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How do Elementary School Students Solve Ill- Structured Problems?

İlköğretim Okulu Öğrencileri Kötü Yapılandırılmış Problemleri Nasıl Çözüyor?

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ÖZET

Bu çalışma, anaokulundan altıncı sınıfa kadar olan öğrencilerin, kötü yapılandırılmış olarak kategorize edilen tasarım ve teşhis et- çöz problemlerini çözerken, kullandıkları stratejilerin belirlenmesi ve değerlendirilmesine dayalıdır.

İlkokullarda, farklı sınıf düzeylerindeki öğrenciler tarafından kullanılan bu stratejilerin uygulanmasındaki farklılıklar analiz edildi. Bu araştırmada veriler yüz yüze yapılan görüşmelerden elde edildi. Veri analizleri, anaokulu, birinci, ikinci ve üçüncü sınıf öğrencilerinin çoğunluğunun, genel problem çözmenin adımları olan, problemi tanımlama, veri toplama, çözümler üretme ve değerlendirme basmağını uygulamadıklarını gösterdi. Onun yerine, öğrenciler, onlara sorulan problemlerden sonra hiç düşünmeksizin en iyi çözümü seçme basamağına atladılar. Dördüncü ve beşinci sınıflardaki bazı öğrenciler ise, problemin çözümünde, ilk olarak problemi tanımlamanın önemli olduğunu açıkladılar. Ayrıca bu grup, küçük sınıflardaki öğrencileri sınırlı veri toplama kaynağı belirtmelerinin aksine, daha farklı veri toplama kaynakları belittiler. Bazı dördüncü ve beşinci sınıf öğrencileri çözüm başarısız olduğunda, çözümün değerlendirilmesinin ve yeni bir çözümün bulunmasının önemli olduğunu açıkladılar. Bu çalışmanın genel sonucu, öğrencilerin büyük çoğunluğu verilen problemleri tanımlama sürecinden haberdar görünmüyorlar. Öğrencilerin önemli bir bölümü, problemi net bir şekilde anlamadan, tanımadan en iyi çözüm basamağına geçiyorlar.

Anahtar kelimeler: Problem, Problem Çözme, Kötü Yapılanmış Problem, Tasarım Problemleri, Teşhis-Et Çöz Problemleri.

ABSTRACT

This paper is based on research that evaluated strategies used by elementary school students (K-5) for solutions to "diagnosis-solution" problems and "design" problems, mainly categorized as ill-structured problems. The differences in the applications of these strategies by students in different grades were analyzed. The research was based *on face-to-face interviews. The analysis of the responses of K-3 students showed that most of them did not apply the general steps of problem-solving such as identification of the problem, data collection, generating possible solutions and evaluation steps. Instead, they immediately skipped to the step of selecting the best solution after the problems were posed to them. Some of the students in the 4th and 5th grades mentioned that it was important to define the problem first and then solve the problem. This group was also able to identify multiple resources for data collection, whereas the younger students were more limited in their choices for data collection. Some of the older students thought that in case the solution failed, it is important to evaluate the results and seek another solution to the problem. The general conclusion of this research paper is that students, for the most part, are not aware of the fact that a major portion of a problem-solving undertaking involves identification of the problem. Most students jump to the step of selecting the best solution without a clear identification of the problem.*

Key words: Problem, Problem Solving, Ill-structured Problem, Design problem, Diagnosis- Solution Problems.

1. Introduction

In this study, the term "problem" signifies a state that differs from a desired goal or end-state and there is some uncertainty about reaching the goal state (Bransford and Stein, 1984). In short, a problem exists when a problem solver has a goal but lacks an obvious way of achieving the goal (Mayer and Wittrock, 1996, 47). Problem-solving is the identification of the problem and application of knowledge and skills that result in goal attainment (Martines, 1998, 605-609).

The problem categories considered are as follows: The first category comprises the "well-defined problems" of mathematics and science, the type of problems that students from kindergarten through junior-high are typically required to solve. Well-defined problems can be formulated clearly, solved by recalling and applying a specific procedure, and result in a solution that can be evaluated against a well-known and agreed-upon standard (Frederiksen, 1984). The second category comprises the "ill-structured problems," which are often encountered in everyday life and in disciplines like economics or psychology. Ill-structured problems are more complex and provide few clues pointing to the solution procedures (Frederiksen, 1984). Eysenck and Keane

(1990), Simon (1978), Dunkle, Schraw and Bendixen (1995), Mayer and Wittrock (1996) have detailed studies on the above problem categories.

Jonassen (1997), Biehler, Snowmen (1993) and Frederiksen (1984) named the above-described categories as well-structured and ill-structured instead of "well-defined and ill-defined." This paper will use the former that is, "well-structured" and "ill-structured," as its terminology.

Jonassen's research classifies the types of problems according to their properties. He classifies problem types and their properties into ten groups. He covers learning activities, inputs, context, structuredness, and abstractness related to each classification in detail with examples. According to Jonassen, diagnosis-solution and design problems, which belong to the category of ill-structured problems, have certain features. In diagnosis-solution problems, analyzing the situation to identify the difficulties is important. The goal is then to propose solution strategies to correct the problem. Design problems, on the other hand, require the organization of domain knowledge in new ways to create an original result (Jonassen, 2000).

Gagne states, "The central point of education is to teach people to think and to use their rational powers to become better problem solvers" (Gagne, 1980, 85). Like Gagne, most psychologists and educators regard problem-solving as one of the most important learning outcomes for life.

Jonassen, explains this as follows: "Virtually everyone, in their everyday and professional lives, regularly solves problems. Few, if any, people are rewarded in their professional lives for memorizing information and completing examinations, yet examinations are the primary arbiter of success in society. Unfortunately, students are rarely, if ever, required to solve meaningful problems as part of their curricula" (Jonassen, 2000, 63).

Regarding the solution process of ill-strucutred problems, Wood(1993), Sinnott (1989), and Jonassen(1997) provide us with different steps to follow. However, there are some subtle differences between the general problem-solving steps taken into consideration in this study and steps suggested by other researchers with respect to the content. The reason why we used the general problem-solving method for ill-structured problems, instead of using steps specifically designed for ill-structured problems, is that the schools that participated in this study were using the general problem-solving methods.

1.1. General Problem Solving Steps

The general problem-solving steps which we used in this study can be explained briefly as follows:

Identification of the problem
Recognizing that there is a problem to be solved. Therefore, teaching students alternative ways of defining and finding solutions to academic and social problems they encounter is critical for successful teaching (Cooper and Sweller, 1987).

Data collection
Collecting the necessary data, which are important for the solution of the problem from related sources? This step can have a broad range of sources from the person's own experiences and knowledge to the Internet and consultations with more experienced persons.

Generating possible solutions
After the problem has been defined and the related data collected, the next step is to generate possible solutions. Possible solutions are alternative ways of solving a problem. Generally, the more possible solutions one generates, the more likely it is that one will solve the problem (Rothhstein, 1990).

Selecting the best solution
Several possible solutions can be normally developed to solve a problem. Educational psychologists emphasize using skills in decision making and problem-solving to determine which solutions should be used to solve the defined problem (Dixon, 1987).

Evaluation the results

This step evaluates the applicability of the proposed solution to the problem. If the selected solution does not solve the specified problem, then the second proposed solution method is used until the problem at hand has been adequately solved.

The reason for using these steps is explained in the Methods section of this paper. Actually, in the process of solving ill-structured problems, a strict problem-solving method cannot be followed. The number of goals in ill-structured problems, which are vaguely defined, must be considered in the problem-solving process. The information available to the decision maker is usually incomplete and inaccurate or ambiguous (Wood, 1993). In these problems, it is uncertain which concepts, rules, and principles are necessary for the solution. There is an inconsistent relationship between concepts, rules, and principles among various cases. Case elements are differentially important in different contexts based on the interaction of the elements with each other in a certain context (Spiro et al. 1987, 1988). The above ideas were taken into consideration while interpreting the data collected in this study.

In the U.S. the need for improving the problem-solving capability of students has been emphasized frequently through educational programs in various States, educational standards, textbooks, educational reports, and presidential speeches. For instance, the 1983 report, "A Nation at Risk," by the National Commission on Excellence in Education, produced during President Reagan's first term in office, had a startling conclusion in terms of mediocrity in U.S. education in general, with possible dire consequences for the nation and its people. Also, the Secretary's Commission on Achieving Necessary Skills (SCANS) listed a number of core competencies and skills among which "thinking skills" was of primary significance (O'Neil, 1991). These reports and undertakings were followed first by President George Bush's and then by President Clinton's leaderships in the establishment of national goals for education. In 1994, the Congress passed the Goals 2000 Educate America Act, which was signed by President Clinton. In line with a society increasingly information-based and reliant on technology, critical thinking and problem-solving were recognized as core skills to be emphasized in the formulation of educational policy.

In addition to the above, several other supporting examples exist in research literature that detail the emphasis placed on developing problem-solving skills. Harty, Kloosterman, and Matkin (1991) investigated how well problem-solving and critical thinking had been incorporated in the elementary school curriculum in a Mid-Western state in the USA. The findings of this study revealed that, although teaching problem-solving was considered as an important goal, instructional practices that emphasized problem-solving were not common.

In a more recent study, Jonassen, upports Harty's ideas and findings. According to Jonassen, problem-solving is generally regarded as the most important cognitive and social activity in every day and professional contexts. However, learning to solve problems is too seldom required in a formal educational setting, in part, because our understanding of its processes is too limited. Instructional-design research and theory have devoted too little attention to the study of problem-solving (Jonassen, 2000).

Other research indicate that "Asian students, well known for their excellence in mathematics, are encouraged not only to learn common strategies (for problem-solving) but to invent their own, which are often more intuitive" (Fuson, 1992). Stevenson and Stigler (1992, 188-89) states, "Mathematics is a body of knowledge that has evolved gradually through a process of argument and proof. Learning to argue about mathematical ideas is fundamental to understanding mathematics. Chinese and Japanese children begin learning these skills in first grade; many American elementary school children are never exposed to them." The Japanese educators focus on error so much that they do not seem to be in a rush; sometimes one class period covers only one problem. The pace is slow, but the outcome is impressive (Robitalle and Kenneth, 1992; Stevenson and Stigler, 1992).

Jonassen , asks the following question on this topic: "Why are we inept at engaging learning in problem-solving? A major reason, we argue, is that we do not understand the breadth of problem-solving activities well enough to engage and support learners in them" (Jonassen, 2000, 63). Jonassen discusses this question in terms of general problem-solving skills. On the other hand, Eggen and Kauchak (1999), inform us about the existence of the difficulty going on for years at schools, even for the *well-structured* problems:

Although students often have difficulty solving this type of problem, its goal is clear and specific strategies exist for solving it. Most students' experiences in school focus on *well-defined* problems. In contrast, students not wanting to "think" for themselves is an *ill-defined* problem. The goal state isn't clear: teachers are often not even sure what "thinking" means and they readily agree on the fact that a strategy for getting students to "think" doesn't exist. The problem can be solved with several strategies, and several right answers can be found.

Eggen and Kauchak's and Cohen's views overlap on ill-structured problems. As Cohen comments, "Unfortunately, improving current solutions and solving unanticipated problems are not major goals of many educational programs" (Cohen, 1981, 19).

Gustafson and Rowell's (1998) study on ill-structured problems is interesting for its results and content. This research focuses on the problem-solving strategies of elementary school students. They were asked how they would start solving a given ill-structured problem. Students' responses were classified into five groups as follows: Drawing the required picture in the problem, looking at a model, collecting data from a library, having discussions with friends, or using one's imagination.

Most of the experimental and survey-based research on problem-solving in the elementary schools focuses on well-structured problems, whereas there are few studies on ill-structured problems. Although it is widely accepted that a student who can solve a well-structured problem can solve ill-structured problems as well, recent studies show that this is not always the case. The reasoning behind ill-defined problems affects the problem-solving strategy and each problem type needs different skills and strategies. "Problem-solving is not a uniform activity. Problems are not equivalent, either in content, form, or process" (Jonassen, 2000, 65). Thus, it is important to determine the problem-solving strategies in both well-structured and ill-structured problems.

There is some research on the development of students' problem-solving skills that provide some observations and ideas about the application of problem-solving skills in U.S. schools. This research provides some general ideas about problem-solving skills of American students. American schools have been criticized for failing to teach problem-solving unlike Asian schools that emphasize problem-solving. American students are too often taught to simply master content (Perry, Vanderstoep and Yu, 1993). To the best of my knowledge, there is no similar research in the literature on ill-structured problem-solving activities of students in elementary schools.

The goal of the research that forms the basis of this paper is to determine the types of strategies students follow for solving ill-structured problems, the reasons as to why they chose these strategies, and how these strategies vary according to the students' levels. It is believed that the results presented here will be helpful for future researchers, especially in comparing the applied strategies on these two problem categories and the curriculum development studies in this area.

2. Methodology

2. 1. Sample and Procedures

This study was conducted in Indiana State in USA, during 2002-2003. This is a survey type study of how problem-solving is used by students and to what extent. This study focused on two questions related to the diagnosis-solutions and design problems.

In recent literature in this area, there are many studies on logical algorithmic and story problems. However, there is not much research on rule using, decision-making, diagnosis solution, strategic performance, case analysis, dilemma, trouble-shooting, and design problems at the elementary school level. The problems studied here were based on Jonassen's research on problem types, which is the most recent and comprehensive, work in this area. Since K-5 students are frequently faced with such problems, both in and out of the classroom, these were chosen to be studied in detail. The opinions of teachers and general requirements of the curriculum were taken into consideration while choosing these problems. The general problem-solving steps were implemented in evaluating the students' answers to the problems. Many researchers and teachers have advised the use of these general problem-solving steps to improve the students' ability to solve problems in a classroom setting. Hence, this method was used to study and analyze the teaching of problem-solving to students at the K-5 level in two schools. However, throughout experiment, the general problem-solving steps were not mentioned to the students because of the possibility that any mention of this methot would affect their normal thinking steps and redirect their natural thinking process.

This qualitative type research was conducted using the interview method. Interviews were done in person by the researcher. Actual interviews started after a four months observation period. During this period, the author observed the classroom settings and developed good communication with the students who were to participate in this research. 36 students from different grades were chosen for preliminary interviews during the observation period. The two questions, related to the diagnosis-solution and design problems, were tested with this sample of 36 students, and later modified for clarity as appropriate, before beginning the real study on 240 students. Actual interviews with the 240 students lasted three months. A *semi-structured*, face-to-face interviewing approach was used as the most appropriate research strategy. This meant that the structured questions were followed by other questions if required. The objective was to focus on obtaining results on diagnosis solutions and design problems. In line with this, data were limited to only these problems keeping in mind that interviewing so many students would take a lot of time further students, due to their young age, could easily get bored during the interviews

In order to prevent data loss and increase the reliability of the research, a voice recorder was used along with the semi-structured interview form. While resolving the data recorded in the cassette recorder, all data related to each student were written on a form for that specific student. Later, the data collected by the cassette recorder and summed up in a related form and the data collected by the semi-structured form were analyzed together. These two forms were combined together so as to form a single data form for each student. Later these data collected in a single form were sorted and classified by using general problem-solving steps. This data analysis process was first done for each student and then for every class level. The final results are shown in Tables 1 and 2.

The problem scenarios were presented to students in grades K-5. There were a total of 240 students in twelve classes, twenty students in each class, and six classes from each school, in two different schools. These two schools were very similar to each other in their socio-economic profiles, a characteristic confirmed by the school directors and by statistical data related to Indianapolis, Indiana. The schools are in the middle-income areas of the city and the State.

The aim of this research was to answer two basic questions, which were as follows:

1. What are the problem-solution strategies employed by K-5 grade students for the two different types of ill-structured problems?

2. Do these strategies exhibit variations depending on the grade levels of these students?

The problems posed to the students, the answers to which were evaluated for the above detailed research purposes, were:

1. Diagnosis-solution problem

You have a plant that appears to be dying. How can you decide on what to do to bring the plant back to health?

2. Design problem

You are given an assignment to build a kite. How would you build it?

The answers were analyzed with respect to the steps below, which are the general steps of problem-solving:

1. Identification of the problem,
2. Data collection,
3. Generating possible solutions,
4. Selecting the best solution,
5. Evaluation the result.

The above steps are the basic steps accepted by many researchers including Bransford and Stein (1984), Souviney (1989), Eggen and Kauchak (1999), Moyles(1989), Kneeland(1999), and Hick(1994) for general problem-solving. Ill-structured problems tend to be more of a situational nature, but well-structured problems tend to rely on general problem-solving skills. However, students may use different techniques and strategies at each step of the problem solution. Individual personal differences or problem type could be reasons for these different approaches. The above steps will also be employed as the basis for discussion of results obtained in this research.

3. Results

The quantitative results of the research are given in the tables below:

1. Diagnosis-Solution Problem

You have a plant that appears to be dying. How can you decide on what to do to bring the plant back to health?

Table-1:*Response frequencies for diagnosis solution problem for all students in all grades (K-5)*

Problem solving steps	Grade level Student response	Kinder garten	1 grade	2 grade	3 grade	4 grade	5 grade
		Number of students for each grade (% Frequency)					
Identification of the problem	I would try to find out why the plant is dying. I would decide what I needed to do afterwards.	0 (0)	0 (0)	0 (0)	0 (0)	7 (17.5)	8 (20)
Data collection	I would ask someone or the teacher what to do.	0 (0)	0 (0)	0 (0)	0 (0)	4 (10)	4 (10)
Data collection	I would ask my parents what to do.	3 (7.5)	3 (7.5)	2 (5)	3 (7.5)	0 (0)	0 (0)

Table-1:*Response frequencies for diagnosis solution problem for all students in all grades (K-5)(Continue)*

Problem solving steps	Grade level Student response	Kinder garten	1 grade	2 grade	3 grade	4 grade	5 grade
		Number of students for each grade (% Frequency)					
Generating possible solutions Selecting the best *strategy (ies)*	I would water the plant. I would put the plant in the sun I would feed the plant.	35 (87.5)	32 (80)	33 (82.5)	32 (80)	27 (67.5)	25 (62.5)
Selecting the best strategy /ies	I would water it again and again	0 (0)	0 (0)	1 (2.5)	1 (2.5)	0 (0)	0 (0)
Selecting the best strategy /ies	I would buy a new plant.	2 (5)	2 (5)	3 (7.5)	2 (5)	2 (5)	2 (5)
Selecting the best strategy /ies	I would transplant the plant in a different pot.	0 (0)	2 (5)	1 (2.5)	2 (5)	0 (0)	0 (0)
Selecting the best strategy /ies	I would put the plant in the shade.	0 (0)	1 (2.5)	0 (0)	1 (2.5)	0 (0)	0 (0)

(Top number in each cell shows the number of students and the number below in parenthesis shows the % frequency).

Sample size for each grade = 40 students. Total sample size = 40 students × 6 classes = 240 student.

Design Problem

You are given an assignment to build a kite. How would you do it?

Table-2: *Response frequencies for design problem for all students in all grades (K-5).*

Problem solving steps	Grade level Student response	Kinder garten	1 grade	2 grade	3 grade	4 grade	5 grade
		Number of students for each grade (% Frequency)					
Identification of the problem	I would think what type of a kite I would need to build. I would draw or imagine it first before building it.	0 (0)	0 (0)	0 (0)	0 (0)	7 (17.5)	10 (25)
Data collection	I would ask my parents what to do.	6 (15)	3 (7.5)	2 (5)	2 (5)	0 (0)	0 (0)
Data collection	I would get information from the library, Internet, or would look at an old one to build a new one.I would build an interesting kite.	0 (0)	0 (0)	0 (0)	0 (0)	6 (15)	9 (22.5)
Data collection	I would follow the instructions to build one.	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.5)	2 (5)
Generating possible solutions	I would decide to shape either diamond or triangle shape.	0 (0)	2 (5)	0 (10)	0 (20)	4 (10)	8 (20)
Selecting the best strategy /ies	I would take paper, stick, rope, glue, paint and scissors. I would start building the kite.	32 (80)	30 (75)	29 (72.5)	26 (65)	24 (60)	16 (40)
Selecting the best strategy /ies	I would buy a new kite from the store and fly it.	3 (7.5)	4 (10)	3 (7.5)	2 (5)	0 (0)	0 (0)
Selecting the best strategy /ies	I would build it with my friends	0 (0)	1 (2.5)	2 (5)	2 (5)	1 (2.5)	3 (7.5)

(Top number in each cell shows the number of students and the number below in parenthesis shows the % frequency).

Sample size for each grade = 40 students. Total sample size = 40 students × 6 classes = 240 students.

In this study, design and diagnosis-solution problems were studied. The responses given by the students as solutions to the problems are grouped according to the general problem-solving steps.

Identification of the Problem

According to this specified grouping, the suggestions given for the *Identification of the Problem* step for both of the problems, which is the first step of general problem-solving, can be interpreted with respect to the class levels. For both of the problems, the students from K-3 did not analyze what the real causes of these problems were and what kind of problem they were faced with. In the diagnosis- solution problem, less than half of the 4th and 5th graders responed by saying they would start to act after they really understood the problem they were facing, and in the design-problem, approximately half of the students said they would act after they decided what to do. In problem-solving, *Identification of the Problem* step is the most fundamental step. This fundamental step of Identification *of the Problem* is not used at all by K-3 students, and only a few students among the 4 th and 5 th graders used this step. In general, students show a tendency to excitedly list their suggestions instantly. Moreover, they feel that they have the correct suggestions even though they are giving their suggestions without clearly defining the problem itself. This result shows that students are not using the step of *Identification of the Problem* (ID) adequately . This tendency points to an important inadequacy in the process of problem-solving.

The importance of this inadequacy has been also stressed by Eggen and Kauchak (1999) who made the following observation regarding students who ignored the *identification of the problem* step: "Students had difficulty understanding what the problem was." Hayes (1988) states "it appears that identifying a problem is simple and straightforward but, in fact, it is one of the most difficult aspects of problem-solving. It requires patience and a willingness to avoid committing to a solution too soon." Also, according to Brunning, Schraw and Ronning (1995), one of the four obstacles in effective problem-solving is lack of experience in problem definition. During the interviews students were excited about the steps of the problem-solving process. When they were asked the questions, they were worried and excited about producing a solution. This result agrees with the observations of other researchers who have pointed out the "tendency to rush toward a solution before the problem has been clearly identified" (Brunning, Schraw and Ronning, 1995). Schoenfeld (1989), Leuvan, Wang and Hildebrandt (1990) observe that novice problem solvers tend to "jump" to a solution before they have clearly identified the problem.

Mayer (1992) asserts that since novices do not possess well-developed problem-solving skills, they are not able to recognize problem types and so they must rely on general problem-solving strategies for problem solutions. This tendency was also observed among the students at the university level, as well as younger students (Schoenfeld, 1989).

Data Collection

The suggestions given for the second step of the problem- solving process, which *is the data collection* step, for both of the problems, can be interpreted as follows according to the class levels: When we look at the solution suggestions given for the diagnosis solution problem, students indicate that they would collect data from two different sources.

In the diagnosis solution problem, students from K-3 show a tendency towards using their families as a source of information; on the other hand, the 4^{th} and 5^{th} graders indicated that they would find someone who knows the subject or they would consult their teachers.

In the design-problem, K-3 students said they would use only their families as a source of information; however, the 4^{th} and 5^{th} graders indicated that they would consider their families, library, internet and some manuals as a source of information, and that they would also use a previously built kite as a source or model. It has been observed that, for both of the problems, K-3 students have exhibited a tendency to use their families as a source of information.

The reason why the K-3 students did not show any significant tendency towards any source of information other than their families is because they don't have enough experience and ability to use other sources adequately.

In the design problems, the sources of information to which a very few students turned were the libraries, the Internet, following and replicating a model kite, and a manual which has instructions that will help them solve the problem. This age group has a tendency to turn to more diverse and independent sources of information for problem solution. This tendency shows some promising potential for the problem when we consider the cognitive abilities of this age group. In contrast to the diagnosis solution problem, in the design problem, none of the students said they would consult someone who knew the subject or consult the teacher as a source of information. When we consider the number of students involved in this study, for both problems, the number of students who used the *Data Collection* step of the problem-solving process is noted to be considerably low.

Students, in general, showed a tendency to rush to the next step without doing adequate data collection. It can be said that they behaved in this way with the idea that the information they had was enough for the problem at hand. This approach will affect the problem-solving process, and the solutions to the problem at hand, negatively.

Generating Possible Solutions

The suggestions given for the 3 rd step, *the step of Generating Possible Solutions*, for both problems, can be interpreted as follows: in the diagnosıs-solution problem, most of the students from all grades produced acceptable suggestions which can be considered as being a part of the step of generating possible solutions. However, K-3 students indicated that they would use all the suggestions they had all at once. In actuality, all the suggestions given as possible solutions turn into one solution in implementation. Selecting the appropriate goal-oriented suggestion given in the problem-solving process is a desirable course of action. The observation that the students state they would use all the suggestions all together tells us that the students are not fully cognizant of the details and purpose of this step.

Application of all suggestions all together without obtaining and analyzing any kind of feedback is not a desired strategy in the problem-solving process. Selecting the most appropriate solution which could solve the problem at hand is very important in the problem-solving process. In contrast to the K-3 students, most of the 4 th and 5 th graders indicated that they would use one of the suggestions they generated for the problem solution and then, according to the results and feedback obtained from the implementation of this chosen solution, they would go to the next choice if warranted. This observation indicates a desired outcome with respect to the problems-solving process.

In the diagnosis solution problem, the number of suggestions related to the *generating possible solutions* step has a tendency to decrease as the class level increases. The reason for this decrease can be attributed to the fact that the students may be thinking it would be better to define the problem first and then generate possible solution suggestions for it later. For the design problem, only few students from the 3 rd, 4 th and 5 th grades, generated two possible solution suggestions for the problem, and they indicated that they would have to choose one of them. They indicated that they would use one of their suggestions, or would later choose the other based on progress in the process. Possible solution suggestions were generated by only a few students. This can be attributed to their backgrounds, their interests, their innovative and creative abilities and the type of problem at hand. Generating more than one possible solution suggestions with a clear objective and understanding of the problem at hand affects positively the solution to the problem. Diverse suggestions for a problem solution will force students to think and act divergently in relation to the solution of the problem. Because of this reason, more than one possible solution suggestion may be needed for the solution of the ill-structured problems. As a result, inadequate usage of this step in the problem-solving procedure can be considered as an important deficiency in an effective problem-solving procedure.

Selecting the Best Solution

The suggestions provided by the students for the fourth step, *Selecting the best strategy*, for both of the problems, could be interpreted as follows; in the diagnosis-solution problem, students from all grades gave three possible solutions suggestions consecutively.

As it was mentioned earlier, when the K-3 students were asked how they would apply those suggestions, they said they would use all three suggestions all at once as if they were just one solution suggestion. This type of interpretation turns the three different solution suggestions into just one solution suggestion.

As a result, however, students were unable to concisely choose the most appropriate solution suggestion for the problem; the 4 th and 5 th graders, on the other hand, indicated that they would choose one solution from all generated suggestions and that they would apply that suggestion and according to the outcome they would consider the other alternatives if needed. The 4 th and 5 th graders indicated that as a result of the above process they would choose one of the suggestions and use it as a solution to the problem. So, the 4^{th} and 5^{th} grade students, based on the above strategy that they said they will use, are able to determine which suggestion can solve their problem and which cannot; K-3 students, on the other hand, are not able to make this determination.

In Table 1, the suggestions considered in *generating possible solutions* step are also considered in *selecting the best solution* step. In the diagnosis solution problem, only few students generated just one solution suggestion. During the interview, when they were asked, students said they did not have another response different from what they had given.

In the design problem, while most of the students directly jumped to the *selecting the best solution* step, a few students headed towards selecting a strategy after generating several possible solutions to the problem. It is an important deficiency to jump directly to *the selecting the best solution* step without generating several possible solution suggestions for the problem. This situation can possibly lead to the students not being able to generate any solution for the problem at hand.

In the design problem, for the *selecting the best solution* step, all levels of students gave some suggestions. The number of solution suggestions was high for K-3 students. The number of solution suggestions gradually decreased for the 4^{th} and 5^{th} graders. The reason for this decrease can be attributed to the fact that these students mentioned that they would first like to see the outcome of their first solution suggestion and then explore other solution options, if needed, based on this outcome. Students were asked how they chose their specific solution suggestions in relation to the diagnosis-solution and design problems. The students indicated that they had earlier done something similar, they were introduced to such situations by their families and by their teachers, or they had simply experienced similar situations before.

The most important element of the problem-solving ability is one's familiarity with the problem type. Sweller (1988) said experienced problem solvers have better-developed problem schemas, which can be employed more easily. According to the results obtained as a result of this research, for both problems, experienced students indicated that they would use their prior experiences in the problem-solving process. This step is the one that is most used by students in the problem-solving process. For both problems, most students at all levels rushed to generate only one solution after listening to the problem.

In addition, most students mentioned that they were sure about the success of the suggestions they had generated for the solution of the problem.

Evaluation the Results

Evaluation is the last step of the problem-solving process. Students were not able to provide meaningful answers in this step that could be included in the evaluation of the approach taken by students. It is possible that since students thought that their suggestion (s) would solve the problem successfully, they did not feel a need for any evaluation as required by this last step. *The evaluation step* provides us with information as to whether the problem was solved in a desired manner or not. If the problem was not solved satisfactorily because of any reason, this step provides an examination of the reasons that led to such a situation. Skipping the evaluation step will result in serious deficiencies in the problem-solving processes. This is in line with a common problem observed in other researches. Schunk (1994) observed that young children in particular have trouble at this stage, wanting to rush through, get on to the next problem, and finish the assignment. Baker (1989) and Zimmerman (1990) argue that this step is really needed for the solution of the problem and that much of the improvement in one's problem-solving ability results from effective evaluation of the results.

4. Conclusion and Educational Implication

In this study, diagnosis solution and design problems were studied. The solution suggestions provided the students with five steps according to the general problem-solving steps found in the research literature in this field. These are the steps of *identification of the problem* (IP), *data collection* (DC), *generating possible solutions* (PS), *selecting the best solution* (SS) and *evaluation the result* (E). Most of the K-3 students, for both of the problems, did not give any possible solution suggestions related to the IP, DC, GP steps. Most of the students in these grades did give their possible solution suggestion(s) related to the SS step immediately after they were asked for their suggestions. It is observed that the students had the tendency to solve the problem by using only one of the general problem-solving steps. When compared to the K-3 students, students from the 4^{th} and 5^{th} grades used the ID, DC, GP, and SS steps of the general problem-solving process more frequently. However, when we consider the number of students that participated in this study, this ratio is still considerably low.

For both the problems, the students that participated did not use the evaluation step.

One general conclusion is that K-3 students think convergently while they are solving problems. Some 4th and 5th grade students, on the other hand, exhibited a capacity to think divergently. This result is important from the instructional outcome's point of view. Learning to think divergently results from having a variety of experiences requiring divergent thinking. This suggests a critical and crucial role for the teachers as they guide students' discussions of problems. They can ask questions to the students that encourage thinking about the problems in different ways. As students acquire experience, they gradually develop their abilities to think divergently (Eggen and Kauchak 1999, 314). In fact, solutions of ill-structured problems are not predictable and convergent. Therefore, involving students in solving ill-structured problems will foster divergent thinking as a welcome outcome.

The overarching conclusion in view of evidence gained from this research study is that there is a need to go to the basics in teaching problem-solving to students at all levels of K-5. Despite the existence of sophisticated approaches for the definition of problem types, and steps to be employed for the solution for each type, students still are not aware of the fact that a major factor in problem-solving is the identification of the problem. Students just want to go through a series of steps or number crunching depending on the type of problem. For the most part they are not able to discern between the process of problem-solving and the concept of solving a problem.

However, at this point, an arguable point emerges. There is no research data related to the importance of each of the general problem-solving steps. We know that each step of the problem-solving process greatly affects the quality of the result. Should we then consider a person, who obtains the same results by using some other process, a problem solver or not?

At this stage, one has to answer the question "who is an excellent problem solver?" Can the problem-solving steps be used for every problem and for every age level? Are we hindering the natural creativity and higher order thinking skills of the students by strictly using the general problem-solving steps?

How and to what extent is the problem-solving process, affected by applying problem-solving steps? These questions have to be argued.

All the problem-solving steps which differ with respect to the terminology, but which essentially have the same content suggested by researchers since Dewey (1910) have to be analyzed in detail in-school settings. For a brief moment, we have to depart from the idea that these general steps create good problem solvers; it is necessary to change the focal point of our thinking process. To analyze all types of problems with respect to the children's conception and their applications can give us some valuable results. Students' problem-solving steps and the quality of their solutions can lead us to new problem-solving steps and lead us to reconstruct the related steps.

As it was mentioned in the earlier paragraphs, this researcher advocates the necessity of studying and analyzing the applicability and effectiveness of the problem-solving steps which are currently used in class, or suggested problem-solving steps to be taught in class, and also believes that we can infer very unique and valuable results from the students' own application of problem-solving steps.

The results also obtained from this study can be attributed to the characteristics of application of specific curriculums in schools, not adequately considering the cognitive abilities of the students related the their ages, or not teaching the problem-solving concepts to the students to the degree warranted in today's environment. There is a need for doing a new research for finding the real causes of these problems. Furthermore, it can be easily seen that there is an inverse relationship between abundant theoretical knowledge about problem-solving in the literature and its application in the classroom settings. It has to be determined why this abundant theoretical knowledge cannot be applied in a classroom setting at a desired level.

An additional recommendation for future research is that this type of research be also done at all levels of classes of secondary and post-secondary education. The diverse approaches to problem-solving by students in each of these levels and their differences should be analyzed for conclusions to provide guidance for educational policy decisions.

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