Peculiarities related to the development of problem-solving skills
1) Methods for the direct development of problem-solving skills	Development of problem-solving skills	A programme to develop inductive reasoning or any subject independent courses introducing students to general problem-solving (information-processing) models	Problem solving cannot be seen just as procedural knowledge; it is a context-bound process; no universal problem-solving approaches exist
2) Content-based methods	Mastering a subject	Problem-based learning	Not enough evidence that it really contributes to problem-solving skills enhancement; not enough attention to facilitation of the very process of problem solving
3) Enhanced instruction	Additional measures to improve subskills or discrete aspects of problem-solving skills (e.g., creation of visual problem representations)	Educational learning environment developed to improve problem-solving skills by encouraging metacognitive thinking (e.g., with the integration of question prompts)	Educator's role is to develop a suitable educational environment with clear focus on the development of problem-solving skills
4) Global approaches	Improvement of interest, motivation and the quality of learning	Inquiry-based science education, project-based learning	Does not include the development of problem-solving skills as a major focus
5) Immersion into problem-solving tasks without explicit teaching of problems-solving subskills	Solving a problem at hand	Giving an ill-structured problem to be solved, Solution-based learning, Challenge-based learning	Not suitable when problems are ill-structured (complex in most cases)

In conclusion, there are various educational methods contributing to the enhancement of problem-solving skills: 1) methods of direct development of problem-solving skills, 2) content-based methods, 3) enhanced instruction, 4) global approaches and 5) immersion into problem-solving tasks without explicit teaching of problems-solving subskills. What unites all methods is that all of them contribute to the development of problem-solving skills in learners with a slightly different emphasis on the aspects, processes and subskills included into each of them. Simple immersion into problem-solving tasks is not enough, since this kind of activity is complex and therefore additional scaffolding and ways to make the process explicit should be employed. The approach of enhanced instruction (that has additional measures to improve subskills or discrete aspects of problem-solving skills) is the most relevant for the educational environments that have the major aim of enhancement of problem-solving skills in students. It integrates explicit measures to support learning to solve problems (for more detailed discussion on them, see Chapter 1.3.4) while students are solving ill-structured problems. This form of learning should also supplemented with metacognitive thinking about learning to solve problems.

1.3.3 Understandings of scaffolding in education

Usually, the research on the development of problem-solving skills has focused on either procedures of solving problems or specific scaffolds that can assist learners learning to solve problems. Scaffolding is considered essential in such complex educational environments (e.g., Wang et al., 2016). However, as observed by Jonassen (2011a), these are the procedures that are overemphasized in the discussion on the enhancement of problem-solving skills, often neglecting the importance of scaffolds that can be used as support mechanisms; aiding learners when learning to solve problems. While procedures of collaborative ill-structured problem solving were analysed in more detail in Chapter 1.1.3, the aim of the current chapter is to analyse the theoretical grounds of scaffolding in education.

In educational literature, the notion of scaffolding has already been used in a very broad sense. As noted by Jonassen and Land (2012), scaffolding helps learners to productively engage in the authenticity, complexity and open-endedness of the learning situation. Jonassen (1999) define scaffolding as a systematic approach to aid learners that "provides a temporary framework to support learning and student performance beyond the learners' capacities" (p. 235). According to Yun-Jo (2010), the concept is currently used to describe any support provided by an expert, a teacher, more capable peers or other resource that may enables learners to perform tasks that they could not without any support independently. Nguyen (2013) concludes that its understanding is no longer restricted to face-to-face interaction between an adult/expert and a child/novice. For example, a number of research articles focus on peer collaboration as scaffolding (e.g., Yun-Jo, 2010; Ge & Land, 2003; Gosen et al., 2015; Hassan et al., 2012; Nguyen, 2013) and the use of technological tools in online environments as scaffolds (e.g., Ge & Land, 2003; Hung, 2013, Jonassen, 2011a; Papadopoulos, 2011; Xie & Bradshaw, 2008). Hannafin et al. (1999) list a wide range of functions scaffolds could serve: conceptual guidance related to the concepts of the problem, metacognitive guidance helping to reflect, plan, monitor, procedural guidance on how to act in the environment of the problem, and strategic guidance that is related to strategies. Thus, scaffolding refers to any type of support given to a learner so that he or she can achieve beyond his or her current level of ability.

The ZPD and scaffolding. The idea that a learner, usually a child, can perform better when assisted was put forward both in a Vygotskian sociocultural framework that is linked with his notion of the Zone of Proximal Development (hereafter ZPD) and in the 'scaffolding' metaphor coined by Wood, Bruner and Ross (1976). As observed by a number of researchers (e.g., Fernández et al., 2001; Nguyen, 2013; Shokouhi & Shakouri, 2015; Warwick & Mercer, 2011), these concepts are usually tied together, no matter that Vygotsky never used the term scaffolding and Wood et al. (1976) did not base their sociocultural concept on his ideas explicitly. Both of them are frequently treated as synonymous and refer to the explicit support given to learners so that they can perform tasks that are beyond their abilities while working alone.

Instead of assessing what a child can do unassisted, Vygotsky (1978) suggested the idea of assessing what he or she is capable of when some structural help is offered by a teacher or an adult. Probably being one of the most popular theories in education, especially in collaborative learning, the ZPD means "the distance between the actual development level, as determined by independent problem solving, and the level of potential development, as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). The ZPD is like a space between the actual development level and the potential development level. The actual development level "defines functions that have already matured, that is, the end product of development" (Vygotsky, 1978, p. 86). Considering problem solving, it is a learner's current ability to solve problems without any assistance or solving problems alone. The level of potential development later "defines those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state" (Vygotsky, 1978, p. 86). In other words, it is a learner's potential ability to solve problems that can be reached when assisted. Vygotsky (1978) believed that when learners are within the ZPD doing a particular task, proper assistance moves them to the position of a better performance in that activity that they would previously not have been able to do alone. The ZPD is the zone by which learners move from their actual development to their potential level of development.

Using the sociocultural concept of "scaffolding", Wood et al. (1976) analysed learning in which an expert (such as a parent) supports a child's progress and achievements through the difficult tasks. The adult lets the child do the task individually and intervenes temporarily only when he or she gets into difficulty and needs some assistance. This assistance is termed scaffolding, which "enables a child or a novice to solve a problem, to carry out task or to achieve a goal which would be beyond his/her unassisted efforts" (Wood et al., 1976, p. 90). Scaffolding helps learners to bridge the gap between their current abilities and intended abilities. As it concerns problem solving specifically, Wood et al. (1976, as cited in Jonassen, 1999, p. 235) describe scaffolding as useful for "recruiting the child's interest, simplifying the task, motivating the child and demonstrating the correct performance".

The IDZ and the importance of effective communication during the process of scaffolding. There have been various interpretations of Vygotsky's notion of ZPD and the concept of scaffolding. Although Vygotsky mentioned collaboration, his definition of the ZPD implies that assistance to perform better is provided by more capable individuals (adults and more capable peers). Wood et al. (1976) also indicated that support is provided by an expert or adult. As observed by Nguyen (2013), one group of researchers do agree that interaction in the ZPD necessarily involves a novice and an expert with *asymmetrical* intelligence existing. However, the second group of researchers highlight the importance of equal peer collaboration, where learners have similar levels of conceptual understanding with *symmetrical* intelligence (Nguyen, 2013) present. Shokouhi and Shakouri (2015, p. 61) stress that "we learn from others, not necessarily because they are more competent, but because they think differently" and, therefore, they suggest considering the contributions of Mercer (1979) with his concept of Intermental Development Zone (hereafter IDZ). Similarly, considering the importance of dynamic processes within dialogues, Fernández et al. (2001) suggest re-conceptualising both the concept of 'scaffolding' and the ZPD in order to go beyond the asymmetrical support and individual focus.

Mercer (1996), who draws on both the concept of the ZPD and scaffolding, highlights the importance of effective communication that can aid learning. As Mercer (2009) puts it, "not only the intellectual development of early childhood but the whole of human life depends on the maintenance of a dynamic relationship between the social and the psychological – the 'intermental' and the 'intramental'" (p. 180). Different from Vygotsky's ZPD, the IDZ is defined as a dialogic phenomenon created and maintained in interaction, rather than a characteristic of an individual ability (Fernández et al. 2001; Shokouhi & Shakouri, 2015). Educational activity takes place in the IDZ, which, according to Mercer (2002), is "reconstituted constantly as the dialogue continues, so enabling the teacher and learner to think together through the activity in which they are involved" (p. 6). The successful maintenance of the quality of the IDZ leads to a reduction of misunderstandings and a maximization of motivations (Mercer, 2002). In this explanation, Mercer (2002) underlines how interpersonal communication or a shared communicative space can aid learning by indicating the responsibility for a teacher to create and maintain both asymmetrical and symmetrical teaching and learning within intermental interactions. When learners share their understandings with others, they develop and clarify their own thinking. Thus, not only the zone where assistance from the more capable is provided but also the zone where learners talk and think together with the rest of the learners determines the learning process.

As observed by Shokouhi and Shakouri (2015) the construction of the IDZ involves using a form of linguistic scaffolding with the help of which ideas can be drawn out rather than be imposed from one to another. Mercer (2009) states that language enables learners to co-think about social experiences and in this way they both acquire and practice ways of using language to think together. However, within most educational systems the role of language is underestimated and language is considered just as a tool for interaction with too little attention to it as a tool for interthinking (Mercer, 2009). Therefore, Mercer (2009) recommends providing learners with the opportunities to learn how "to use language more effectively as a means for learning, pursuing interests, developing shared understanding and –

crucially – reasoning and solving problems together" (p. 182) in formal education. In this respect, the quality of talk among learners is the essential factor influencing educational outcomes, determining the success of the IDZ. Due to the great reliance on the use of conversation among learners, educational environments engaging learners in CPS might be considered beneficial for advancing ways of using language. In such scenarios, language serves not just as a tool for interaction but also for interthinking, which invites to reconsider the quality of conversation among learners.

Several studies have focused on linguistic scaffoldings and the use of language for helping learners to develop and learn. To analyse the discourse of learners, for example, Fernández et al. (2001) relied on the typology of three emerged types of talks proposed by Mercer and Wegerif (as cited in Fernández et al., 2001):

a) *Disputational talk* which can be characterised by disagreements of learners, individualised decision-making as well as short assertions and counter-assertions,

b) *Cumulative talk* characterised by repetitions, confirmations and speakers remaining positive but uncritical towards the ideas of the other,

c) *Exploratory talk* where speakers express constructive criticism towards each other's ideas.

More specifically, Fernández et al. (2001) indicated that within cumulative talk, ideas are just added without arguments, options are proposed without reasoning and group members try to be friendly and avoid conflicts. Disputational talk involves contrapositioning of ideas without arguments, proposing options, challenging others without providing reasons for individual choices of answers and imposing group members' viewpoints. Exploratory talk involves expositioning of ideas and arguments, exploring different options and giving reasons for suggestions, trying to collaborate and understand each other's points of view. As it is defined by Mercer (2009):

> *Exploratory Talk* is that in which partners engage critically but constructively with each other's ideas. Relevant information is offered for joint consideration. Proposals may be challenged and counter-challenged, but if so; reasons are given and alternatives are offered. Agreement is sought as a basis for joint decision-making and action. Knowledge is made publicly accountable and reasoning is visible in the talk. (p. 184)

Mercer (2002) states that it is namely exploratory talk that scaffolds learning and brings about better learning outcomes, because learners can share perspectives, highlight different things, negotiate strategies, and share responsibility. In contrast, just adding discrete facts to an existing store of knowledge instead of finding more efficient ways to relate new information and understandings to a learners' existing knowledge does not lead to cognitive development. Unfortunately, according to the research findings cited by Mercer (2009), when learners are asked to work in groups their talk was "either disputational or blandly and unreflectively co-operative, only involving some of the children and providing no more than a brief and superficial consideration of the relevant topics" (p. 182).

Fernández et al. (2001) analysed the types of talk among groups of students solving problems. Their conclusion was that the talks students used combined their intellectual resources and allowed them to solve problems they could not otherwise solve. Cumulative discourse was appropriate when dealing with easy problems, the solution of which did not require distributed cognition of the group. Disputational, together with explanatory talk, helped them to solve medium problems; while for the hard problems none of the types allowed students to achieve solutions. Exploratory talk was proved to be the most effective when solving more difficult problems because of being oriented to co-operative, critical and situated reasoning.

To foster exploratory talk, Fernández et al. (2001) suggested establishing implicit ground rules. They included the agreements that group members should share information, take joint responsibility, give clear reasons for opinions expressed, not be afraid to accept challenges, discuss alternatives, encourage each other to talk and reach agreements. After analyzing the discourse transcripts, the authors found that all the mentioned aspects were present in exploratory talk. However, this is the idealized version of problem solving with learners sharing knowledge and understandings in unplanned ways (Fernández et al., 2001).

In the study of Warwick and Mercer (2011), the authors analyzed what additional ways teachers use to support joint collaborative group activities. A crucial role was assigned to the use of language as a tool for learning and problem solving. After reviewing a number of research articles, the authors pointed to a paradox. Although collaborative work was proved to be useful for developing learners' understanding and communication skills, it was usually observed as not very productive, since learners did not know how to collaborate effectively and simply argued without reasoning, did not share their knowledge efficiently and not all of them participated. What was proved by their research is the necessity for teachers to model discussions for learners to become more engaged and agree about a set of appropriate ground rules that could transform the quality of talk. To ensure a more productive group learning, Warwick and Mercer (2011) suggested that participants should be sharing all information, participating equally and contributing to discussions, respecting and considering ideas and opinions of each other, negotiating alternatives and reaching agreements before acting properly.

Roschelle and Teasley (1995) used the notion of "a shared conception of the problem" (p. 8) which was created via social interactions in the context of problem-solving activities. To construct and maintain joint or shared understanding, conversation was considered to be crucial. Collaborators were suggested to find ways of introducing and accepting knowledge by "monitoring on-going activity for evidence of divergences in meaning, and repairing divergences that impede the progress of collaboration" (Roschelle & Teasley, 1995, p. 9). Their conclusion was that language allowed learners to overcome impasses in shared understanding and coordinate the learners' activity for more satisfactory results. The researchers proved that supportive dialogue of peers can facilitate the problem-solving process when their talk is coordinated and jointly constructed.

The aforementioned studies prove that social interaction with at least partly coordinated collaborative talk helped to use language in ways that are more effective. In addition, the empirical evidence suggests that collaborative talk among group members is no less or even more important than support or scaffolding from more capable peers. Namely, it is the encouragement of exploratory talk which is considered to be the most necessary linguistic scaffolding. To ensure a qualitative dialogue or that exploratory talk dominates, educators should seek to influence and transform the quality of dialogue among peers. As suggested by the researchers already cited, one of the ways to achieve this is the establishment of ground rules, instead of believing that important collaboration and task completion rules are taken for granted by the learners themselves.

Both Vygotsky (1978) and Wood et al. (1976) were focusing on asymmetrical teaching and learning with individuals being supported by more capable teachers or peers. However, these concepts can be expanded with Mercer's Intermental Development Zone (IDZ) that highlights symmetrical peer collaboration, which is also a move towards a more dialogic interaction. While the ZPD functions temporarily, the IDZ is a more pervasive zone (even without an educator present) in which students learn how to solve problems. When learners are engaged in solving problems or any other type of activity with scaffolding provided both by a facilitator and themselves, it can be stated that two zones of the ZPD and the IDZ overlap. If taking into account only the ZPD where asymmetrical interaction is commonly considered; that would be an attempt to underestimate the role of all problem solvers in the process of problem-solving. In any educational environment that is based on either pair or group work, learners may benefit not only from those that are more capable (like teachers or adults) but also from those that think differently and in this way the zone of intermental thinking is created. In it, linguistic scaffolding is the most important tool, not only for communication but also for interthinking. In this aspect, language serves not only as a tool for communication but also as a tool for shaping learners' thinking and the quality of talk is of major importance for effective educational outcomes.

In the IDZ, the proper use of linguistic scaffolding and using a language to interthink is of paramount importance. First, it is the educators' responsibility to create and maintain a good quality of the IDZ for the learners learning in the same educational environment. The types of disputational (contrapositioning of ideas without arguments, short assertions and counter-assertions, group members disagree) and cumulative (ideas are just added, group members remain friendly and no conflicts arise) talks should be minimized as much as possible and it is exploratory talk that learners should be encouraged to use. For it, group members are required to explain their ideas by providing arguments, explore different options, give reasons for suggestions, collaborate and understand each other's points of view. This type of talk is most desirable for modern educational environments based on problem-solving and learning to solve problems. One way this can be achieved is by establishing group ground rules.

Considering the necessity of scaffolding for problem solving, it is a crucial element in such complex learning environments because, it cannot be assumed that learners are naturally skilled in solving ill-structured and complex problems (Jonassen, 2011a). According to the cognitive apprenticeship model, complex tasks are usually comprised of implicit processes and, therefore, they should be made visible (Collins et al. 1990, as cited in Wang et al., 2016). Learning while solving problems engages learners in complex processes that require multiple aspects and therefore may overburden problem solvers. Consequently, specific scaffoldings should be integrated into educational environments for each subskill, as part of the process of problem solving or type of knowledge.

1.3.4 Types of scaffolding suitable for learning to solve problems

While theoretical aspects of scaffolding were considered in the previous chapter, the aim of the current section is to analyse the practical aspect of scaffolding as it could be applied in the processes of learning to solve problems. Apart from the exploratory talk as a type of linguistic scaffolding already discussed in the previous chapter, the educational environment may include various scaffolds enhancing and facilitating problem solving. The table below summarizes various scaffolds suitable for solving ill-structured problems.

Table 13. Summary of various types of scaffolds to help students learn problem solving

Scaffold and its description	**Author/s**	**Problem-solving learning outcome**	**Examples of tools/ ways to achieve**
Exploratory talk (a type of linguistic scaffolding)	Fernández et al., 2001; Mercer, 2009	Allows to achieve a better quality of language used for interaction and interthinking among learners	Ground rules and norms (principles on which talk is based)
Visual thinking tools (an externalized problem conceptualization or representation; either individual or collective)	Bai, 2013; Everling et al., 2011; Halpern, 2014; Hung, 2013; Jonassen, 2011a; Simone et al., 2001; Wang, Wu and Kirschner, 2016	Ensure easier and deeper problem understanding; help to retain knowledge; increase creativity; allow to achieve shared understanding	Concept mapping, mind mapping, system modelling, structure maps, networks, schematic models, problem schemas
Dialogue mapping (visual representation of ideas and questions that are discussed by a group during its meetings)	Ng, 2008	Produces a more effective collaboration and facilitates the creation of shared understanding among learners; helps to organize group's memory	Dialogue mapping (Ng, 2008)

Question prompts (asking and answering questions during the problem-solving process)	Yun-Jo, 2010; Ge et al., 2016; Ge and Land, 2003; Ge et al. 2010; Jonassen, 2011a; Papadopoulos et al., 2011; Xie and Bradshaw, 2008	Ensure a more effective monitoring and regulating of the problem-solving process; direct to most important aspects of problem solving; make it easier; encourage a more effective argumentation	Taxonomy of question types (Graesser et al., as cited in Jonassen, 2011a, pp. 287-288), various kinds of questions (Jonassen 2011a)
Causal reasoning (defining causal relationships)	Eseryel et al., 2013; Jonassen, 2011a	Allows to better understand cause-effect relationships among the elements of the problem	Causal influence diagram (Eseryel et al., 2013)
Argumentation (a type of linguistic scaffolding similar to exploratory talk, e.g., providing learners with the correct structure of the argument)	Ge, Law and Tawfik, 2016; Jonassen, 2011a; Nussbaum, 2012; Tawfik & Jonassen, 2013	Promotes problem solving; engages in deeper learning and thinking at a more multiplicity level; leads to more rational solutions of the problems	Argumentation mapping (Nussbaum, 2012)
Expert modelling/ advice/ view (support from experts in problem-solving domain)	Hung , 2013; Ge et al., 2010; Jonassen, 2011a; Zou and Mickleborough, 2015	Allows to improve problem-solving performance based on experts' reasoning and views on the same problem, the same or similar problem-solving behaviour can be copied	Expert's problem-solving report (Ge et al., 2010); worked examples (Jonassen, 2011a); advice on problems related to a particular area (Zou & Mickleborough, 2015)
Case-based reasoning (problem-solving narratives)	Jonassen, 2011a; Tawfik and Jonassen, 2013	Facilitates the whole process of problem solving	Case library (Tawfik & Jonassen, 2013)
Problem-solving rubrics (instructional guidelines on expected performance)	Ge and Land, 2003; Ge et al., 2010; Jonassen, 2011a	Facilitate problems solving processes; more suitable behaviour can be achieved	Performance rubrics (Jonassen, 2011a)
Instructional dashboards	Chen et al., 2016; Mitchel et al., 2012	Support the process by making instructions clearer	Horward dashboard (Chen et al., 2016), Pco-Vision platform (Mitchel et al. 2012)
Peer tutors/peer review (advice from students that undergone the same	Ge et al., 2010; Zou and Mickleborough, 2015	Facilitate the process of collaborative problem solving by sharing experience on the same process; by providing	Supporting network of peer tutors (Zou & Mickleborough, 2015)

problem-solving processes)		alternative views on the problem and its solution.	

Visual thinking techniques. Given the fact that about 70 percent of our sensory neurones are related to visual processing and interpretation of what we see, visual thinking techniques seem to be relevant for learning to solve problems. Researchers and practitioners (e.g., Halpern, 2014; Hung, 2013; Jonassen, 2011a; Simone et al.; 2001) have offered a range of tools to support external visualization of a problem or its solution process. Such tools include concept maps, infographics, graphs, mind maps, influence diagrams, system modelling, networks, schematic models, structure maps, etc.

For instance, Hung (2013) confirms that problem conceptualization can be enhanced by visual external representation of a problem at hand, especially for PBL problems that are ill-structured or complex. Simone et al. (2001) suggest externalizing thinking by employing concept maps, which allow students "to abstract important information, relate ideas, and represent them in a structured manner" (p. 265). Wang et al. (2016) observe that concept mapping fosters in-depth understanding, high-order thinking and knowledge retention. Bai (2013) proved that those students who were using digital mapping tools performed better when providing arguments and justifying their solutions. According to Tony Buzan (2006), the inventor of mind maps, these visual thinking tools can help to save time, work more efficiently, concentrate, see the "whole picture", organize thinking, remember better, plan, solve problems and become more creative.

Dan Roam (as cited in Solomon, 2017) also believes that visual thinking is beneficial for solving complex problems. He suggests visualising our ideas to understand them better and clarify what is in our minds. Whenever our internal ideas become visible, they can be shown to other people and this ensures they see what we see. Visual thinking can be used to get the essence of the problem and divide the problem into smaller pieces, which simplifies the process of problem solving. Roam (as cited in Solomon, 2017) concludes that people who use visuals are more influential nowadays and has even launched the online Napkin Academy for learning new ways to give visual forms for our ideas https://www.napkinacademy.com/.

Csapó and Funke (2017) also argue for visual representation as a general aid for better understanding of learning materials and claim that this tool is the prerequisite for a successful complex problem-solving process. They suggest using either descriptive or depictive multiple representations and train students to be able to use transformations between representations. Problem solvers are first encouraged to start creating individual visualizations and then continue with merging their individual understandings into the shared understandings.

As powerful scaffolding tools, Jonassen (2011a) suggests using problem schemas which "include semantic information and situational information about the problem associated with the procedures for solving that type of problem" (p. 242). Problem schemas are suggested to be used both for problem representation and its solution. Problem representation (its understanding) "includes two processes:

representing patterns of information in the meanings of terms in the text and constructing a conceptual model that represents the situation in the text" (Jonassen, 2011a, p. 242). In short, problem schema is a visual layout or a drawing of structural (semantic information) and situational properties or characteristics of a problem.

Apart from knowing the elements that constitute the problem, it is also important to know how they might affect each other and, therefore, the third element for problem schemas suggested are structural relationships (Jonassen, 2011a). Halpern (2014) distinguishes among various types of relationships: 1) part of link (hand -finger), 2) type of/ example of link (school – private), 3) leads to link (practice – perfection), 4) analogy link (school – factory), characteristic link (sky – blue) and 5) evidence link (broken – x-ray arm).

Considering various types of structural relationships, causal relationships (also causal representations) are most common and illustrate "the conditions under which problem variables are interdependent and the effects of that interdependence" (Eseryel et al., 2013, p. 444). They allow understanding the entire problem space, choosing the most appropriate solution and justifying decisions (Eseryel et al., 2013). Problem solvers' mental representations of the variables of the problem space and the interrelationships among them may significantly influence the process of its solving, especially when problems are complex and have many variables.

To sum up, visual thinking tools may facilitate the understanding of structural and situational characteristics pertinent to a particular problem. They are indispensable in creating shared understanding of an ill-structured problem and facilitating a group's work, both in the problem representation stage and during the later stages. Problem schemas may allow seeing more paths (solutions) from the current to the goal state, as well as trace more constrains. It is also possible that they might ensure greater engagement of students and help them stay less stressful when facing problems. Furthermore, having a plethora of modern online tools nowadays, the process can be very quick and easy. Some of these tools even allow a synchronous collaboration by providing learners with a website address of a particular concept/mind map.

Dialogue mapping. Ng (2008) suggests using dialogue mapping and indicates it to be a type of visual tool facilitating meetings of groups. It is a shared display of ideas and questions discussed during the meeting. Such kind of mapping is expected to produce a more effective collaboration and shared understanding among learners. According to Ng (2008), this tool allows solvers to explore ill-structured problems from different viewpoints, trace different pathways and arrive at different solutions. Learners have limited capacity for short-term memory and therefore some ideas can be repeated over and over again. However, recorded ideas in a shared display allow individuals to address this problem by better organizing the group's memory.

Question prompts. They are used as a set of questions to be asked and answered during the process of problem solving. Ge et al. (2010) calls them "mind-extension cognitive" (p. 49) tools that help learners to become better problem solvers. Jonassen (2011a) and Ge (2010) came to a conclusion that it is also a type of effective scaffold aiding students in the problem-solving processes, because it allows tutors to guide students' reasoning and helps them to understand what they already know about the problem, what they still need to find out, and what they have to do in order to solve the problem. After reviewing a number of studies, Ge (2010) concluded that question prompts are effective because they direct attention to the essential aspects of a problem, encourage self-explanation, planning, elaboration, monitoring, self-reflection and evaluation. In their study on scaffolding ill-structured problems with question prompts, Ge and Land (2003) proved that students were better at problem representation, making justifications, monitoring, and evaluation. Similarly, Papadopoulos et al. (2011) investigated the effectiveness of question prompts while guiding students through ill-structured problems in a technology-enhanced environment. Their findings confirmed that those students who were working under prompting techniques outperformed the ones that did not. The examples of question prompts are "What facts from this case suggest a problem? (. . . .) What is (are) the probable cause (s) of the problem? (. . . .) Why is this plan the best choice? (. . . .) What secondary problems should you watch out for, and how would you do that?" (Ge et al., 2010, p. 55).

Causal reasoning. Causal reasoning is the cognitive process that belongs to the essential characteristics of scientific reasoning and aids to a deeper understanding of the cause-effect relationships among the phenomena in the problem (Jonassen, 2011a). It can be achieved by involving problem solvers into asking various types of questions. As explained by Sterman (1994, as cited in Hung, 2013), this process helps to understand the inter-causal relationships among the variables in problems, identify their causes and solution paths.

Argumentation. When solving ill-structured problems, arguing for alternative interpretations as well as solutions to them is a crucial skill, since these problems are more difficult to be solved (Jonassen, 2011a). As already discussed in Chapter 1.1.1, difficulties arise because ill-structured problems do not have convergent answers (one correct answer) or may have no answer at all, may have many alternative solutions, multiple criteria for evaluating them, multiple solution paths, not always clear goal state and a number of constraints. Thus, learners' abilities to construct arguments to justify their own assumptions, propose solutions and solution paths are essential to solve ill-structured problems.

In essence, argumentation is central to all higher order thinking and thus the most important skill in learning to solve problems. It is also "associated with a social-constructivist conception of meaning making, where students learn through reflective interactions (arguments) that engage in the social co-construction of knowledge" (Driver et al., 2000; Newton et al., 1999, as cited in Jonassen, 2011a, p. 322). By arguing, problem solvers engage in deeper learning, thinking at a more multiplicity level, more rational resolutions to problems and conceptual change (change in the understanding of concepts relevant to problem) (Jonassen, 2011a).

According to Jonassen (2011a), "an argument consists of a claim (solution) that is supported by principles (warrants), evidence, and rebuttals against potential counterarguments" (p. 321). Kuhn (1991, as cited in Jonassen, 2011a) provides another conception of argumention as a form of thinking by explaining that it is comprised of "formulating, and weighing the arguments for and against a course of action, a point of view, or a solution to a problem" (p. 324). According to Kuhn (as cited in Jonassen, 2011a), for an argument to be strong, it has to support claims (supportive theory), be based on evidence to support theories (evidence), generate alternative theories (alternative theory), have counterarguments and rebuttal.

Effective argumentation containing all the necessary components is similar to the type of linguistic scaffolding as already discussed in exploratory type of talk, where it is not enough that problem solvers just build on each other's ideas without disagreeing or just contraposition. The talk among learners should be both critical and constructive where they remain friendly when trying to understand each other's point of view. Baker (as cited in Nussbaum, 2012) adds another salient aspect of argumentation, which is articulation; meaning that problem solvers should be engaged in articulating their own ideas and questions so as to address their gaps in knowledge and flaws in the flow of their own reasoning.

To prompt better arguments and facilitate their construction, problem solvers may be given specific question prompts or encouraged to be using various graphical argumentation display systems (Jonassen, 2011a). For instance, Nussbaum (2012) recommends using argumentation mapping that is a visual organization of ideas by putting them into categories of components that arguments are expected to contain (also called argument ontologies). One example of such ontologies provided is the Toulmin's (1958, as cited in Nussbaum, 2012) ontology, consisting of claims, grounds and warrants. Having such scaffolds, problem solvers are provided with more structured ways to organize their ideas. Question prompts may also be a way to prompt better arguments and deeper thinking (Jonassen, 2011a). For example, the following Vee diagram was proposed by Nussbaum and Schraw (2007, as cited in Jonassen, 2011a, p. 335):

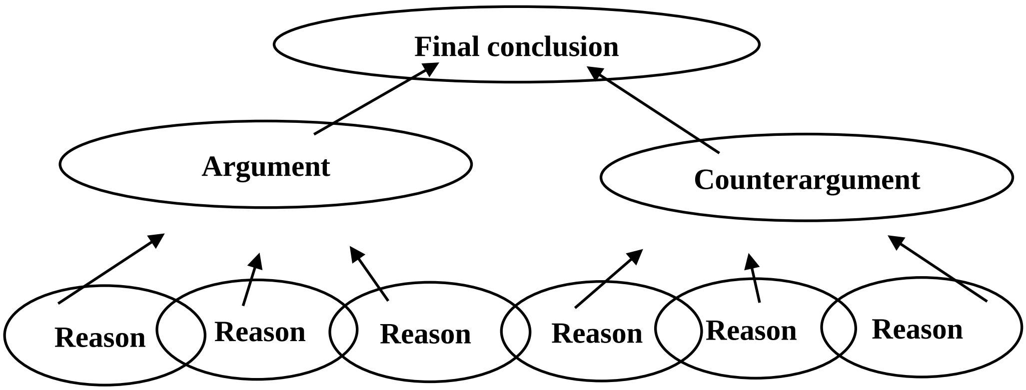

Figure 11. Graphic organizer for developing arguments, counterarguments, and a final conclusion on an issue (Nussbaum & Schraw, 2007, as cited in Jonassen, 2011a, p. 335)

The diagram can facilitate the interaction among learners and be used in educational contexts that require exploratory talk.

Problem-solving rubrics. Problem-solving rubrics can be used not only to assess student's problem-solving performance but also to facilitate the whole process of problem solving. For instance, Jonassen (2011a) proposes using clear acceptable and unacceptable performance rubrics that may facilitate problem solver's performance if provided in advance. A more thorough discussion on problem-solving rubrics is present in the following chapter.

Expert modelling/advice/view. Since most problems are contextualized, domain-specific knowledge, advice and views on the same problem from experts in that domain is also a useful support mechanism (Ge et al., 2010; Jonassen, 2011a; Zou & Mickleborough, 2015). For instance, Ge et al. (2010) incorporated this kind of scaffolding for pharmacy students when dealing with real-world clinical communication problems in a web-based learning environment. Their intention was that students improve their reasoning and problem-solving reports after comparing experts' reasoning on the same problem. Their study revealed that after having the experts' thinking visible, students were able to note discrepancies between their own thinking and the experts' reasoning in order to better understand their own problem solving performance. Jonassen (2011a) suggested using worked examples that are illustrations on how experts have solved the same problem; hoping that problem solvers will analyse and copy it. In their course on engineering grand challenges offered at Hong Kong University of Science and Technology, Zou and Mickleborough (2015) used the practice of experts as guest speakers from outside the university specialising in the areas related to engineering problems in the course on engineering grand challengers, where students tackled with problems, such as providing access to clean water, improving city infrastructure or making solar energy more economical, to name only a few.

Case-based reasoning. A very similar type of scaffolding is called cased-based reasoning, when problem solvers are encouraged to rely on problem-solving narratives. Tawfik and Jonassen (2013) suggest using case libraries of stories of problem solvers' experiences from which learners can construct meaning for themselves. Whereas expert modelling involves narratives of those with problem-solving expertise, it is possible that case libraries may not be restricted to just experts' stories. For example, students can be asked to study real examples from the videos they find on YouTube channel and then share these stories among themselves.

Instructional dashboards. For the PBL online learning environment, Chen et al. (2016) designed and developed a dashboard to support instructions. It included built-in tools for students such as an archive of videos to introduce the tool and contextual factors of a problem, a chat space for their free discussions, brainstorming and a PBL-whiteboard as a metacognitive scaffold to communicate the PBL tutorial process. Michel et al. (2012) also designed a dashboard for PBL processes (more particularly for self-judgement and self-monitoring) so that learners become more self-regulated. Their conclusion was that it was especially useful for giving problem solvers instructional information and encouragement of self-judgement.

Both developed dashboards are examples of technology-rich learning environments and the use of mind tools. In education, the idea of the use of a computer as *mindtools* originates from David Jonassen's work. As explained by the researcher (Jonassen et al., 1998), technology should not be seen as a tool to transmit information and provide learners with the feedback of how well they are able to remember information, just for the sake of information acquisition and repetition. Rather, it should serve as a tool for knowledge construction and representation using it to learn not *from* but *with* (Jonassen, 2011a).

Peer tutors/Peer review. In the previously mentioned course, Zou and Mickleborough (2015), talk about a beneficial practice of inviting peer tutors to facilitate the process of CPS. These tutors were also students that demonstrated excellent performance while solving the same problems in the same course previously. Similarly, in their study to investigate the effects of a cognitive effect system when scaffolding problem-based learning, Ge et al. (2010) used the peer review mechanism as a part of the system. Students were reading their peers' problem-solving reports and in this way were supposed to be more active in self-reflection of the problem-solving process. The findings of the study revealed that this type of support mechanism facilitated problem representation, as problem solvers were additionally provided with multiple perspectives and various problem-solving approaches. Probably, educators could use two types of peer review – from those that participate in the same process and from those that are outside. Both types seem to be useful for prompting different views on problems and their solutions.

To sum up, educational environments that are developed for the aim to enable learners to learn problem solving may include various types of scaffoldings: exploratory talk (encouragement of the right type of talk among learners), problem schemas (construction of external problem conceptualization), dialogue mapping (visual representation of ideas and questions that are discussed by a group during its meetings), question prompts (asking and answering questions during the problem-solving process), causal relationships (illustration of problem variables, their interdependence and effects of that interdependence), argumentation (providing learners with the correct structure of the argument), expert modelling/advice/view (providing problems solvers with support from experts), case-based reasoning (using problem-solving narratives), problem-solving rubrics (using instructional guidelines on acceptable performance and its assessment), instructional dashboards (using computers as tools to learn with), peer review (using advice from peers) or various problem-solving worksheets (e.g., Force Field analysis).

1.3.5 Assessment and analysis of collaborative problem solving

In general, the comprehensive assessment methods to evaluate the progress of learners in situations involving ill-structured problems and collaborative problem solving are at their initial stage of development (Eseryel et al., 2013; Funke et al., 2018; Jonassen, 2011a; Siddiq & Scherer, 2017; Wang et al., 2016). Well-established typical examination-oriented methods or standardized tests are not appropriate to assess learning in problem-oriented contexts, because they focus on domain knowledge and do not include a broader range of cognitive and social aspects necessary in solving ill-structured problems. Therefore, the goal of this chapter is to analyse suitable assessment and analysis methods for collaborative ill-structured problem solving.

There are several reasons that make the assessment of CPS challenging. First, the main reason is that problem solving is a mix of skills, abilities and knowledge and thus a very complex construct (Funke et al., 2018; Siddiq & Scherer, 2017). For instance, Funke et al. (2018) divide problem solving into cognitive aspects (such as model building, causal reasoning, rule induction and information integration), and non-cognitive aspects (such as motivation, social skills and self-regulation) and conclude that there is no single assessment instrument that covers all this broad range of aspects altogether. Thus, the first challenge of problem solving assessment lies in the fact that it should address a number of mixed learning outcomes. Second, CPS assessment can be based on either individual (individual contribution, e.g., information search) or collaborative problem solving (group performance, e.g., effective knowledge sharing and effective communication) (Funke et al., 2018). In addition, it can be a hybrid assessment model when students' individual contributions are considered alongside the group's performance to which they belong (Lai et al., 2017). Third, difficulties may arise because of the inherent characteristics of ill-structured problems. While well-structured problems usually have a single correct answer, ill-structured problems do not have single correct answers. Fourth, the fact that the components of problem-solving competency can vary in their degree of generalizability may cause additional difficulties (Funke et al., 2018). For instance, Funke et al. (2018) consider content knowledge to be very domain specific, self-regulatory abilities as very general and generic problem solving strategies as the type of competency that is in the middle position. Finally, the assessment may be based either on problem-solving performance or its outcomes, which, as mentioned can be either individual or created in collaboration.

To assess problem-solving performance, according to Jonassen (2011a), the most critical goal to achieve is that problem solvers are able to perform the given task. While solving ill-structured problems, students are usually required to construct a product (e.g., problem-solving report produced by the group or individual's written or verbal accounts of problem solving as a response) and, thus, one way to assess is by assessing that product (e.g., Ge et al., 2010; Jonassen, 2011a; Lai et al., 2017). The second way of assessment can be based on the process of problem solving in the form of observations of group interactions (e.g., Lai et al., 2017; Jonassen, 2011a). Both the first and the second method can involve educators or peers undertaking the assessment. In addition, a third way could be a form of self-assessment, with the use of so-called experience reports where each student describes his or her contribution to the team (e.g., Lai et al., 2017). Students can be asked to reflect on their learning as a group, which can be done not only in writing but also in the spoken form.

Additionally, the assessment should be grounded on modern ideas related to the assessment of learning in general. While summative assessment simply tells a learner what he or she should have done differently (too late because the grade is already written), formative assessment is more relevant, since it tells what a learner should be doing differently now in order to succeed in the future.

Behavioural or performance observation (performance-based assessment) is indicated to be the most common form to assess CPS, which can be done by a human (an educator, expert or peers) or computers, which additionally ensures better control over the collaborative work (Lai et al., 2017). For example, Massive Open Online Courses (e.g., Coursera, edX, FutureLearn), shared writing platform (e.g., Google

Docs) or collaborative gaming environments can already automatically analyse the logged students' actions. No doubt, the emergence of artificial intelligence technologies into education will allow even more objective and sophisticated ways to analyse students' achievements.

A useful assessment tool might be a rubric, which is a sort of description of the desired performance (outlining the type of behaviour required) or a product (e.g., problem-solving report) so that students know where the evaluation comes from or what it consists of (Griffin & Care, 2016, Hesse et al., 2015; Lai et al., 2017). The introduction of such rubrics at the beginning of a problem-solving task may facilitate students' understanding of the process and the task itself, but it is very important that such rubrics clearly explain ways students should be performing. For example, they might list the parameters of the acceptable solution to a problem.

One way to apply rubrics in practise is to copy the same rubric for each group member and highlight the level each student's behaviour matches or ask peers to do that. Of course, peer evaluations risk a lack of some objectivity. Simple Likert-type scales can also be used as ways to evaluate problem solving behaviour (Lai et al., 2017).

For example, a teamwork rubric was developed by teams of experts from various American universities and colleges (Association of American Colleges and Universities, 2009). It was created to assess the teamwork of an individual learner and not the team as a whole, which means that any student's rating is independent of the way the whole group performs. Also, the rubric measures the quality of the process, not the quality of the end product, which points to the fact that the final products (e.g., problem solving reports) any team creates are insufficient to assess the behaviour of each individual student. It is advisable to be used with at least one of three (or combination of several) sources: feedback of evaluation on students' contributions to the team's functioning provided by fellow members or outsider observers or student's own reflections about their contributions. The mentioned rubric has five main dimensions, which are individual's contribution to team meetings, his or her facilitation of contributions of team members, individual contributions outside of team meetings, fostering of a constructive team climate and responding to conflicts. It can be downloaded from https://www.aacu.org/value/rubrics/teamwork.

Based on sound research, the international ATC21S project developed a framework of skills included into collaborative problem solving (Hesse et al., 2015). The framework distinguishes between two broad classes of skills: social skills that are related to the collaborative aspects of problem solving and cognitive skills that are related to the problem-solving task. Its rubric of social skills consists of three main subskills that are included in collaborative work: participation, perspective taking, social regulation (Hesse et al., 2015). The following rubric (see Table 14) can be used as one of the ways to assess students' social skills or collaboration.

Table 14. Social skills in collaborative problem solving (Hesse et al., 2015, p. 43)

Element	*Indicator*	*Low*	*Middle*	*High*
Participation				
Action	Activity within environment	No or very little activity	Activity in familiar contexts	Activity in familiar and unfamiliar contexts
Interaction	Interacting with, prompting and responding to the contributions of others	Acknowledges communication directly or indirectly	Responds to cues in communication	Initiates and promotes interaction or activity
Task completion/ perseverance	Undertaking and completing a task or part of a task individually	Maintains presence only	Identifies and attempts the task	Perseveres in task as indicated by repeated attempts or multiple strategies
Perspective taking				
Adaptive responsiveness	Ignoring, accepting, or adapting contributions of others	Contributions or prompts from others are taken into account	Contributions or prompts of others are adapted and incorporated	Contributions or prompts of others are used to suggest possible solution paths
Audience awareness (Mutual modelling)	Awareness of how to adapt behavior to increase suitability for others	Contributions are not tailored to participants	Contributions are modified for recipient understanding in the light of deliberate feedback	Contributions are tailored to recipients based on interpretation of recipients' understanding
Social regulation				
Negotiation	Achieving a resolution or reaching compromise	Comments on differences	Attempts to reach a common understanding	Achieves resolution of differences
Self-evaluation (Metamemory)	Recognizing own strengths and weaknesses	Notes own performance	Comments on own performance in terms of appropriateness or adequacy	Infers a level of capability based on own performance
Transactive memory	Recognizing strengths and weaknesses of others	Notes performance of others	Comments on performance of others in terms of appropriateness or adequacy	Comments on expertise available based on performance history
Responsibility initiative	Assuming responsibility for ensuring parts of task are completed by the group	Undertakes activities largely independently of others	Completes activities and reports to others	Assumes group responsibility as indicated by use of first person plural

In conclusion, the assessment of CPS is complicated because of the fact that it combines a mix of skills, abilities and knowledge and thus should address mixed learning outcomes. Also, CPS assessment can be based either on individual problem solving (individual contribution is assessed), collaborative problem solving (group performance is assessed) levels or be based on a hybrid assessment model including both individual and collaborative aspects. Difficulties may additionally arise because of the characteristics of ill-structured problems. CPS can be assessed as a product that problem solvers create (outcome-based assessment) or by observing the process/performance (behavioural observation or performance-based assessment). Problem solvers can be asked to produce either written or spoken experience reports, each of them individually or as a group. Students' reflections on the process of their learning may help them to observe their changed competencies. Comprehensive rubrics describing the desirable problem solving behaviour can be used as a form not just to assess CPS but also to facilitate the task itself. They can also serve as tools for formative assessment if given in advance.

Whenever there is such a large number of aspects of CPS competency to be considered, it may be deduced that the assessment instrument covering everything is probably too complicated. A wise decision for an educator could be to decide which aspects are most important and then continue with the assessment of them. For the sake of convenience, an educator could devise an integrative rubric that incorporates all expected outcomes and their detailed descriptions.

1.3.6 Modelling of educational environments enabling students to learn problem solving

The goal of the following chapter is to summarize the ideas that are important when designing educational environments that could enable students to learn problem solving. The chapter starts with the conceptualization of educational environments and then proceeds with a range of variables that may exist in them. The main aim is to construct a more generalizable model of educational environments enabling students to learn problem solving that could be implemented in the studies of foreign languages.

Considering various conceptions and definitions of a learning environment, it can be observed that educational researchers have not been unanimous. The most general understanding of it is as any surrounding environment influencing students' learning. It is also labelled as a learning space, an educational environment, educational setting, academic environment, educational learning space, educational space, educational climate, academic environment, etc. For the current thesis, the comprehensive classification of potential learning environment, personal learning environment and educational learning environment is applied.

First, Juceviciene (2007) draws attention to the group of researchers, especially from the Computer Science domain, who define the learning environment as any environment that surrounds a learner. However, she points to the limitation of this understanding and concludes that not every environment containing information and surrounding a learner may become a learning environment for an individual, which influences his or her learning in reality (Juceviciene, 2007). The learner may reject information, be unmotivated or not ready to complete the task and in this way that particular environment may have varying degrees of influence each learner or no influence at all. For the sake of clarity, Juceviciene et al. (2010) suggest using the concept of a potential learning environment, because it has just the potential to influence a learner. Only in cases when it becomes accepted by a learner, it starts having some kind of influence on his or her learning and performance in that environment.

Considering the type of environments that are intentionally designed for the purpose of education, having some particular educational aims, Juceviciene (2007) observes that the term 'educational environment' emerged in Educational Sciences (Pimparyon, Caleer, Pemba, 2000; Roff, McAller, and Skiner, 2005 as cited in Juceviciene, see Duobliene et al., 2013). The particular term was distinguished from the most general term of a learning environment. According to Juceviciene et al. (2010) and Juceviciene (2013), educational environments can be defined as dynamic spaces of information for learning and performance that are developed and influenced by an educator and determined by educational aims, relevant content, methods and aids, educational information and ways it reaches a learner, as well as having other objects and people in them that somehow affect a learner. Furthermore, Juceviciene (2007) relates educational environment to the institutional level, while a learning environment can be related to the individual level. A learner learns in this environment and it is a constituent part of his/her personal learning environment.

As explained by Juceviciene (2007), the best case is when an educational environment coincides entirely with the personal learning environment of a learner (maximum effectiveness from the institutional point of view); however, there may be different degrees of overlapping or these environments may mismatch, meaning that some educational environments have no impact on the learner. For instance, although a learner may be present within some particular educational environment with the educator having clear educational aims and willing to influence his or her learning, no learning can occur because of various different reasons. In addition, different educational impacts or their intensity can be observed for each individual learner. Clearly, the more a university educational environment is accepted by a learner, the greater impact of an educator on a learner.

In addition, Juceviciene (2007) explains that there is a difference between what is commonly understood as pedagogical system (a learner, an educator, educational aim, methods of teaching, content, instruments, etc.) and an educational environment. As the author states, first, the pedagogical system is paper work designed and then it is realized in an environment. While it can be considered as a static plan in advance, an educational environment is said to have the aspect of dynamicity. Therefore, a pedagogical system makes only a part of the educational environment. Different from the pedagogic system, learning can be additionally influenced by other things and subjects in a particular educational environment, which are not always foreseen easily. As explained by Juceviciene (2007), teaching and learning processes depend on three aspects: the pedagogical system (it is a designed or preplanned educational project), the educational environment (it is an educational reality), and the learning environment (it is a reality used by a learner), where all three aspects are interrelated. If the pedagogic systems can be arranged in advance, the educational environments are far more complex educational phenomena.

In educational research, the use of the notion of a personal learning environment is more common than an educational environment. Specific for each learner, a personal learning environment is determined by the learners' personal goals, abilities, needs, and experiences (Juceviciene, 2007; Lipinskiene, 2002), it is like a part of the information space that is recognized and used as one's learning environment. This environment encompasses the particular information targeted at a learner, communication tools and methods it reaches a learner, as well as other things and people acting in that environment. Personal learning environments can be comprised of a potential learning environment and an educational environment (Juceviciene et al., 2010).

A critical tenet of the theory is that no matter that one specific educational environment is designed for all learners, each learner may create his or her specific personal learning environment in the same educational environment based on one's own perceptions, goals, motivation, abilities, knowledge, etc. (Juceviciene at al., 2010). For instance, the number of different personal learning environments may be the same as there are learners participating in the same study process. The researches admit that a personal learning environment is specific for each individual and it is the environment within which learning takes place in reality (Juceviciene at al., 2010).

Similarly, a number of educational researchers (e.g., Drew & Klopper, see Scott-Webber et al., 2014; Jacobson & Kapur, see Jonassen & Land, 2012) also agree that environments in which learning takes place are complex systems with multiple variables. Thus, educational environments are comprised of a complex set of motivational, emotional, social, cognitive and situational variables that interact with each other. The remaining part of this chapter considers what learning and performing conditions or what set of such variables should be created/ offered that might enable learners (both individually and as a group) to learn problem solving and improve foreign language proficiency at the same time. The major focus is on the enhancement of problem-solving skills while the improvement of foreign language proficiency is just the secondary aim.

A set of variables/ factors/ characteristics/ core principles of educational environment that might create enabling conditions for learning to solve problems in collaboration are described in detail below. The list includes: selection of problems, group formation, motivation, selection learning and the teaching approach contributing to the development of problem-solving skills, educational aim, aspects of solving ill-structured problems, social skills or collaboration, linguistic scaffoldings, other types of scaffoldings, foreign language learning aspects and assessment of problem solving.

<u>Selection of problems</u>

Based on the discussion in Chapter 1, suitable problems should be:

- ill-structured (because they resemble real life problems)

- but with a moderate degree of complexity (too difficult problems may demotivate students),
- authentic and open-ended,
- related to students' life and/or career (so as to be meaningful and purposeful),
- knowledge-lean (little prior knowledge is needed)
- or even knowledge-free problems (no previous knowledge is required) (whenever they are offered during a FL course, the main goal is that problem solving evokes real communication with domain-specific knowledge development being less relevant).

Group formation

Groups can be formed according to either a self-selection principle or assigned by an instructor (either randomly or according to some certain criteria). Research gives evidence that groups formed on a self-selection principle show a greater level of satisfaction. In addition, learners can be given special roles (e.g., source searchers, theoreticians, summarizes, moderators, starters, etc.) to increase their responsibility and activity within the groups.

Motivation

Problem-solving experience should be adjusted to the learner's prior knowledge, aptitudes, and cognitive abilities. In such cases it becomes more motivational. Using a FL as a working language adds additional stress, thus, educators should think of additional ways to deal with this aspect. It is also possible that problem selection influences the learners' motivation significantly.

Selection of learning and teaching approach contributing to the development of problem-solving skills

There are various educational approaches or methods contributing to the enhancement of problem-skills: 1) direct development of problem-solving skills, 2) content-based methods, 3) enhanced instruction, 4) global approaches and 5) immersion into problem-solving tasks without explicit teaching of problems-solving subskills.

Considering all five, the approach of enhanced instruction (that has additional measures to improve subskills or discrete aspects of problem-solving skills) is the most relevant for the educational environments that have the major aim of the enhancement of problem-solving skills in students. For a more detailed discussion on the use of each, see Chapter 1.3.2.

Educational aim

The main aim of the designed educational environments is to support the development of collaborative problem-solving skills, which can be divided into two broad classes of skills:

1) social skills for managing participants, and

2) cognitive skills for managing the task of problem solving at hand.

See the operationalization of these skills in Figure 12 below. While IPS requires just cognitive skills, CPS adds the second class of skills – social skills. Apart from problem solving, these skills are typical to many collaborative tasks.

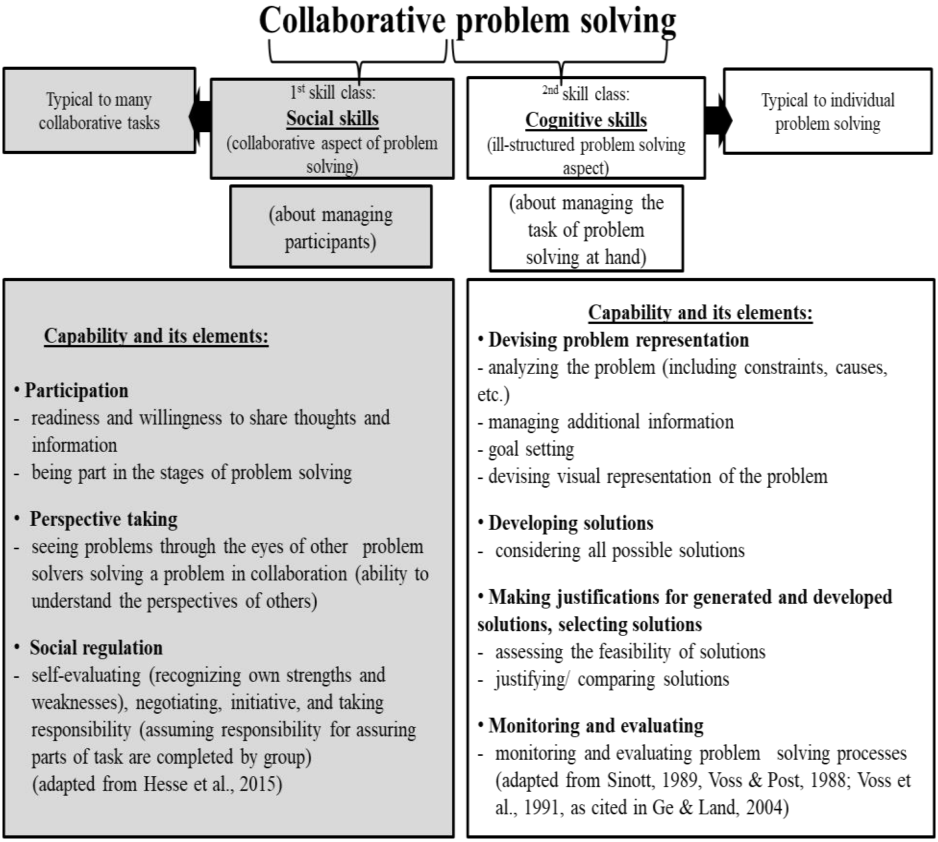

Figure 12. Social skills (adapted from Hesse et al., 2015) and cognitive skills (adapted from Sinott, 1989; Voss & Post, 1988; Voss et al., 1991, as cited in Ge & Land, 2004) required for collaborative problem solving

Aspects of solving ill-structured problems

Consistent with the cognitive processing typical to IPS (Chapter 1.1.3) and the core characteristics necessary for CPS (discussed in Chapter 1.1.4), the process of ill-structured problem solving in a collaborative manner consists of the processes described in detail below.

The process starts with problem representation, which means understanding of the situation described in the problem. It involves the processes of defining the problem, figuring out what is known and what should be additionally searched for, as well as sharing the already available and additional information. The process includes identification of all elements of the problem, its contextual factors, causes and constraints.

It is necessary that the process of the problem representation is based on collaborative work and shared understanding. Naturally, it can start with individual representations, for example, the construction of individual problem schemas but later these individual understandings should be merged in order for the group to create the shared understanding of the problem space. Jonassen (1997) claims that the construction of multiple representations or problem spaces helps to solve ill-structured problems. Hesse et al. (2015) observe that the more information is shared, the higher level of breadth in understanding can be achieved and this leads to useful re-organisations of the problem space. In addition, it is likely that whenever problem solvers within the same problem-solving environment belong to different disciplines, this results in more diverse problem representations and seeing its space from different contexts. In order to achieve a more comprehensive problem representation, relevant background knowledge is a prerequisite (Lai et al., 2017). Learners need to share (each group members usually demonstrates different problem-relevant knowledge) and additionally acquire knowledge that is necessary for the specific problem. They can discuss all possible ways and sources for the collection of new information. After a group agrees on a shared understanding, it is necessary that all of its members share it and have similar problem representations. Klimoski and Mohammed (1994, as cited in Hesse et al., 2015) conclude that when individual problem representations are similar among problem solvers working in the same group, a more efficient problem-solving performance can be expected. Similar representations can be achieved by effective communication (participation). Shared problem representation serves as a basis for the whole collaborative problem-solving process. Problem solvers should be discouraged from starting to offer solutions without a thorough interpretation of the problem.

Joint planning to achieve the goal state should continue. It is necessary that all group members participate in the joint planning of how to reach the goal state or intermediate states towards the goal of the problem. Research has shown that groups are more efficient when their members know precisely who knows what (Hesse et al., 2015). Thus, it is very important that group members plan explicitly on how they will be acting. Tolerance for ambiguity, novelty, creativity and cognitive flexibility are suggested as useful working conditions for this stage. For instance, Hesse et al. (2015) notes that tolerance for ambiguity and flexibility in changing plans are useful ways to overcome barriers during the problem-solving process. Collins et al. (2016) highlight the importance of tolerance for novelty, creativity and cognitive flexibility. When problem solvers are creative and flexible, it ensures a greater number of solutions, at least at the beginning of problem solving. Being cognitively flexible, allows holding multiple pieces of information in one’s head and being able to connect the dots (Jonassen, 2004). Again, all members of the same group should participate actively in trying to reach the agreements about the goal state. When it is difficult to agree on it, a new problem representation may be helpful.

The process also includes the development of solutions and making justifications. Learners can start with the development of individual solutions and construction of arguments to justify them. Educators might think of ways to prompt better arguments and facilitate their construction (see Chapter 1.3.3 for the available ways). The available solutions should be evaluated and compared. They can be based on thinking how to eliminate the causes of the problem after they are identified during the process of problem representation. A group may agree on some important criteria according to which they judge the available solutions. Again, this process can be successful via effective communication and interaction as well as sharing all available information. Group members should be expressing and sharing alternative perspectives and views (perspective taking), which helps to agree on the best solution/s. All members should be equally participating while considering usefulness, effectiveness and suitability of their solutions. The best case is when a group reaches consensus on the best solution/s.

Collaborative monitoring and evaluating of a group's activities and progress should be present throughout all CPS process. Problem solvers should engage in the self-regulation of the whole process. It involves considering the effectiveness of their cognitive and social processing or the efficiency of the group's work. The process gives a basis for modifications, if necessary. For example, learners may decide to come back to problem representation after they discover that they placed constraints that do not exist in reality.

Social skills/Collaboration

Group work should be incorporated into the curriculum so that learners have repeated practice of it. There are some explicit techniques for fostering collaboration: explaining to students why the skill is important, encouraging group members to share the task and the responsibility fairly, teaching to resolve conflicts, providing checklists of good behaviours in rubrics or ground rules, studying and analysing worked examples of CPS.

When a collaborative task starts, additional time should be spent for deliberate noticing and discussing of what is being done incorrectly and how to improve it by receiving feedback on it. It is an effective measure to support the development of collaborative skills and can be provided in various forms. First, it can be the educator who does it, for example, by providing students with some rubrics in advance and then highlighting a result of each student on that rubric. Second, peer evaluation is also possible. For example, Likert-type scales with some indicators of proper collaborative behaviours can be offered and students simply mark the achievements of their peers.

Students should be explained that collaborative aspects of problems solving (social skills) include participation, perspective taking and social regulation. This can be defined in rubrics and/or laid down in ground rules. Required levels of participation, perspective taking and social regulation were proposed by Hesse et al. (2015):

- *Participation:* Every group member should participate equally and effectively. It is not enough to show some activity; actions of each member should be coordinated with the efforts of the rest group members. Group members should interact with each other and show continued effort and determination to complete the task.
- *Perspective taking:* Group members should react to contributions of others by ignoring, accepting or adapting them. In addition, each student should be willing to adapt his or her own behaviour to increase its suitability for the rest of the group members. A significant aspect of perspective taking is a responding skill, which means that group members should be willing to integrate contributions of the rest of he group members into their actions and thinking (e.g., rethink problem representation based on new evidence from a

group member). For example, the willingness to integrate contributions of the rest of the group members into their own actions and thought is, rethinking the problem representation based on new evidence provided by a group member. Perspective taking requires group members being empathetic to understand others emotionally and seeing states of affairs from different perspectives.

- *Social regulation:* Group members bring diverse knowledge, viewpoints, expertise, opinions and strategies and this diversity is useful when solving problems. However, they should know how to use its power by employing proper social regulation and negotiation. Group members should regulate conflicts and be able to control biased information. It is also very important that learners are able to recognise diversity of each group member. They should be willing to be tolerant and negotiate differences in order to avoid conflicts. Every learner should be responsible for the progress of a group.

Linguistic scaffoldings

One type of suitable linguistic scaffolding can be the encouragement of exploratory talk, which is the type of talk that brings about the best quality of communication among learners (for a more detailed discussion on the types of talks, see Chapter 1.3.3). Another type of linguistic scaffolding might be the use of question prompts that help to increase the quality of communication and cognitive processing (for a more detailed discussion about question prompts, see Chapter 1.3.4).

Other types of scaffoldings

Various types of scaffoldings are necessary to attract and sustain learners' interest, simplify the task, demonstrate and make the correct performance more vivid, to speed up the solution process, reduce the fair or failure, and draw learners' attention to the most critical aspects of the problem or steps in its solution process. There is a range of scaffoldings educators can choose from: problem schemas (representation of structural and situational characteristics of a problem), dialogue mapping (visual layout of ideas and questions that are discussed by a group), question prompts (asking and answering questions during the problem-solving process), causal relationships (visual representation of problem variables and their relationships), argumentation (encouragement of the correct argumentation), expert modelling/advice/view (providing problems solvers with support from experts), case-based reasoning (relying on problem-solving narratives), problem-solving rubrics (using instructional guidelines on acceptable performance and its assessment), instructional dashboards (using computers as tools to learn with), peer review (using advice from peers) or various problem-solving worksheets. For a more thorough explanation of each, refer to Chapter 1.3.4.

Foreign language learning aspects

The aspects of solving problems in a FL are summarized in Table 15 below.

Table 15. Problem solving in a foreign language

	PROBLEM SOLVING IN A FOREIGN LANGUAGE
DEFINITION	Searching through a problem space from its current state to the goal state using a FL.

CHARACTERISTICS	When engaging learners in solving ill-structured problems in a collaborative manner, language learning is based on the action-oriented approach or learning by doing. Learners learn by performing meaningful tasks in a social environment. Language learning is related to real world use. The task has both linguistic and non-linguistic goals. It allows to develop all three aspects of communicative competence (linguistic, sociolinguistic and pragmatic). In addition, these tasks are beneficial for the inclusion of learners in both relational and cognitive mediation activities (according to CEFR (2018), mediation activities are most crucial when learning languages) and ways of advancing with mediation strategies.
DIFFICULTIES	Using a FL as a working language may cause barriers for successful communication because of mismatches of the underlying representations (thoughts learners want to convey) between the sender and the receiver; communication anxiety (when the reason is the use of a FL as a working language); different speed of communication.
IMPLICATIONS FOR DESIGNING EDUCATIONAL ENVIRONMENTS	Language educators should think of authentic and motivating problems for FL classes. They should devise ways to facilitate learners' interaction and participation in relational (the process of establishing and managing interpersonal relationships in order to create a positive, collaborative environment) and cognitive mediation (the process of facilitating access to knowledge and concepts, particularly when learners' language proficiency is different).

Assessment of problem solving. CPS assessment can be based on either individual (individual contribution is assessed) or collaborative problem solving (group performance is assessed) levels. Also, a hybrid assessment model including both individual and collaborative aspects can be applied. The major ways to assess problem solving are as a product that problem solvers create (e.g., problem-solving report) or by observing the process (behavioural observation), (outcome-based assessment) or by observing the process/performance (behavioural observation/performance-based assessment).

Comprehensive rubrics can be used not just as a form to assess CPS but also as a way to facilitate the completion of tasks. If given in advance, they can serve as tools for formative assessment. Formative assessment should include multiple checks so that learners are able discover their gaps and strengths, track progress, and summarise learning should be used.

Since problem solving includes a large number of aspects of problem-solving competency to be considered, it may be deduced that an assessment instrument covering everything is probably too complicated. A wise decision for an educator could be to decide which aspects are most required and then continue with the assessment of them. Following all important aspects discussed above, the model of educational environments enabling students to learn problem solving was designed (see Figure 13 below).

I. Educational environments of introductory enablement

1.1 Introduction to the task
- Introduction to the dual task (learning to solve problems and improving communicative competence in English), its aims, process and assessment system.
- Students form groups according to the self-selection principle.

1.2 Preparation for the collaborative aspects of problem solving
- Provision of additional knowledge of collaborative aspects of problem solving, discussion on differences between individual and collaborative problem solving and analysis of examples.
- Agreements on ground rules.

1.3 Development of students‘ understanding about ill-structured problems and their solving
- Provision of knowledge of ill-structured problems and the process of solving such problems (question prompts for each stage are provided).

1.4 Introduction to the tools facilating ill-structured problem solving
- Introduction to the visual thinking technique - construction of problem schemas.

Results expected: *increased understanding of collaborative aspects of problem solving, ill-structured problems and the process of their solving as well as tools faciliating this process.*

II. Educational environments of inclusion in collaborative ill-structured problem solving

2.1 Problem representation: creation of individual and shared understanding of the problem (clarification of the situation described in the problem, identification of its causes, constraints, variables and their interrelationships, agreements about goals). Each group member constructs his/her individual problem schema which are merged into the collective schema.

2.2 Development of solutions (clarification of multiple alternatives, opinions and positions, generation of solutions and ways to achieve them).

2.3 Evaluation of solutions, making justifications and construction of arguments (choosing which solution/s is/are most appropriate and constructing arguments to justify them).

Evaluation of the problem solving processes (necessary during 2.1, 2.2 and 2.3).
Using scaffoldings/tools facilitating ill-structured problem solving.

Results expected: *increased experience of collaborative ill-structured problem solving and the use of tools facilitating the process.*

III. Educational environments of result sharing and evaluation of developed skills

3.1 Presentations of solutions reached in each group and their evaluation
- Presentations of problem solutions reached by each group and their discussion.
- The assessment of presentations and problem-solving reports.

3.2 Identification and reflections on new/improved skills and subskills related to collaborative ill-structured problem solving
- Participation in self-assessment and assessment of others by using rubrics defining three levels of social aspects (participation, perspective taking and social regulation).

Results expected: *presentation of results, identification and evaluation of new/improved skills and subskills related to collaborative ill-structured problem solving by additionally learning at this stage.*

Figure 13. A tripartite model of educational environments enabling students to learn problem solving in foreign language studies

2: SUBSTANTIATION OF EMPIRICAL RESEARCH METHODOLOGY OF EDUCATIONAL ENVIRONMENTS ENABLING STUDENTS TO LEARN PROBLEM SOLVING IN FOREIGN LANGUAGE STUDIES

The aim of this part is to substantiate the empirical research methodology for the study. More specifically, the chapter gives a detailed description about the rationale for a case study, introduces multiple-case study design, its methods and processes followed to gather and analyse qualitative data as well as ethical guidelines.

2.1. Research strategy

This section explores the rationale for a case study as a strategy for this research.

A case study as a research method has been explored in depth by three foundational scientists, in particular, Sharan B. Merriam (1998), Robert K. Yin (1984, 1994, 2009, 2014), and Robert E. Stake (1995). Commenting on the significance of a case study in education, Yin (2005) holds the view that case studies provide a descriptive richness of real-life people and events without separating them from the context in which they exist. In addition, Yin (2014) states that researchers should opt for this particular research strategy when "the boundaries between the phenomenon and context may not be clearly evident" (p. 16). Accordingly, context is considered as one of the most salient aspects while doing a case study (Yin, 2014). It is also agreed that this method is suitable when researchers seek to explain "how" or "why" a social phenomenon works, by focusing on process (how something was done) and outcome (did it work) by providing extensive descriptions of a social phenomenon (Gibbs, 2012; Yin, 2014). The goal of a researcher is to expand and generalize theoretical propositions through analytical generalizations and do not extrapolate probabilities as in statistical generalizations (Gibbs, 2012; Yin, 2014).

Researchers (e.g., Cohen et al., 2007) agree that case studies should be more descriptive than largely interpreted by the researcher. Consequently, case studies are criticized for not being rigorous enough, merely illustrative or lacking objectivity (Cohen et al., 2007; Rowley, 2002; Yin, 2014). However, to avoid this, researchers are advised to follow systematic procedures and not allow equivocal evidence to influence the direction of their findings and conclusions (Yin, 2014; Cohen et al., 2007). Therefore, the researcher of the current case study followed the methodological aspects and systematic procedures as they are proposed by Yin (2014) in his fifth edition of *Case study research: Design and methods*.

A case study is a significant research strategy along with other research strategies, such as phenomenology, etnography, biography, action research and grounded theory. Yin (2014) warns that the boundaries among the methods or cases when each is to be used are often not clear and, despite the fact that a particular method has its distinct characteristics, there might be great overlaps among them. For example, some of the mentioned case study characteristics can be attributed to several methods. However, constructing a preliminary theory related to the topic of research prior to data collection differentiates case studies from other methods, for example, etnography or grounded theory, which do not require specifying any theoretical propositions at the outset of an inquiry (Yin, 2009). Experiments may also employ "how" and/or "why" research questions but they include control of behavioural events, which are not typical to case studies (Yin, 2014). In addition, the requirement to use multiple sources of evidence is one of the most distinctive features differentiating case studies from other research methods (Yin, 2014).

Based on these ideas, the selected strategy of a case study is expected to ensure an in-depth and extensive description of the researched phenomenon existing in the real world setting without separation from its context. Specifically, the current study aims to investigate the complex educational phenomenon of university educational environments enabling students to learn problem solving implemented in foreign languages studies. Given the desire to understand how learners learn to solve problems, how the designed educational environments enable them to achieve it, how specific factors of these environments affect their learning and what results are achieved, a case study is a suitable approach to use. In addition, the current research is expected to add extra knowledge on the development of educational environments that could enable students to learn problem solving.

The literature review done led both to theoretical propositions and the model of educational environments. They both are interrelated and form the groundwork for analytical generalizations that are expected to be done in order to corroborate or modify the model. As Yin (2014) explains, analytical generalizations, regardless of whether they are made from the theoretical propositions at the outset or uncovered in the form of conclusions, are at a conceptually higher level than that of the specific case at hand. The current study and its analytical generalizations are expected to be beneficial, not just for similar cases but also for other subjects that aim to engage students into learning to solve problems.

Considering possible designs, case studies can be either single- or multiple-case studies (Yin, 2014). When a single case study is conducted, it is organized around a single case. On the other hand, multiple-case studies are organized around two or more cases and end with cross-case conclusions (Yin, 2014). For the current research, the use of multiple-case design was predetermined by the fact that students were learning in several groups in the same study module. Consequently, the logic of analysing multiple-cases was followed, i.e. each case was analysed separately and then results from all cases were cross-checked. It was hoped that this design would ensure more robust findings and more reliable analytical conclusions in comparison to the ones that are drawn from just one case (Baxter & Jack, 2008; Yin, 2014). Multiple-case design was also used to explore similarities and differences among three cases.

Based on Yin's (2014) classification of the types of cases studies, the aim of a descriptive case study is to describe a phenomenon in its real-world context by dealing with the "how" question of a situation. For the current research, a descriptive case study was chosen with the aim to analyse and describe how students were learning to solve problems in designed educational environments, how factors of these environments enabled them and what results were achieved in a specific university model – *English (C1 level)*. By following Yin's (2014) recommendations, the researcher aimed to illustrate the complexities of the situation by involving information from a variety of sources.

Usually, case studies are not limited to either qualitative or quantitative evidence solely and involve mixed evidence (Yin, 2014; 2013). However, using qualitative research is considered to be more common for a case study, especially in education, when a phenomenon is complex and needs to be studied in its context (Baxter & Jack, 2008; Merriam, 1998; Kohlbacher, 2006; Yin, 1994; 2014). Namely, the complexity of the current phenomenon determined the choice of a qualitative approach. In addition, this choice was justifiable because of the small number of students learning to solve problems, which means that a sample size would not be representative enough for quantitative research.

A general orientation of the world and the nature of research is called worldview, which usually determines which method a researcher embraces; be it a quantitative, qualitative or mixed methods approach (Creswell, 2009). For instance, postpositivists see research independent of the investigator and their assumptions "hold true more for quantitative research than qualitative research" (Creswell, 2009, p. 24). "The knowledge that develops through a postpositivist lens is based on careful observation and measurement of the objective reality that exists 'out there' in the world" (Creswell, 2009, p. 24). The worldview held for this study is **social constructivism.** The position taken is that truth is constructed and manifolded; knowledge, meaning and facts are context-based and produced by the interactions between the informants and the researcher, which is congruent with the characteristics of qualitative research (Creswell, 2009).

Inquiry as a stance/Practitioner research. The notion of *inquiry as a stance* was coined by Cochran-Smith and Lytle in the late 1990s and further expanded in their publications. According to this view, knowledge on how to enhance students' learning (including the decisions on how something should be done, what to get done, who decides and whose interests it serves) can be better achieved not by researchers working outside the classroom but by those practitioners that become researchers engaged in the inquiry at the same time (Cochran-Smith & Lytle, 2009). Inquiry as a stance or practitioner research might be useful in a number of forms of research, including case studies (Cochran-Smith & Lytle, 2009).

To sum up, doing **a descriptive multiple-case study** for the current research was chosen with the aim that it allows rich descriptions of complex cases (contemporary events) in their real-life context. The nature of a case study well suited the research purpose, in that it required direct access to participants' behaviour during the period they were learning to solve problems and their views after it. Since the study included three groups of students, a multiple case study design was applied to identify patterns of similarities and differences.

2.2. Research design

The goal of this section is to define the study's questions, theoretical propositions or theory, its unit of analysis, the logic of linking data to the propositions and criteria for the interpretation of findings, as they are indicated to be essential components for a case study (Yin, 2009, 2014).

The case study's questions

The main research question for this multiple-case study was '**what university educational environments should be to enable students to learn problem solving (in foreign language studies?)'.** To answer it, a comprehensive literature review was done. According to the review, theoretical propositions and a theoretical model of educational environments that could enable students to learn problem solving were made. The model was implemented in practice. The purpose of the empirical part was to investigate the phenomenon of students learning to solve problems in the designed educational environments implemented in a foreign language course (*English for C1 level*) and validate whether this model was appropriate/effective to achieve the main purpose of learning to solve problems. The main empirical research questions were:

RQ1: Process: How do students learn to solve problems in the developed educational environments?

RQ2: Impact and results: How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?

Propositions or theory

Yin (2014) argues that research questions alone are not sufficient to guide the research process. They do not fully reveal the logic or guiding ideas obtained from the literature review that result in the formulation of such research questions. The construction of a prior theory or theoretical propositions from the comprehensive literature review is one of the most beneficial features of a case study (Rowley, 2002; Yin, 2003, 2014). It can facilitate both data collection and analysis by directing the researcher's attention to what should be examined within the scope of the research (Rowley, 2002; Yin, 2003, 2014). Researchers may seek to answer research questions by confirming, rejecting or refining these propositions.

For the current research, the formulated empirical research questions did not thoroughly point out what should be studied within the scope of the research. Therefore, the theoretical model of educational environments was used, since it reflected the theoretical propositions that were examined during the research. The aim was to answer the main empirical questions by testing these propositions. For example, one the propositions of educational environments of inclusion in CPS was that the construction of individual and collective problem schemas facilitates problem understanding. Thus, the right direction to answer the empirical research questions was to observe the construction of these schemas, ask students the influence they made on the process of problem solving and study the ready-made schemas, all of which helped to organize data collection and analysis.

Unit of analysis

The unit of analysis defines what a "case" is in a case study. Yin (2014) warns about a common confusion between a unit of analysis and a unit of data collection that occurs in cases when they belong to different levels. For example, individual people may be the data collection sources (e.g., semi-structured interviews with them), whereas the unit of analysis may be collective (e.g., an organization or a community to which the individual belongs), with reverse situations possible (Yin, 2014). In the case described, even though data collection may rely on information from individual interviewees, the conclusions cannot be based entirely on the interviews as a source of information. The current case was typical to the aforementioned example.

The unit of analysis (case) for the current research was collective: ***A small group of students learning to solve problems (in educational environments designed to enable students to learn problem solving and implemented in the study module of English for C1 level).***

As noted by Rowley (2002), research purpose, its research questions, theoretical propositions and context determine the case selection. The constraints can be accessibility, resources and time available. For the present study, the researcher chose groups from the same academic group and this option corresponds to the principle of convenience sampling (Merriam & Tisdell, 2016). It was hoped that these groups will produce enough information-rich cases so as to spot important similarities and differences. All groups of students were learning in the same educational environment as designed by the instructor. Three groups of students were of mixed gender, language proficiency and different sizes. For more details, refer to Chapter 3.1.

The possibility of testing the same model in each case/group (within a different context) was expected to ensure greater applicability of the research.

Units of data collection

Units of data collection were both individuals (all students from each group) and collective (3 groups). Table 16 below summarizes data collection sources from each.

Table 16. Data collection sources

Data collection sources	
From an individual	**From a group**
Semi-structured individual interviews	Document analysis (problem-solving reports including problem schemas)
Observations	

As explained by Merriam and Tisdell (2016), the unit of analysis or the case should be bounded in order to be suitable for a case study. Cases can be bounded by some specific time period, relevant social group, specific geographical area, types of evidence to be collected or priorities for data analysis (Yin, 2009).

To bound the cases for the current research, they covered only those formal educational environments that were developed at the university (with the clear purpose in mind – learning to solve problems). Concerning time boundaries, they included only the life cycle of learning to solve problems as a part of a university module. The context comprised the context of a study module and the context of the faculty and university. In addition, each group had its own learning context in terms of individual differences of learners and the unique educational environment each group formed.

<u>Linking data to propositions and the criteria for interpreting the findings</u>

In the study, data collected from each individual and each group was analysed carefully to compare the emergent patterns with the ones in the theoretical propositions coming from the model of educational environments. To achieve convergence of multiple sources of evidence, Yin (2014) states that findings cannot be analysed taking each source separately but they should converge from each of it altogether for each research question. Therefore, findings and conclusions were based on combined multiple sources.

General analytic strategy. Yin (2014) suggests four general strategies to be used for a case study: relying on theoretical propositions (similar to deductive strategy), working data from the "ground up" (inductive strategy – conventional content analysis), developing a case description (preparing a descriptive framework in advance) and examining plausible rival explanations. For the current study, the general analytic strategy of developing a case description was chosen, because the original aim was to describe multiple cases. The description was done according to the model and its propositions relevant to enabling students to learn problem solving.

Analytic techniques. Yin (2014) indicates five specific techniques to be applicable within any general strategy: pattern matching, explanation building, time-series analysis, logic models, and cross-case synthesis. The technique of patter matching logic is indicated as one of the most advisable ones and matching the goal of a descriptive case study (employing the predicted patterns of descriptive conditions defined prior to data collection or predicted patterns of outcomes) (Yin, 2014). In cases where the empirical and predicted patterns are similar, it strengthens the internal validity of the case (Yin, 2014). At the same time, Yin (2014) explains that "the actual pattern matching procedure involves no precise comparisons" (p. 14), which means that a low level of precision is suitable for case studies. Of course, this can result in interpretative discretions, which can be avoided by not including very subtle patterns (Yin, 2014).

First, by using the technique of pattern matching, the researcher aimed to compare empirically based patterns with the predicted ones from the literature review, in order to find out whether the developed educational environments had actually produced the predicted patterns of outcomes or still need to be revised according to the findings. Initially, the multiple stage model was designed according to the thorough literature review. The researcher formulated the predicted patterns according to the findings on various aspects that might be included in such educational environments.

Second, the research utilized the technique of **cross-case analysis** to find out whether the cases had replicated or contrasted with each other. As suggested by Yin (2009), this was done by using word tables where similar basic themes answering RQs from each case were grouped together.

Logic of data analysis. The logic of data collection and analysis was based on the model of educational environments and focused on its three stages. Each RQ was addressed for each stage of the educational environments. Table 17 summarizes stages of educational environments and data gathering methods for each.

Table 17. Stages of educational environments and data gathering methods for each

Stage of educational environments	Data gathering methods for each stage
I. Educational environments of introductory enablement	Semi-structured interviews Document analysis
II. Educational environments of inclusion in collaborative problem solving	Observations Semi-structured interviews Document analysis
III. Educational environments of result sharing and evaluation of developed skills	Observations Semi-structured interviews Document analysis

The logic results were presented is the following: 1) description of results from each case relevant to various aspects of educational environments, and 2) cross-case analysis (see Table 18 below).

Table 18. The logic results are presented

Sequence of results	Purpose
1. Within-case analysis (description of results from each case)	To describe the results related to various aspects of educational environments obtained from each case in order to answer both RQs.
2. Cross-case analysis (comparison of content analysis among cases)	To check whether the empirical and predicted patterns are similar or if the developed educational environments had actually produced the predicted patterns of outcomes or still need to be revised according to the findings from the cross-case analysis. To compare three cases in order to determine similarities and differences.

Empirical research design

The model of educational environments enabling students to learn problem solving was designed as the sequence of educational environments and, therefore, the logic of its empirical testing in reality is organized according to this structure. The researcher attempted to validate or extend the model by looking for evidence of how three different groups of students were learning to solve problems, how the factors of these environments enabled students to learn problem solving and what results were achieved. Although educational environments usually include a large number of predetermined, as well as non-predetermined factors, the major focus of the researcher was on those aspects that were pre-determined in the model.

To analyse qualitative data, the approach chosen was deductive (less typical to qualitative research), which requires the definition of questions and formulation of preliminary theoretical proposition prior to data collection (Rowley, 2002). As noted by Rowley (2002), in this way it contrasts to the inductive approach, in which insights, propositions and patterns emerge from data collection (Rowley, 2002). More specifically, qualitative data analysis was based on directed (deductive) content analysis, which is specifically designed for validation or conceptual extension or theoretical framework or existing theory (Hsieh & Shannon, 2005). Data was coded using the framework of theory/model-driven codes that were defined before data analysis. The codes were derived from relevant research findings, following the procedure for directed content analysis as suggested by Hsieh and Shannon (2005).

Following Maxwell's (2005) categorization for the types of questions in a qualitative inquiry, the first research question was more descriptive (what was going on in terms of observable events and behaviour). The second question was more interpretative and sought to explore the meaning of situations and conditions that problem solvers were involved in.

Each research question was to be answered for each stage of the educational environments (introductory enablement, inclusion and evaluation). To answer the first research question (RQ1. How is each group learning to solve problems in each stage?), the process was described in a narrative form, taking data from observations (its descriptive and reflective sections presented in the researcher's observational sheets), semi-structured interviews and document analysis (module documents and problem-solving reports created by each group). The researcher attempted to provide empirical evidence to describe whether the designed model included students in learning to solve problems (preparation for learning, inclusion into learning by doing and evaluation of learning). To answer the second research question (RQ2. How do the factors of the developed educational environments enable students to learn problem solving and what results are achieved?), empirical evidence was analysed to find out how specific factors of the educational environment have influenced learning to solve problems and what results were achieved. The same as for the first RQ, data taken from multiple sources was analysed.

The logic of data collection and analysis was based on the model of educational environments and its three stages (see Table 19 below). To ensure internal validity, triangulation was achieved by employing two main types of it: 1) the use of multiple methods, and 2) the use of multiple sources of data (observing and asking participants at different times) (Merriam & Tisdell, 2016). The methods of data collection were organizing semi-structured interviews with each student at the end of their study, observing and analysing data from the researcher's notes and reviewing documents.

First, data from each case/group was analysed. Then, the data was cross-checked across cases to see the existing similarities and differences. In addition, emerging different contextual factors were discussed in each group.

Table 19. Stages of educational environments, research questions and data gathering methods for each

Stage of educational environments	Data gathering methods for each stage
I. Educational environments of introductory enablement	
RQ1: Process: How do students learn to solve problems in the developed educational environments?	**Semi-structured interviews** **Document analysis** (problem schemas)
RQ2: Impact and results: How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?	

I. Educational environments of inclusion in collaborative problem solving	
RQ1: Process: How do students learn to solve problems in the developed educational environments?	**Observations** **Semi-structured interviews** **Document analysis** (problem-solving reports created by each group, including problem schemas)
RQ2: Impact and results: How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?	
III. Educational environments of result sharing and evaluation of developed skills	
RQ1: Process: How do students learn to solve problems in the developed educational environments?	**Observations** **Semi-structured interviews** **Document analysis** (problem-solving reports created by each group, including problem schemas)
RQ2: Impact and results: How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?	

Stage I. Educational environments of introductory enablement. For the current stage, the researcher aimed to find out whether students were initially prepared for learning to solve problems. To answer the first RQ, the aim was to look for evidence on how students were gaining introductory knowledge on collaborative aspects of problem solving, on ill-structured problems and peculiarities of their solving, and on the process of constructing ground rules. Also, the researcher looked for evidence on how students were gaining additional knowledge and experience of using tools facilitating the process of solving problems, namely the construction of problem schemas for problem representation. For answering the second RQ, evidence on the results achieved and influence of the mentioned factors was analysed. The logic used to analyse Stage I is presented in Table 20 below.

Table 20. Predicted patterns of outcomes according to each theme during Stage I

Themes/ Codes	Code description (according to the stage from the model)	PATTERNS (predicted patterns of outcomes)/which patterns are searched for/what process/results/influence are expected)	
I.	**Educational environments of introductory enablement**		
		Process (RQ1)	***Results/Influence (RQ2)***
1.1: Introductory knowledge on collaboration	1.1: Providing more knowledge of collaboration (explicit teaching of collaboration)	*Students are provided with the additional knowledge on collaborative aspects of problem solving and introduced to differences of CPS from an individual one.*	*Increased understanding of collaborative aspects of problem solving.*

1.2: Introductory knowledge on solving ill-structured problems	1.2: The introduction to the typical processes of solving ill-structured problems	*Students are provided with the additional knowledge on ill-structured problem solving.*	*Increased understanding about ill-structured problems and their solving.*
1.3: The construction of ground rules	1.3: The construction of ground rules (agreements about the required behaviour/ quality of talk)	*Students are provided with the additional knowledge on the exploratory type of talk and construct of ground rules.*	*Students find out what exploratory talk among learners is (requiring group members to encourage each other to talk, tolerate ambiguity, share information and give reasons for their opinions, discuss alternatives and seek to reach agreement).* *The constructed ground rules are supposed to facilitate the process of solving ill-structured problem/enhance the quality of talk.*
1.4: Knowledge and experience of constructing problem schemas	1.4: Introducing learners to a tool of visually representing problems (problem schemas) and allowing them to gain practice of using them	*Students are introduced to one of the ways to externalize or visualize thinking - representing problems by constructing their problem schemas.*	*Students know what problem schemas are and how to draw individual and collective schemas/gain experience of that.*
1.5: Other aspects	1.5: Other aspects		

<u>Stage II. Educational environments of inclusion in collaborative problem solving.</u> The empirical evidence about stage II was collected to answer the questions of whether students increased their experience on how to solve problems collaboratively and learned to use various tools aimed to facilitate the process through being involved in a real problem solving or learning by doing. To answer the first RQ, the researcher looked for evidence on 1) collaborative (social) aspects (namely participation, perspective taking and social-regulation) and 2) cognitive skills related to solving ill-structured problems. To answer the second RQ about this stage, evidence on the results achieved and influence of the mentioned factors is analysed. Similar to the first stage, the researcher anticipated new codes to emerge for the new factors affecting learning to solve problems. All sources of data (researcher's observational data, students' feedback in semi-structured interviews, and documents created) are considered to be essential for answering both RQs of this stage. The logic for the analysis of Stage II is presented in Table 21 below.

Table 21. Predicted patterns of outcomes according to each theme during Stage II

Themes/ Codes	**Code description (according to the stage from the model)**	**PATTERNS (predicted patterns of outcomes)/ which patterns are searched for/what process/results/influence are expected)**	
II.	**Educational environments of inclusion in collaborative problem solving**		
		Process (RQ1)	***Results/Influence (RQ2)***
2.1: Cognitive processes			
2.1.1 Problem representation	2.1.1: Inclusion into problem representation (including the construction of individual and collective problem schemas).	*Problem solvers figure out what information is known and what should be additionally searched for, agree on how to collect it, distinguish between relevant and irrelevant information.* *They define the problem, clarify the situation being described in the problem, identify its causes and constrains, try to understand variables in the problem space and their interrelationships, agree about subgoals and goals.* *Learners construct multiple comprehensive individual problem schemas (external problem conceptualizations), share them, agree about similar representations and then construct collective visual problem schemas.*	*Problem solvers increase understanding and experience of representing ill-structured problems.* *They gain additional experience on the construction of problem schemas.* *The constructed schemas include representations of problem structural and situational characteristics as well as structural relationships among elements.* *The collective problem schemas show a more thorough/ deeper problem understanding.* *The construction of problem schemas involves students in devoting more effort for problem representation and this process facilitates the group's work.* *Group reaches shared understanding of the problem.*
2.1.2: Development of solutions	2.1.2: Inclusion into development of solutions	*During the process of generating and evaluating solutions, each problem solver develops personal solutions and constructs arguments to justify them (explain their feasibility).*	*Group reaches shared understanding of the goals to be achieved and possible solution/s of the problem.* *The agreed solution is based on multiple sources of knowledge and perspectives.*
2.1.3: Evaluating solutions, making justifications	2.1.3: Inclusion into evaluating solutions, making justifications and constructing arguments	*Group members engage into the constructive discussion of considering the usefulness, effectiveness and*	

and constructing arguments		*suitability of alternative solutions.* *Problem solvers put effort into making an agreement about the final solution/s.*	
2.1.4: Monitoring and evaluating problem-solving process	2.1.4: Inclusion into monitoring and evaluating problem-solving process	*Problem solvers look back and monitor the efficiency of the group's work and progress made (consider the effectiveness of cognitive processing during the given problem solving).*	*Monitoring and evaluating problem-solving stages is present throughout all the process. It allows solvers to improve the group's work.*
2.2: Collaboration	2.2: Attendance, perspective taking and social regulation	*Students attend classes, every student shows engagement with the task, they do not just participate but also interact with each other, share understanding and knowledge, try to understand the perspectives of others, appreciate information from others, negotiate, take responsibility to complete the task and show initiative.*	*Students increase understanding and gain experience of collaborative behaviour/collaborative aspects/peculiarities of collaboration/team organisation.* *Their performance is collaborative but not cooperative (no division of work).*
2.3: Use of English	2.3: Use of English as a working language	*Students use English as a working language throughout all the process.*	*Problem-solving task serves as a beneficial context for the improvement of communicative competence in English.*
2.4: Provision of detailed procedural guidelines (including question prompts)	2.4: Providing detailed procedural guidelines including question prompts (regulation of the problem-solving process).	*Students are asking and answering questions during each problem-solving stage.*	*The process becomes more understandable and easier. Students engage in an effective monitoring and regulating of the problem solving process; more effective argumentation is present.*
2.5: Provision of assessment rubric	2.4: Agreements about the required behaviour (regulation of the problem-solving process, assessment of it).	*Students use the assessment rubric.*	*Students perform the task in a more structured way, know clear criteria for the assessment, understand the desired behaviour and expected outcomes of the task.*
2.6: Other aspects	2.6: Other aspects		

Stage III. Educational environments of result sharing and evaluation of developed skills. The analysis of the current stage was done in order to answer the main question of whether the assessment stage was designed properly to engage students in the process of results' sharing and reflections on the changed competencies related to collaborative problem solving. To answer the first RQ, the researcher looked for evidence on how students were sharing the results achieved and evaluating their changed competencies. As it concerns the second RQ, the evidence on what results were achieved and their influence on students' learning to solve problems was searched for. Again, to achieve data triangulation, all sources of data were analysed. Table 22 below summarizes the logic for the analysis of Stage III.

Table 22. Predicted patterns of outcomes according to each theme during Stage III

Themes/ Codes	Code description (according to the stage from the model)	PATTERNS (predicted patterns of outcomes)/ which patterns are searched for/what process/results/influence are expected)	
III.	**Educational environments of result sharing and evaluation of developed skills**		
		Process (RQ1)	***Results/Influence (RQ2)***
3.1: Assessment of others	3.1: Inclusion into the assessment of others	*Students participate in the assessment of others.*	*The process allows students to identify improved/learnt new skills related to CPS, as well as evaluate new perspectives for future collaborative problem-solving environments.*
3.2: Self-assessment	3.2: Inclusion into the self-assessment	*Students participate in the self-assessment, reflect on their changed competencies.*	
3.3: Result sharing	3.3: Result sharing among groups	*Students share the achieved results among groups.*	
3.4: Other aspects	3.4: Other aspects		

To sum up, the design of empirical data analysis is predicted according to the model of educational environments enabling students to learn problem solving, namely its three stages of learning – introductory enablement (preparation for the learning process), inclusion in real problem solving (learning by doing) and, finally, inclusion into the evaluation process. Each stage was analysed in order to answer two main research questions of how each group was learning to solve problems in each stage and how factors of the developed educational environments enabled students to learn problem solving/what results are achieved. The next chapter includes the detailed description of the research instruments and data analysis procedures applied.

2.3. Data collection methods, its analysis approach and process

The current part gives an overview of data collection methods, their analysis approach and processes.

For data to be converging in a triangulating fashion, the following three multiple methods of data gathering were used: observation, semi-structured interviews and documents. Data was analysed using directed content analysis (Hsieh & Shannon, 2005). See Table 23 below for the data gathering methods, timing, sources of data and its analysis methods.

Table 23. Data gathering methods, timing, sources of data and data analysis methods

Data gathering method	Data gathering time	Source of data	Data analysis method
Observations	Educational environments of involvement in problem-solving process Educational environments of assessment	Field notes - written notes (descriptive running records of events and reflections on the process of learning, results achieved and the influence of factors of the developed educational environments)	Content analysis (directed) (Hsieh & Shannon, 2005)
Semi-structured interviews	During and after educational environments of assessment	Full verbatim transcript	Content analysis (directed) (Hsieh & Shannon, 2005)
Documents and artefacts	During all phases of research	1. Naturally occurred: the description of the module 2. Researcher-generated: 2.1 prepared by the researcher (guidelines for the problem-solving sessions, assessment rubrics used), and 2.2 prepared by participants (ground rules, problem schemas, presentations, problem-solving reports)	Content analysis (Merriam, 2009)

Observations. The decision to collect observational data was based on several important facts. Such data is usually acknowledged because of being more realistic than interview data. It occurs naturally over a longer period of time and in this way allows the researcher a deeper understanding of the phenomenon. Observational data is not a one-time hit and superficial, but contextualised because of being collected in some specific context (Merriam & Tisdell, 2016).

A special mode of observation through which data was collected was participant-observation (Yin, 2014). The researcher could not stay merely as a passive observer because the researcher's role in the actions being observed was as a lecturer of the course. Trying to control as little as possible behavioural events, as Yin (2014) suggests, the role brought about both opportunities and challenges. The advantage of this was perceiving reality from the viewpoint of being an insider and in the role of someone who developed the educational environment. This was expected to produce a more vivid and accurate portrayal of the phenomenon being studied. A number of researchers agree that the development of problem-based environments is a complex task; therefore, a researcher who is not familiar with this issue might not have created the rich descriptions of what is happening. In addition, this role allowed the researcher to manipulate the situation, at least minimally, in order to facilitate understanding and students' learning (in the form of timely scaffolds).

Additional challenges were caused because of the fact that each study was conducted simultaneously in the same auditorium with each group sitting in one of the three corners of it. The researcher did not have sufficient time or the possibility to observe each event happening in each group. Second, observational data is usually blamed for being biased, since it is taken from one person's perspective. However, as agreed by some researchers (e.g., Kawulich, 2005), both objectivity and subjectivity can coexist in a qualitative research and can facilitate the understanding of the phenomenon being studied.

By using observations, the researcher sought to overcome the common discrepancy in collecting data between what participants report in their answers and what occurs in reality (Merriam & Tisdell, 2016). For the mentioned constraints, observations were not considered the primary source of data. However, this data source was useful in revealing individual differences of each group and additionally served as a way to assess the groups' activity.

An observation schedule was employed in order to alleviate the researcher biases. The notes were organized as a 'running record' of events and subdivided into descriptive data (factual information – date, time, setting, actions, behaviours and conversations) and reflective data (records of ideas, questions, thoughts and concerns), which is recommended by Creswell (2009). Areas on the observation schedule included information 1) on process of learning and results achieved, and 2) on diverse factors of the educational environment that might influence learning.

Semi-structured interviews. Yin (2014) suggests that interviews for case studies should be like guided and fluid conversations instead of the structured queries. This means that it is not possible to know all the questions in advance. In addition, when adopting a social constructivist worldview and qualitative research methodology (as for this case study), it is recommended to include more open-ended questioning, since in this case a researcher can listen carefully to what participants say or do in their settings (Creswell, 2009). Therefore, the type of unstructured interview resembling a conversation manner and including open-ended questions was chosen. Semi-structured interviews served as the primary source of data.

The aim of the semi-structured interviews was both to corroborate findings (from the literature review according to which the theoretical model was constructed) and to capture the students' own sense of reality. The interviews were designed to collect data about both the individual and group's learning to solve problems from the individual student's perspective. The main goals were to assess the inclusion in the learning to solve problems process, to diagnose students' social and cognitive skills when solving problems, to assess the effectiveness of the model being implemented in *English (for C1 level)* course and the effects of enabling factors on learning to solve problems. In addition, the interviews served the purpose of self-reflection for each participant, since they could understand, look back and contemplate about the changed competences necessary for collaborative ill-structured problem solving. The guide for the semi-structured interview is provided in Appendix I and these questions served just as prompts to open further discussions.

Moreover, as the study was conducted in Lithuania with the students studying English (for C1 level), most of the interviews were carried out using the students' native language, so as to avoid any language barriers for the students in expressing themselves and in this way to gain as much of an in-depth understanding as possible. Only two participants (one non-Lithuanian and one who asked to be interviewed in English) were answering questions in English. After the data from the semi-structured interviews was collected, it was transcribed in Lithuanian and the quoted parts were translated into English. Each interview lasted approximately 60 minutes with each participant.

Documents. Concerning the research methodology terminology, a document is "used as an umbrella term to refer to a wide range of written, visual, digital, and psychical material relevant to the study (including visual images)" (Merriam & Tisdell, 2016, p. 162). They can be divided into occurring naturally in the study environment and containing much irrelevant data or be research-generated, which are usually considered as more valuable (Merriam & Tisdell, 2016). The latter can be subdivided into prepared by the researcher or prepared by the participant for the researcher in the process of the study (Merriam & Tisdell, 2016).

For the current study, apart from the ways to mine data from the interviews and observations, documents and artefact was the third important source of data. The current study included both types of documents. Description of the module was a naturally occurring document studied, while research-generated documents were: 1) prepared by the researcher (guidelines for the problem-solving sessions) and representing the development of the educational environment, and 2) prepared by participants (ground rules, problem-solving reports including problem schemas, presentations) representing their learning outcomes. Problem-solving reports were expected to provide data about the process of problem solving and the results achieved. Its collective problem schemas were expected to show the final representation of the problem.

Data analysis approach: directed content analysis. Content analysis is said to be primarily aimed at the description of a phenomenon on a conceptual level (Elo & Kyngäs, 2008). It is used as "a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns" (Hsieh & Shannon, 2005, p. 1278). Hsieh and Shannon (2005) distinguish among conventional, directed and summative approaches of content analysis. The directed approach, which is usually conflated to deductive modality of content analysis, is considered to be more relevant than prior research or existing theory about the phenomenon existence but is still incomplete and requires further description. According to Hsieh and Shannon (2005), the goal of a directed approach is "to validate or extend conceptually a theoretical framework or theory" (p. 1281). Data analysis starts with the initial codes obtained from the literature review and are later supplemented with the new ones which could not be coded (Hsieh & Shannon, 2005).

Lauri and Kyngäs (2005, as cited in Elo & Kyngäs, 2008) also recommend using a deductive approach "when the structure of analysis is operationalised on the basis of previous knowledge and the purpose of the study is theory testing" (Kyngäs &

Vanhanen, 1999, as cited in Elo & Kyngäs, 2008, p. 111). In this case, data is analysed based on the theory or model and analysis moves from general to more specific.

The researcher has chosen the deductive modality (also called directed) of content analysis, which is suitable for a less rich description of the data in general but more for a detailed analysis of some particular aspects in it (Braun & Clarke, 2006). It is acknowledged as a more systematic approach to analyse data and look for supporting and non-supporting evidence for a theory obtained from the literature review (Hsieh & Shannon, 2005). Therefore, deductive modality was considered as a better option for the validation of the model. In addition, the phenomenon (educational environments) studied in the current research could be too wide to be analysed using inductive analysis.

Hsieh and Shannon (2005) suggest using one of two possible strategies for the coding process. Either it starts with the highlighting of the transcript for the parts that are related to the studied phenomenon and then coding these highlighted passages with predetermined codes or another option is to start coding immediately with the predetermined codes. The researcher chose to utilize the second strategy. As suggested by the authors, the codes that do not fit into the initial coding scheme were given new codes. The findings were expected to offer both supporting and non-supporting evidence for the theory and presented "by showing codes with exemplars and by offering descriptive evidence" (Hsieh & Shannon, 2005, p. 1282).

Directed content analysis is usually criticised for making researchers blinder to observe all contextual aspects of the phenomenon, because of too much emphasis on theory, however, at the same time it ensures a more structured way for data analysis (Hsieh & Shannon, 2005). Another limitation mentioned is a strong bias, as the researcher is more likely to find evidence that is more supportive than non-supportive (Hsieh & Shannon, 2005). In addition, when questions are prepared according to the predetermined categories, participants might get clues to provide answers in certain ways; even sometimes to please the researcher (Hsieh & Shannon, 2005). To avoid these limitations, the researcher did not ask very specific question and tried to remain in the conversational manner with new questions emerging. Additionally, hoping to achieve greater rigour, the researcher used more specific pre-determined categories and questions for the process and results, which were described in the literature in greater detail. On the other hand, for the questions about the impact of educational environments, the researcher used less specific questions and predetermined categories (which factors were positive, negative or of little importance/not clear impact).

Data analysis process for all data sources. Data analysis in this study was an ongoing and recursive process, along with the data collection. In addition, the researcher adhered to the rule that each data source cannot be treated independently and findings reported separately, since this is not typical for a case study (Baxter & Jack, 2008; Yin, 2014). Rather, as Baxter and Jack (2008) warn, "the researcher must ensure that the data are converged in an attempt to understand the overall case, not the various parts of the case, or the contributing factors that influence the case" (p. 555). Therefore, data triangulation by means of presenting the case study's findings supported by more than a single source of evidence or converging evidence was sought.

Following the procedure suggested by Hsieh & Shannon (2005), the predetermined coding system was created (see 3 tables: Table 20. Predicted patterns of outcomes according to each theme during Stage I, Table 21. Predicted patterns of outcomes according to each theme during Stage II, and Table 22. Predicted patterns of outcomes according to each theme during Stage III in Chapter 2.2).

The process of data analysis consisted of three main phases: preparation, organising and reporting (Vaismoradi et al., 2013). The preparation phase required to immerse into the collected data and obtain the sense of whole (Elo & Kyngäs, 2008). All transcribed verbatim interviews, observational data and documents collected from one group were considered as one unit of analysis. The running records of observational data, as well as interview transcripts, were firstly read and then re-read in order to become familiar with the data. The data was then analysed using the pre-determined coding scheme. Data that could not be coded according to the scheme devised was coded using the inductive method, as recommended by Hsieh and Shannon (2005).

For the reporting phase, data analysis resulted in a descriptive account of a process of model implementation, impact of the factors from the designed educational environment and results achieved. The researcher decided to organize descriptive accounts according to the model of educational environments and its three stages. First, results according to each important aspect of educational environments were reported from each case study and then proceeded by the cross-case synthesis of findings. The evidence is presented by showing pre-determined codes with exemplars and by providing descriptive evidence, as suggested by Hsieh and Shannon (2005). Accordingly, the findings obtained were expected to support or contradict evidence from the literature review.

To sum up, various data gathering methods were chosen in order to achieve data triangulation and collect evidence on the process, results achieved and impact of educational environments on students' learning in them. Directed content analysis was applied in order to achieve systematic validation of the model created and not get lost among a great number of variables usually existing in educational environments.

2.4. Research organization and ethics

The following chapter includes the detailed description of the research organization, criteria for judging the quality of its design and ethics. The designed educational environments enabling students to learn problem solving were grouped into three main stages (see the model developed in Chapter 1.3.6).

In stage I (*Educational environments of introductory enablement, Introductory steps*) students were introduced to the problem-solving task (its purpose, process and evaluation), to the expected process of how to collaborate when doing the task, to the characteristics of ill-structured problems, the processes of solving such kind of problems and the tools that may enhance collaborative ill-structured problem solving (question prompts and problem schemas).

In stage II (*Educational environments of inclusion in solving of problems in groups, Steps 1-5*) students were involved in four main processes of solving ill-structured problems (problem representation, developing solutions, making justifications for generated and developed solutions and evaluating and monitoring of the whole problem-solving process). During this stage, it was expected that students engage in real life problem solving and prepare problem-solving reports. The procedural guidelines were prepared to explain every stage of the problem-solving process, which started from Stage II as no procedural guidelines were offered during Stage I or introductory steps. The problem-solving session will be recorded and later transcribed verbatim. It is hoped that recordings of their communication will serve to motivate students to use English and not the native language throughout all process.

In stage III (*Educational environments of result sharing and evaluation of developed skills, Steps 6-7*) students were engaged in the presentation of their results, discussion of the results of other groups and reflection on their learning. Afterwards, individual time for each student was planned for the conduct of semi-structured interviews.

The criteria for judging the quality of the research design. As indicated by Yin (2014), some certain logical tests can be used to judge the quality of any given research design. Yin (2014) summarizes four tests that are applicable for establishing quality of any empirical social research, including case studies.

Table 24. Case study tactics for four design tests (Yin, 2014, p. 45)

TESTS	Case study tactic	Phase of research in which the tactic occurs
Construct Validity	Use multiple sources of evidence Establish chain of evidence Have key informants review the draft case study report	Data collection Data collection Composition (reporting case studies)
Internal Validity	Do pattern matching Do explanation building Address rival explanations Use logic models	Data analysis Data analysis Data analysis Data analysis
External Validity	Use theory in single-case studies Use replication logic in multiple-case studies	Research design Research design
Reliability	Use case study protocol Develop case study database	Data collection Data collection

Yin (2014) indicates that triangulation is among the distinctive features of doing a case study research and it should rely "on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result" (p. 17). To ensure internal validity and credibility, Merriam & Tisdell (2016) also point to triangulation as the best-known strategy for qualitative research. Referring to Denzin's (1978) classification (as cited in Merriam & Tisdell, 2016), triangulation can be achieved by using two types of it: 1) the use of multiple methods, and 2) the use of multiple sources of data (observing and asking participants at different times). For the current research, data was collected using multiple methods and times: by asking students during semi-structured interviews at the end of the study, by observing and then analysing data from the researcher notes and reviewing documents created by the participants during the study.

Based on the above Yin's (2014) classifications, the following tactics were used for the current research:

Table 25. Tactics to ensure construct validity, internal and external validity and reliability for the current study (based on Yin's (2014) classification)

TESTS	Case study tactic	Phase of research for the tactic
Construct Validity	Use multiple methods for data collection and multiple sources of data	Data collection
Internal Validity	Do pattern matching	Data analysis
External Validity	Use replication logic in multiple-case studies	Research design
Reliability	Developing case study database	Data collection

To explain each tactic more specifically:

1. Triangulation of data sources, i.e. the convergence of data collected, was achieved by using different methods for data collection and multiple sources of data in order to determine the consistency of findings. The following multiple methods were used: observation, semi-structured interviews, and documents (problem-solving reports including problem schemas and problem-solving presentations). Data was collected at different times.
2. To ensure internal validity, initial theoretical propositions based on the comprehensive literature review were used to produce empirically based findings.
3. The type of replication used was theoretical (when different results are predicted) to ensure more informative and reliable findings.
4. The case study database, including all of the data from the case, was developed so as the data can be retrieved if needed.

Krippendorff (2004, as cited in Vaismoradi et al., 2013) notices that the best indicator about the quality of findings is the provision of new insights about the phenomenon being studied, in order to increase the understanding of it or informed practical actions. Therefore, the study findings were aimed at providing new insights about practical actions on how educational environments that empower students to learn problem solving can be developed, including the ways a theoretical model could be improved.

Ethical assurances. Ethical issues were an important consideration, because the current study involved human participants – students learning in the module. In addition, the process of learning was organized by the researcher herself. To stay ethical, the purpose of the study was explained at the beginning of the module and additionally during the data collection process. The explanation was done in a way that was both understandable and accurate. Also, the participants' time commitment was addressed, since all study and data collection was conducted during the course of the module. In addition, there were no concerns for repercussions from the researcher due to participation in problem-solving sessions and interviews (students were offered the right of refusal to answer questions during the interviews). The collected data was recorded in the researcher's private field notes and stored in the solely use computer, with the data only being able to be accessed by the researcher. Finally, confidentiality and anonymity was addressed by not revealing the real names of the participants.

To conclude the methodological part, these key characteristics of a case study research are retained for the current study: 1) "how" research questions, 2) focus on contemporary events, 3) no attempt to separate a phenomenon from its context, 4) data triangulation (reliance on multiple sources of evidence and usage of multiple methods for data collection), and 5) use of a preliminary theory related to the topic of research (a highly recommended characteristic for a case study) that was reflected in the model. Qualitative data was analysed using directed content analysis as a systematic way to test the model.

CHAPTER 3: ASSESSMENT OF THE EFFECTIVENESS OF EDUCATIONAL ENVIRONMENTS ENABLING STUDENTS TO LEARN PROBLEM SOLVING IN FOREIGN LANGUAGE STUDIES

The research design derived from the purpose of this multiple-case study, which was to investigate what educational environments should be to enable students to learn problem solving (in a foreign language course). To answer the main research question, the model of such environments was constructed according to the comprehensive literature review. The empirical part aimed to assess the effectiveness of such environments for learning to solve problems. It was framed by the following research questions: How do students learn to solve problems in developed educational environments? (process), How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved? (impact and results).

This chapter includes the results of the empirical part. First, the findings from each case are presented under each factor of the educational environments, divided into three stages. Then the findings are cross-checked to find out similarities and differences among all three cases. The chapter starts with the setting/context and participants' description (Chapter 3.1). Afterwards, it continues with the description of how the model was implemented, which was the same procedure applied to all cases (Chapter 3.2). Chapter 3.3 contains the results from each case while Chapter 3.4 includes the cross-case synthesis of findings. The last chapter (Chapter 3.5) presents the discussion based on cross-case findings and also on peculiarities across educational environments in each case.

3.1 Setting/context and participants

Formation of groups. This study was conducted at X university during the spring semester of the 2016-2017 academic year. It was carried out during the study course of English (C1 level) for second-year students doing their bachelor degrees. One academic group of 21 students, which initially was divided into four groups, participated in the study. As research does not inform about the best size for group formation (Lai et al., 2017), students were asked to form groups of 4-6 students. The researcher was planning to collect data from four groups of students to be engaged in the same module task, however, later the fourth group split up, with two students joining one of the existing groups. Initially, in order to achieve higher levels of satisfaction (as suggested by Lai et al., 2017), students were allowed to form groups according to the self-selected method. In addition, there was no role division applied and student matching according to abilities of English proficiency was not considered. The initial division resulted in four groups that were made of 4 students (one group), 6 students (two groups) and 5 students (one group) of mixed gender and language abilities. Later, after the observed non-attendance of three students in the group of 5, two remaining students were asked to join the second group, which then resulted in a group made of 8 students. This was done after two face-to-face meetings during Stage II because the researcher did not want to leave the fourth group of just of two students.

The size of groups was considered to be the informative feature of the group learning to solve problems. More specifically, each group made a separate case study and is described in detail below.

Group 1 (Case study 1). The group was made of 4 students: two female and two male students. The age of students ranged from 19 to 21 years. Three students were Lithuanians while the fourth was Indian. While the Lithuanian students knew each other before from the previous semester, the Indian student joined this group only for this semester. Before coming to the course, approximately a year and a half before it, all three Lithuanians took the national examinations in English and their scores were 96, 75 and 63. These results indicated that the students had already attained a B2 level of English language proficiency (according to Common European Framework of Reference for Languages). The student from India had already achieved an international exam score. More specifically, his TOEFL score was 89, which according to *Linking English-language test scores into the common European framework of reference: An application of standard-setting methodology* (Tannenbaum & Wylie, 2008) matches B2 level. The group was formed on the principle of the self-selection principle.

Group 2 (Case study 2). Initially, the group was made of 6 students: one male student and five female students that were later joined by one more additional male and female student. In total, there were 8 students in the second group. All students were Lithuanians and their age ranged from 19 to 21 years. They came to the course having scores from the national examinations in English that ranged from 43 up to 98. Only one student had a lower score of 17. Thus, only one students had B1 level while the remaining students had the prerequisite level of B2, which was required to continue studies for the C1 level. Initially, the group was formed on the principle of self-selection, which was then violated by asking the group to accept two more students from the fourth group, which split up.

Group 3 (Case study 3). At the outset, the group was made of 6 students: all female students whose age ranged from 19 up to 22 years. Again, all students were Lithuanians and had scores from the national examinations in English that ranged from 42 up to 96, which showed their readiness to continue to the C1 level at university. The group was formed according to the principle of self-selection. University X is following the recommendations expressed in the European documents that were analysed in detail in Chapter 1.2.1. It provides students with the opportunities to further enhance their language proficiency and thus be better prepared for personal, academic and professional contexts. At the university, learning of foreign languages remains as one of the intended learning outcomes of non-language programmes across all faculties.

The same English (C1 level) course is being suggested for all students at the university. The main aim of it is that students advance with English language proficiency and move to the higher C1 level (Effective Operational Proficiency). The requirement to attend this course is that students have B2 level (Vantage) according to CEFR common reference levels. The national examinations of English are made of 40 percent of tasks that match B1 level and 60 percent of tasks matching B2 level. In order to take this exam, a student has to score 16 points out of 100 and this corresponds to B1 level. The result of 40 or more points scored indicates a student has the language proficiency equal to B2 level.

According to the study module description, the objectives of this 6-credit course are that students 1) obtain knowledge of flexible and effective usage of the English language in social, academic and professional environments; 2) acquire correct usage of the language of science and technology along with the effective usage of all language skills, and 3) develop competence in performing scientific paper (text) analysis as well as oral presentations on the topics related to their major. The desired results to be achieved are as follows: ability to speak and write correctly; use all language skills for effective professional communication in spoken and in written forms; read and interpret scientific information; ability to explain, describe and summarize technologies, phenomena and processes; ability to compile a glossary of terminology related to the major, and ability to prepare presentations. A variety of learning methods are suggested: discussions, individual projects, practical tasks, role-plays, group work, recommended readings, brainstorming maps and information search tasks. The following evaluation methods are indicated: exam, individual work, test, text analysis, group projects and spoken presentations.

The selection of the task for the English course. First, the task of problem solving matches the task types suggested for the course. Second, the task of problem solving was selected so as to follow the recommendations of The Common European Framework of Reference for Languages: Learning, Teaching and Assessment (CEFR) according to which learning foreign languages is informed to be based on an action-oriented approach where mediation activities are considered to be central. Problem-solving tasks were offered because it matched the characteristics of action-oriented tasks: the learning situation was authentic, the outcome of activity required was completion of the task (problem solving), collaborative learning environment was created, the task was designed to incite interaction and meaningful communication, and it had both language-related and none language-related goals. The task was seen as a suitable type of task to foster mediation activities and the development of mediation strategies. Specifically, it was anticipated that this type of prolonged communication would cause obstacles in understanding, communication and cognition that group members will have to overcome by participating in both concept and communication mediation activities, and in this way improve mediation strategies.

The selection of the problem. The problem was selected according to the characteristics provided by Jonassen and Hung (2008) (see Chapter 1.3.2). The problem selected was not too complex, moderately ill-structured (not self-contained, having multiple solutions and no preferred, prescribed solution processes), resembling real-life and matching students' readiness. It was expected that the suggested problem would be interesting and challenging for the students. Specifically, the following problem was given to all groups:

Our university, as well as all European universities, seeks to participate in the Erasmus+ exchange program allowing students to study at various universities across Europe. However, this exchange is not equal as more students choose to study abroad than come to study at Lithuanian universities. This is a problem that could be solved *not only by the administrative and teaching staff of the university, but also by students. How can you as students contribute to solving this problem? Think about various ways (action plans, advertising campaigns, initiatives to make new connections, etc.) how you as students from the faculty of Chemical Technology can contribute to attracting foreign students to study at your faculty for one semester.*

The selection of the learning and teaching approach contributing to the development of problem-solving skills in students. There are various educational methods contributing to the enhancement of problem-solving skills, which were discussed in detail in Chapter 1.3.2. From the methods discussed, the researcher applied the method of enhanced instruction (that has additional measures to improve subskills or discrete aspects of problem-solving skills) as the most relevant for the educational environments that have the major aim of the enhancement of problem-solving skills in students.

The assessment system. Students were explained that the assessment of the task is made of two major parts: 1) assessment of group CPS outcomes (60% = Group GPS outcomes (Presentations of the group's problem solution that makes 20% of the final mark plus group problem-solving report that makes 40% of the final mark), and 2) 40% = Individual CPS performance (see the rubric of the desired behaviour in Table 14). Students were explained what each of these parts would require them to prepare and what performance was expected. Detailed explanations on what had to be included in each group problem-solving report and a presentation were provided. As it concerns individual behaviour, students were told they would be given a performance rubrics with their typical highlighted marked behaviour. For the detailed explanation of the system, see Appendix B.

3.2 The implementation process of the model

The following chapter presents the model implementation according to the stages it included. It helps to answer the first research question of how students were learning to solve problems, namely what processes they were involved in and what educational measures were applied.

The designed educational environments consisted of three main stages:

Stage I. Educational environments of introductory enablement

Stage II. Educational environments of inclusion in collaborative problem solving

Stage III. Educational environments of result sharing and evaluation of developed skills

Table 26 below provides a more detailed timing for each stage.

Table 26. Stages of educational environments, their steps and timing for each

Stage I:
INTRODUCTORY STEPS – Introductory classes 1, 2, 3, 4 and 5 (7,5 hours)
Stage II:
STEP 1 – Class 1 (0.5 hour)
STEP 2 – Classes 1, 2 and 3 (4 hours) plus individual work
STEP 3 – Class 4 (1.5 hour) plus individual work

STEP 4 – Class 5 and Class 6 (3 hours) plus individual work **Stage III:** STEP 5 – Class 7 Face-to face and online meeting (min 1.5 hour) STEP 6 – Class 8 (1.5 hour) STEP 7 – Individual meeting with each student (appr. 1 hour)		
Stages of educational environments	**Their steps/as were reflected in the procedural guidelines (see Appendix A)**	**Timing for each**
Stage I. Educational environments of introductory enablement (1.1, 1.2, 1.3 and 1.4, see the model)	INTRODUCTORY STEPS. Preparation for CPS, familiarization with the construction of problem schemas as one of the scaffolding tools and the construction of ground rules.	Introductory classes 1, 2, 3, 4 and 5 (7,5 hours) plus individual work
Stage II. Educational environments of inclusion in collaborative problem solving (2.1, 2.2, 2.3 and 2.4, see the model)	STEP 1. Describe the problem preliminary.	Class 1 (0.5 hour)
	STEP 2. Make deep individual and collective understanding of the problem space (including devising an external (visual) form of problem representation).	Classes 1, 2 and 3 (4 hours) plus individual work
	STEP 3. Generate possible problem solutions and make justifications (provide arguments).	Class 4 (1.5 hour) plus individual work
	STEP 4. Finalize your group's solution and monitor the whole problem-solving process.	Class 5 and 6 (3 hours) plus individual work
Stage III. Educational environments of result sharing and evaluation of developed skills (3.1 and 3.2, see the model)	STEP 5. Prepare a presentation.	Class 7 Face-to face and online meeting (min 1.5 hour)
	STEP 6. Share your results and evaluate your group's work.	Class 8 (1.5 hour)
	STEP 7. Reflect on your individual and group learning.	Individual meeting with each student (appr. 1 hour for each)

Stage I. (Educational environments of introductory enablement, INTRODUCTORY STEPS in Table 26 above)

1.1 Introduction to the task. The study module *English (C1 level)* started on the 5th of February and ended on the 30th of May, 2017. It was designed to last for 16 weeks. Specifically, its second part (9 weeks) was aimed at the engagement of students into collaborative problem solving. During **the introductory class 1**, students were explained that the task had two main goals in it: 1) learning English by participating in problem-activities, and 2) learning to solve problems so as to develop/enhance the skill of problem solving. They were also given the detailed explanations about the process (Procedural guidelines for CPS, see Appendix A) and the assessment (Assessment system, see Appendix B). Students were additionally provided with a short version of the plan for all problem-solving sessions (see Appendix M). More specifically, students were introduced to all goals of the CPS process: to increase understanding and knowledge of collaborative problems solving, gain experience of using tools that might facilitate it and get hands-on experience of solving an ill-structured problem in a collaborative manner. Also, the goal was that they learn to monitor and evaluate problem-solving performance and reflect/assess newly acquired competences.

During **the introductory class 2**, students were given the opportunity to meet foreign students in order to hear their ideas on what it means to be studying in a foreign country. It was the kind of scaffolding offered to facilitate problem representation, which was expected to serve as a motivational factor. One student invited was from Spain who studied at this university on the basis of an Erasmus+ visit. Another one was from India that studied as a regular student. They were asked to prepare short presentations on the aspects related to their studies at University X in Lithuania. The presentation of each lasted for about 15 minutes and was followed by question and answer sessions. Students were encouraged to ask various types of questions.

1.2 Introduction to the collaborative aspects of problem solving. 1.3 The introduction to cognitive aspects of solving ill-structured problems. 1.4 The introduction to the tools facilitating problem solving. During **the introductory classes 3 and 4,** students were introduced to collaborative aspects of problem solving, cognitive aspects of solving ill-structured problems and tools facilitating problem solving. During **the introductory class 3**, students were engaged in the discussion titled *For better living and preparation for the labour market: collaborative ill-structured problem solving (CPS).* Specifically, students were first given additional information on the issue and later involved in the discussion on the following topics and subtopics:

<u>What changes occur today?</u>

Major societal changes (information society, knowledge economy, knowledge-rich society, life-long learning)

Major changes in labour markets (technology rich work environments, automation of work places, increase in jobs that require non-routine analytical and interpersonal skills, tendency of working in teams, increased complexity of problems)

<u>What skills matter/ are most important today?</u>

The most important skills of the 21st century as they are listed in major educational frameworks (e.g., Assessment & Teaching of 21st Century Skills' (ATC21S), Partnership for 21st Century Skills (P21Skills))

The most important skills of the 21st century as they are listed by employers (Future of Jobs Report, findings from the Google company)

Examples of new ways of thinking, ways of working, tools for working, and living in the world

<u>What is collaboration?</u>

The current understanding of collaboration

Its definition and differences from cooperation

Advantages of this practice

Examples of previous collaboration cases/Successes and failures

<u>What is an ill-structured problem and what is typical to its solution?</u>

Definition of a problem

Ill-structured vs well-structured problems

Salient aspects of solving ill-structured problems (not self-contained, may have multiple solutions or no solution at all, no preferred solution processes)

<u>What is collaborative problem solving?</u>

Definition and understanding of CPS

Individual problem solving vs collaborative problem solving

Similarities and differences between the two

Advantages of collaborative problem solving

Essence of consensus seeking

Watching the video summarizing the differences between collaboration and cooperation (1.24) (https://www.youtube.com/watch?v=Gr5mAboH1Kk)

<u>How to use visual thinking techniques that might facilitate CPS?</u>

Introduction to different types of visual thinking techniques: concept mapping, mind mapping, system modelling, structure maps, networks, schematic models, problem schemas (their characteristics and uses)

Problem schemas as tools for problem representation and solution (3 constituent parts of them: structural information (semantic information, connected with meaning of words), situational information and structural relationships (including various types of links)

Studying real examples of problem schemas

Collaborative aspects of problem solving. For the following aspect, students were asked to carefully read the rubric describing the desired collaborative problem-solving performance and its levels (see Table 14).

Regulation of the quality of talk/towards an exploratory talk. All group members were explained about three types of talk – disputational (involving contrapositioning of insights without arguments, short assertions and disagreement among group members), cumulative (when ideas are just cumulated in a friendly manner without conservative discussion) and exploratory (requiring not just to add ideas but also to provide arguments, explore different opinions, give clear reasons, to collaborate and try to understand each other’s points of view). Students were reminded that this is the type of talk that is most desirable for educational environments based on problem solving. Students were asked to agree about the ground rules that could satisfy the exploratory talk.

Afterwards, students were asked to form groups according to the self-selection principle and were given the first practical task: to find an example of CPS in practice, discuss it and be ready to introduce it in the class. They did the first task during the introductory class 3 (excluding sharing their findings) and were asked to start doing the second task at home. The second task was to agree about the problem they would like to visualise as a group, find additional information on it and draw a problem schema, i.e. visual externalisation of its structural (semantic information, connected to meaning of words) and situational characteristics, as well as include structural relationships (any types of links). Inclusion of its solution/s was indicated as an optional element. They had to draw the method they represented the problem individually at home and told that they were going to merge their individual schemas into a collective one during class 4. All students were introduced to the ideas of how to construct problem schemas and showed a number of examples of problem schemas containing situational and structural elements, as well as various types of structural relationships following the division proposed by Halpern (2014), which was introduced in more detail in Chapter 1.3.4.

During **the introductory class 4**, students were first asked to share their group's examples on CPS and then continue with the collective construction of a visual representation of the chosen problem.

The procedure for the construction of a collective problem schema included 6 phases. Students were given the following instructions:

1) Brainstorming: Share your individual problem schemas by identifying facts, elements, terms, and ideas that are in anyway associated with the structure and situation of the chosen problem. List these items in a very brief form (use either single words or short phrases). Since it is a brain-storming process, write down everything that anyone in your group thinks is relevant. Avoid discussions on how important the items are at this phase. Do not worry about redundancy or relationships at this point. Generate the largest possible list of structural and situational characteristics.

2) Organizing: Spread out your structural and situational elements on a collaborative problem schema and create groups and sub-groups of the related items.

3) Representing: Try to agree about the layout that best represents your shared understanding of the interrelationships and connections among groupings. Rearrange groupings or bring back the items that were omitted at any time during this phase. Your thinking should be directed by the fact that your group has to connect the items in simple sentences, showing the relationships among them.

4) Linking: Use lines either with or without arrows to connect and show the relationships between the connected items. In addition, you can write a word or short phrase by each arrow to name the relationship. You are allowed to include various types of relationships: 1) part of link (hand -finger), 2) type of/ example of link (school – private), 3) leads to link (practice – perfection), 4) analogy link (school – factory), characteristic link (sky – blue) and 5) evidence link (broken – x-ray arm) (Halpern, 2014).

5) Finalizing: After your group agrees on the arrangement that matches your shared understanding, finalize the problem schema into a form that is attractive, informative and accurate. Be creative through the use of colours, fonts, shapes, border thickness, etc. Use any technological tool for that.

6) Review: Check your collective problem schema for the following aspects:

Accuracy. Are the ideas and relationships correct? Are any important ideas missing?

Organization. Is the problem schema easy to follow?

Appearance. Is the problem schema constructed with careful attention to details such as spelling? Is it neat and logical or is it messy and chaotic? Are fonts big enough?

Creativity. Is the constructed problem schema attractive? Does it stimulate interest?

Availability: Does the tool allow accessing it anytime you wish (by sharing the link)?

During **the introductory class 5**, students were given the task to revise and practise asking different types of questions in order to prepare properly for causal reasoning, which is the essential cognitive process necessary for scientific thinking. It was an individual task for every student:

Choose and watch a documentary related to your major of about 1 hour and write 10 questions on its content to a person that has not watched it. In addition, write the answers to these questions. Do not forget to provide the title of your documentary and the link to it. In addition, write a list of 10 new words/terms (with their definitions) that you have learnt from it. To formulate a question correctly, study the grammar of the provided examples carefully and do not forget about the two most important aspects when formulating questions in English - inversion and the use of auxiliaries. Turn on subtitles while watching.

Different kinds of questions compiled by Graesser, Person, and Huber (1992, as cited in Jonassen, 2011a, p. 287) were taken as examples. Kinds of questions that students could formulate were concept completion (In which liquids does nitrogen dissolve?), feature specification (What kind of polluting process is present?), disjunctive (Are clouds made of water vapour or are they made of droplets?), comparison (What is the difference between water vapour and water droplets?), interpretation (What is happening? Does that graph show a main effect for A?), etc.

Cognitive aspects of solving ill-structured problems. The cognitive aspects of solving ill-structured problems were addressed by introducing students to two main types of problems, typical processes of solving ill-structured problems and providing detailed procedural guidelines, including question prompts (see Appendix A).

Stage II. (Educational environments of inclusion in collaborative problem solving, STEPS 1-4 in Table 26 above)

During Class 1, students were reminded about their involvement in the four main processes necessary for solving ill-structured problems (problem representation, development of solutions, making justifications for generated and developed solutions as well as evaluating and monitoring the whole problem-solving process). They were told that the task is to solve the problem and prepare problem-solving reports, as well as problem solving presentations in each group.

Furthermore, students had to describe the problem preliminary (STEP 1; see Appendix A). The guiding questions included in the procedural guidelines were expected to make the process of problem solving visible and easier. The given question prompts were recommended both for their individual and collective considerations. They included:

What is the problem that the case reveals? (Maybe, there are several problems).

What facts indicate it to be a problem?

Why is it a problem?

What do I/we already know about the problem?

If there are several problems, how are they related to each other? Which of them has the highest priority and why?

Who are the stakeholders in the problem situation, and what are their goals?

What benefits may the solution bring? What are the consequences if the problem is not solved?

By using the questions, students were asked to individually read the case and try to understand if the problem really exists, formulate it as a goal or a question, think about the benefits a solution of the problem may bring and about consequences if the problem is not solved. As a group, they were asked to discuss if a problem really exists and what they already know about it, collectively formulate the problem as a goal or question based on their shared knowledge and group discussion, and formulate the benefits of the problem solution and the consequences if the problem is not solved. In addition, students were reminded not to jump right to the solution process and not to offer solutions during Steps 1 and 2 without first trying to interpret the problem.

For reflection of STEP 1 (the same questions were included for the rest of the steps too), problem solvers were asked to answer the following questions: How do you evaluate your actions and result achieved in STEP1? (Were you deep enough? Are you satisfied with the result achieved? What could be done better? What have you learnt? What has influenced your learning on how to solve this problem and in what ways?).

During classes 1 (the remaining part of it), 2 and 3 (STEP 2) students were asked to continue discussing and making shared understanding of the problem space (including the construction of the external form of problem representation). Individually, they were encouraged to identify what is already known about the problem and collect any missing information by using different sources and forms of evidence. The task was to construct individual problem schemas at home, which they had to bring for the following class. As a group, students were advised to share what they have read or listened to about the problem, listen to the alternative positions and opinions of each member in the group and discuss them. In each group, they had to construct the collective problem schemas (using the same procedure for the construction of collective problem schemas as during the introductory class 4). Finally, students were reminded to reflect as a group on the progress made and results achieved. During this step, learners were additionally warned that proper problem representation (its conceptualization or understanding) is the key to problem solving and multiple representations are desirable.

The guiding questions for STEP 2 were:

What do I/we already know about the problem?

What are its elements, context, causes, constraints, stakeholders involved, etc.?

Is there any missing information? What information is missing?

What are relevant sources for the gathering of information?

How are the facts, context, causes and constraints interrelated to each other?

How could I/we present them structurally as interrelated with each other?

Have I/we collected enough evidence for understanding the problem?

Do I/we need additional evidence?

What type of additional evidence do I/we need?

During Class 4 (STEP 3), students were asked to generate possible problem solutions and make justifications (provide arguments) for them. First, they were encouraged to think about and be ready to present their individual solutions. Afterwards, in groups, problem solvers were asked to share personal positions about the preferred solution(s) and construct arguments for them (give reasons).

Furthermore, they were instructed to discuss the alternative solutions (proposed by each member in the group) by asking additional questions and assessing their viability. If necessary, each group was advised to create new collective ideas of alternative solution(s). The groups were informed that they do not need to finalize their solutions in STEP 3 (more time for that was allocated during STEP 4). Finally, students were reminded to reflect on what they were doing and what results were achieved.

The guiding questions for STEP 3 were:

What do you think the best solution could be?

How would you prove that this is the best solution (be ready to give reasons)?

What might somebody else say to show that your solution is wrong?

What could you tell him or her to show he or she is wrong?

Do outcomes of this solution match the goal of your group?

Is your solution feasible after considering all the constraints of this problem?

What is its way of implementation?

Do we have all candidate solutions?

Do they eliminate the whole problem or its part/elements (which?), eliminate or diminish causes (as entity or some of them)? Is it possible to show this relationship on our problem schema?

What are the pros and cons of these solutions?

Have we considered all the constraints?

Have we taken into account all the perspectives of different stakeholders?

Do outcomes of these solutions match our group's goal?

What are the probabilities that our solutions will be implemented successfully? Which ones?

Throughout STEP 3, students were constantly reminded that ill-structured problems may have many alternative solutions and multiple solution paths. In addition, they were asked to generate arguments not only for their own solutions but also for or against those that were proposed by the other members of the group.

During classes 5 and 6, the groups had to undergo STEP 4 that asked them to finalize their groups' solutions and monitor the whole problem-solving process. More specifically, they were advised to discuss the available candidate solutions, select and apply certain criteria to judge them and, finally, reach a consensus as a group by agreeing on 1-2 solutions. In addition, the provided procedural guideline suggested to discuss and agree on the best course of action to implement the agreed solution/s with assessing the outcomes that match the goal. At the end of STEP 4, students were reflecting on the process and results achieved.

The guiding questions for STEP 4 were:

What are the available solutions?

What could be the counterarguments (arguments against) to these solutions?

What could be the criteria to judge the solutions?

Why is this solution the best choice? Why do we choose this way to solve the problem (discuss the reasons for it)?

How will it solve the problem? Do outcomes of this solution match the goal?

Have we considered all the constraints? Have we taken into account the perspectives of different stakeholders?

What are the ways to implement this solution? What do we need to do additionally?

Do we need additional information?

What should be done about any difficulties the solution might pose?

Have we considered the implementation plan in detail?

Throughout STEP 4, students were repeatedly reminded that ill-structured problems may have multiple criteria for evaluating solutions. In addition, students were explained that the best solution is the one that is most viable, defensible and for which the group can provide the most cogent arguments.

Stage III. (Educational environments of result sharing and evaluation of developed skills, STEPS 5-7 in Table 26 above)

During classes 7 and 8, students had to undergo STEP 5 that asked them to prepare a collective presentation on the solution/s that the group has arrived at. Furthermore, they had to share their results and evaluate both group and individual work. Afterwards, individual time was agreed to conduct semi-structured interviews with each student, so that students can reflect on their changed competencies and provide the data necessary to analyse their views on the process, results achieved and impact of the educational environments.

The subsequent chapters include the results from each case, cross-case synthesis of results including conclusions based on results from all cases, summary of peculiarities in each group and discussion of cross-case findings.

3.3 Findings from Case 1, Case 2 and Case 3

The findings from each case are presented separately under each factor of educational environments that are divided into three stages according to the model devised. Cross-case synthesis of findings is not present in this section. The description of each stage is organized to answer all research questions: how each group was learning to solve problems, how factors of the following stage enabled students to solve problems and what results were achieved in each stage. Each aspect of the educational environment is given a separate section with its title under which results are listed. For their special importance, cognitive and collaborative aspects are separated for each group when presenting the results of Stage II.

The procedures to implement all three stages of the planned educational environments were already described in detail in Chapter 3.2 (The implementation process of the model), which partially answers the first research question on how groups were learning in terms of what educational measures were developed by the instructor.

Stage I. Educational environments of introductory enablement

Additional knowledge on collaborative aspects of problem solving. Concerning additional introductory knowledge on the collaborative aspects of problem solving, students from Group 1 reported on diverse aspects related to the increased understanding about it. All four students mentioned the idea that the most common type of their interaction was usually cooperation. Two students observed that cooperation was different from collaboration in terms of time management.

We usually divide our work in order to complete the tasks quicker. We did it very frequently at school too.

Working in this way (collaboration) is unusual and an interesting experience, though time consuming.

I understood that we have never had real collaboration as we usually divide our tasks among ourselves.

Now I see, it (collaboration) is different and agree that we should be working exactly in this way.

Students also commented on the changed understanding about the difference between individual problem solving and collaborative one.

Well, I have never thought about that but now I see the difference between them.

I do agree that whenever everything becomes that complex we certainly need collaborative efforts towards the solutions of problems.

Seeing the changes around us, I believe that it is collaborative problem solving that might help to succeed.

Students from Group 2 also commented on similar aspects about this stage. As in the first group, an eye-opening insight was about too frequent cooperation instead of real cooperation. The following excerpts exemplify this:

It is even so common among us that it is difficult to imagine how to change all this practice.

We like cooperation because you can do everything easier.

Of course, cooperation is more successful here at the university because at school we usually encounter the problem of not equal time spent when dividing our tasks. Here we divide tasks in equal portions.

Now I see it (collaboration) a bit differently. Nothing else I can remember.

Members from Group 3 also commented that this stage was most useful because of new insight into what real collaboration meant, which proves the fact that the practice of real collaboration is still rare among students.

Earlier I have not understood collaboration correctly.

It opened my eyes about collaboration…the rest do not remember.

Such cases (collaboration) are rare if ever present. I liked the ideas we shared.

I think the examples (of CPS) have changed my attitude towards it.

Additional knowledge on solving ill-structured problem. In Group 1, there was no supporting evidence that additional knowledge students had been provided with somehow affected their learning. In addition, observational data had no entries on this aspect. In Group 2, there was also no supporting evidence that it had somehow affected students' learning. Neither in Group 3 did students explain that additional knowledge had somehow affected their learning to solve problems. During the later stages, it was difficult to trace how the attempts to provide additional knowledge on ill-structured problem solving during introductory educational environments was beneficial for students.

Ground rules. After all students were reminded about the importance of the quality of their communication and participated in the discussion on these aspects (namely, to become able to distinguish among disputational, cumulative and exploratory types of talk), ground rules (agreements about the desired behaviour) were formulated. All groups were contributing to the formulation of the following ground rules:

- ✓ *Everyone is required to share information.*
- ✓ *Joint responsibility for performing the task should be present.*
- ✓ *Everyone is required to participate equally.*
- ✓ *All opinions are welcome but compelling reasons for them should be provided.*
- ✓ *Agreements should be reached by retaining a friendly atmosphere.*
- ✓ *Monitoring and evaluating of the process and progress made should be present.*

When sharing their opinions about the use of these rules, students from the first group simply answered that they either had not been following them or had forgotten about them all together.

Ground rules, yes…we had them on the table. To confess, I do not remember exactly.

I am not sure whether they changed anything.

To my best knowledge, we had neither time nor reasons for coming back to these rules.

The members from Group 2 also contributed to the formulation of the aforementioned ground rules. Similarly, there was no supporting evidence for the enhancement of problem solving and improvement of the quality of talk due to the presence of these rules. Students' answers confirming it were:

….do not know, probably helped…

At first, they seemed useful but probably we were not thinking about our agreements but concentrated on the outcome we have to achieve…

…I forgot about them…

In Group 3, there was also no explicit supporting evidence that they had any significant influence on the quality of students' communication or the very process of problem solving.

<u>Introduction to problem schemas.</u> The comments from Group 1 about the construction of problem schemas can be divided into positive and negative responses. Among the positive responses, members of this group mentioned that this experience was new, rewarding and useful for learning new ways of visual thinking. Some students listed the benefits of this activity for problem representation. In addition, all students confirmed that this stage helped them to be more successful during the later stages.

Easy to remember information…

Thinking differently. It was interesting to find out how to visualize and summarize information in this way.

It helps to see and understand how others see the same issue.

It was useful to do because we learned how to do it (I personally liked it). And it was also useful to broaden the horizon and learn something new. We used this later.

Yes, it was new and helped later to understand the problem we had to solve.

Negative aspects mentioned were about too much time required for searching new technological solutions and complaints that group members had not been equally participating while doing this task, which also proves the fact that students do not participate equally whenever collaborative efforts are required.

...got to know new programs though it required much time...most of them are not free.

I did not notice anything difficult, except we were missing some group members.

Although we were expected to collaborate, I had to finish it alone and it took much time.

I learned to work with new programs.

It took very much time until I found the right program.

The constructed collective problem schema in Group 1 (see Appendix C) is the proof that students managed this way of visual thinking. As required, the schema had both structural and situational elements of the problem as well as the links between them. Although the links had no labels above them, students were creative in the usage of shapes and colours for their ideas. The observational data also revealed that Group 1 was enthusiastic in the process of this schema construction.

Again, as in the first group, students from Group 2 were commenting both on positive and negative sides of this stage. The most frequent positive aspects were that it was a new and enjoyable experience. One student found the relationship between problem schemas and concept maps he was drawing at school. Students from this group mentioned the lengthy time for mastering new technological ways of how to draw them as the main problem they encountered. The excerpts below exemplify these insights:

I did it for the first time and now can tell that I would like to use it more.

It was an interesting experience and probably might be useful for my studies.

No, now I can do it quicker.

I enjoyed this activity and learned a new app. It is a true imagination booster.

New? Maybe, it looks similar to concept maps.

It took much time.

Long process but it pays off in terms that I enjoyed all this.

It took much time until I found the correct app for that.

Observational data revealed that students from this group were active in the construction process and it took much time until they found the right program for completing this task. As it can be seen in Appendix D, the collective schema they constructed contains both structural and situational elements as well as various types of links. In addition, this group was creative in the use of colours for the layout and organization of their collective ideas. They applied short phrases for the labelling of links.

While commenting on the introductory learning to construct problem schemas, members of the third group indicated that it was the kind of activity they liked; as well as it was new for them. The following excerpts exemplify this:

I can say that it was a type of activity that we enjoyed. We learned new tools and then shared these ideas among ourselves.

I like to learn new technological solutions because we need them nowadays more than ever before.

I like visualising what I think, that is an interesting idea.

It allowed us to structure our shared ideas in new forms of thinking.

In my opinion, everyone in our group enjoyed this process (the construction of problem schema).

As it is shown in Appendix E, this group included structural, situational elements and various types of labelled links in the collective schema they created. In addition, they showed the solution of the problem in the same schema. This collective visual representation of the problem serves as proof for the increased experience of constructing problem schemas.

<u>*Other aspects (during the introductory enablement).*</u> <u>*Group formation.*</u> All students in Group 1 were satisfied about the self-selection principle their group formed and indicated it to be a very important stage in determining group performance.

We were lucky to know each other before…we had some cases of collaboration before…trusted each other…except X but everything was perfect.

Our group was excellent…we were happy to be allowed to choose.

Our success was greatly dependant that we were such a group… I think we were different

We liked X (one of its members) in our group.

Luckily, we were allowed to be in the same group because we knew each other earlier…no difficulties were caused…I trusted X, X and X.

Students liked the foreigner X to be in their group, who was seen as a motivating factor for the rest of the members. Despite the fact that he was collaborating with this group for the first time, all group members were very friendly with him and there were no obvious signs he had just joined the group. In addition, two students confirmed the fact that earlier relationships mattered for the selection of group members. As this view was expressed by two students, relationships based on trust was the main reason of why these students had merged into one group.

As it concerns group formation in Group 2, students' comments were very scarce. No important ideas were expressed. However, observational data revealed that having eight students in this group was too large a number, as some students were skipping classes and were less active in the process.

Similarly, as in the first group, students from the third group considered group formation to be an essential factor determining group work. Students' comments were that they prefer self-selection and not the other way:

It is better we are allowed to choose which members are in our group. It matters a lot.

I did not like them (two girls) to join our group, we did not know them very well…they are not tested over time.

Everything was ok except these two members (two girls)…sometimes it was teasing me.

We could have done everything better if not wasting that much time trying to explain repeatedly what they missed. I did not like this. They were skipping classes.

<u>*Selection of the problem.*</u> Students from Group 1 expressed positive attitudes towards the problem and indicated it as an important motivational factor determining the performance of its members.

I personally liked the problem.

Well, the problem was very interesting, especially when having X (a foreigner) in our group.

We were very interested in it.

We liked it and this made us more focused on the task. We enjoyed the way the other groups have to offer solutions to the same problem and waited for that moment impatiently.

An interesting finding expressed in this group was that engagement of students into ill-structured problem solving that is coupled with competition among groups was a motivational factor.

Data from observations of this group also prove the fact that all members welcomed the suggested problem enthusiastically.

Students from Group 2 also expressed divergent views on the problem and indicated it to be a significant motivational factor in the tasks like these.

I think our views about it were changing over time.

Not sure whether it was really interesting…we may have solved something more closely related to our major.

Whenever it is interesting, the task becomes different.

It (problem) was quite challenging.

The problem was ok.

First, the given problem seemed to be boring but later I really got interested in it.

Similarly, the answers of students from Group 3 showed that students saw the problem selection to be an important motivational factor determining performance of separate individuals. Again, different opinions about the problem were expressed:

Students could be involved in the choice of the problem.

Not sure (about the problem). Maybe it was interesting.

Do not know (about the problem).

First, it was quite interesting, later I saw no personal interest in it.

<u>*Expert modelling/ advice/ view.*</u> During the introductory class 2, two foreign students telling about their experience in Lithuania served as an unplanned type of scaffolding. The observational data revealed that problem solvers were interested in what these students were saying and were very active in asking questions. Although no evidence supporting these facts was collected, it might be that both students added a more diverse perspectives about the problem solved and served for better problem representations in each group.

<u>Stage II. Educational environments of inclusion in collaborative problem solving</u>

Similarly, as for Stage I, the procedures to engage students into CPS developed by the researcher were described in detail in Chapter 3.2. The current part provides the results on how each group was learning to solve problems, how factors of the following stage enabled students to do that and what results were achieved.

Group 1. *Cognitive processes (problem representation, development of solutions, evaluation of solutions, making justifications, construction of arguments and monitoring, as well as evaluating the problem-solving process).* As it concerns cognitive processes, all members from Group 1 were observed to be participating in the problem representation process, by taking part in the discussions aimed to clarify the situation described in it, identify its causes and constrains; as well as to understand its variables and their interrelationships. They were sharing the information that was already known and new information, were figuring out what information should be additionally searched for and discussing on how and where to collect it. Each student was reading additional material at home and bringing short summaries to the classes. All students were active in the process, with two students dominating in this group. Dominance was observed because these students were speaking for a longer time in comparison with the remaining two.

Furthermore, all group members from Group 1 were observed to be participating in the process of problem schema construction. First, all members constructed their individual schemas and then merged them into the collective one by following the suggested procedure, including 6 phases (see Chapter 3.2). While three students were more resourceful with the number of ideas in their individual schemas, one student had fewer ideas in her schema. The individual schema constructed by one member of the first group (see Appendix F) exemplifies a thorough initial individual problem representation before offering available solutions.

The problem-solving report Group 1 created was the outcome of students' learning to solve problems and inclusion into all three stages of the developed educational environments. It contained all required parts: 1) description of a collaborative process of each stage, including reflections on it, 2) a collective problem schema, 3) problem solutions, and 4) the list of useful vocabulary all group member compiled throughout all the process (with 126 new vocabulary items in it).

The constructed collective problem schema of Group 1 (see Appendix G) confirms their inclusion into the problem representation phase. Their solutions offered were the result of inclusion into the development of solutions. The group decided to provide three versions of their collective problem schema in the problem-solving report (the provided appendix includes Versions 1 and 2). This proves the fact that this group was successful in achieving one of the essential outcomes during CPS – shared understanding creation based on multiple representations. In addition, each later version shows the improved problem representation in comparison to the first one, which confirms the presence of a high level of breadth in the understanding of the given problem.

Their collective schema contains structural elements, situational characteristics and structural relationships among them. It is quite accurate because it includes important problem aspects that were advised to be considered and formulated in the questions during the problem representation (benefits, consequences, etc.). It is also well-organized, easy to follow and uses different sizes of boxes according to the importance of structural and situational elements. Although a couple of spelling mistakes are left, the constructed schema has an appealing appearance and shows creativity of this group.

Observational data also confirm that the construction of the collective problem schema engaged students in shared and deep understanding creation. During classes 2 and 3 (STEP 2), all students participated in its collective construction process (by merging individual problem schemas into the collective one). The members of the first group used various technological solutions to construct their individual schemas: Microsoft Visio, Google Drawing and Microsoft Word. Among the benefits of constructing problem schemas, students listed that this process had made both the remembering of ideas and problem representation easier. One student repeated the idea that all the group had enjoyed this activity again.

We were very enthusiastic about its (collective problem schema) creation.

Definitely, I will use this new capability (problem schemas) because I could see how useful it was for our group…you do not need to remember everything, it is all seen on a sheet of paper

It helped to understand the problem better.

Without it, remembering all the discussed points could have been much more difficult.

In the problem-solving report and semi-structured interviews, when describing the process, students commented on the creation of their shared understanding, attempts to reach consensus, seeking thorough understanding of the problem and lengthy discussions about it. They also listed the benefits of constructing problem schemas. A useful idea mentioned was that the schema had facilitated the remembering of ideas.

After brainstorming our opinions in the second problem-solving session, we have agreed.

After a long discussion and use of additional information gathered…

…were shared our individual solutions. Since some solutions sounded very similar, we combined them.

In this way we merged what each other found out.

It was the time to agree on final solutions and after detailed discussion based on consensus we came up with two possible solutions

I was not expecting it might be such a long time but after all it resulted in a full understanding, at least, as I imagine.

We all realized that the constructed schema helped us to remember all ideas that we had already shared.

It helped us to collect our ideas into one place and not to miss important ideas.

Furthermore, all group members were observed to be participating in the discussion of the solutions the problem might have. Each of them were offering and justifying their own solutions. As it concerns additional information collection, students were observed to be not equally reading on the problem. The instructor trusted students and was not checking the list of references before Steps 2 and 3 that required additional information collection.

All group members were active during the process of preparing a group presentation and drawing the poster with their ideas for the stand they offered.

Drawing the poster was suggested by one group member and was not among the requirements of the task (see Appendix M).

During step 3, students were offering their own solutions. For example, the solution offered by one member in this group was:

I would like to create a website and add all necessary details for those that would like to study in Lithuania.

Both in their written problem-solving report and in the presentation, this group suggested two solutions for the problem:

> *The first one is to form mixed study groups by accepting the English speaking students. This could improve relationships between native and foreign students. The international students could broaden their understanding of our country and university. This could also encourage those students to recommend our university in their home countries. It could be implemented by collecting signatures for a petition to have an opportunity to choose between subjects taught in English or Lithuanian. Moreover, it could be a good opportunity to improve the English language proficiency for the teaching staff too.*
>
> *The second one, which we think is the better solution, is that our university might encourage students to form KTU representative groups made of Lithuanians studying at various European universities according to the ERASMUS/ERASMUS + programme. To implement this system, students should be offered opportunities to join these groups and represent KTU. To support them, KTU could invest and provide extra funding for those students. These groups could make a website or social media profile that would be easily accessible for everyone. This group could also allocate some time to consult students by the stand of KTU and in this way advertise our university. The aim of this group would be to provide awareness about our country, our university, its faculties, study programmes and its partners. This could be the best solution to attract more foreign students because it can be easily implemented in various European countries at the same time without our university investing much money into it.*

As it can be seen from the quote above, the first group offered two creative solutions and included explanations on how these solutions could be implemented.

Concerning students' reflections on the activity and results achieved, the provided procedural guidelines included questions to reflect on their group's activity and results achieved. Students were reminded to answer these questions after each problem-solving step. The group was following this instruction and spending time for reflections at the end of each step.

***Group 2**. Cognitive processes (problem representation, development of solutions, evaluation of solutions, making justifications, construction of arguments and monitoring, as well as evaluating the problem-solving process).* Concerning the cognitive aspects in Group 2, all students were observed to be participating in representing the problem, generating and evaluating solutions as well as evaluating and monitoring the process and progress made. While three of them were very active, the remaining were less involved.

During the process of problem representation learners were defining the problem, discussing its causes and constraints and trying to understand all the unknowns. The majority of students were searching additional information at home and then sharing it during the classes. In addition, students were not only looking for new information at home but also using their screens to collect additional information during the classes. Even though some attempts to suggest solutions were present from the very beginning, students engaged in the process of suggesting solutions more actively only after a deeper understanding of the problem.

All students were observed to be participating during the construction of individual problem schemas and then the collective schema. Only one student was late to bring his individual problem schema; but did it later. This proves that this group shared multiple problem representations that were later merged into the shared understanding of the problem. The joint schema prepared contained both structural and situational elements of the problem as well various types of links. It was prepared in a creative manner, was well-organized, accurate and attractive. Despite this, the group had the longest discussions on how to merge all individual ideas into one collective schema. The members of the second group also applied various technological solutions to construct their individual schemas: Microsoft Visio, Power Point, Draw.io, Liucidchart and Paint.

During the process of generating and evaluating solutions, each problem solver developed personal solutions. While some were offering more than one possible solution, the rest offered just one. Group members engaged into lengthy discussions of considering the appropriateness of the proposed solutions. In addition, different criteria were suggested to judge them. During the process of monitoring and evaluating students looked back and monitored the efficiency of group's work, as well as discussed what could be improved. They used questions provided in the procedural guidelines.

The group was able to complete the steps for each problem-solving stage in the time required. Only the last step 5 of preparing a presentation required more than one class for face-to face meetings. For this group, Steps 3 and 4 were observed as needing less time than it was planned in advance.

This group was additionally noticed to be having frequent periods of time for off-task joking and chatting or there were cases when two students (not necessarily the same each time) were detaching from the rest and engaging into off-task activities. Some students were frequently seen to be watching their screens of their smartphones. Maybe these were cases for note taking or checking of new words, but probably multitasking cases were also present.

In their created problem-solving report and semi-structured interviews, students commented on the processes to create shared understanding, arrive at consensus and reach a deep understanding of the problem. They reported about spending plenty of time for discussing the problem and its possible solutions.

I brought my ideas and then all our ideas reflected in our schema even though some of them we decided to omit. Having all of them on the same space made it too complicated.

I was able to share my ideas and the rest did the same, some of them were the same.

It was difficult to agree which of them (ideas about the problem) we should be leaving on our sheet.

These questions involved us in lengthy discussion about the problem.

The next class it (the discussion) was even longer because some of us brought more ideas.

After brainstorming our opinions in the second problem-solving session we have agreed.

I had to stay friendly and agree…

It was very useful as I was able to see how everyone approaches the problem and what I miss in that.

In their problem-solving report, Group 2 suggested one interesting solution that was expressed both in their written problem-solving report and in the presentation (see Appendix J for proof of its implementation):

> *We reached the common solution to write a blog titled Erasmus + Lithuania and spread everything what is happening at KTU. In this way we will make Lithuania more famous and attractive. Also, we offer foreign students to contact us in case they have any questions or want more details about the study programmes at our university. In addition, we suggest to answer any question about living and studying in Lithuania.*

At the end of each step, the group was repeatedly reminded to reflect on their activity and progress made. In some of the cases, students were not very serious about these reflections and were simply skipping this part.

Group 3. *Cognitive processes (problem representation, development of solutions, evaluation of solutions, making justifications, construction of arguments and monitoring, as well as evaluating the problem-solving process).* In Group 3, the observations revealed that all 6 members of this group demonstrated behaviour that is required for CPS in terms of cognitive skills. All students participated in the processes of representing the problem, generating and evaluating its solutions, as well as evaluating and monitoring the process and progress made. During the stage of problem representation, learners were clarifying the situation described in the given problem, discussing its causes and constraints and were agreeing about the common goals. In addition, they were showing efforts to collect additional information which was related to the problem. Some attempts to start suggesting solutions were present before students defined the given problem thoroughly.

All students participated in the construction of individual problem schemas and then in the collective schema. This proves that they created multiple problem representations that were merged into the collective schema and in this way a shared understanding was created. For their collective problem schema, see Appendix H. The members of the third group also used various technological solutions for the construction of schemas: Microsoft Visio, Power Point, Google Drawing and Microsoft Word. They were additionally consulting each other on which tools were better.

Visual representation of the problem was first done by each group member at home individually. Only one out of six students did not prepare his individual problem schema. The creation of the collective problem schema was observed to be enhancing students' engagement and creativity. The given problem was analysed in greater depth and therefore a longer time was required. This group was additionally observed to be experiencing difficulties in the stages of organizing ideas because the individual maps each member created (all members completed the task) were very resourceful.

During the process of generating and evaluating solutions, each problem solver developed personal solutions. Group members engaged in the constructive discussion of considering the usefulness, effectiveness and suitability of alternative solutions. The group managed to complete the steps for each problem-solving stage during the time provided.

During the semi-structured interviews (this group did not include its reflections about CPS in their problem-solving report), the students' descriptive accounts included repetitive quotes of how they were creating shared understanding. Students were also repeating the idea of a long time spent on the task, as well as considerable efforts to understand the problem. The following excerpts from the semi-structured interviews conducted with the members of this group exemplify the mentioned results:

Yes, it took long time for us…

X presented his ideas and then we supplemented him.

We could all share what we read at home.

…joining our ideas was a lengthy but a useful process.

Without it (collective problem schema), I am not sure whether we could reach such a thorough understanding of all causes it (problem) had.

Our initial understanding of the problem was refined later

To make the big problem more manageable, we together broke it down to smaller bits and

Making consensus was a simple process as we had enough information on what issue should be focused to make a change.

In Group 3, students offered solutions that could be implement by them as students:

> *The solutions we offer include both the ones that we as students could implement and those that would require more influential factors, which we cannot really impact, like spreading information through the international media. We also tried to explore the general ideas of how some of these solutions could be implemented, like having to create a profitable story to give media a reason to talk about Lithuania in the first place. This step was not the case of one person offering a solution and explaining how it works to the rest of us, but rather a person offering a solution and everyone brainstorming how it would work, therefore these solutions are not individual but all made through group effort. Out of these many solutions we chose two which we can implement as students. The first solutions is choosing the modules in English and making more international connections. It seems to be the most straightforward one, the effect of which is the improvement of both students and lecturers' English skills, which would then make the university more attractive on the international level, as*

well as create a possibility for the Lithuanian students to meet foreign students already here. Of course, there are obstacles to implement this solution, for example, the reluctance of the Lithuanian students to leave their comfort zones and learn their subjects in another language in fear of not understanding the subject.

The second one of making international connections also relies on students' initiative to take actions and change their learning environment. As far as we analysed this solution, it could be simply put into effect by the Lithuanian students participating in international exchange programs like Erasmus+ and actively befriending international students and inviting them to study in Lithuania. On a smaller scale similar actions can be taken by participating in international students' conferences or competitions. The restraints of this solution are similar to the first solution's restraints which is the reluctance of Lithuanian students to leave their comfort zone by going abroad or engaging in conversations that would improve the image of Lithuania in foreigners' eyes.

All group members were participating in the discussion on their progress made. During it, students were also planning their further steps. Also, there were cases when this group lacked time for reflections and did not consider it as a necessary part at the end of some steps.

Group 1. *Collaboration (attendance, perspective taking and social regulation).* Students from Group 1 were observed to be showing high levels of collaboration (the performance of all students matched either middle or high levels, see elements of collaboration and their descriptors in Table 14). Despite the fact that one student missed two classes, the quantity of participation was satisfactory. All students were not just participating but also active during all the classes. The quality of interaction was also noticed to be high. Students were seen assuming responsibility equally and no division of work was present.

The data from the semi-structured interviews revealed that members of this group highlighted the importance of equal and fair contributions of each group member, which was present in this group. They indicated shared responsibility as an important aspect towards the achievement of the group's goal:

I liked my group, we were lucky that all members were participating equally.

All of us were contributing to the task equally and I think it should always be so when we are asked to collaborate.

Everyone in our group was responsible…there was no student that did not contribute to the task

Despite successful participation of the members in this group, one students explained that he still preferred working individually:

Let me think…I always prefer working individually because I am used to it.

A significant factors that affected this group's learning was the presence of a foreign student who was very active. First, students were prevented from using their native language and, second, he was like a person who could represent the perceptions of what it meant to be a foreign student abroad.

Three students from Group 1 observed that they advanced in the way they could adapt to and respect each other.

Never thought it (collaboration) is that difficult but, I think, I improved in the ways I can adapt to the rest group members. I knew I have to.

We became more polite to each other and had to adapt our behaviour to avoid conflicts.

I had to respect the ideas of my colleagues.

***Group 2.** Collaboration (attendance, perspective taking and social regulation).*

In terms of collaboration, the majority of students from Group 2 were observed to be showing high levels performance. There were 3 students out of 8 who missed part of 13 classes when the group had face-to-face meetings. One of them missed 3 classes while the other two missed 2 classes. This fact caused some short process losses, i.e. the rest of the group members had to spend additional time to explain the progress already made by this group after the classes these students missed. However, while the missing students were trying to catch up as soon as possible, one of the students did not demonstrate a willingness to find out what he missed and thus reconstruct shared understanding fully. In addition, the researcher observed the increased attendance of two students in comparison to their attendance during the earlier classes before the problem-solving session. In Group 2, during the face-to-face meetings, there was no division of work observed. However, during semi-structured interviews, two students from this group explained that they were cooperating by dividing tasks among themselves when they met outside classes:

We had probably two or three times when we divided the task among ourselves.

We were talking online and agreeing who has to do what.

We lacked time to finish it during the class, thus X told me what I had to do and what the rest were expected to be doing.

In Group 2, its members experienced some difficulties with shared responsibility. For example, when it was time to upload the collective problem-solving reports, it was not clear who has to do that and no one wanted to take this responsibility. This group had 8 students with no clear leader in it. While some students were active during some particular steps, the others were more active during the rest.

***Group 3.** Collaboration (attendance, perspective taking and social regulation).*

Regarding students' participation in Group 3, the observational data revealed that out of 6 students and 13 classes that the group had for the face-to-face meetings, there were only 2 students who missed part of the classes. One of them missed 3 classes while the second one missed 4 classes. Again, this caused slight process losses as the other students had to use time to reconstruct the shared understanding and tell about the progress the group had made.

In Group 3, two students commented about the learnt new ways of how to adapt to each other:

I was speaking very quickly but had to adapt to the rest because it seemed that sometimes they do not understand me that quickly.

Even though I was lazy sometimes, I had to do the same the rest do.

Seeing the problem from many perspectives makes you admit that not only your own vision about the problem is right.

Frequent complaints were about two students that had not been active enough during the whole process. The excerpts exemplify this:

I did not like X was participating not equally for most times.

Yes, she was participating but not speaking that frequently as the rest in the group.

They both could have been more active, I think, it is not fair.

During the face-to-face meetings, there was no division of work observed. However, during semi-structured interviews, two students from this group shared their experience about dividing tasks among themselves when they met outside classes:

We divided what each of us have to do via the Messenger chat.

X promised to complete the slides, I was responsible for preparing the speech during the presentation.

We agreed that X finishes it at home alone.

Each of us had to do this separately.

In this group, two students expressed interesting findings about the lack of trust in each other.

Two members in our group were probably not trusting each other and willing to do at least some parts of the task individually.

I did not like X was trying to do it alone. Probably he thought of being able to do it better.

In Group 3, the researcher observed uneven shared responsibility as some students were more active than the others. Two students seemed to be very relaxed and were waiting for the others to be responsible for the achievement of subgoals of the task.

Use of English. In Group 1, no important difficulties in terms of language usage were observed. All students were expressing their ideas and were able to participate in the processes that required lengthy discussions. Of course, one student was observed to be most fluent and talking for the longest time. One student was slower in expressing her ideas but she was trying hard. Overall, the students' comments about English as a working language proved it not to be a hindering factor of the educational environment. Among the benefits of such language learning, they mentioned the reduced fear of speaking, as well as indicating this type of learning to be different from what they were used to earlier. In addition, students observed the progress made.

First, I thought how I can speak for that long time just in English, but I did it.

Speaking so long in English was unusual but it helped a lot…I felt that it was much easier later.

You do not need to worry about your mistakes because you simply forget when you have to speak for such a long time.

…seeing others not caring about their mistakes made me relaxed too.

I think I was improving slowly…yes, it [expressing ideas in English] was easier

What I could not understand she always reformulated and explained in other words.

It (speaking English) was not a problem.

Maybe it was more difficult in the beginning but later I was not even thinking about it

I was a bit hesitant about it in the beginning. But later I got rid of my stage fear.

It was extremely helpful and useful. Now I am able to talk confidently in front of anyone. I am not afraid to make mistakes.

Everyone did a great job. I saw some people hesitating in the beginning which was changing towards the end of the course.

In Group 2, although students were not equally active and quick in expressing their ideas, the use of English as a working language was not seen to be a problem for the process of learning. Students were also commenting on improved English, increased speed to express ideas and, most importantly, reduced fear of speaking. They indicated problem solving during the English classes as a new form of learning for them.

Even though I am not used to such activities, it helped to improve my speaking abilities

I observed that each class I was more confident and able to express my ideas…

No doubt, it was very different, so long time for speaking...even at home it seems I kept thinking in English.

…did it no matter that it difficult to believe that you can speak English for such a long time.

First, I was afraid that the rest might laugh at me for not being that good in expressing my ideas…no thought about that later.

No matter you do not want, you were made to speak English, there was no way to escape.

…increased vocabulary and speed of speaking

We had to work much and it was different. I liked we were doing listening tasks at school.

This was very different from what we had at school…speaking for that long time …I am not saying it was useless.

In my opinion, earlier it took longer to find ways in expressing my ideas, now I can do it quicker.

Despite the fact that most of us were slower in expressing our ideas in English, it was a valuable experience.

In Group 3, students were highlighting various benefits of such an English learning task. They mentioned that their speaking time increased a great deal, speaking anxiety reduced, their observed progress made in communicating. Furthermore, two students indicated frequent cases when students had been supporting each other in expressing ideas and facilitating understanding and in this way participating in mediation activities. Three of them saw this kind of activity very unusual and making them even forget they are learning English.

I knew there was no way to be not participating and that is why I had to overcome this fear (of speaking English).

I observed not only myself but also X progressing in the speed we could express our ideas.

I became quicker in expressing myself and increased my vocabulary.

Could not imagine….this helped me to improve (speaking English).

He was always helping me with the new words

X was initiating our talk.

In the cases I did not know a word, I was writing it on a sheet of paper and the rest helped me quickly.

Although it was not traditional, I was relaxed and enjoyed this type of learning…

<u>Provision of detailed procedural guidelines (including question prompts).</u> In Group 1, the observational data revealed that students were asking and answering questions according to the order they were listed in the provided procedural guidelines. The questions served for the engagement of students into a thorough and lengthy discussion about the problem. Students' answers in the first group supported the fact that these guidelines made the process easier and made all learning processes more structured:

Yes, without them, probably, messy ideas and no logic.

The guidelines were useful. We always knew what we are expected to do and what we are expected to be talking about, especially, when random discussions seemed to be leading us in the positions not related to the problem itself.

I could not imagine what we will be doing for that long time but the procedural guidelines helped a lot.

The questions prompt played a huge role in our problem solving. They widened our horizons and made us approach the problem in different dimensions.

In Group 2, the observational data revealed that students were using the provided procedural guidelines. The following excerpts exemplify the fact that students from this group also found the provided guidelines useful, even though some parts of it were indicated to be too long.

The whole procedure was clear. Yes, these sheets (the procedural guidelines) were useful, maybe a bit to too long. We are not used to that.

I agree they (the procedural guidelines) should be given to students.

We have not encountered any problems, everything was clear in terms of what we are expected to be doing and discussing. Some parts of it were a bit too long.

Probably, without them, we could have been not that successful and not knowing what to talk about starting from the first time.

Both during semi-structured interviews and in their problem-solving report, students from Group 3 were reporting that the provided procedural guidelines were useful and facilitated their group work. In addition, they mentioned that some of the steps in the procedural guidelines did not match the time required.

Yes, they were quite useful.

They (procedural guidelines) helped us, especially, when we were running out of ideas.

…it (STEP 3) was too long so we did not what to talk about, everything was mentioned already…

We were impatient to continue and no need to have this process (STEP 3) that long …

We lacked time to prepare our presentation and had to meet additionally…

This time could have been saved for the presentations…

Although it was not a recurring insight, one student observed that the provided question prompts had served for the facilitation of the discussion, since students had not been using their native language.

It was useful because we had to use English all the time. Sometimes there were pauses in our communication but these questions helped us to come back on track.

In addition, observational data revealed that students were constantly referring to these guidelines. In most cases, they adhered to the order of the stages. Although there were some attempts to start offering solutions without a deep understanding of the problem made, the reminder in the procedural questions stopped students from doing that.

<u>*Provision of the assessment rubric*</u>. In Group 1, students' comments were that the provided rubric was useful, they knew the exact criteria of the assessment. The following excerpts exemplify this:

I always want to know clearly what a teacher expects me to be doing. It also helped to understand what good collaboration means. Though some of the explanations were a bit not clear.

I like to be assessed in this way.

It was useful because we always want to know what assessment comes for what.

Similarly, in Group 2, students were expressing positive attitudes towards the use of the assessment rubric:

It help me to understand everything clearly

I have found out additional ideas about collaboration itself

It (assessment rubric) should be given us.

In Group 3, there were views expressed by two students that the provided assessment rubric had been beneficial for understanding the learning process and social skills required for successful collaboration.

<u>Other aspects:</u> <u>Physical environment.</u> Although students from the groups were not complaining about the psychical environment in which they were solving the problem, it was observed not to be suitable, since all groups were solving the problem in the same auditorium and sometimes some of the students were seen to be interrupted by the members of the other groups.

In addition, it was observed that those students that really spent time at home for additional information gathering, affected the groups discussion positively and were more active. The tendency observed was that students were sharing information that they gathered from what they read frequently themselves – short blogs and Facebook.

<u>Stage III. Educational environments of result sharing and evaluation of developed skills</u>

In Group 1, observational data revealed that students were positively accepting the devised assessment system. During the semi-structured interviews, students revealed new understandings about their changed competences.

<u>New skills, knowledge and insights related to CPS</u>

Frequent quotes were about new insights of what collaboration means and how it happens in reality. In addition, students listed the mastering to construct problem schemas.

At school, we did it very differently and always divided tasks…probably to complete them quicker

I learned how important is to listen to other points of views…it broadens your mind

This experience made us friendlier

I was used to doing everything individually…the power of collaboration was evident

The more we were working together, the easier it was to understand each other and the real process of collaboration…

Although we already had some experience of collaboration, I think we became better in understanding ourselves.

It (collaboration) was not completely new experience but this time it was most effective. We were asked to be collaborating earlier but this experience was different.

In Group 2, students also mentioned new aspects of collaboration observed:

My real issue was always to trust others in collaboration…

I observed that this way of working is more valuable and requires practice…

In my opinion, all opinions were equally important and served for real collaboration….

I learnt to use some useful techniques for search of information on Google

All ideas on how to create problem schemas with the help of the computer were new

I think I became more confident ….observed how important equal participation is.

Collaboration helps to become more patient and focused on the task, especially when it requires long work.

Students from Group 3 listed new insights and skills they gained from the process:

It was great to see that groups used all the modern technologies to implement their solutions. For example, there was one group which created a blog for students in Lithuania to share their experiences. The solutions involved lot of fun which showed their positive way of approaching problems.

I understood that in cases we divide our tasks we do not collect enough information individually. Thus, you have to look for it additionally, so it is better to be looking for it synchronously.

As I am writing my research paper now, I applied the same schema to summarize and understand all ideas included into my topic.

I understood that ill-structured problems are more interesting since they do not have one single answer.

<u>New vocabulary acquisition.</u> One of the sub-goals of the task was that students compiled a list of new words that the group was coming across during all problem-solving sessions. These lists were present in the problem-solving reports. Students from the first group collected a total list of 126 new words, the second group 115 new

words and the third one 98 new words. At the end of the sessions students were tested on these words by simply asking to give English definitions for 10 words randomly from the list. The marks they got were very high in comparison to the marks they were usually getting from earlier vocabulary quizzes: Group 1: 9, 10, 10 and 10; Group 2: 8, 9, 9, 10, 10, 10, 10 and 8 and Group 3: 7, 9, 9, 10, 10 and 10.

3.4 Cross-case synthesis of findings

The major aim of this section is to collate the results obtained from all three cases, in order to see the differences and similarities among the cases. Based on these findings, conclusions are made.

Stage I. Educational environments of introductory enablement

Table 27. Cross case synthesis of findings for RQ2 (results and influence). Lessons learnt about the influence of the stages of educational environment/results achieved across all three groups during Stage I

Stage I. Educational environments of introductory enablement	**RQ2. How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?**	***Case 1***	***Case 2***	***Case 3***
Group formation	An important starting point predetermining group performance	✓	-	✓
Selection of the problem	Highly motivational factor	✓	-	-
	Divergent views on the problem selected (its complexity and dynamicity)	-	✓	✓
	An important factor influencing group performance	✓	✓	✓
Introductory learning to construct problem schemas	Mastering new technological tools is time consuming	✓	✓	-
	New and rewarding experience	✓	✓	✓
Ground rules	No explicit supporting evidence for positive effects found	✓	✓	✓
Introductory knowledge on ill-structured problems and their solving	No explicit supporting evidence for positive effects found	✓	✓	✓
Introductory knowledge on collaboration	Increased understanding of how to distinguish cooperation from collaboration	✓	✓	✓
	Students lack understanding and practise of real	✓	✓	✓

The table above summarizes what similarities and differences were found across three cases in Stage I. The lack of understanding of what is meant by real collaboration was common among all groups. This proves the fact that students need additional knowledge on this aspect. As it concerns additional knowledge on ill-structured problems and peculiarities related to their solving, as well as construction of ground rules, no supporting evidence about the benefits of these stages were found in each group. Thus, it remains unanswered as to whether these steps have enhanced learning to solve problems and needs to be included in the introductory stage. Although indicated as a time consuming task by members of two groups, the integration of learning of how to construct problem schemas was indicated to be a new and engaging task in all three groups. This proves the fact that students need to learn new ways of how to employ visual thinking during the introductory stages of CPS.

Additionally, all three groups shared a common opinion that problem selection was one of the most important factors influencing group performance. While students in the first group demonstrated high motivation towards the problem they had to solve, views on it were divergent in Groups 2 and 3. Students answers were that it was dynamic (their opinions about it were changing). Also, their view diverged in the understanding of its complexity. The following findings mean that educators should spend a considerable amount of time for problem selection and probably find out students' opinion about the problem before they are engaged in its solution. Both in Groups 1 and 3, group formation principle was indicated as an important starting point in predetermining group performance.

Stage II. Educational environments of inclusion in collaborative problem solving

Table 28 below provides synthesis of findings of how three groups were learning to solve problems in terms of cognitive processes during Stage II.

Table 28. Cross case synthesis of findings for RQ1 (process). Lessons learnt about the differences and similarities among groups in terms of their learning to solve the problem during Stage II

Stage II. Educational environments of inclusion in CPS	**Cognitive processes**

RQ1: How do students learn to solve problems in the designed educational environments?	Creation of individual problem representation/multiple representations	Creation of shared understanding and interthinking during problem representation	Development of solutions and their evaluations	Monitoring and evaluating problem-solving processes/Metacognitive thinking	Attempts to offer solutions before fully representing the problem	Frequent off-task chatting	Cases of irresponsible process evaluation	Lengthy discussions to understand the problem\ Interthinking
Case 1	✓	✓	✓	✓	-	-	-	✓
Case 2	✓	✓	✓	✓	✓	✓	✓	✓
Case 3	✓	✓	✓	✓	✓	-	✓	✓

In terms of cognitive processing during the process of inclusion into solving the provided problem, students from all three groups created their individual problem representations (excluding 1 student in Group 3), which means that multiple problem representations were created. Following this they merged their individual understandings into one collective problem schema, serving as an instance of shared understanding. Students participated in lengthy discussions about the problem from its initial state to the goal state and thus interthinking conditions were created. All groups created a shared understanding of the problem. They were also participating in the development of solutions and their evaluations, as well as monitoring and evaluating the problem-solving processes. Both in Group 2 and 3 there were cases when students were trying to offer solutions without fully representing the problem. In Group 3, which was the biggest, cases of frequent off-task chatting were present, which was different from Group 1 and 3. In both Groups 2 and 3, cases of irresponsible process evaluation were observed.

The table below summarizes how three groups were learning to solve problems in terms of collaboration (social skills) during Stage II.

Table 29. Cross case synthesis of findings for RQ1 (process). Lessons learnt about the differences and similarities among groups in term of their learning to solve the problem during Stage II

Stage II. Educational environments of inclusion in CPS	Collaboration (social aspects of problem solving)							
RQ1: How do students learn to solve problems in the designed educational environments?	Equal and fair contributions of group members	Difficulties with shared responsibility	Cases of cooperation outside class	Insufficient collaboration (Low levels of collaboration)	Additional time to reconstruct shared understanding required	Increased adaptability to each other (audience awareness)	Lack of trusting each other	Cases of reticence
Case 1	✓	-	-	-	-	✓	-	-
Case 2	-	✓	✓	✓	✓	-	-	✓
Case 3	-	✓	✓	✓	✓	✓	✓	✓

The results of collaboration highlighted the first group was different, as it was a case where the members showed fair and equal contributions towards achieving the task. On the other hand, cases of low collaboration were found in Groups 2 and 3. This resulted in additional time to reconstruct a shared understanding.

Different from the second group, problem solvers from Group 1 and 3 reported about increased adaptability to each other, which is a crucial element among the social subskills of participation. The lack of trust in each other was observed in Group 3. The cases of reticence or communication anxiety were found in Groups 2 and 3.

Table 30. Cross case synthesis of findings for RQ2 (results and influence). Lessons learnt about the influence of the stages of educational environment/results achieved across all three groups during Stage II

Stage II. Educational environments of inclusion in CPS	Procedural guidelines		Assessment rubric	Use of English			
RQ2. How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?	Useful and facilitating learning process tool	The guidelines were too long	Clear criteria and more understandable way of performing the task	Improved language proficiency	English as a working language was not a significantly impeding factor	Unusual way of learning a language	Reduced fear of speaking
Case 1	✓	-	✓	✓	✓	✓	✓
Case 2	✓	✓	✓	✓	✓	✓	✓
Case 3	✓	✓	✓	✓	✓	✓	✓

As it can be seen in Table 30, procedural guidelines were indicated to be useful and facilitating the process of solving the problem for all three groups. In two groups, students observed them to be too long. The assessment rubric served as a guiding tool for the performance of all three groups. Various benefits for English language improvement were mentioned in each group, the most frequent were that English as a working language was not a hindering factor for the learning process, students observed progress made in their language proficiency, a reduced fear of speaking, as well as indicating this type of task to be very unusual for English classes.

Separate cross-case analyses were done for the construction of problem schemas (problem representation stage), solutions suggested in problem-solving reports and problem-solving reports each group created.

Table 31. Cross case synthesis of findings for the construction of problem schemas in all groups

Stage II. Educational environments of inclusion in CPS **Inclusion into problem representations/ Collective problem schema RQ2: How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?**	Contains a number of problem structural elements	Contains a number of problem situational characteristics	Includes various types of structural relationships	Includes problem solution(s)	Accurate	Well-organized	Having appealing appearance	Creative
Case 1	✓	✓	✓	-	✓	✓	✓	✓
Case 2	✓	✓	✓	-	✓	✓	✓	✓
Case 3	✓	✓	✓	✓	✓	✓	✓	✓

First, cross-case analysis revealed that the problem schemas the three groups created were similar. What was different, is that Group 3 included solutions to the problems, which was an optional requirement. In addition, in Groups 1 and 2 students observed that the problem schema helped to retain memory. In Groups 1 and 2, students stated that this activity was interesting and they liked it. For additional findings, see Table 32 and 33 below. All three groups shared the attitude that schemas were beneficial for making problem representation easier and more in-depth. Students were spending more time understanding of the problem. In Group 1, it was also described as an interesting activity.

Table 32. Cross case synthesis of findings for the construction of problem schemas in all groups. RQ2: How the construction of problem schemas has affected students' learning to solve problems

Stage II. Educational environments of inclusion in CPS **How the construction of problem schemas affect students' learning to solve problems? RQ2: How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?**	Made easier understanding	Made spend more time on it	Engaged into deeper understanding	Helped to retain working memory	Increased learners' interest
Case 1	✓	✓	✓	✓	✓
Case 2	✓	✓	✓	✓	-
Case 3	✓	✓	✓	-	-

Stage III. Educational environments of result sharing and evaluation of developed skills

Each group prepared its problem-solving report, the cross-case analysis of which is present in the Table 33 below.

Table 33. Categories included into problem-solving reports of each group/cross-case analysis of content

Stage III. Educational environments of result sharing and evaluation of developed skills **RQ2: How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?**	Detailed description of CPS	Reflections on CPS	Collective problem schemas	Problem solution/s	List of new vocabulary compiled by all group members	List of references plus short summary of each
Case 1	✓	✓	✓	✓	✓	✓
Case 2	✓	✓	✓	✓	✓	✓
Case 3	✓	-	✓	✓	✓	✓

Group 3 has not included reflections on CPS, their problem-solving report was the shortest in comparison to the other groups. The remaining parts were included by all three groups. In addition, Group 1 included three versions of their collective problem schema. Furthermore, all groups included lists of new vocabulary and references with short summaries of the sources.

Table 34. Cross case synthesis of findings for Stage III

Stage III. Educational environments of result sharing and evaluation of developed skills **RQ2: How do the factors of the developed educational environments enable students to learn problem solving? What results are achieved?**	Active participation in the assessment of others	Active participation in the self-assessment	Result sharing	Reflections and identification of the skills and subskills related to CPS
Case 1	✓	✓	✓	✓
Case 2	✓	✓	✓	✓
Case 3	✓	✓	✓	✓

As can be seen from the table, all groups participated actively in the assessment of each other and self-assessment, they were sharing results and reflected on the skills and subskills related to CPS developed. Even though Group 3 did not include their reflections in the collaboratively written problem-solving report, they were making reflections during semi-structured interviews.

To conclude, various data collated revealed that the developed educational environments served to be suitable for learners to gain more understanding and experience in CPS. For most educational factors, the included steps influenced students' learning positively. The indicative behaviour to CPS was present throughout all three groups. While the first group was most successful, the other two groups were a bit similar.

3.5 Discussion of cross-case findings

The current discussion section is based on the cross-case synthesis of results from all three cases. Results are explained in terms of whether such results were expected or not according to the model of educational environments constructed and the patterns predicted. In addition, the findings of previous research (see Chapter 1) are compared to the current research. Deduction principle is applied for the discussion on how the obtained results could be applied more generally. This chapter also includes the discussion on peculiarities across educational environments in each case, considerations on the wider application of the model, aspects of it that could be improved and limitations on the study. In addition, the emerging new research questions and areas are indicated. The chapter is organized according to the three stages of educational environments.

Stage I. Educational environments of introductory enablement

The aim of this stage was to introduce students with the problem-solving task (its purpose, process and evaluation), collaborative and ill-structured aspects of problem solving; as well as the tools that might facilitate the process of solving problems, namely the construction of problem schemas. In addition, by constructing ground rules, students were expected to identify the exploratory types of talk and agree about the kind of interaction that ensures effective collaboration and interthinking.

Additional knowledge on collaborative aspects of problem solving. The results expected were that students increase their understanding of CPS by gaining additional knowledge on its main aspect – collaboration or social aspects. After additional knowledge was provided and students participated in the discussion on the necessary characteristics of effective collaboration, as well as sharing real life examples, their comments were based on their previous experience mostly. The most common of them was the lack of understanding and practice of collaboration. The recurring insights and perceptions were that the most common scenario where they work together is typical to cooperation but not collaboration (students tend to be dividing tasks among each other). The result is in line with the existing body of literature describing the necessity to include additional knowledge on these aspects because this is not a skill students can learn on their own (Lai et al., 2017). The finding illustrates at least a partly increased understanding of collaboration, which was achieved with the application of explicit measures to teach this aspect. This result is consistent with other research, which found that explicit teaching of collaboration greatly contributes to the development of this skill (e.g., Lai et al., 2017). To conclude, educators should be creative in finding ways to provide additional knowledge on the collaborative aspects no matter what type of a collaborative task is given to the students. Probably, a better practice could be not just to give additional knowledge during the introductory steps but also merge it with the reflections after some experience has been gained. Data from this study suggests that the provision of additional knowledge related to collaboration is a necessary introductory step in educational environments aimed to engage students in effective CPS.

Additional knowledge on ill-structured problems and their solving. The results expected were that students increase understanding of ill-structured problem solving. However, it is not clear what results were achieved in reality because no student in any group commented that it has somehow influenced their learning. The researcher believes that learning by doing might have been a more valuable experience for students than just theoretical insights shared during the introductory stage.

Introductory learning how to construct problem schemas. As expected, the benefit of this stage was an increased students' understanding and experience of how to employ this visual thinking technique. The process of learning to construct individual and then collaborative problem schemas appeared to be to a useful and new experience for the majority of students in all groups. Although indicated as a too much time consuming activity, it proved to be a suitable start used for later stages when students had already constructed the given problem schema. Students' complaints about this task as too long for them and requiring additional efforts to learn technological ways to draw schemas was the unexpected finding because usually the representatives of Generation Z are very tech savvy. However, the interesting and informative schemas all groups created were the proof of a new experience gained and this corresponds to the results expected. It is almost certain that the longer time spent on learning new ways to represent problems visually or externalize their thinking shortened the time necessary for the same activity during the later stages.

Even after this short introductory practice, students had already observed that visual problem representation was helpful for them to become more systematic, which is in agreement with Simone et al.'s (2001) findings. Although not expressed explicitly by them, it was the kind of task that made them involved in shared understanding creation both by discussing problem elements and visually representing them on the schema. A useful finding is that students enjoyed this part of the task. Thus, there is a strong possibility it may increase motivation when learners encounter ill-structured tasks. All in all, this prerequisite stage of learning to visually represent information could be present while preparing students to solve complex problems (Csapó & Funke, 2017) or making difficult learning visible.

Ground rules. The mentioned ground rules (see Chapter 3.3) that all groups created during the introductory stage covered all major characteristics of CPS and reminded students about the necessity of shared understanding, consensus seeking, presence of constructive criticism, equal participation, shared collaborative responsibility, proper argumentation, conflict avoidance and reflections on the process and progress made. The other important characteristics which were not included in the ground rules were reminded in the procedural guidelines (see Appendix A). They informed students about the necessity of multiple representations while constructing problem representations, the need for additional information collection and the group's agreements on how to acquire it, the importance on agreements about shared goals, as well as joint planning and awareness of common goals.

It was hoped that the constructed ground rules would facilitate the process of problem solving and enhance the quality of talk. However, there was no explicit supporting evidence found for this result in any group. It may be that students need some more repeated practice of formulating ground rule so these ideas become more influential.

Since there was no clear evidence that the ground rules were somehow explicitly referred to by students after they were formulated, it can be concluded that despite recommendations to include this measure (see, for example, Fernández et al.'s, (2011) research findings), educators should probably think of more varied and influential ways exploratory talk and other positively influencing collaboration aspects could be supported and encouraged. For example, one of such solutions could be the provision of examples of disputational, cumulative and exploratory talk so that students could trace the differences among them. Another measure could be the kind of rubric that indicates varying degrees of behaviour with tick boxes, which can be marked by students to engage them in a more frequent and active self-evaluation. In this way, educational environments are made closer to a modern view on education – reflexive pedagogy where students are equally responsible for their learning (Kalantzis & Cope, 2016).

The study's limitation is that it did not explain whether such rules really contributed to the quality of talk. A simple discourse analysis of the groups using ground rules and the ones learning without them, could have been the opportunity to collect evidence showing the relationship between this and indicating whether it contributed to the increased incidents of exploratory talk, instead of just cumulative or disputational. Given the fact that a number of researchers (e.g., Warwick & Mercer, 2011) concluded that even during the most interesting collaborative tasks students might not be productive if their talk is not regulated, further research is necessary. Considering the complexity of educational environments engaging students in problem solving, the quality of discussions seems to have a crucial role.

As it concerns other aspects that were significant during the introductory stages, the findings further inform that such steps as group formation, problem selection and assignment to roles should be given special attention in advance because they might predetermine and then influence group performance significantly.

Group formation. Although some differences in groups' performance that might have been influenced by its size were observed (see Chapter 3.5), this difference did not prevent all groups from reaching the main goal of the developed environments – learning to solve problems by gaining experience and increasing understanding of this activity. The self-selection principle of forming groups proved to be positively affecting the groups' performance and satisfaction of its members, which goes in line with the findings cited by Lai et al. (2017). This result seems to suggest that the self-selection principle matters more for the tasks which are lengthy and complex.

In addition, although students in all groups did not report on the observed benefits when group members are of mixed abilities, the researcher believes that problem-solving tasks require that group members are of mixed abilities, because these tasks are complex in terms of variety skills and abilities required.

Problem selection. In Group 1, it is most likely that high motivation towards the problem was the result of having a foreigner among its members. In the other groups, students expressed divergent views on the given problem. There were also opinions that their attitude towards the task was dynamic over the process. This evidence is in line with Jonassen's (2011a) conclusion that ill-structured problems are dynamic. Therefore, the designers of educational environments should anticipate varying levels of learners' motivation.

Since there were several students giving account of the fact that the problem was not relevant and motivating, some additional measures could be introduced into the model. For example, a useful procedure could be the inclusion of some survey before students start solving the problem to find out about their motivation and interest level into it. Following the ideas of Jonassen and Hung (2008) who advise that problems should be complex to a degree that motivates and engages students' interests, as well as adapted to solvers' prior knowledge, cognitive development and readiness, such a survey could include questions for determining these aspects. The suggested problems could be related to students' major and future career, which corresponds to Jonassen and Hung's (2008) recommendations to relate them to the problem solvers' future or potential workplaces. The latter ideas were also mentioned in two of the three groups. In addition, students can be provided with a list of problems to choose from. Further studies taking the discussed problem selection variables into account needs to be completed.

One more additional challenge observed and confirmed by students themselves was the fact that this task was longer than traditional tasks in the classroom. It is likely that this reduced motivation of some group members. On the other hand, such activity resembled a real world working condition and, no doubt, provided learners with opportunities to become more perseverant and patient. Taken together, these findings indicate the problem selection to be one of the most challenging aspects for educators when designing educational environments based on problem solving.

Assignment to roles. Although the technique of assignment to roles was not utilized, the researcher could have followed up, since there were some students observed (in Groups 2 and 3) as lacking responsibility and interest. The positive impact on the enhancement of student responsibility, activity and interest was indicated by Strijbos et al. (2004), who suggested that group members could be divided according to the functions desired (e.g., communicator, planner, editor or data collector). Similarly, assignment into roles is widely applied in PBL practise. In problem-solving environments, these roles could be organized according to various functions. At the same time, the researcher believes that the division into some functional roles is risky because it might be understood as a step towards cooperation, which, according to students, was a more frequent working and learning condition in their past. Thus, this question remains unanswered. Probably, a relationship between the quality of collaboration and assignment into roles could be one more valuable research question for designers of problem-solving environments.

Stage II. Educational environments of inclusion in collaborative problem solving

The main aim of Stage II was the inclusion into learning by doing, while getting each group to solve the same problem. Students were expected to undergo the main processes required for solving ill-structured problems: problem representation (including devising an external visual form of problem representation), development of solutions, evaluation of solutions, making justifications, construction of arguments and monitoring and evaluating the problem-solving process. The main result expected was an increased understanding and experience of solving ill-structured problems in a collaborative manner.

Provision of detailed procedural guidelines (including question prompts). The given procedural guidelines were observed to be a useful tool to organize all the groups' work and scaffold learners' thinking processes. This is in line with the results expected and previous research evidence confirming that this type of scaffolding transforms complex tasks into easier ones, by making implicit processes visible and reducing overburdening of problem solvers (Collins, Brown & Holum, 1990; Wang, Wu, Kinshuk, Chen, & Spector, 2013, as cited in Wang et al., 2016). This also confirms the findings of Hattie (2009, as cited in Luckin et al., 2017) who concluded that making learning and teaching visible was the key factor influencing learning outcomes. Similarly, this finding supports the conclusion made by Riis et al. (2017), stating that learners need to be properly guided when dealing with complex tasks such as ill-structured problem solving. Overall, the students' positive attitudes towards the procedural guidelines guiding their learning process indicated the fact that students prefer guided instruction, especially when the task is difficult and requires longer time periods. This also matches the conclusions of Kirschner et al. (2006), suggesting that guided instruction produces more effective learning environments for learners.

Such procedural guidelines were used to fulfil various types of functions scaffolds might be used – conceptual, metacognitive, procedural and strategic guidelines (see Hannafin et al., 1999). Students' complaints about them being too lengthy and having repeated ideas could be improved by refining the guidelines, for example, by splitting them into smaller parts or by allowing students themselves to generate question prompts. Educators might also consider inviting experts in the field for the refinement of such complex tasks. The prepared guidelines could additionally include boxes for ticks so that groups can follow the progress already made.

Concerning the evidence of whether a more effective argumentation was fostered because of the provided guidelines, evidence was difficult to collect. Again, a future CPS research question could be posed to answer whether these guidelines contribute to the quality of argumentation. Further studies on the current issue might again utilize the discourse analysis of groups working with them and without them.

Considering their wider application, such procedural guidelines could be provided every time students are given complex tasks, for example, when educators seek the development of specific skills or to explain the most difficult parts of a process. For example, Kirschner et al. (2006) reviewed a considerable body of research and found that learners, when dealing with novel information, should be explicitly provided with a detailed guidance as to what to do and how to do it.

Provision of assessment rubrics. The provided rubrics were useful for the students of all groups. Students had clear views on what type of performance was most desirable regarding various aspects of CPS. The current research findings support the fact that rubrics are especially useful for the assessment of learners' performance during CPS. In addition, the unforeseen observation finding was that students were not used to being assessed with the help of rubrics. Although rubrics are considered to be among valuable tools for modern assessment (e.g., Griffin & Care, 2016, Hesse et al., 2015; Lai et al., 2017), the findings point to the fact that formal education still lacks the practice of using it as an assessment tool.

Inclusion into problem representation using the construction of problem schemas. During the problem representation stage, students were expected to construct multiple comprehensive individual problem schemas (external problem conceptualizations), share them, agree about similar representations and then construct collective visual problem schemas. Problem schemas constructed were required to include representations of problem structural and situational characteristics, as well as structural relationships among these elements. It was anticipated that the constructed collective problem schemas reflect the deeper understanding of the problem and facilitate learning of each group.

All groups were very creative in completing this task, both individually and in collaboration. The finding that this activity was beneficial in different ways confirms the fact that the construction of problem schemas is a suitable educational factor that positively affects students' learning to solve problems, especially contributing to the development of the capability to externalize thinking and advance the ways of visual thinking. The findings are in line with Wang et al.'s (2016) claims that visual thinking makes understanding deeper and helps to retain knowledge or memory, as was observed by students. The activity helped to understand the problem, its structure and situation, as well as inter-causal relationships, which was confirmed by Csapó and Funke (2017), Jonassen (2011a) and Simone et al. (2001). The logic of asking students to firstly construct individual schemas and start with individual brainstorming was based on Halpern's (2014) recommendations. It can therefore be assumed that this activity increased both the quantity and quality of ideas. Most importantly, the suggested procedure allowed students to create multiple representations and then shared understanding. In addition, the process was beneficial for seeking agreements, which is an essential characteristic of CPS (PISA 2015, 2017). The constructed schemas show that learners were able to reach agreements, despite different amounts of time required in each group.

This study illustrates that the construction of multiple representations helps students to understand and solve ill-structured problems. This finding is in accord with the studies of Jonassen (1997). Another useful finding was that this procedure engaged problem solvers into a deeper understanding of the problem and made them less superficial, which is usually observed to be common among the representatives of Generation Z. It matches Hesse et al.'s (2015) conclusion that the more information is shared, the higher the level of breadth in understanding can be achieved and, thus, allowing new re-organisations of the problem space. Although it is difficult to identify, the possibility that students will be aiming for multiple representations in this way during their next engagements in CPS remains.

One of the challenges observed was that those groups that had many ideas on their individual schemas struggled and had to spend more time during the stage of organizing the problem representation. A possible explanation for this might be that the process of reaching agreements was not easy, due to the size of the group.

After the construction of the problem schema for the given problem representation, there were no more students' complaints that it is time consuming, which proves the fact that students were already prepared for this process. In all three groups, students managed various technological solutions for the construction of problem schemas.

Although researchers indicate that the usage of visual thinking may make an educational environment less stressful, students were not expressing such views. In addition, although not explicitly stated by students, this visual thinking technique no doubt adds to the enhancement of creativity (Buzan, 2006).

A promising finding is that this activity was an enjoyable experience for learners. It suggests the fact that Generation Z likes the way of representing information visually and being instructed to organize their problem-solving environment in this manner. Such a finding was not supported in educational literature. In addition, there are more specific tools suggested for the externalisation of thinking or visual thinking (e.g., concept mapping, influence diagrams, system modelling, networks, schematic models and structure maps) (for more detailed explanations, see Chapter 1.3.4), however, problem schemas seem to be the most relevant form for problem-solving educational environments. However, the question remains of how problem schemas can show solutions of a particular problem.

Most importantly, it is clear that this procedure engaged learners into more purposeful and meaningful discussions and, no doubt, improving all aspects of communicative competence of English. In the opinion of the researcher, students would not have been able to participate in such lengthy and thorough discussions concerning the same issue without the use of problem schemas.

Cognitive aspects. During the stage of inclusion into real life problem solving, problem solvers were expected to represent the problem (define it, clarify the situation described it, identify its causes and constrains, discuss its variables and their interrelationships and agree about group's goals). They were expected to identify what information is known and what should be additionally searched, agree on how to collect additional information and distinguish between relevant and irrelevant information.

In each group, both lengthy discussions and the constructed individual and later collective problem schemas in each group showed that learners were successful in the problem representation process, which is agreed to be the first and essential factor determining problem-solving success (e.g., Jonassen, 2011a; Robertson, 2001). The visual thinking technique employed may have promoted a more complex cognitive processing of the problem and, no doubt, reduction of cognitive load in one's head; as many ideas could be visible and recalled by just a glance at the schema.

During the later stages, students had to develop solutions and construct arguments to justify them (explain their feasibility). All group members were anticipated to be participating in the constructive discussion of considering the usefulness, effectiveness and suitability of alternative solutions. The main result expected was the creation of a shared understanding based on multiple sources of knowledge and perspectives, as the core feature of CPS.

The participation of students during the collaborative problem schema construction and discussions about the problem, as well as its solution, confirms the occurrence of the processes of shared understanding creation and interthinking. It is in line with Mercer's (2009) ideas that the language problem solvers use is not just for interaction but also for interthinking. In Mercer's (2009) terms, students were in the Intermental Development Zone where problem solvers are present in symmetrical interaction, which means that learners were learning and benefited not only from those peers that were more capable but also from those that think differently (all problem solvers in the same group) (Shakouri, 2015).

The constructed schemas show multiple variables of the problem and interrelationships among them. Although all aspects of what information each group searched for are difficult to assess, what can be evaluated is that students included a list of references of where they found such information. This confirms the result expected that students' solution were based on multiple sources of knowledge.

Even though students were participating in the evaluation of their progress made, it is difficult to identify to what degree this process involved them in the refinement or adjustment of the problem-solving process. One proof present is, for example, that Group 1 included three collective problem schemas instead of one into their problem-solving report.

The most significant result of cognitive processing is that learners were engaged in metacognitive thinking related to learning to solve problems, which is a necessary characteristic of a good problem solver (Davidson & Sternberg, 1998, as cited in Jonassen, 2011a). It was achieved by making the learning process explicit (utilization of procedural guidelines including question prompts) and engaging learners into monitoring of the process and progress made (inclusion of reflection questions in the procedural guidelines), as well as by regulating the process of learning (for example, suggesting not to offer solutions without first trying to understand the problem thoroughly). Metacognitive knowledge development was present because of not just involving learners into the problem solution process but also by integrating enhanced instruction to emphasize the development of problem-solving skills. In this respect, it was hoped that learners were learning much better, which is in line with Winne and Hadwin's (1998, as cited in Serra & Metcalfe, 2009) conclusion.

Collaborative aspects. The cases of insufficient collaboration during the classes (as observed and reported by students in Groups 2 and 3) were not frequent. However, the process was uncontrollable outside classes and students reported about the cases of cooperation (in Groups 2 and 3). This corresponds to Ge and Land's (2003) finding who conclude that group members tend to cooperate and divide their work depending on each student's expertise, especially when the time for the tasks is ending. This can be supplemented with the finding that cooperation is usually opted for when students' behaviour is not monitored (outside classes, as reported by students).

Insufficient collaboration may have been caused by the inadequate ways to support and encourage this aspect in the developed model. The designed educational environments included explicit instruction on collaboration and appropriate scaffoldings (ground rules, worked examples and rubrics) during the introductory stage. Accordingly, it was anticipated that students would be able to regulate the process according to the initial agreements and knowledge themselves.

Although feedback on students' collaboration was provided at the end of the problem-solving sessions, the applied measure was insufficient and learners may have lacked constant or intermediate feedback on it. This confirms the findings of Zou and Mickleborough (2015) who conclude that all three methods (explicit training, appropriate scaffolding and constant feedback) are important to ensure the process of CPS goes smoothly and students develop CPS skills. In the EESCOLE model discussed by Vizgirdaite and Juceviciene (2012), as well as Vizgirdaite (2013), the authors also note that students should be provided with both the educator's and peer assessment after they perform the task together with an ongoing assessment.

The ongoing constant feedback can be provided both by learners themselves (self-assessment) and educators. This can be achieved, for example, by adapting rubrics of desired collaborative performance into the Likert-type surveys to be filled in during the process so that a learner can improve his/her performance. This complies with a more modern view on assessment - the principle of formative behaviour. The application of intermediate peer assessment is also congruent with the core principles of reflexive pedagogy, which include the idea that learners should be given equal responsibilities in the control of their learning (Kalantzis & Cope, 2016). Therefore, the developed model should also include measures to ensure constant and intermediate feedback on students' collaboration (not only at the end of the performance).

It might also be deduced that cases when collaboration was insufficient might have been directly influenced by students' previous learning experience. Some of them may have been unfamiliar with inquiry-based learning and a collaborative learning culture or cases when their collaborative efforts are assessed. It is also likely that some students were unwilling to change the practice to which they were familiar with for a long time. In such cases, educators should be including detailed explanations of the benefits of these aspects so that students do not start solving problems with insufficient levels of motivation and understanding of CPS.

Low collaboration, specifically the lack of participation and activity of some group members, caused process losses or additional time to reconstruct shared understanding (as observed and reported by students in Groups 2 and 3). Although not explicitly expressed by these students, this may have additionally decreased their motivation and interest in the continuation of interaction (Häkkinen et al., 2004) or even incapability of considering alternative or future states of the problem (Hesse et al., 2015).

These findings are rather disappointing and confirming the fact that it is not an easy task to develop CPS skills in students. What is obvious is that they need multiple learning tasks that require collaboration in order to get extra development of CPS skills. These tasks should include the assessment of both the product and the outcome of it, as well as include intermediate reflections on the development of CPS skills. It can also be concluded that face-to-face collaborative situations are more appropriate to develop this skill while organizing collaborative learning outside the classroom might be detrimental to it. Proper time management is necessary so that students are able to complete tasks in face-to-face learning environments, where cooperation is less common, especially when tasks are monitored by educators.

The cases of reticence were found in cases 2 and 3. These results are consistent with the conclusion made by Li and Liu (2011), who state that it is one of the most common problems in EFL classes. According to the authors, there might be different reasons of this situation and not necessarily related to the language use. The reasons some students in Groups 2 and 3 were reluctant/less active to participate in communication activities remain unclear.

A useful finding is that students from two groups (Group 1 and 2) reported about their increased adaptability to each other and understanding about the importance of such a working condition. According to Hesse et al.'s (2015) classification, it is audience awareness which requires adapting behaviour to increase suitability for others. In this way, learners advanced one of the seven essential survival skills of the future – adaptability (Wagner, as cited in Bidshahri, 2017).

Additionally, although not explicitly stated by students, it might be deduced that a collaborative learning context and properly guided instruction with the prepared instructional guidelines might have reduced the cases of procrastination, which are common among students. In all cases, students were able to complete the tasks according to the time requirements, as they were agreed in advance.

Use of English. The devised educational environments were beneficial not just for learning to solve ill-structured problem but also for learning English in such a context. Students could improve all three constituent parts of communicative competence – grammatical, sociolinguistic and strategic competences (according to Canale & Swain's (1980) classification). It was beyond the scope of the study to assess the development of communicative competence very precisely but, according to students themselves, this task has contributed to this greatly. What was measured is that they mastered new vocabulary, which means that learners developed their grammatical competence. In addition, students reported about becoming quicker in expressing their ideas, finding new ways to help each other to communicate, cases of finding ways to compensate breakdowns in group communication, reduced fear of speaking and making mistakes, as well as increased self-confidence in expressing themselves using a foreign language. These results prove the fact that they additionally developed the other constituent parts of communicative competence - sociolinguistic and strategic competences. The development of these competences may have been caused not only by each individual efforts but also because of learning in a social context of a group, where the presence of other members influenced the achievements of each group member.

It is somewhat surprising that most students were commenting on the task as if it was done using their native language without strong emphasis on English as a working language. A possible explanation of this could be that they seemed to forget that these were English classes and focusing on the task itself and its completion rather than thinking of it as a FL learning process. It might be that the task was so meaningful for students that they seemed to forget about learning English in this way. Furthermore, it might be that a prolonged activity diverted their attention from English as a major goal of the classes.

A note of caution is due here because of the significant findings that students were commenting that this was a very unusual way of learning English. This points to the fact that, although an action-based approach has been promoted among modern views of learning FLs, including the updated CEFR (2018), students might not be ready for such educational environments. Learning a FL by doing situations when learners are involved in purposeful communication while learning in a social context for a prolonged time is different from what they were used to at school for maybe eleven years. In addition, the task itself is very unusual because it is authentic and open-ended (not heaving readily made multiple choice answers, having more than one possible answer). It may be that not all students are ready to leave their "zones of comfort" and welcome the tasks that have both linguistic and non-linguistic goals, especially such long and complex ones. Not all students might be prepared for a collaborative learning culture and the assessment of collaborative efforts (both product and process) instead of individual ones (the traditional assessment way to what they are used to for a long time).

Despite these cautionary considerations, such tasks are in line with the recommendations of those scholars and practitioners that indicate the need for transforming foreign language studies, so as to engage learners in learning not about language (the long tradition in English course books) but with and through language (see, for example, Cammarata et al.'s (2016) research). Such learning environments are also in agreement with a number of scholars and practitioners indicating the urgent need to integrate the development of problem-solving skills into every subject (e.g., Cho et al., 2015; Csapó & Funke, 2017; Luckin et al., 2017; Siddiq & Scherer, 2017). Although not included among the researched aspects, the researcher is sure that they gave plenty of opportunities for mediating texts, concepts or communication, all of which are essential parts of mediation – the central activity while learning FLs (CEFR, 2018). Most importantly, such learning tasks were closer to real language use and meaningful communication having purposeful goals.

Stage III. Educational environments of result sharing and evaluation of developed skills

The aim of this stage was to include learners into the assessment of others and self-assessment, as well as sharing the results on what solutions each group agreed on. Students were expected to participate in the process of identification of new competencies gained/learnt from each other and evaluate new perspectives for future CPS environments.

The devised mixed assessment system to evaluate both the performance of each student (by using a rubric of a desired collaborative performance), and group's CPS outcomes (presentations of the solutions and problem-solving reports) was in line of the research findings that learning tasks, including diverse learning outcomes, should be assessed accordingly (see, for example, Lai et al., 2017). All groups accepted both parts of assessment positively. The present finding is significant for the thin body of research on the assessment of CPS.

Although the behavioural/performance observation (performance-based assessment) was chosen as a suitable method for testing CPS (Lai et al., 2017), the way it was implemented in reality was inappropriate since both observational data and students' answers revealed that it was the collaborative aspect of CPS which caused most difficulties. As already discussed, intermediate assessment to regulate students' collaboration (participation, perspective taking and social-regulation) was lacking.

When designing such educational environments, the researcher was hesitating whether students should know that one of the aims of them was the development of CPS. The decision opted for was that they should know about it and be explicitly told about it. It was additionally done to ensure the ethics of the research. Such an issue could be an interesting future research question. For example, Riis et al. (2017) described the study where students were involved in CPS without knowing what they were learning during the process, however, later learners were able to reflect on a wide range of skills and subskills they were developing. In addition, one the conclusions of this research was that final reflections during the semi-structured interviews added to an increased students' understanding of what skills and subskills they were developing. The findings of this study are the same as the present research. Problem solvers of all groups listed a number of improved skills and useful insights related to CPS – a clearer vision of what real collaboration means, increased understanding of its positive aspects, learning to resolve conflicts and stay friendly, learning useful ways of searching new information and new technological solutions of how to visualise information, among others.

A major limitation of the assessment was the fact that the provided procedural guidelines were focusing and engaging students into reflections mostly on cognitive aspects of problem solving (see questions for reflections in Appendix A). However, they could additionally address social aspects of problem solving. For example, in order to better control this process, such questions could have been included: do I participate in the group's work evenly, am I able to adapt my behaviour so that it suits for the others in the group, do I tolerate ambiguity, do I act properly on the diversity of other group members or does my talk match the characteristics of exploratory talk (the ones we agreed about during the introductory stages).

To conclude, two most important aspects of educational environments devised for enabling students to learn problem solving are the educator's efforts to guide complex learning in order to make it more visible and emphasis on social aspects of CPS. Finally, since there are so many variables of both the complex phenomenon of CPS and educational environments themselves, future studies on these broad topics are necessary. For example, it could be an interesting research on the effectiveness of problem-solving tasks for learners having lower levels of language proficiency both in terms of language learning and the development of CPS skills. In the opinion of the researcher, such learning environments are most suitable for those learners that seek the highest levels of FL proficiency (C1 and C2 according to CEFR's classification).

Peculiarities across educational environments in each case. The current chapter includes the discussion on the peculiarities across educational environments in each case. It does not follow the logic of pattern matching of educational factors present in the model but follows the sequence of each case description in terms of their peculiarities.

Although the stages of educational environments were intentionally developed to be the same for all groups, their reactions to them were different. It confirms the conception of educational environments including the tenets that educational environments developed for the same educational purpose may have a diverse impact on each learner, are dynamic and difficult to be predicted in advance (Juceviciene, 2007; Juceviciene et al., 2010; Juceviciene, 2013). The observed differences prove the fact that although the same task was given to all groups, it did not result in the same learning process or impact of the educational environments on students' learning and results achieved. The peculiarities may have been caused by both external (related to the problem itself) and internal characteristics of the problem (related to problem solvers) as well as characteristics related to each group.

Case 1. In Group 1, the process of learning was observed to be the most successful. In addition, students themselves indicated the greatest satisfaction and progress made in comparison to the other two groups. The members of this group showed the highest level of participation and equal responsibility sharing.

One of the essential reasons of this may have been its members' high motivation towards the problem it had to solve. Most importantly, as mentioned already, the group had a foreigner in it and this fact may have greatly affected the situatedness of the problem, as well as its complexity and transparency. The foreigner may have explained the context described in the problem, its variables and a number of unknowns related to the problem. In this way, the group benefited from the diversity of its members, since this brought more different perspectives to the processes of shared understanding creation and generation of solutions. The following finding points to at least two significant educational factors that might determine the success of CPS. First, when selecting the problem, educators should think of some personal relevance the problem may have for its solvers. Problems given to learners should be realistic and have meaningful goals. This can be achieved by not only having various stakeholders of the problem in the same group but also, for example, by asking problem solvers to invite them at least for a short period. Second, a greater diversity of group members could also serve as a valuable factor when solving ill-structured problems.

An important indicator of this group's success may have also been the fact that students formed the group according to the self-selection principle, with three students knowing each other very well before. Students' comments were that their formed the group according to the mutual trust principle. This result seems to suggest that mutual trust when forming groups is a significant prerequisite. At the same, the successful performance of the foreigner who joined this group for only this semester proves the fact that when the majority of the group members is made of those that trust each other mutually, it can be expected that newcomers would also follow the group's performance in order not to stay outsiders. Thus, it can be concluded that a group has to have at least the majority of active members who trust each other so that the rest could follow their example.

The number of group members in this group was four and it was the smallest group in comparison to the other groups. One possible implication of this may be the fact that having four members in a group is a satisfactory number for the engagement in ill-structured problem solving. It may have influenced the most equal participation and responsibility sharing in this group.

The group was observed to be very enthusiastic and responsible, both in the process of problem solving and preparing for sharing results. For instance, its members organized additional meetings to finalise their problem solving and presentation. In addition, they prepared a poster as an aspect to implement or visualise their solution, which was optional and exceeded the requirements or expectations of the task. The most responsible attitude to the task was also reflected in the problem solving report, which included all three versions of the problem schema, contained all necessary parts and had the longest lists of sources and new vocabulary.

The findings from this case suggest that the larger number of group members does not necessarily result in a better group's performance and results achieved. What matters mostly are attitudinal and motivational aspects of ill-structured collaborative problem solving.

Case 2. Although the major goal of the development of problem-solving skills was achieved in this group, members of it showed the lowest level of responsibility towards the completion of the task, as well as towards its quality in comparison to the other groups. There were cases of unequal attendance, off-task chatting, attempts to offer solutions without first representing the problem thoroughly, cooperation outside class, lack of perseverance, process losses and cases of reticence or communication anxiety.

Members of this group expressed divergent views on the problem and varying degrees of it during all the process, which may have caused unequal motivation. It is likely that motivation towards the problem may have greatly influenced students' performance and the results achieved. Inconsistency of a positive attitude towards the problem proved the fact that ill-structured problems are dynamic and with a varying degree of transparency specific to each individual. All educators developing problem based learning environments should take these aspects into account carefully.

There is a strong possibility that the majority of the mentioned detrimental aspects to CPS were also influenced by the size of this group. Although it was initially planned that Group 2 would have six members in it, the number increased to eight students and therefore it was the largest group. As there were problems of sharing responsibility observed, it is possible that having more people in the group results in a less amount of responsibility for each member. The group had no clear leaders who might have been good examples in showing persistence towards the achievements of the goals. It may also have been that some less responsible members were negatively affecting the performance of the whole group. Indeed, there were recurring comments from most of the groups' students about the cases where their performance was somehow influenced by the other members of the group. This suggests the finding that each group develops its own learning environment, where not only learning and thinking but also the performance of each individual is affected by the rest. Personal factors play an important role among educational factors.

No doubt, unequal attendance of this group members caused process losses or ineffective use of time, because additional time was necessary to give accounts of the progress made for those that skipped some of the classes. In addition, disappointment when seeing others less engaged in the process may have caused the other members to be unwilling to collaborate.

The cases of reticence may have been caused by the fact that the same amount of scheduled time for discussions had to be divided into smaller parts, as there were more problem solvers in this group. This may have made some group members stay less voiced, especially those that were seen as slower in expressing their ideas.

Some of the members were observed to be impatient, as they were starting to offer solutions without first properly interpreting the problem. A prolonged activity was also a challenge for this task because some students were seen as not used to staying focused on one task for such a long time. It might be that this condition was one of the causes of off-task chatting and multitasking sometimes.

The findings from this group suggest that the larger the number of students in the same group brings additional challengers and requires educators to think of more diverse ways to ensure equal responsibility and participation. For instance, in cases when ineffective group performance is started to be observed, educators should think of immediate measures of how to improve the situation (e.g., change the problem or resize the group). Apart from this, group members themselves can be engaged in fostering a more effective team organisation. Ineffective aspects of the CPS should be communicated to the group as quickly as possible, so it is able to refine its performance.

Case 3. In Group 3, the process of learning to solve the given problem was similar to the second group. Although less often, there were cases of unequal attendance, attempts to offer solutions without first representing the problem thoroughly, cooperation outside class, lack of trusting each other, process losses and cases of reticence or communication anxiety.

Unequal attendance was present because of two students skipping some classes and being less active in the process. Consequently, it caused process losses and probably demotivation for those that were active. This also proves that this group did not reach a shared collective responsibility or it was not divided equally.

Lack of trust in each other can be deduced from the fact that two students were trying to do some parts of the task individually and in this way were not willing to cooperate. It may have been that the presence of two less active students inspired them in acting in this manner.

Cases of reticence were typical for those students that skipped classes. As observed, it was not affected by the fact that they were less fluent but probably because of lacking a more serious attitude to the completion of the task.

What was frequent in this group were the students' comments that they were learning from each other, for example, new technological tools, ways of searching information or being more patient with each other.

To sum up, although case studies cannot be applied for statistical generalizations (Gibbs, 2012; Yin, 2014), the obtained analytical generalization based on the peculiarities of each case may be useful for future research and need to be additionally tested in different contexts and across larger samples. What is obvious is that the interplay of both external and internal factors of the problem determine the success of each group. Taken together, these findings suggest that the task of developing educational environments serving for learning to solve problems is a rather challenging task for educators, due to not being able to predict students' reactions in advance.

Suggested improvements for the model. Although the proposed model proves to be beneficial for learning to solve problems, it still needs to be revised according to the findings of the research.

What is the most important factor that should be additionally addressed in the model is the social aspect of problem solving. For example, the introductory stage could include the step of assignment to roles in order to increase the responsibility, activity and engagement of each problem solver. The model could also include some more diverse ways of pre-teaching collaboration, since the practise of providing students with some additional theoretical aspects, provision of the assessment rubric with the desired collaborative behaviour and feedback on students' collaboration at the end of the task were insufficient.

Concerning the necessity to include additional knowledge on ill-structured problems and peculiarities related to their solving, additional explanations during the introductory stage are not playing a significant role. Informed by the results achieved, the researcher believes that some additional explanations included in the procedural guidelines are enough.

Even though students were introduced to the desired collaborative performance in advance, the practice was insufficient. The devised assessment system had the drawback of lacking intermediate feedback on students' collaborative processing of the task. Therefore, the model could include additional stages for students' reflections on their collaboration.

In addition, the model is depicted as a one-way direction, however, in real practice, the stages are cyclical and interactive. This change could be additionally reflected in the model. For example, the model should indicate that problem solvers can move backwards to the problem representation stage if necessary, for example, during the stage of developing solutions.

Wider application of the model. Empirical results confirm the devised model to be beneficial for learning to solve problems in the specific context where it was implemented. To apply the same model in different contexts, additional research is necessary.

Limitations of the study. The phenomenon of learning to solve problems is too broad to address all of its aspects in one research. For example, the empirical research did not give attention to the areas of both procedural and strategic knowledge required for solving problems. In addition, although various types of scaffolds are available to facilitate problem solving, the model devised included only four types of them - ground rules, exploratory talk, question prompts and problem schemas. At the same time, the possibility of comprehensive research encompassing more factors related to CPS is hardly conceivable in reality.

The fact that the research was carried out synchronously in all three groups prevented the researcher from recording all of group members' interaction and then using the recorded discourse data for a more comprehensive picture of how students were learning. For example, it could have revealed what type of talk was dominating among students. It may have also provided more accurate data on how communicative competence of learners was developing. It could have also revealed the relationship between students' language proficiency and the development of problem-solving skills. It is possible that the discourse analysis can additionally reveal a more detailed picture of individual progress of each student because this task was long.

Moreover, this research was just a short-term intervention which may have been insufficient for learners. The research gave no possibility to assess the lasting effect of learning to solve problems for each group or individual.

Taking the stance of inquiry while being a practitioner (the educator who implements the devised educational environments) and a researcher at the same time may have served both as an advantage and as a limitation of the study. Although it allowed to understand the phenomenon more thoroughly, it may have also affected the students' openness towards what was happening in the classroom. A limitation also remains in the fact that students' attitudes and opinions were collected after all the learning process was over. Some fresh insights may have been simply forgotten by the study participants.

The mentioned limitations point to new areas and refinements for personal future research. Simultaneously, given the fact that the research on designing an educational environment aimed for the development of CPS skills is still in the developmental stage, the researcher looks forward to seeing more research in this area done by other researchers and practitioners.

CONCLUSIONS

1. After the literature review was completed, the following features of university educational environments enabling students to learn problem solving can be concluded as the most important:

- Giving students to solve an ill-structured problem and integrating the development of domain-general problem-solving skills in the studies of foreign languages is in line with learning by doing or an action- oriented approach. Learning becomes organized around meaningful communication and a purposeful goal, which makes learners more focused on the results of their actions instead of language learning outcomes.
- Students' learning to solve problems can be achieved if enhanced instruction (inclusion of additional measures to improve subskills or discrete aspects of problem-solving skills) is applied in educational environments made of three stages:

I. Educational environments of introductory enablement where students 1) gain additional knowledge of collaborative and ill-structured aspects related to problem solving, and 2) master the competency to use scaffolds facilitating problem solving (the model includes ground rules, question prompts and problem schemas).

II. Educational environments of inclusion in collaborative problem solving where students are engaged in realistic problem solving (learning by doing) by inclusion into four main processes: devising both individual and collective problem representation (analysing the problem, including its causes, consequences, etc., managing additional information, setting goals, devising visual representation of the problem), developing solutions (considering possible solutions), making justifications for the developed solutions and selecting solutions (assessing their feasibility and justifying/comparing them), and finally monitoring and evaluating all problem-solving process.

III. *Educational environments of result sharing and evaluation of developed skills* where students present and share their results and assess each other, as well as reflect on mixed learning outcomes.

2. Descriptive multiple-case study is a suitable method to test the model and understand the complex phenomenon of university educational environments enabling students to learn problem solving. To achieve greater generalizability and trustworthiness of the research, the model was tested in three groups synchronously and cross-case analysis of findings completed. Directed qualitative content analysis was chosen as an approach for testing the preliminary theory, i.e. model of educational environments created. The role of the researcher as a participant-researcher is believed to ensure a more in-depth understanding of the phenomenon. The design of empirical research reflects the model, including three stages of educational environments.

3. During the empirical assessment, the model of educational environments, which was not only theoretically validated but also practically implemented in the study module *English for C1 level*, proved to be effective in enabling students to learn

problem solving. In each group, students demonstrated the necessary social (collaborative aspect of problem solving – managing other people including oneself) and cognitive (managing the task of problem solving) skills, as well as an increased understanding and experience of collaborative problem solving.

The following factors of educational environments were seen to be the most influential for enabling students to develop collaborative problem-solving skills:

- The most beneficial stage for the development of collaborative problem-solving skills was the inclusion into an authentic ill-structured problem-solving task in groups.
- The most impeding factor for the groups' success was some of its members' insufficient social skills. Students still lack sufficient understanding about collaboration and readiness for a collaborative learning culture. Therefore, a collaborative learning culture should be fostered.
- Proper guidance with detailed procedural guidelines was an essential scaffolding that makes complex and latent learning visible and clear.
- The inclusion into visual thinking by constructing individual and collective problem schemas served as a significant scaffold, facilitating not only the problem representation process but also the whole problem-solving process. It also increased students' motivation towards the task.

English, as a working language, was not listed among the factors impeding students' learning to solve problems. However, learning to solve problems was indicated as a highly beneficial context for the improvement of their communicative competence in English.

Aiming to equip learners with a wide range of skills, educational environments merging foreign language learning and the development of problem-solving skills is a modern approach both to foreign language learning and studies at the university. Such educational environments are not restricted just to collaboration and problem solving, but can aid the development of diverse skills and competences in learners: students can master new technological solutions, improve visual thinking techniques, become more perseverant and patient, develop empathy and emotional intelligence, reduce fear of failure, learn to understand new perspectives, become more tolerant for ambiguity, increase capability to manage vast amounts of information, increase self-efficacy and improve critical thinking. They also contribute to the change of traditional mind-sets of learners towards a more valued collaborative culture and new ways of learning – learning can occur not only by learning intentionally but also while acting purposefully – solving a problem at hand. All these aspects are essential for future personal, academic and professional success of each learner.

RECOMMENDATIONS

For stakeholder responsible for the study quality in higher education:

- Encourage teaching personnel to be developing and implementing modern educational environments that allow learners to develop a number of the essential twenty-first century skills.
- Reward those educators that are trying out new learning approaches and are willing to leave their "zones of comfort" because new initiatives are usually time-consuming and not easy. Groups of educators could be formed for the design of complex educational environments.
- The model could be applied for modern foreign language studies, especially in those higher education institutions that seek longer-term goals. Above all, it is suitable for learners of English seeking the highest levels of language proficiency (C1 and above), because it allows practising real world language use.

For educators:

- The designed model of educational environments can be implemented in diverse learning modules that indicate the development of CPS skills in learners as one of its aims.
- Such educational environments are not just restricted to collaboration and problems solving. They can aid the development of diverse skills and competences in learners: students can master new technological solutions, improve visual thinking techniques, develop empathy and emotional intelligence, reduce fear of failure, learn to be more tolerant for ambiguity and increase capability to manage vast amounts of information, among others.
- As it concerns introductory enablement, educators should think of more engaging ways to provide additional understanding on the importance of sufficient collaboration. In addition, they should invest a considerable amount of effort and time for the careful selection of problems, since it is an important predetermining factor. Some type of initial inquiry to find out students' motivational level/attitude to the problem could be utilized.
- Self-selection principle (as opposed to random selection or according to some predetermined variation criteria) for group formation motivates students better and is also a significant predetermining factor impacting group's performance and success.
- There are various forms of scaffolds to support the development of CPS skills that can be utilized to supplement or replace the ones suggested in the model.
- Educators should consider using multiple problem-solving tasks during the same course, so that students are given more time and practice for the development of CPS.
- Educators should use formative assessment that takes into consideration diverse learning outcomes (both product and process). The assessment system might integrate the assessment of both individual and collaborative learning outcomes. An intermediate feedback on students' learning should be present.

For this purpose, rubrics with the levels of desired behaviour (for example, include Likert-type scales) might be developed.

- Such educational environments might be used for boosting creativity and divergent thinking in learners because the promotion of convergent thinking by inclusion into solving well-structured problems is still dominant in formal education.
- They are suitable to bridge the gap between what is learnt in formal education and real life because of the inclusion into solving ill-structured problems, which are the types of problems encountered in real life.
- Such environments are suitable for preparing students for collaborative learning and a working culture that has been gaining increasing popularity nowadays.

For researchers:

- The same model can be empirically tested in diverse contexts and modules across various forms of education.
- Valuable research could be one that employs discourse analysis of problem solvers solving ill-structured problems in a foreign language course.
- The applicability of the same model could be tested for language learners of different levels.

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Dissemination of research results at international scientific conferences

2017 November 24, an oral presentation "Students' Reflections on Collaborative Tasks in ESP Courses" at the international conference "ESP studies in the context of European higher education: theory and practice", Vilnius Gediminas Technical University, Lithuania.

2017 May 26-27, an oral presentation "The Integration of Problem-Solving Activities into the EFL Classroom" at the international conference "Sustainable Multilingualism 2017", Vytautas Magnus University, Lithuania.

2016 November 11, an oral presentation "Foreign Language Teaching in Higher Education is Crying for Reform" at the international conference "Foreign language studies in higher education", Lithuanian University of Health Sciences, Lithuania.

2016 April 14-17, an oral presentation "Revitalizing Foreign Language Learning in Higher Education Using a PBL Curriculum", at the international conference "Teaching and Learning English as an Additional Language", Antalya, Turkey.

2015 September 17, an oral presentation "What Educational Environment May Meet the Needs and Expectations of Generation Z" at the international conference "Linguistic, Educational and Intercultural Research 2015", Vilnius University, Lithuania.

2015 May 29, an oral presentation "Reconsidering University Educational Environment for the Learners of the Net Generation" at the international conference "Sustainable Multilingualism: Language, Culture And Society", Vytautas Magnus University, Kaunas, Lithuania.

2015 June 06, an oral presentation "Bridging the Gap between Educators at Universities and the Learners of Generation Z" at the annual research postgraduate conference, Faculty of Social Sciences, The University of Hong Kong, Hong Kong.

APPENDICES

APPENDIX A. Procedural guidelines for CPS (for steps 1-5)

PROCEDURAL GUIDELINES. TIMING, REQUIREMENTS AND EVALUATION FOR PROBLEM SOLVING SESSIONS

TIMING:

Stage I:
INTRODUCTORY STEPS – Introductory classes 1, 2, 3, and 4 (6 hours)
Stage II:
STEP 1 – Class 1 (0.5 hour)
STEP 2 – Classes 1, 2 and 3 (4 hours) plus individual work
STEP 3 – Class 4 (1.5 hour) plus individual work
STEP 4 – Class 5 and 6 (3 hours) plus individual work
STEP 5 – Class 7 Face-to face and online meeting (min 1.5 hour)
Stage III.
STEP 6 – Class 8 (1.5 hour)
STEP 7 – Individual meeting with each student (appr. 1 hour)

ASSESSMENT:

1) 60% = Group GPS outcomes (Presentations on your group's problem solution that makes 20% of the final mark plus group problem-solving report that makes 40% of the final mark)
2) 40% = Individual CPS performance

- **Individual problem-solving behavior** (40% of the final mark, see the rubric for the desired behavior)
- **Group presentations** on problem solution (makes 20% of the final mark)
- **Group problem-solving report** (makes 40% of the final mark, it should include 3 sections: 1) description of collaborative process of each stage including reflections on it, 2) collective problem schema, 3) problem solution/s, 4) list of new vocabulary compiled by all group members and 5) list of references with their short summaries)

EACH STEP IN DETAIL:

STEPS	*CONTENT AND WORK INCLUDED*	*QUESTION PROMPTS FACILITATING PROBLEM SOLVING*	*EXPECTED RESULTS:*
STEP 1. Describe the problem preliminary IMPORTANT: *When solving ill-structured problems, you cannot jump right to the solution process*	***1A) Individually:*** 1. Read the case and try to understand if the problem really exists. 2. Formulate the problem(s) as a goal or question. 3. Think about the benefits a solution of the problem may bring. 4. Think about the consequences if the problem is not solved.	***The same questions can be used both for your individual considerations and group discussion:*** *What is the problem that the case reveals? (Maybe, there are several problems).* *What facts indicate it to be a problem?* *Why is it a problem?* *What do I/we already know about the problem?*	**Include into your group problem-solving report:** 1. Preliminary definition of the problem based on the shared understanding in the group. 2. Description of the benefits the solutions of the problem may bring. 3. Description of the consequences if the problem is not solved.

without first trying to interpret the problem. Thus, do not offer solutions during Steps 1 and 2.	***1B) In a group:*** 1. Discuss if a problem really exists and what you already know about it. 2. Collectively formulate the problem as a goal or question based on your shared knowledge and group discussion (different persons may come for a group discussion having different understandings of the problem). 3. Think about the benefits of the problem solution. 4. Think about the consequences if the problem is not solved.	*If there are several problems, how are they related to each other? Which of them has the highest priority and why? Who are the stakeholders in the problem situation, and what are their goals? What benefits may the solution bring? What are the consequences if the problem is not solved?*	**Give reflections on the actions and results achieved by answering these questions:** How do you evaluate your group actions and results achieved in STEP1? (Were you deep enough? Are you satisfied with the result achieved? What could be done better? What have you learnt? What has influenced your learning on how to solve this problem and in what ways?)
STEP 2. Make deep individual and collective understanding of the problem space (including devising an external (visual) form of problem representation) IMPORTANT: *Problem representation is the key to problem solving.*	***2A) Individually:*** 1. Identify what you already know and do not know about the problem (the facts of the problem, its context, causes and constraints, i.e. circumstances which you are not able to change). 2. Collect missing information by using different sources and forms of evidence. 3. Describe the structure of the problem space as an individual problem schema. Bring it to the next class. 4. Reflect individually on what you have been doing and the results achieved. ***2B) In a group:*** 1. Share what you have read/ listened to about the problem. 2. Listen to the alternative positions and opinions of each member	***The same questions are used both for your individual considerations and group discussion:*** *What do I/we already know about the problem? What are its elements, context, causes, constraints, stakeholders involved, etc.? Is there any missing information? What information is missing? What are relevant sources for gathering information? How are the facts, context, causes and constraints interrelated to each other? How could I/we present them structurally as interrelated with each other? Have I/we collected enough evidence for understanding the problem? Do I/we need additional evidence?*	**Include into your individual problem solving report:** 1. Individual problem schema. 2. A list of useful vocabulary which you can share with the group members. 3. Sources of references that you have used with a short summary on each of them (introducing the information which was useful for you). **Include into your group problem-solving report:** 1. Improved definition of the problem based on your shared understanding after sharing the information that you have found out about the problem. 2. Description of the problem's context, causes and constraints.

	in the group and discuss them. 3. Construct the collective problem schema. Follow all 6 phases (brainstorming, organizing, layout, linking, finalizing and review). Reflect as a group on what you have been doing and the results achieved. (For more detailed guidelines how to construct individual and collective schemas, use "How to construct problem schemas" ppt.	*What type of additional evidence do I/we need?*	3. Your group's collective problem schema: "Problem space". **Give reflections on the activity and results achieved by answering these questions:** How do you evaluate your group actions and results achieved in STEP2? (Were you deep enough? Are you satisfied with the result achieved? What could be done better? What have you learnt? What has influenced your learning on how to solve this problem and in what ways?)
STEP 3. Generate possible problem solutions and make justifications (provide arguments) IMPORTANT: *Ill-structured problems may have many alternative solutions and*	***<u>3A) Individually:</u>*** 1. Think about and be ready with the individual solutions (several alternative solutions may be constructed). 2. Reflect individually on what you have been doing and the results achieved. ***<u>3B) In a group:</u>*** 1. Share personal positions about the preferred solution(s). Construct arguments for them (give reasons). 2. Discuss the alternative solutions (proposed by each member in your	*What do you think the best solution could be? How would you prove that this is the best solution (be ready to give reasons)? What might somebody else say to show that your solution is wrong? What could you tell him or her to show he or she is wrong? Do outcomes of this solution match the goal of your group? Is your solution feasible after considering all the constraints of this problem? What is its way of implementation?*	**Include into your individual problem-solving report:** 1. Supplement the list of useful vocabulary.

multiple solution paths. *You should generate arguments NOT ONLY for your own solutions but also for or against those that are proposed by other group members.*	group) by asking questions and assessing their viability. It is very important that all members in your group generate arguments and counterarguments (arguments against) for each solution. 3. If necessary, create new collective ideas of the alternative solution(s). 4. Your group does not need to finalize its solution in STEP 3 (more time for that in STEP 4). 5. Reflect as a group on what you have been doing and the results achieved.	*Do we have all candidate solutions?* *Do they eliminate the whole problem or its part/elements (which ones?), eliminate or diminish causes (as entity or some of them)? Is it possible to show this relationship on our problem schema?* *What are the pros and cons of these solutions?* *Have we considered all the constraints?* *Have we taken into account all the perspectives of different stakeholders?* *Do outcomes of these solutions match our group's goal?* *What are the probabilities that our solution/s will be implemented successfully? Which ones?*	**Give reflections on the activity and results achieved by answering these questions:** How do you evaluate your group actions and results achieved in STEP3? (Were you deep enough? Are you satisfied with the result achieved? What could be done better? What have you learnt? What has influenced your learning on how to solve this problem and in what ways?)

STEP 4. Finalize your group's solution and monitor the whole problem-solving process IMPORTANT: *Ill-structured problems may have multiple criteria for evaluating solutions.* *The best solution is the one that is most viable, most defensible and for which the group can provide the most cogent arguments.*	***<u>4) In a group:</u>*** 1. Discuss the available solutions (candidate solutions). Every group member should be active in generating arguments and counterarguments (arguments against) for each solution. 2. If possible, select the criteria to judge them and apply to the solutions. 3. Reach a consensus, agree on 1-2 solutions in your group and finalize it. 4. Discuss and agree on the best course of action to implement that solution with assessing the outcomes that match the goal (it should be prepared in detail). 5. Reflect as a group on what you have been doing and the results achieved.	*What are the available solutions? What could be the counterarguments (arguments against) these solutions? What could be the criteria to judge the solutions? Why is this solution the best choice? Why do we choose this way to solve the problem (discuss the reasons for it)? How will it solve the problem? Do outcomes of this solution match the goal? Have we considered all the constraints? Have we taken into account the perspectives of different stakeholders? What are the ways to implement this solution? What do we need to do additionally? Do we need additional information? What should be done about any difficulties the solution might pose? Have we considered its implementation plan in detail?*	**Include into your individual problem-solving report:** 1. Supplement the list of useful vocabulary**.** **Include into your group problem-solving report:** 1. Group's solution that was reached by making a consensus with a description on how it may be implemented. You should describe it in detail. **Give reflections on the activity and results achieved:** How do you evaluate your group actions and results achieved in STEP4? (Were you deep enough? Are you satisfied with the result achieved? What could be done better? What have you learnt? What has influenced your learning on how to solve this problem and in what ways?)
STEP 5. Prepare a presentation	***<u>5) In a group:</u>*** Prepare a presentation on the solution that your group has arrived at.		Upload your group's presentation into Moodle.

APPENDIX B. The assessment system for CPS

ASSESSMENT:

1) 60% = Group CPS outcomes (presentations of your group's problem solution that make 20% of the final mark plus group problem solving reports that make 40% of the final mark)

2) 40% = Individual CPS performance

- **Individual problem-solving behavior** (40% of the final mark, see the rubric for the desired behavior)
- **Group presentations** on problem solution (20% of the final mark)
- **Group problem-solving report** (40% of the final mark)

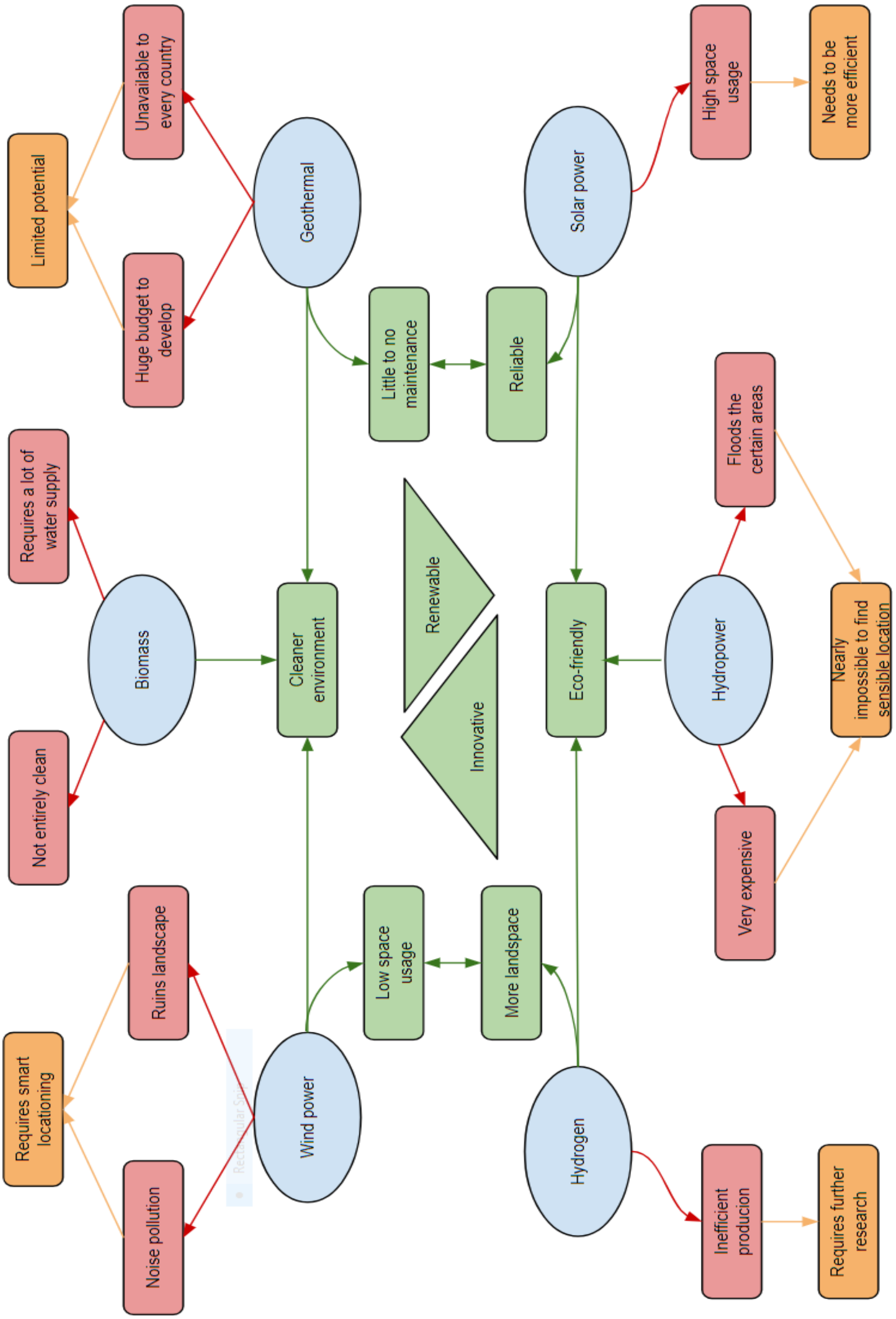
Requirements for problem schemas:

- Problem schemas should show your understanding of the problem. Visualize elements constituting the problem – its structural and situational characteristics or properties. In addition, show how they might affect each other – structural relationships. If possible, visualize its solution process (optional).
- Structural relationship can be shown by lines, with or without arrows. You can use various types of links (1) part of link (*hand -finger*), 2) type of/ example of link (*school – private*), 3) leads to link (*practice – perfection*), 4) analogy link (*school – factory*), characteristic link (*sky – blue*) and 5) evidence link (*broken – x-ray arm*) (Halpern, 2014).

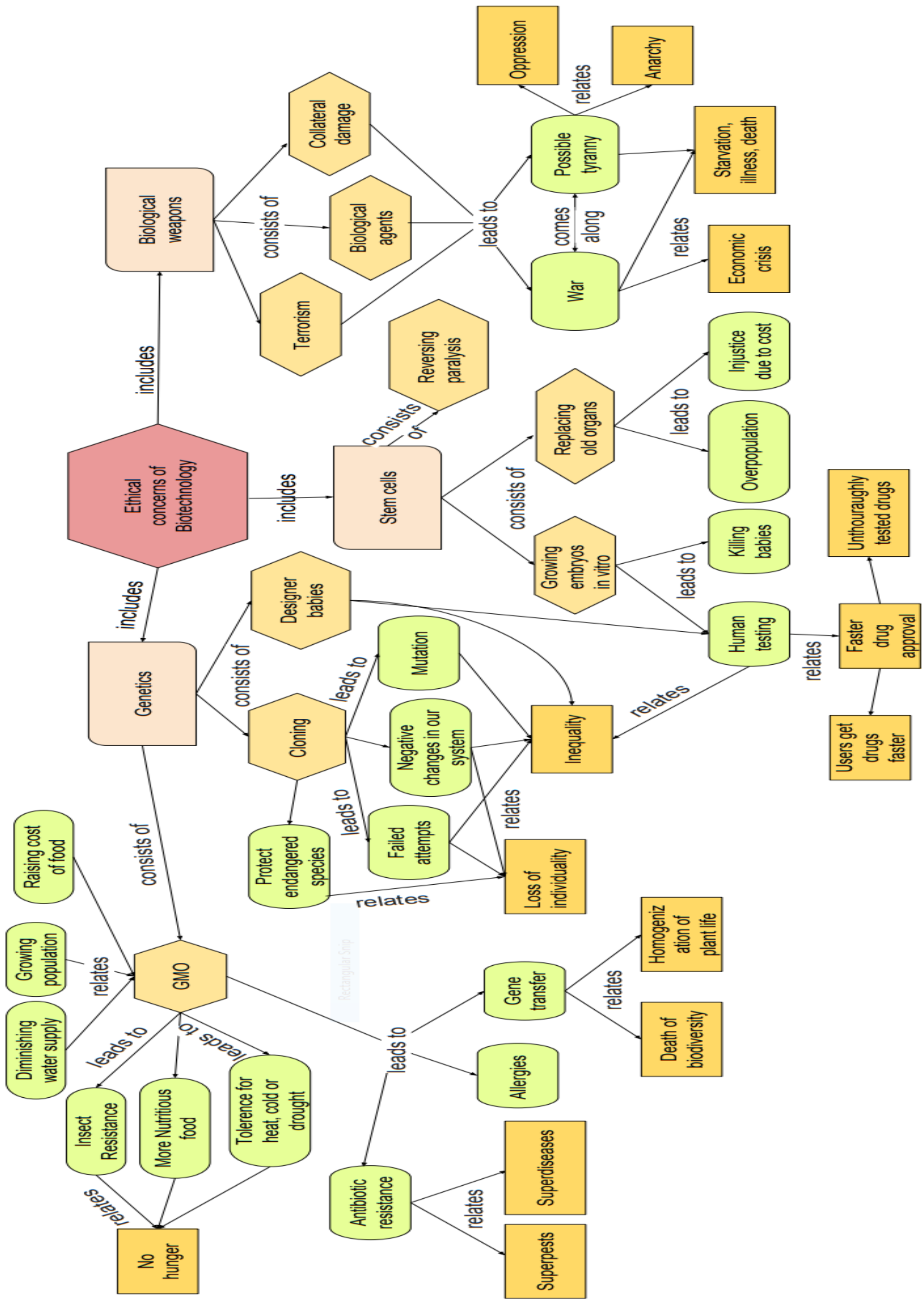
Requirements for problem-solving reports:

It should include 5 sections: 1) a description of collaborative problem-solving process of each stage including reflections on it, 2) a collective problem schema, 3) a list of problem solutions, 4) a list of new vocabulary compiled by all group members, and 5) a list of references with a short summary on each.

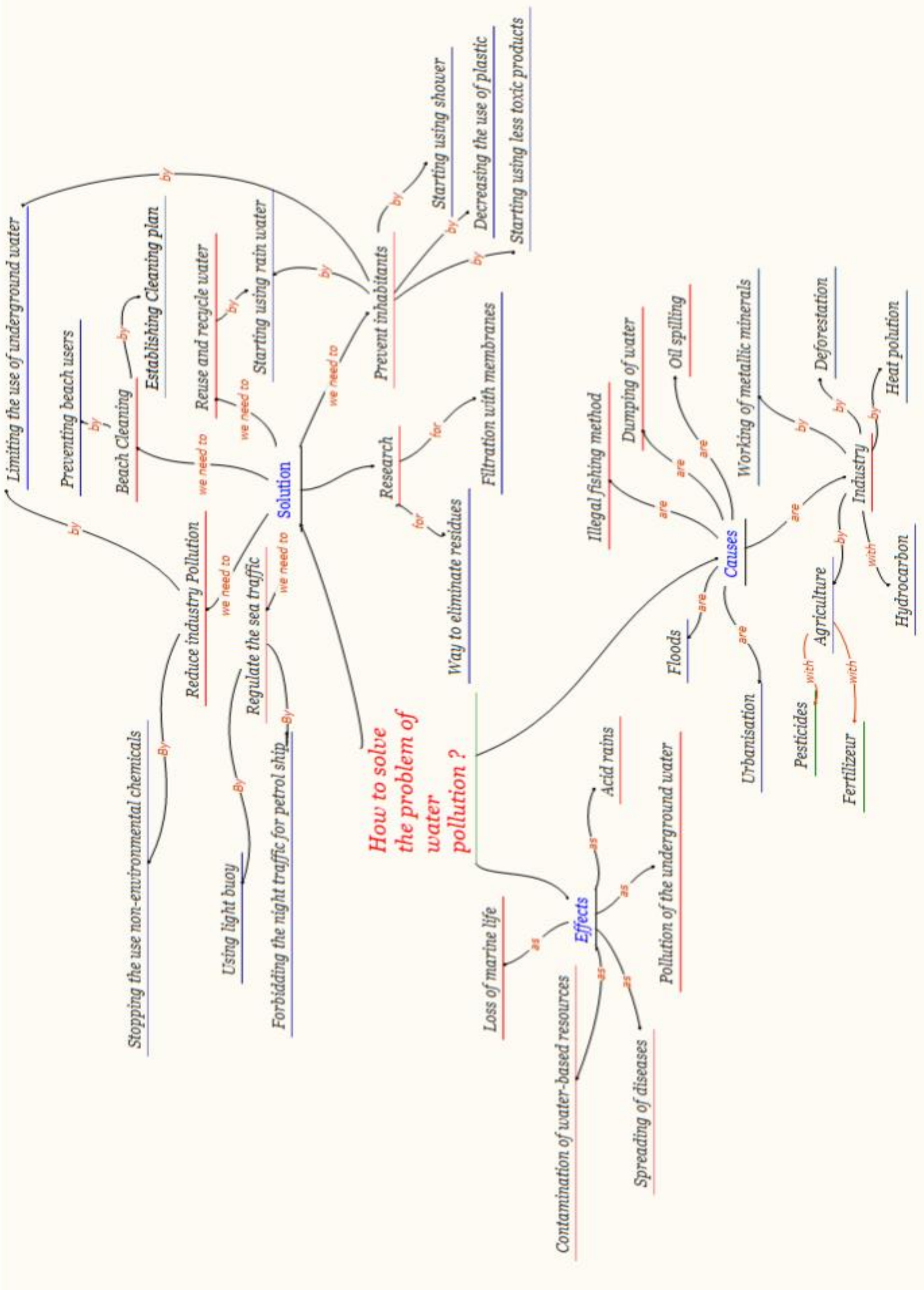
APPENDIX C. Example of collective visual thinking during the introductory class 4 (Case study 1)



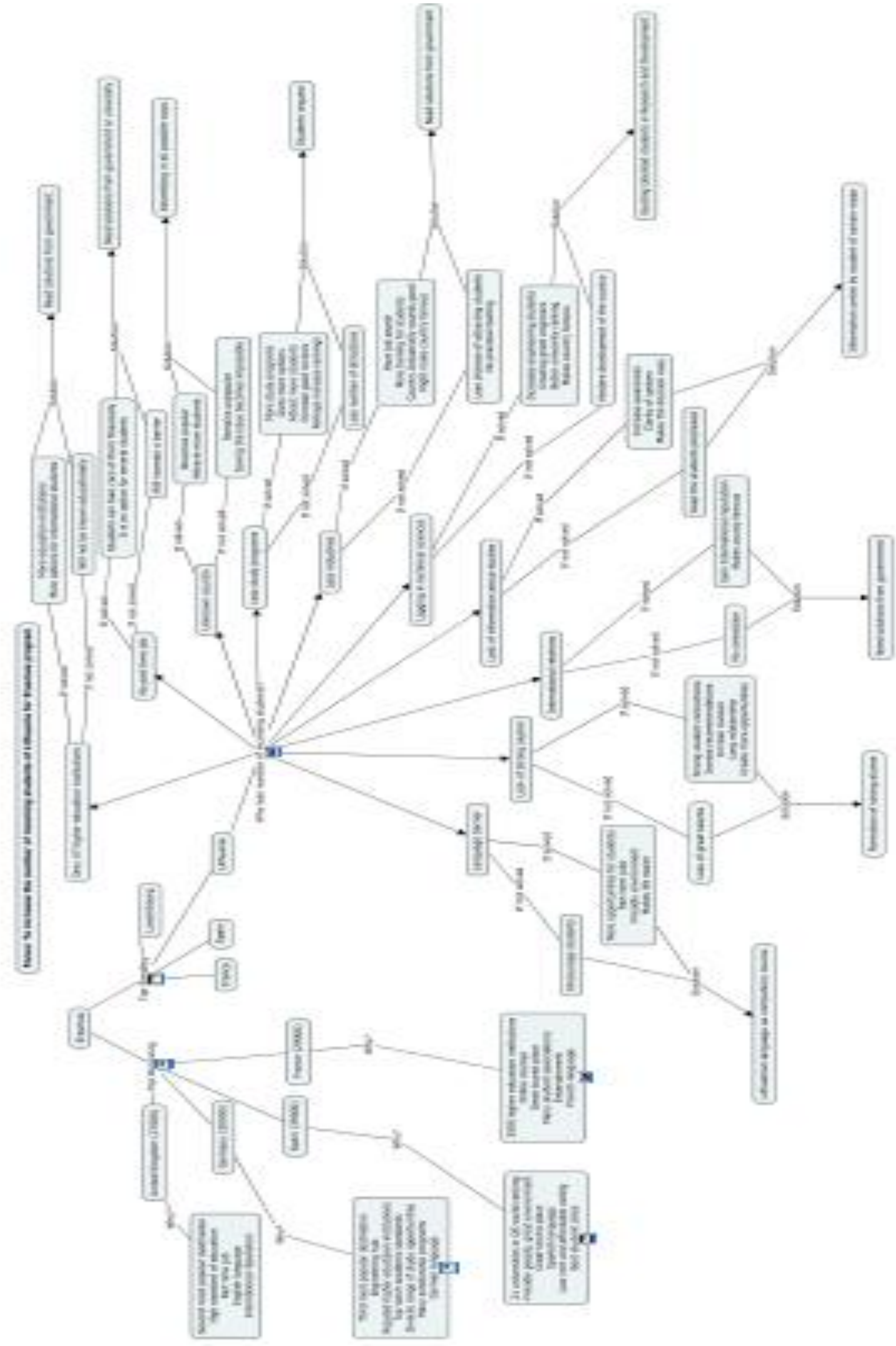
APPENDIX D. Example of collective visual thinking during the introductory class 4 (Case study 2)



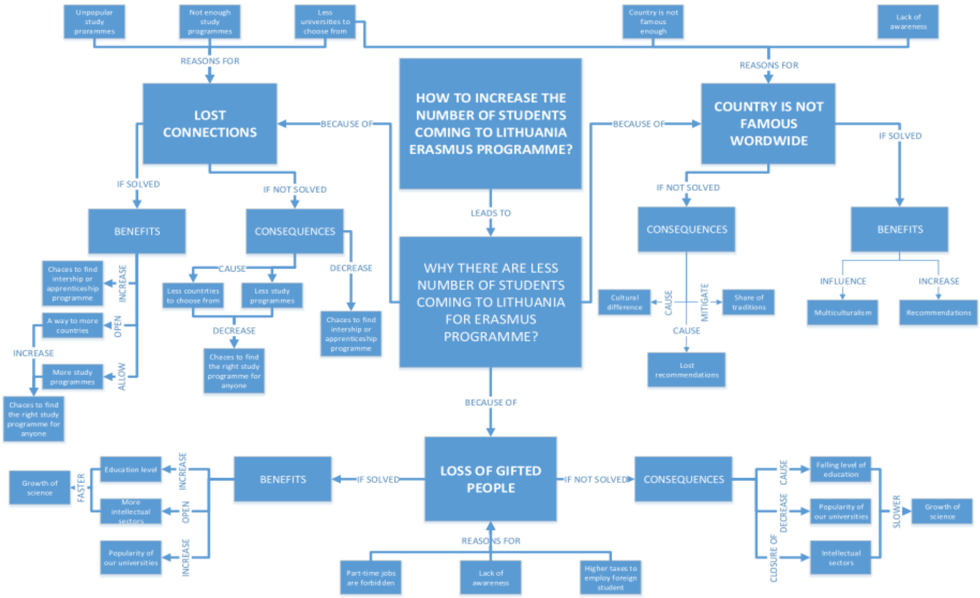
APPENDIX E. Example of collective visual thinking during the introductory class 4 (Case study 3)

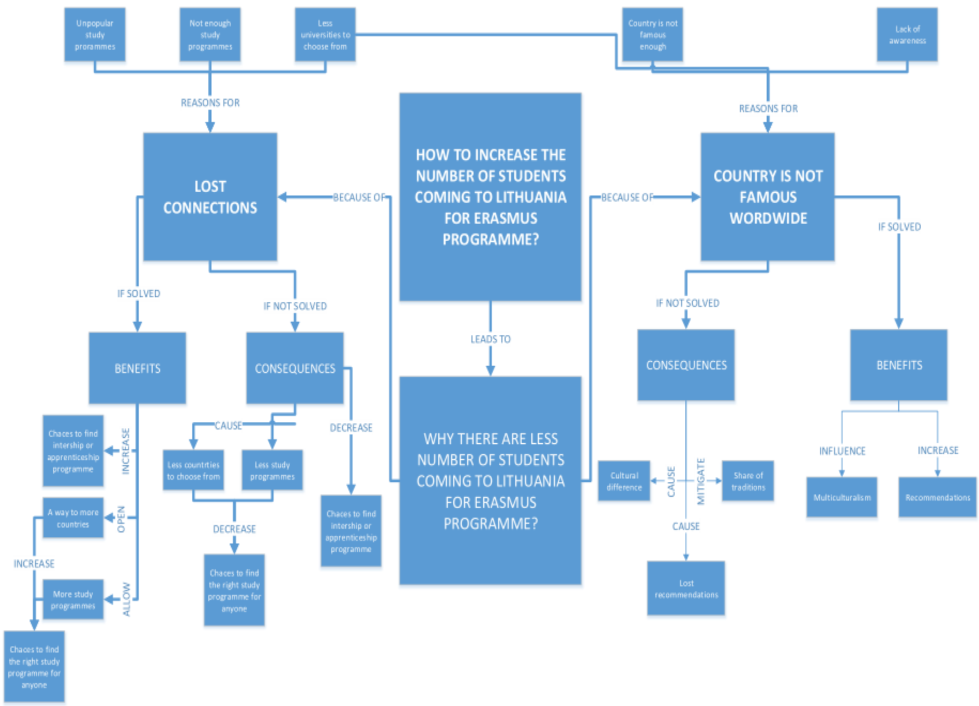


APPENDIX F. Example of an individual problem schema from Case study 1

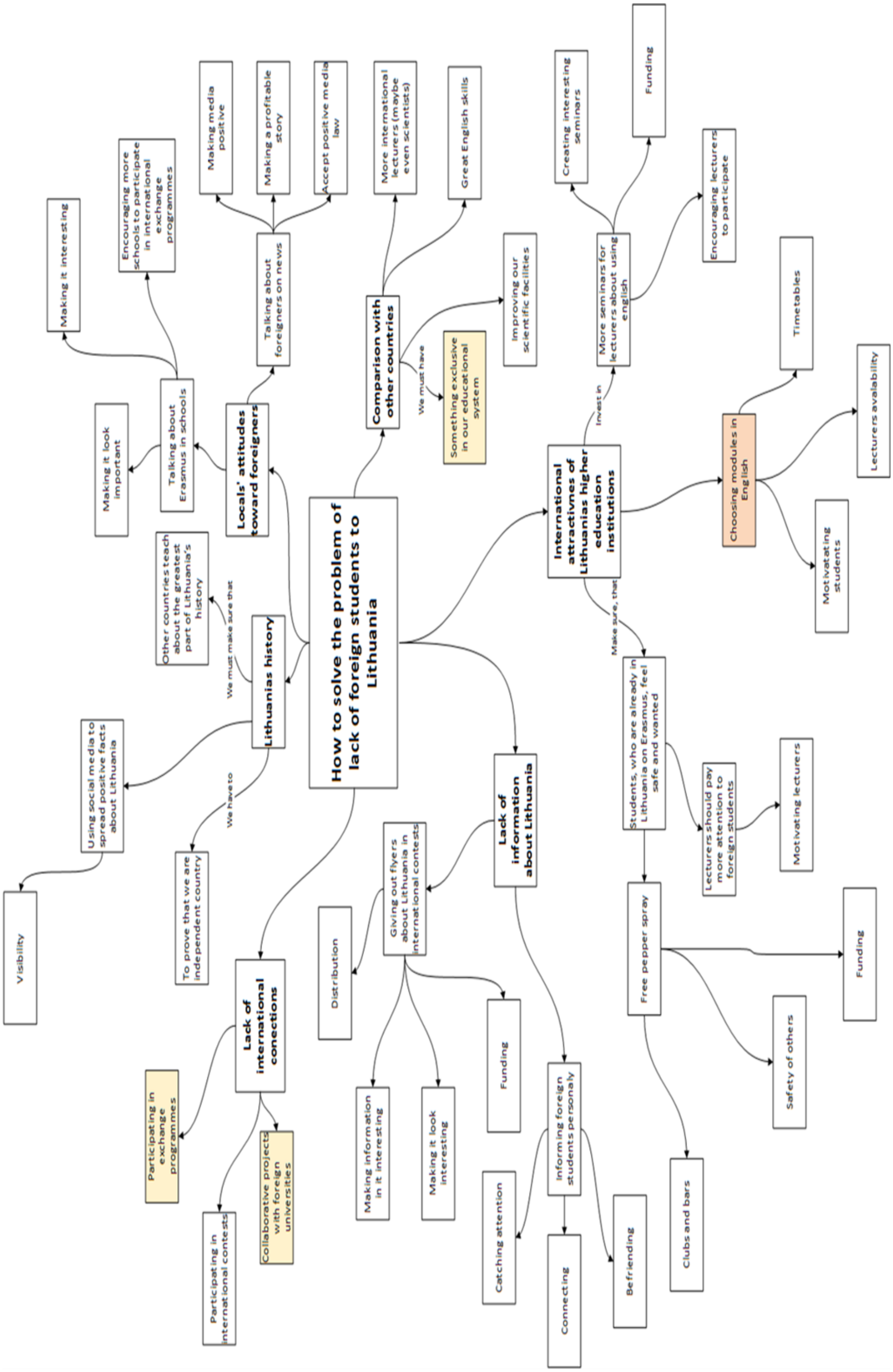


APPENDIX G. Collective problem schemas from Case study 1 (versions 1 and 2)





APPENDIX H. Collective problem schema from Case study 3

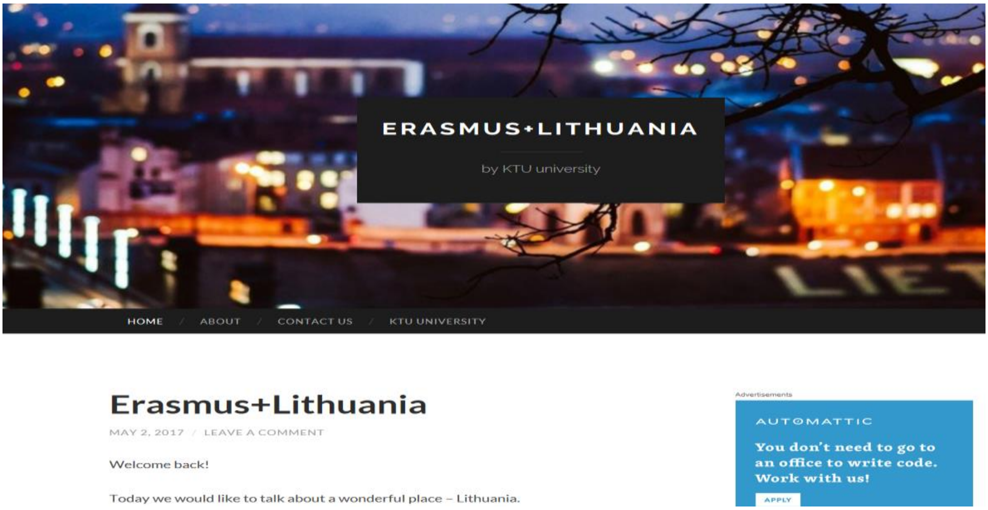


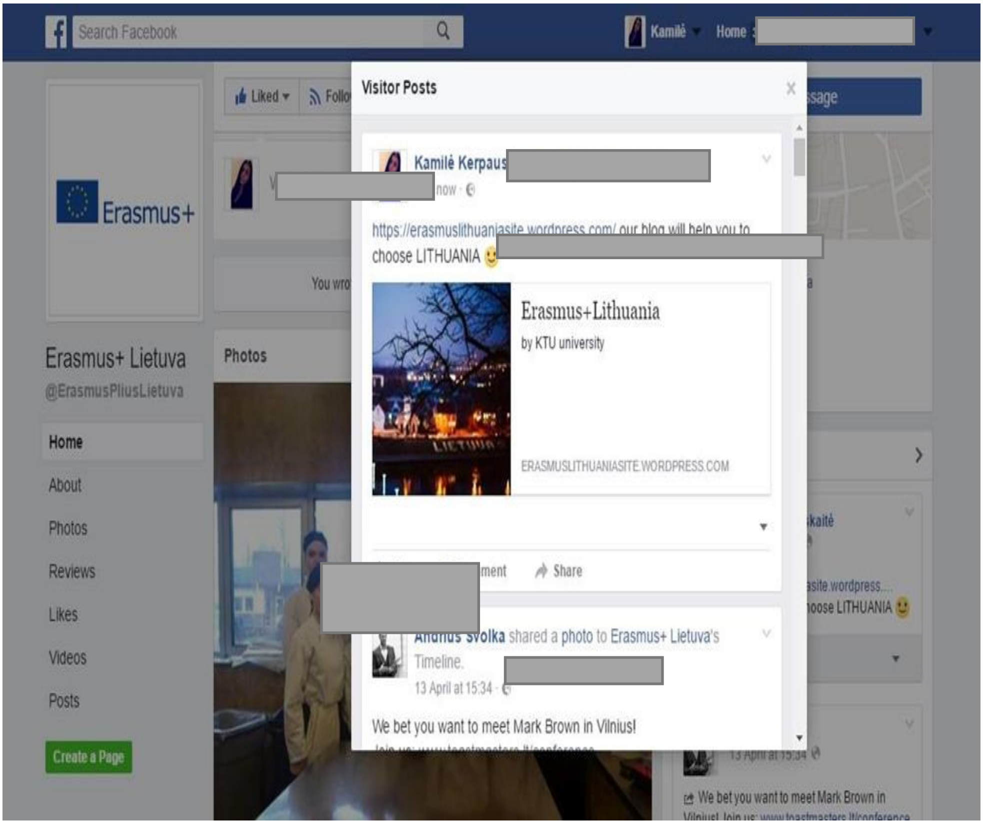
APPENDIX I. Guide for semi-structured interviews

Klausimų blokas ir jo tikslas:
Kaip studentai mokosi spręsti problemas? – sužinoti, ar šios aplinkos buvo veiksmingos mokytis spręsti problemas, kaip kiekvienas grupės narys patobulino socialinius ir kognityvinius gebėjimus, reikalingus spręsti neaiškios struktūros problemas bendradarbiaujant.
Papasakok detaliau, kaip prisidėjai prie savo grupelės problemos sprendimo. Kaip manai, kuo naudingas buvo tavo prisidėjimas prie bendro grupės tikslo? Kaip vertini savo veiklą grupelėje? Ar buvai pakankamai iniciatyvi/us ir atsakinga/as už grupės darbą? Kaip rodei iniciatyvą ir atsakingumą? Ar buvai pakankamai aktyvi/us grupės diskusijoje? Ar pastebėjai, ką jūsų grupė darė gerai ir ko trūko? Kaip vertini grupelės narių asmeninį atsakingumą ruošiant bendrą pristatymą ir ataskaitą? Kaip regavai į kitų išreikštą nuomonę? Kokias kitų grupelės narių stipriasias ir silpnąsias puses pastebėjai? Kaip vertini grupės darbą? Prisiminkime problemos pristatymo ir darbo ją sprendžiant etapus. Ką sužinojai ir išmokai įvadiniame etape, kai mokėmės konstruoti individualias ir kolektyvines problemų schemas? Ką sužinojai ir išmokai įvadiniame etape, kai vyko įvadinių žinių apie neaiškios struktūros problemų sprendimą bendradarbiaujant pristatymas? Kaip dalinaisi informacija apie problemą? Ar pakankamai jos surinkai/sužinojai? Kaip supranti, kas yra dalijimasis žiniomis su kitais, kas yra bendrų žinių ir bendro supratimo kūrimas? Ar esi tai praktikavusi/ęs anksčiau? Kuo prisidėjai ir ką išmokai problemos supratimo etape? Kaip tau pavyko konstruoti individualią problemos schemą šiame etape? Ar tai buvo nauja patirtis? Su kokiais sunkumais susidūrei? Kaip vyko ir kokią reikšmę turėjo kolektyvinės problemos schemos konstravimas? Kuo prisidėjai ir ką išmokai sprendimų alternatyvų generavimo etape? Kuo prisidėjai ir ką išmokai sprendimų pagrindimo, argumentavimo ir parinkimo etape? Kuo prisidėjai ir ką išmokai viso proceso stebėjimo ir jo iekvieno etapo vertinimo etape? Ką išmokote paskutiniame etape, kai grupelės dalinosi savo sprendimais? Kaip pasikeitė Tavo supratimas apie problemų sprendimą bendradarbiaujant? Duok pavyzdžių. Kaip pasikeitė Tavo gebėjimas spręsti problemas? Kaip manai, ar kolektyvinis problemų sprendimas yra efektyvesnis už individualų? Kaip? Kaip manai, ar būtumei šią problemą geriau išsprendęs vienas, ar ji buvo geriau išspręsta, dirbant visiems grupėje drauge? Kaip manai, kokie dalykai yra svarbiausi, kurių išmokai? Jeigu dar kartą tai kartotųsi, ko norėtumei, kad būtų kitaip?

Kaip konkretūs šių aplinkų veiksniai (pati problema, motyvacija, pasiruošimas konstruoti individualias ir kolektyvines problemų schemas, įvadinės žinios apie neaiškios struktūros problemų sprendimą bendradarbiaujant, procedūriniai reikalavimai, užvedantys klausimai juose, individualių ir kolektyvinių problemų schemų konstravimas, grupės narių bendradarbiavimas, diskusija, informacijos dalinimasis, anglų kalbos kaip darbinės kalbos vartojimas ir kiti) **įgalina studentus mokytis problemas? Kokie rezultatai pasiekiami? – sužinoti, kaip konkretūs edukacinių aplinkų veiksniai prisidėjo prie kiekvieno grupelės nario mokymosi spręsti problemas ir kokie rezultatai buvo pasiekti.**
Ar Tau patiko ši užduotis ir kodėl? Ką manai apie problemą, kurią teko spręsti? Kaip keitėsi tavo supratimas apie problemą? Ką manai apie problemos sprendimų sesijų organizavimą, ar pakako informacijos ir laiko, ar viską supratai? Kuo naudingi buvo procedūriniai nurodymai, pateikti kiekvienam problemos sprendimo etapui? Kaip naudojaisi užvedančiais klausimais, kurie buvo pateikti kiekvienam etapui? Kuo jie buvo naudingi? Kokią reikšmę jie turėjo? Kaip kolektyvinės problemos schemos konstravimas prisidėjo prie problemos supratimo? Ar jis buvo naudingas? Ką jis davė? Kaip vizualinis problemos pavaizdavimas problemos schemose keitė jos supratimą? Kaip kiekvienas grupės narys pakeitė Tavo supratimą apie problemą? Kuo prisidėjo prie problemos sprendimo grupės narių informacijos dalinimasis? Kuo buvo naudingas? Kokios buvo stipriausios kitų grupės narių pusės ir ką iš jų išmokai?
Kaip anglų kalbos kaip darbinės kalbos naudojimas darė įtaką tavo mokymuisi spręsti problemą? Kas būtų kitaip jei problemą būtumėte sprendę lietuvių kalba? Kaip vyko diskusijos? Ar kitiems grupės nariams pavyko visas norimas mintis išreikšti anglų kalba? Ką pastebėjai? Kas buvo sunkiausia? Ar visi buvo vienodai aktyvūs? Ar tau pavyko visas norimas mintis išreikšti anglų kalba? Kas buvo sunkiausia? Kaip jauteisi? Kaip manai, ar pasikeitė Tavo gebėjimas išreikšti savo mintis angliškai? Kaip jis pasikeitė? Ar keitėsi kalbos įvairovė? Ar kartodavai kitų studentų frazes? Ar vienodai galėjai reikšti savo mintis pirmos diskusijos lyginant su tolimesnėmis? Ar patobulinai savo anglų kalbos žodyną? Ar buvo naudinga žodyno dalinimasis? Ką darei, kai nežinojai žodžio? Ar kiti nariai tave pataisydavo, padėdavo suformuluoti mintį, primindavo nežinomą žodį? Kaip problemos sprendimo veikla leido patobulinti tavo užsienio kalbos žinias ir praktinį kalbėjimą? Kas dar įtakojo Tavo mokymąsi spręsti problemą ir kaip? Kurie edukacinės aplinkos faktoriai labiausiai įtakojo mokymąsi spręsti problemą? Kaip? Kurie buvo nenaudingi/ trukdanys mokytis? Duok pavyzdžių. Kaip pasikeitė Tavo supratimas apie problemų sprendimą bendradarbiaujant? Jeigu dar kartą tai kartotųsi, ko norėtumei, kad būtų kitaip? Ką norėtumėte pridėti, kas atrodo svarbu, ko nepasakiau, ką pasakiau tik paviršutiniškai?

APPENDIX J. The proofs of solution implementation



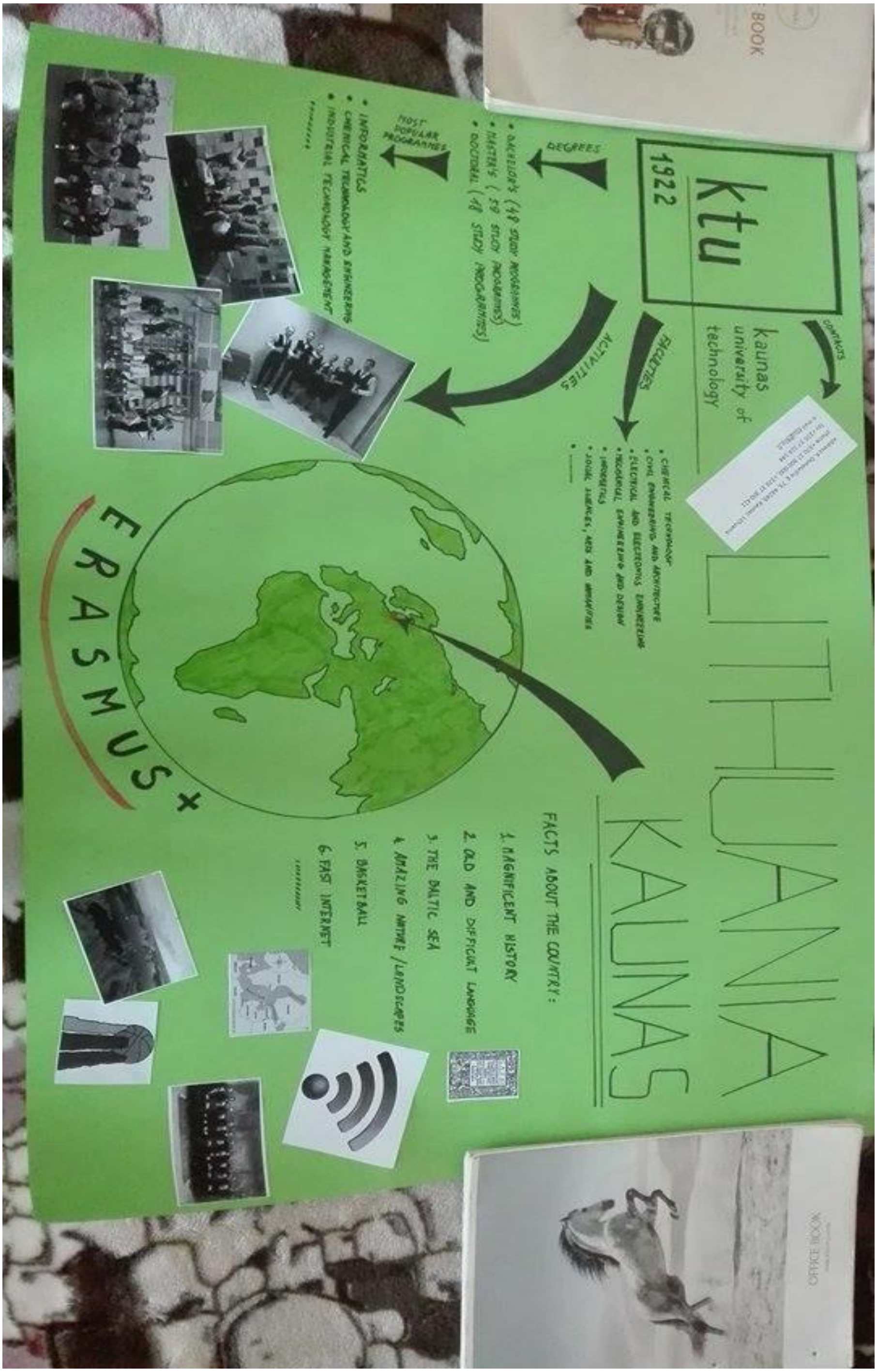


APPENDIX K. Observational protocol

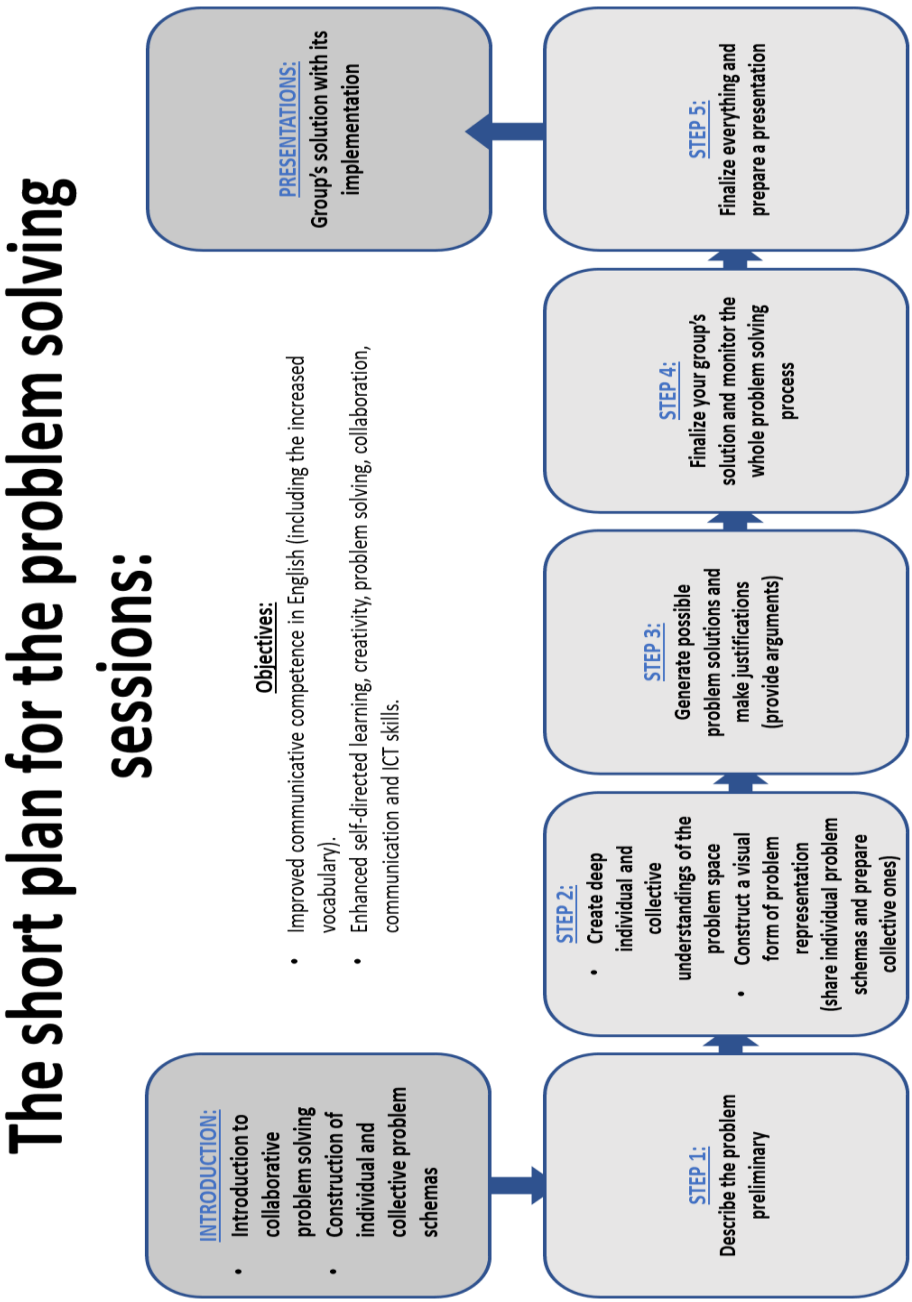
Group observed:	
Class/ Step:	
Date:	

Descriptive data	**Reflective data**
"portraits of the participants, a reconstruction of dialogue, a description of the physical setting, accounts of particular events, or activities" (Creswell, 2009, p. 181)	"the researcher's personal thoughts, such as speculation, feelings, problems, ideas, hunches, impressions, and prejudices" (Creswell, 2009, p. 182)"
Additional notes:	**Additional notes:**

APPENDIX L. The poster created by Group 1 (Case study 1)



APPENDIX M. Short plan for all problem-solving sessions



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Spausdino leidyklos „Technologija“ spaustuvė, Studentų g. 54, 51424 Kaunas