Problem solving skills in primary education: context and outcome of teaching intervention

Dimitra Kafka, *Laboratory Teaching Staff , School of Pedagoical and Technological Education of Athens, ASPETE , dimitrakauka@gmail.com*

Abstract: This paper lies within the field of training on skills and presents the pedagogical aspects associated with problem-solving skills in primary school. The supportive pedagogical factors and the educational strategies that were adopted at the implementation of the teaching intervention in the third grade of Primary School are presented.The questioned concerned us was the following: To what extent can the issue of problem solving be taught, so that students can, firstly, understand and identify the aspects of each problematic situation and, secondly, make proposals on solutions, based on their cognitive abilities and their age.The implementation of the teaching intervention was organized on the basis of a targeted learning environment. In its context, learning opportunities emerged and a productive learning process was formed. As regards the evaluation of the teaching intervention, its results converge with the findings of research on the learning and development of the child (Cantor, Osher, Berg, Steyer, & Rose, 2018), the facilitating and supporting factors that contribute to it.

Key words: Skills, problem solving

1.Intoduction

It is generally accepted that knowledge on human development and learning is constantly expanding. The framework of methodological principles and proposals seems to be moving at a similar ground. The implementation of these developments requires the integration of the scientific principles of pedagogy and psychology, since the development and growth of the child is determined by a multilevel system of interactions.

By this paper we are forming a learning trajectory of integration of all students in the learning process. Starting from the experience and the principles of experiential learning, we focus on cultivating problem-solving skills, accepting the importance of these skills for the modern citizen.

By specifying the work environment in the first part, which is the theoretical framework, we try to clarify the theoretical concepts. We thoroughly analyze the concept of skills, the concept of problem solving, both as a concept and as an object of teaching. In the second part we present in detail the structure of the teaching intervention, as it was applied in a school classroom of the third grade of Primary School, and we present the levels of activities. In the third part of the paper, we present the findings of this specific intervention, as captured in the context of the qualitative analysis.

2. Theoretical framework

2.1 The concept of skills

For more than two decades, researchers, teachers, policymakers and business leaders have stressed the need to support the skills of the "21st century".

Acquiring these skills presupposes the ability of schools to shape environments, structures and practices tailored to students' learning and developmental needs. Achieving this goal requires the development of relationship trust among all those involved in the learning process, an emotional security environment, but also the building of learning structures that allow continuity in relationships, consistency in practices and predictability in routines that reduce stress and support learning (Spencer, 2007). Secondly, as regards educational strategies an organized learning environment that highlights students' prior knowledge and experiences and actively engages them in interesting activities that lead to conceptual understanding and transferable knowledge and skills is required. More specifically, well-designed learning practices that encourage students to ask, explain and process their thoughts and co-construct solutions are also required. (Bransford, Brown, Cocking and National Research Council [NRC], 2000). Thirdly, teaching opportunities are needed to develop metacognitive skills through the planning and management of complex tasks, self-assessment and peer review, in the context of ongoing diagnostic assessments.

Many organizations and researchers have focused in their studies on the importance of defining 21st century skills (Voogt & Pareja Roblin 2010), trying to cover a wide range of knowledge and skills that are not easy to be defined, codified and categorized accurately. This paper uses as a frame of reference the 21st century skills model presented by Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., & Rumble, M. (Binkley, Erstad, Herman, Raizen, Ripley, & Rumble, 2010). Based on the study of researchers in the detailed curricula and evaluation frameworks from different countries, a broad and extensive list of ten important skills necessary for the 21st century has emerged, which includes all the different approaches. Table 1 shows the axes of the frame of reference of 21st century Skills.

Table 1: KSAVE model (Knowledge, Skills, Attitudes, Values, και Ethics)

Methods of thinking	Methods of working	Working tools	Social life skills
1. Creativity & innovation	4.Communication	6. Information literacy	8. Citizen status (local & international)
2. Critical thinking, Problem solving, Decision taking	5.Cooperation (groups)	7. Digital (ICT) literacy	9. Life & career
3. Metacognition, «Learning how to learn»			10. Personal & social responsibility

2.2 Learning through problem solving

For much of the 20th century, the scientific community has turned to trying to define and teaching problem-solving skills.

Theoretical approaches converge on the view that, a problem is a situation that requires solution (Krulik and Rudnick 1987). In general, they treat problem solving as a situation and process that depends on the environment, depth, knowledge structures and experience (Palumbo, 1990; De Bono, 1983; Beyer, 1984). In the context of theoretical approaches, the need to utilize an authentic problem in a realistic context is also emphasized, so that previous knowledge and experiences to be exploitable.

In 2002, Torp and Sage defined problem solving as a targeted learning process, organized based on research and solving of real problems (Torp & Sage2002). In 2004 Hmelo-Silver defines problem solving as a teaching strategy in which students learn based on complex problems, which are not solved only by a single correct answer (Hmelo-Silver 2004). As part of this process, students, working in groups, maintain autonomy in how they work, apply their knowledge to solve the problem and reflect on what they have learned and to what extent the strategies they have used have been effective. However, selecting clearly formulated problems and the coordinating - guiding role of the teacher are prerequisites for the success of the problem solving process (Savery, 2006). In terms of the methodological framework, in the early 1900s, problem solving was seen as a mechanical, systematic and often abstract set of skills. However, under the influence of cognitive learning theories, problem solving has become a complex learning activity that aims to cultivate a wide range of skills. A brief overview of the problem-solving models reveals relevant but not identical positions, as concerns the procedural part.

At a first theoretical approach, problem solving involved skills of visualization, connection, subtraction, comprehension, reasoning, analysis, synthesis, and generalization (Garofalo &

Lester, 1985, p. 169). Gradually, after the decade 1960-70, goals began to become more specific, and researchers developed general problem-solving models with which they also identify their solving processes (Newell & Simon, 1972; Polya, 1957; Bransford & Stein, 1984). For example, in the model developed by Bransford it incorporates methodological principles and procedures such as problem identification, recording relevant information, finding solutions through brainstorming and different points of view, finding solution strategies, evaluating solution options. Also, in Barrows' model (in Mavroskoufis, 2010: 152 & Barrows (1985), we observe that the steps to be followed are clearly stated. According to this model, students read and identify the problem, discuss it and analyze it based on the knowledge they have, but also based on the appropriate sources of information, while the teacher asks questions and encourages the formulation of assumptions. Then the students decide on the action plan to solve it, examine the problem based on the new information, evaluate the outcome of their work and training.

As results by the theoretical and methodological framework, problem solving involves a complex set of cognitive and behavioral processes, in the context of which the student is required to develop cognitive strategies. For this reason, it is often necessary to allot the problem, the objectives, and the solution processes into smaller contexts. This alternation between smaller, intermediate, and final goals is a testament to higher order thinking skills, according to Gagne, since they are processes of applying "rules and concepts" to different situations (Gagne, 1985).

In the problem-solving process, it is essential that students recognize and understand the problem, believe in their individual abilities, and mobilize to solve it (Mauffette et al, 2001: 11-25) within an organized, targeted, and pedagogically safe manner environment (Jonassen, 2004). By learning to solve authentic situation problems students will be able to implement these methods in other situations and solve corresponding problems. In this context, both declarative and procedural knowledge should have parallel paths in the problem-solving process. (Newell and Simon, 1972). According to Savery, the most important element of problem-based learning is the problem itself (Savery, 2006). Thus, the need to formulate problems and select central concepts, goals and framework of action, appropriate to the school environment, arises (Duch 2001) and they need to be distinguished by openness in terms of their solutions (*Jonassen & Hung, 2008*).

As the theoretical approaches show, problem solving is a student-centered approach that enables students to research, to link theory with practice in order to produce a satisfactory solution to a particular problem. Duch, Groh, and Allen (2001), while describing problem-solving practices, identified some special skills and abilities that students develop when solving problems. They learn to think critically, to solve complex and authentic problems, to seek, to evaluate, to use sources of information, to work together in harmony, to develop their communication skills and to use knowledge and cognitive strategies for the purpose of learning.

Assessment is also intertwined with the process and development of learning and teaching. The detailed reference to the forms of problem-solving assessment is not included in the target of

the paper, which is why we are limited to a brief reference to its directions and forms, as shown from the literature. We distinguish three directions regarding assessment in problem solving. Firstly, we distinguish types of assessment designed specifically for problem solving, secondly a formula that connects principles of authentic assessment with those of problem solving and thirdly the type of *self-assessment, peer assessment and collaborative assessment* (Savin-Baden, 2003 Macdonald, 2005).

3. The teaching intervention

3.1 Purpose of the teaching intervention

The purpose of this specific didactic application was to develop skills in students of the third grade of Elementary School to identify problems and make proposals for solutions, taking into consideration both their age and cognitive level.

3.2 General question

Can the development of problem-solving skills be the subject of training in the context of the cognitive subjects of the third grade of Primary School?

3.2.1. Individual questions

a. Do students know what a problem means?

b. Have they been taught problem-solving strategies?

3.2.2. Methodology

Teaching intervention that we are talking about was implemented in a Primary school in a class of the third grade of the Primary School during the school year 2020-21, from September to June.

The questions in the context of the modules of the cognitive subjects of Language and Environmental Studies, constituted the beginning for the implementation of the teaching intervention. Questions like, what problem do you see?, what do you suggest? fueled the formation of a targeted learning environment.

At the planning stage we took into account parameters that were related on the one hand to the student population and on the other hand to the procedures and methodology of implementing the intervention. Considering the fact that in every school classroom there is a heterogeneous composition of the student population in terms of its cognitive and learning abilities, our priority was to select the questions that would facilitate the participation of all students in the learning

process. At the heart of the intervention program, we put the reliability of implementation by applying a standard framework of intervention. At the same time, factors such as the systematicity of the intervention, the combination of methods, the duration and the prospect of continuing the intervention were taken into account (Barry, 2013)

In the first phase of the intervention action we focused on building the conceptual framework as regards the concept of the problem. The students' cognitive background regarding the concept of the problem was pre-checked, examples were given and their further sensitization towards the concept of problem followed. In the second phase the implementation of the teaching intervention in a targeted environment followed and the post-check followed after the completion of the teaching intervention.

In order to support the above activities, we were usually using the brainstorming technique, in order for the student experiences to be captured through questions that enhanced the deepening, analysis and mapping of the problems. The implementation environment was framed by a series of activities, based on interpersonal communication and interaction, exchange of views, formulation and support of opinions.

3.2.3 The sample

The specific intervention took place in a class of the 3rd grade, in a school of the Directorate of Primary Education of the B' region of Athens, table 3, for a total of 25 students, in which there was a student with learning disabilities and 3 students facing difficulties in the management of information and the interconnection of data with requests.

Table 2

Third Grade

	1st class
Boys	**12**
Girls	**13**
Total	**25**

3.2.4. The research tools

In the context of research design and data collection (Creswell, 2002), the class of the third grade was the experimental group, which contributed significantly to the conclusion drawing.

Focus groups technique was adopted as research tool, in the context of qualitative research (Vaughn, ed al 1996). Based on a general overview of the theoretical approaches we observe that the views of the scientific community conclude that it is a technique of "reading" and analyzing the polyphony of views. According to Krueger, this technique is defined as "a carefully organized discussion, which is designed to draw perceptions and beliefs on a specific research topic, within a permissive and non-threatening environment" (Krueger, 1998). The views of Wilkinson, who defines it as an environment in which researchers are confronted with the multilevel and dynamic nature of human perception, with the fluidity and contrasts of the views, feelings and experiences of the respondents are moving towards the same direction (Wilkinson, 1998). In addition, in the context of this technique, the researcher has access to the ways in which people think or why they think as they think (Kitzinger, 1994). Basically, it is "a way of listening to people and learning from them" as Morgan observes (Morgan, 1998).

3.2.5. Method of collecting data

In order to collect research data, we adopted a bilateral format. Pre-checking preceded, exploring students' knowledge regarding what the word problem means, and then post-checking followed. Firstly, the students' knowledge about what is a problem was researched and secondly, the skills of locating, interpreting and solving the problem were examined, table 4.

Table 3: Pre-checking, Evaluation sheet before starting teaching intervention

1st Question	What words come to your mind automatically when you hear the word problem?
2nd Question	In which subjects have you dealt with problems?

Post-checking

In the post-checking stage, in addition to the initial question of what the word problem means, we also asked questions about the subjects in which we encountered problems that required solutions. The questions remained in the same direction but were modified in terms of wording.

1st Question	What does the word problem mean?
2nd Question	In which subjects did we encounter problems that required solutions?

The process of decoding and recording the students' answers followed, which, as it turned out, enlightened the aspects of the questions we had asked.

4. The learning environment of the teaching intervention

First level

At the first level and in particular in the immediate environment of the students, we try to highlight their experiences, related to the problems encountered in the immediate and man-made environment, in order to gradually move to the definition of the problem concept, table 5.

Table 4

Learning environment				
First level	Study environment	Question	Teaching techniques	Teaching means
Highlighting experiences [Man and his problems]	"People with problems"	Can you name some people problems?	Brainstorming Questions-answers Filling in a worksheet	Photographic and printed material of man-made and living environment facing problems. Table Projector

The answers are recorded on a piece of paper of one meter, a framework for discussing the problems and their role in people's lives is formed and the issue of the need to solve them is raised.

Second level

In the second level we examined, in more detail, issues that reflect realities from the man-made and living environment, table 6. The aim was students to focus on problems, as well as on the grid of problems that arise. In this activity as well, the answers were recorded on a one-meter piece of paper and a discussion framework was formed based on their views.

Table 5

Learning environment			
Second level	Subject	Teaching techniques	Teaching means
Experience review, forecasting, extensions. [Grid of problems]	"The problem and the problems"	Brainstorming Questions-answers Filling in the worksheet	Utilization of additional pictorial historical material, at the discretion of the teacher. Table Projector

In the context of this activity, students, going beyond the simple quotation of words, have the opportunity to argue and express their views, through the "dialogue" environment that is formed in the classroom (Englezou, 2015). Utilization of additional pictorial historical material, at the discretion of the teacher.

Third level

Third level aims at conceptualization, Table 7. The conclusions that can be drawn between the theoretical and the practical dimension of the topic, are expected to be completed in the fourth stage, in which the students connect each problem with individual and collective actions.

Table 6

Learning environment			
Third level	Subject	Teaching techniques	Teaching means
Formulation of concepts	Interpretation of concepts and terms: "The terms derive from the subject of the study"	Brainstorming Filling in the worksheet	Table Projector

Through the technique of brainstorming, the students' answers are recorded on a one-meter piece of paper, grouped and remain in a prominent place in the classroom for further search and processing. The learning concepts of this stage form secure conceptual networks and conceptual conclusions that are reflected in the wider social environment and gradually lead to the core of the subject matter.

Fourth level

In the fourth level, students apply and test new knowledge. They use the new knowledge more "effectively", as it is now integrated into their way of thinking. At this stage, the goal is to highlight problems of modern reality and their school life.

Table 7

Learning environment			
Fourth level	Subject	Teaching techniques	Teaching means
Active experimentation with social problems ["I", "we" and the problems]	Actions of active citizen	Filling in worksheets	Table Projector One-meter piece of paper

As part of the activities, students fill in worksheets, table 9, based on specific questions about their role as citizens of the world. Their answers are first recorded at the individual level and then processed at the group level, in order to be announced to everybody.

Table 8

Indicative worksheet		
What is the problem;	What are the solutions to this problem?	What can I do to solve the problem? Or what can "we" do as citizens?

In this context, students have the opportunity to argue by creating printed material, with letters and suggestions to competent bodies and to suggest solutions that are positive for society and the individual.

5. Data analysis - writing a research report

5.1 Data analysis of the Pre-checking

Based on the answers given to us by the students before our teaching intervention, the need arose for their additional training in problem solving skills, a fact which was the basis for the integration of our intervention in the learning course of the Study of the Environment.

The definition that was taken into consideration for the interpretation of the students' answers was that a "*Problem is an obstacle, difficulty, challenge that makes it difficult to achieve a goal or result that can be addressed and possibly solved. In other words, a problem is a situation that needs to be addressed, requires a solution, and its solution is neither known nor obvious*"(Vakali, I. Giannopoulos, N. Ioannidis, Ch. Koilas, K. Malamas, I. Manolopoulos, P. Politis 2011)

In the first question, *which words come to you automatically when hearing the word problem,* from the analysis of the data the following emerged. In a total of twenty seven (25) students, one (1) student did not give any answer, three (3) students identified the problem with Mathematics, two (2) students interpreted the problem as a situation that *requires a solution, and its solution is neither known nor obvious* and, nineteen (19) students interpreted the problem as a difficulty. We ostensive mention: "*I think and solve something in Mathematics. We encounter a problem in Mathematics. It is a word that indicates difficulty. It means I have to solve something. Something that creates obstacles*".

To the second question: *In which subjects have you dealt with problems, all the students stated that only in Mathematics they have tried to solve problems*. According to the students' answers, the students had not understood the scope of the word problem. It turned out that the students considered the problem only as part of Mathematics. Their answers documented the need for their familiarization with processes of understanding and problem solving, through a wide and varied thematic field.

5.2 Data analysis of the post-checking

Based on the answers given to us by the students after our teaching intervention, the view on the education of the students on the problem solving skills was substantiated. As regards the first question: What does the word problem mean, the students' answers met the accepted conceptual definition. We ostensive mention: "*Problem means difficulty. Problem means that something is causing problems. Problem means that something creates obstacles*". As can be seen from the students' answers, their interpretations are not limited to identifying the concept

of the problem with Mathematics. On the contrary, the answers they gave us cover a broader conceptual framework having as a basis on the accepted definition.

As regards the second question: In which subjects did we encounter problems, all the students stated that in all the subjects we encountered problems, issues that had to be solved. We ostensive mention: "*I thought that only in Mathematics there are problems. When I was hearing the word problem my mind was going to Mathematics, Now I understand that there are problems everywhere*".

6. Conclusions

As the data analysis shows, the view is that the targeted learning opportunities and teaching guidance cultivate positive and collaborative learning relationships, support learning, and cultivate social, emotional, and cognitive skills based on the Curriculum. In the context of targeted learning environments, students are trained in practices of observing, recording, managing and dealing with complex issues, as future active citizens.

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