Investigation of STEM Competencies of Teacher Candidates

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Abstract

This research is a descriptive study that aimed to investigate STEM competencies of science and mathematics preservice teachers. For this purpose, a group of science and mathematics preservice teachers were asked to design and conduct parachutes covering the topics of movement (free fall, air resistance and lift force) in the course of physics I. It was expected to consider variables such as the qualities to be used in parachute design and the geometry of the parachute surface. It is recommended to choose materials which are easily found in everyday life, such as rope, fabric, paper, nylon, etc., Parachutes were assessed according to their longest stay in the air and thus they were expected to have a result. A total of 106 first grade preservice teachers studying at Faculty of Education Department of Mathematics and Science Education at a public university in Turkey were included Faculty of Education Department of Mathematics and Science Education were included in the study. The findings showed that three categories existed, and the ratio of the most desirable category was found 6.6%. All the results obtained are evaluated and the reasons for the low success are discussed.

Keywords: STEM competencies, experiment design,, physics education, teacher candidate

INTRODUCTION

Scientific and technological developments entering life extremely rapidly and effectively have brought along the need for raising knowledgeable and skilled individuals to contribute via internalizing this development. And as an education model to meet this need, the STEM (science, technology, engineering and mathematics) education model has been seen appropriate and become widespread. Moreover, this model is also regarded today as the key concept to the technical and economic development of countries.

According to Kennedy and Odell (2014), while STEM includes formulating an answerable question through scientific research and inquiry, engineering design includes a solvable problem to be structured and evaluated at the post-design stage and the STEM education eliminates the traditional obstacles between these four disciplines by combining them in the context of teaching and learning appropriately.

By indicating the existence of some researchers defining STEM with an interdisciplinary viewpoint in a way to include concepts and skills, which are specific to disciplines, English (2015) notes that the first of these are critical thinking, problem solving and inquiring processes, teamwork and design processes and the last of these is the engineering connection meaning the core of all these.

Moreover, Siekmann and Korbel (2016) described the STEM education and teaching in the way that "it establishes a relationship between these four disciplines aiming to develop people's abilities via supporting technical and scientific education by laying a strong emphasis on critical and creative thinking skills". Furthermore, according to Jolly (2016), STEM is a classic example of the saying that 'the whole is greater than the sum of its parts'.

The four disciplines included in the STEM education should not be considered independently from one another. For this reason, the interdisciplinary or the integrated STEM concept emerged. According to Siekmann and Korbel (2016), the interdisciplinary or the integrated STEM education can be explained as a combination of disciplines and used to understand examples in real world and solve problems related to these. Of course, it is achieved via using the critical and creative thinking, researching and experimental skills and understanding social needs.

Moore, Stohlmann, Wang, Tank, Glancy, A. And Roehrig, G. (2014) described the integrated STEM education as "an effort to bring some or all of the four disciplines of science, technology, engineering and mathematics together", "a class, unit or course based on the connections between subjects and real-world problems". Gonzalez and Kuenzi (2012) note that the STEM education covers educational activities, which are specific to the mentioned four fields, at all class levels ranging from preschool education to the doctoral stage both in formal and informal environments.

According to Kelley and Knowles (2016), the engineering design approach aiming to give the STEM education forms an ideal entry point to include engineering practices into the current secondary education curriculum and the use of engineering design as a factor to the STEM learning is of vital importance to develop all of the four STEM disciplines on an equal platform. Likewise, according to Fan and Yu (2017), the engineering design is a complex decision-making and problem-solving process and, in addition to this, higher-order thinking skills are essential to analyze problem solving skills, predict the feasibility of different solutions, evaluate results and optimize the solution in the engineering design process. Establishing problem states which students might encounter in real life and require the integration of related disciplines is regarded as the most important point of the STEM education and, hence, this situation makes the problem-based learning one of the important ways of the STEM education (Çepni, 2017).

In the study, which was conducted by Mcdonald (2016) and where the publications related to STEM were examined, the findings obtained from many studies revealed that participation in the technology and engineering learning experience developed creativity and higher-order thinking skills, facilitated the integration between the STEM disciplines and indicated learning contexts resulting in higher motivation and success. National Research Council, (2012) justifiably emphasizes the necessity that science and engineering practices should start at early classes and then exhibit performance at higher levels beginning from secondary school students toward high school students.

In the 2018 Ministry of National Education sciences course teaching program put into practice in Turkey, under the heading of field-specific skills, STEM was emphasized as Engineering and Design Skills by explaining it as follows:

"*By achieving the integration of physical sciences with mathematics, technology and engineering, with an interdisciplinary viewpoint of problems, this field covers developing strategies in relation to students' creating products by using knowledge and skills which they have acquired and how they can add additional values to products by having students reach the level of being able to make inventions and innovations*."

Stem Competencies and Skills

The concept of competency is an integrated concept covering the concepts of knowledge, ability, skill and attitude displayed in the context of a range of professional occupations (Cited by Hager and Gonczi 1996, from Gonczi et al., 1990; Hager, 1994; Biggs, 1994). In this respect, it is necessary to distinguish between these two concepts. In the report entitled 'Identification of the 21st Century Skills', Binkley, Erstad, Herman, Raizen, Ripley and Rumble (2010), identified the use of the types of reasoning such as inductive, deductive, etc. which they put forward as belonging to such skills as critical thinking, problem solving and decision-making skills, making connections between knowledge and arguments, making the best analysis by interpreting knowledge and being based on results and evidence and making evaluations by considering evidence as the STEM competencies.

EU Skills Panorama 2014 defines the STEM skills as the ones "which people having received education about the subjects of science, technology, engineering and mathematics at higher education level are expected to possess". These skills were determined as "the ability to produce, understand and analyze empirical data including arithmetic and critical analyses; understanding of scientific and mathematical principles; the ability to evaluate complex problems systematically and critically and the skill of being able to implement the theoretical knowledge of a subject to problems; the skill of communicating scientific subjects to stakeholders and others; creativity, logical reasoning and practical intelligence". According to Siekmann and Korbel (2016), the STEM skills belong to technical skill groups. These are the ability to produce scientific knowledge supported via mathematical skills in order to design technological and scientific products or do engineering and occupations in the science and technology sectors and establishing the relationship between qualities belonging to these are also a method of defining the STEM skills.

In the report published in the USA and entitled "Rising Above the Gathering Storm", the STEM skills are highlighted and the importance of these skills for the future prosperity of the USA is emphasized. From a different perspective, for many occupations not having been conceptualized yet in the 21st century, it is also regarded as the key to all students' success (Breiner et al, 2012). Moreover, according to the EU Skills Panorama 2014, the STEM skills are of critical importance for innovation and in creating competitive advantage in knowledge-intensive economies.

Carnevale, Smith and Melton (2011) carried out a comprehensive study in the United States of America with the aim of determining the STEM competencies generally aiming at business life and based on a detailed occupational database of the workers.

According to Carnevale et al. (2011), skills are competencies allowing the learning in a knowledge domain to continue. In this context, as it is seen in Table-1, they gathered the STEM competencies under three main headings, namely knowledge, skills and abilities.

Table 1- STEM Competencies (Carnevale et al.,2011)

Knowledge	Skills	Abilities
Production and processing	Mathematics	Problem sensitivity
Computers and electronics	Science	Deductive reasoning
Engineering and technology	Critical Thinking	Inductive reasoning
Design	Active learning	Mathematical reasoning
Building and construction	Complex problem solving	Number facility
Mechanical	Operation analysis	Perceptual speed
Physics	Technology design	Control precision
Chemistry	Equipment selection	
Biology	Programming	
	Quality control analysis	
	Operations monitoring	
	Operation and control	
	Equipment maintenance	
	Troubleshooting	
	Repairing	
	System analysis	

In this study, with the aim of determining the science and mathematics preservice teachers' STEM competencies, of the competencies given in Table-1, the competencies belonging to the group of knowledge (knowledge of mathematics, physics) and the ones belonging to the group of skills (complex problem solving, critical thinking, technology design, mathematical reasoning) were taken into consideration. If we examine these competences, Funke (2010) describes a complex problem as a problem including numerous interconnected variables and identifies a range of cognitive action steps such as action planning, knowledge acquisition and evaluation as complex problem-solving skills. There are two steps suggested by Fischer, Greiff and Funke (2012) for the complex problem-solving process. These were stated as:

1. Knowledge acquisition: For the sufficient understanding of the problem, problem solver's producing knowledge systematically (searching for informative data), integrating this knowledge to a feasible mental model of the situation sufficiently

(making inquiries for sufficient hypotheses) and focusing by selecting the most related and central aspects of the problem.

2. Knowledge implementation: Based on the acquired explicit and implicit knowledge, problem solver's making some independent decisions (dynamic decision making) and monitoring the pre-conditions and results of these decisions continuously in order to solve the problem systematically.

Moreover, mathematical reasoning was evaluated by the Australian Curriculum Assessment and Reporting Association (ACARA, 2013) as a key competency and defined as "logical thinking and actions such as analyzing, verifying, evaluating, explaining, making inference, justifying and generalizing" (Davidson, Herbert & Bragg, 2018).

English and King (2015) described the technological design process as a five-stage process, namely determining the problem, generating an idea, designing and doing, evaluating and re-designing. When technology is mentioned, computer and digital media come to many people's minds. In reality, technology is defined as any novelty or device created by people in order to fulfill a person's need or desire. In this context, in STEM classes, students actually create technologies while producing products or prototypes in order to solve problems and, by means of STEM, learn how to use technologies, know how to develop new technologies and analyze how new technologies affect us and others (Jolly,2016). Moreover, the integration of the STEM content and the technology and design-based approaches force tomorrow's problem solvers to acquire required cognitive requirements (Wells, 2016).

When we take critical thinking skill in hand, we see a multi-variate structure. Critical thinking (CT) is conceptualized as a tool facilitating decision-making or problem solving and CT has many key aspects such as verbal reasoning, evidence analysis, evaluation of probability and uncertainties, making healthy decisions and thinking as hypothesis testing (Halpern, 2003: Cited by Liu, Frankel, Roohr, 2014).

STEM Education and Teacher

The successful implementation of the STEM education model depends on training teachers possessing required qualities. For this reason, the problem of training teachers to implement this education model successfully comes into prominence. Indeed, today, rapidly advancing scientific research and technology are changing current and future needs and affecting educators in this context.

According to Siekmann & Korbel (2016), one of the most important implementers of the STEM education is teachers and educators, who are able to integrate the basic STEM knowledge and skills and teach them inspiringly successfully. Therefore, Bell (2016) emphasizes the training of qualified teachers for the STEM education being introduced as a future-oriented way as an indispensable part of reaching this vision. Moore, Stohlmann, Wang, Tank, Glancy and Roehrig, (2012) noted that technology having rapidly grown in the 21st century generally caused workforce and needs to change and, depending on this, changed the expectations of teachers and students, too.

For all these reasons, the need for training STEM teachers emerged and, in relation to this, some researchers developed programs. For example, Rinke, Brown, Kinlaw and Cappiello (2016) mentioned that the need for the preparation of STEM teachers increased especially at elementary education level and, in their study, developed a program built on teacher training principles both in general and in particular to STEM and analyzed the results of the program. In a study made with the aim of developing the STEM education, Dailey, Bunn and Cotabish (2015) implemented a STEM Teacher Preparation Program composed of two steps and built upon research and inquiry-based approach. Hence, they noted that this implementation will provide preservice teachers at university with the opportunity to develop lessons and then teach these lessons to children at schools. Nadelson, Callahan, Pyke, Hay, Dance & Pfiester (2013) established a professional development program in relation to attitude, knowledge and competency about the inquiry-based STEM teaching for K-5 teachers and put into practice.

In Turkey, too, some projects were made. Of these, the aim of the integrated teacher training project is to provide teachers, teacher educators and researchers, who are STEM implementers, with a teaching-oriented route map developed based on different knowledge and data sources (Aşık, Doğança Küçük, Helvacı & Çorlu, 2017). In our world experiencing the information age and the use of information, the STEM education model has a strategical importance for our country to protect the competitive force at international scale (Çorlu, Capraro and Capraro, 2014).

In this context, it was regarded as important to determine the teachers' STEM competencies and aimed to investigate into the science and mathematics preservice teachers' STEM competencies. In the study, answers were sought to the following two questions:

1. What are the STEM competencies and skills which preservice teachers, who will be the implementers of STEM programs, should possess?
2. Do preservice teachers possess the required competency?

For this reason, in the study, the parachute design problem was given to allow the preservice teachers to display these competencies.

METHODOLOGY

This study is a qualitative one carried out with the aim of determining the preservice teachers' STEM competencies. In the study, the preservice teachers were given the problem of designing and making a parachute model required to land safely (one which is able to hang in the air for the longest period of time). In relation to this, the preservice teachers were expected to design and make a parachute model within the scope of the course of Physics I in a way to include the topics of movement on earth which they have seen (free fall, air resistance and ascending force) by following the STEM design steps given in Figure 1 and in accordance with the steps of "STEM Learning Cycle and Line" suggested by Çorlu (2017) and also take into account such variables as type of material and geometry of parachute surface while doing the design. In the selection of materials, they were advised to prefer such materials as thread, cloth, paper, nylon, etc., which can easily be found in daily life. They were expected to evaluate the parachutes by trying various parameters according to if they fitted for the required criteria and, hence, reach a result.

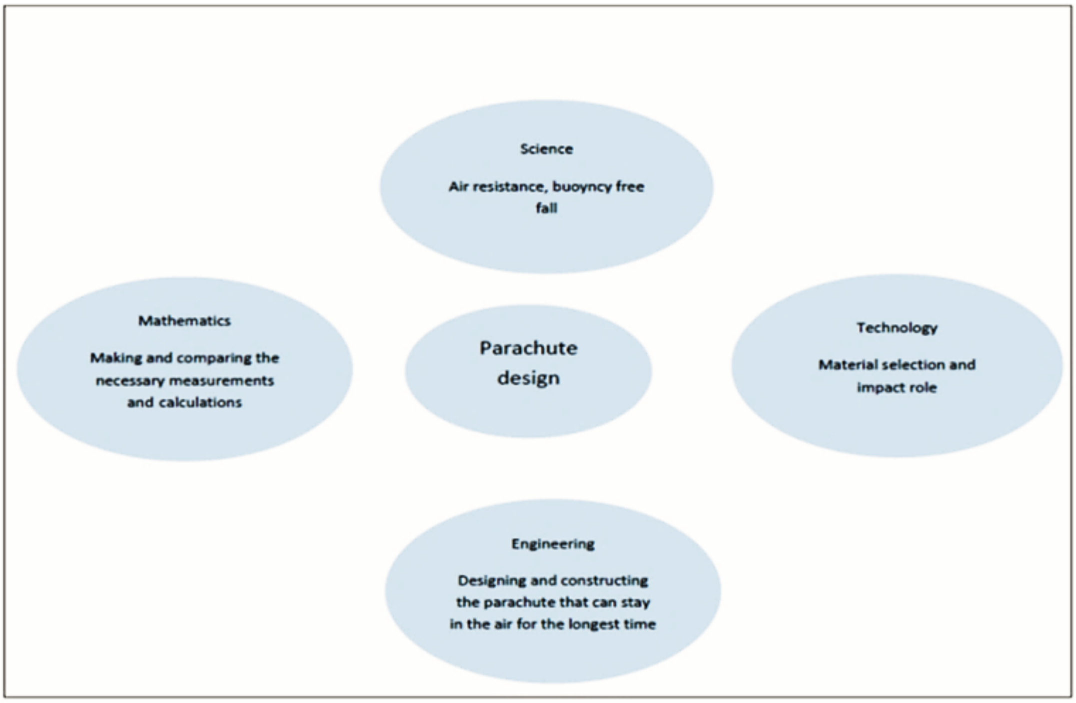


***Figure 1**. STEM steps of Parachute Design*

The preservice teachers were given a working time of two weeks, as it was mentioned above, to design and make a parachute model and they were asked to present all the obtained information in detail as a written document at the end of this period of time and introduce the designed parachute model in the classroom environment.

The preservice teachers were asked to specify every step which they took in accordance with the written documents clearly and the descriptive analysis was applied in the evaluation by looking at these steps (Çepni, 2018).

In the study were included a total of 106 science education and mathematics education preservice teachers taking education at the Mathematics and Science Education Department of the Education Faculty of Bursa Uludağ University. In the sample selection, the criterion sampling method was used based on the purposeful sampling method. The criterion was determined as having taken the course of Physics I.

The reliability of a study is achieved when the study is repeated by another researcher in the same way and yields similar results (Yıldırım and Şimşek, 2005). For this reason, all the steps followed in the study were clearly identified and supported via related documents. With the aim of achieving internal validity, the data was discussed with another researcher and reconciliation was sought.

Of the competencies included in Table- 1 and determined in accordance with the problem given with the aim of determining the preservice teachers' STEM competencies, the ones belonging to the knowledge group (knowledge of mathematics, physics) and the ones belonging to the skill group (complex problem solving, critical thinking, decision making, technology design, mathematical reasoning) were taken into consideration and the students were evaluated over these competencies. When making evaluations, as it was mentioned before, as complex problem solving skills, a range of cognitive action steps defined by Funke (2012) such as action planning, knowledge acquziation and evaluation; for mathematical inquiry, "such actions as analyzing, verification, evaluation, explanation, making inference, justification and generalization determined by (ACARA, 2013); to determine the technology design skill, English and King's (2015) five-stage process, namely determining the problem, generating an idea, designing and doing, evaluating and re-designing; for the critical thinking skill, the skills determined by Halpern (2003) as verbal reasoning, proof analysis, evaluating probabilities and uncertainties, decision making and thinking as hypothesis testing were taken into consideration.

The written documents given by the preservice teachers were evaluated and the mentioned competencies of complex problem solving, critical thinking and decision making, technology design and mathematical reasoning were determined as themes. In the direction of these themes, three categories were formed and named as C1 (Being competent), C2 (Having incompetences) and C3 (Being incompetent). Similarly, in accordance with the determined themes and categories, the preservice teachers were categorized and grouped as G1 (Being competent), G2 (Having incompetency's) and G3 (Being incompetent). The groups and their features were determined as follows:

The preservice teachers included in G1 group showed having the competencies determined as themes. By using the STEM steps belonging to the parachute model design given in Figure 1, the preservice teachers performed the STEM learning cycle steps correctly. That is to say, they understood the given problem completely, used the required knowledge of physics and mathematics, drew design plans toward the solution, planned and performed the related experiences in order to determine such features as parachute geometry, material selection, arranged the obtained data in tables, determined the data fitting for the required criteria by putting forward the proofs and, in this direction, realized the making of the parachute model and after putting the result down on paper, presented it in written report.

While the preservice teachers included in G2 group became successful in some themes, they failed to become successful in others. For example, they preferred to prepare a design by directly writing the data belonging to the experiment results related to the given problem without stating what they did or would do or explaining the process or clearly putting forward for what reasons and how they decided to prepare that design. Or some preservice teachers directly made a parachute model and only provided some theoretical knowledge about the solution without making any comments about how they made it and its results in their written reports.

The preservice teachers included in G3 group failed to show any success in relation to the specified themes. It is definitely not clear what the preservice teachers in this group did. When their reports were examined, it was seen that they mostly included explanations, experiments and/or experiment results, figures and the like information directly downloaded from the Internet and not overlapping what was desired.

FINDINGS

The percentages of the groups determined in the mentioned way are given in Table 2.

***Table 2**. Number of preservice teachers and Percentages Determined according to the Groups*

Group Number	G1	G2	G3
Number of students	7	59	94
Percentage (%)	4.38	36.87	58.75

As it is seen in Table 2, the G2 ve G3 groups compose the great majority (95.62%) of all the students. When we evaluated the G2 group in detail, the distributions obtained according to the determined themes were given in the following tables.

***Table 3**. Complex problem-solving competency belonging to G2 Group*

Theme	Category	Number of Students	%
Complex problem-solving competency	Being competent	3	5.08
	Having incompetences	37	62.71
	Being incompetent	19	32.20

***Table 4**. Critical thinking and making-decision competency belonging to G2*

Theme	Category	Number of Students	%
Critical thinking and making-decision competency	Being competent	7	11.87
	Having incompetences	23	38.98
	Being incompetent	29	49.15

Table 5. *Technology design competency belonging to G2*

Theme	Category	Number of Students	%
Technology design competency	Being competent	3	5.09
	Having incompetences	31	52.54
	Being incompetent	25	42.37

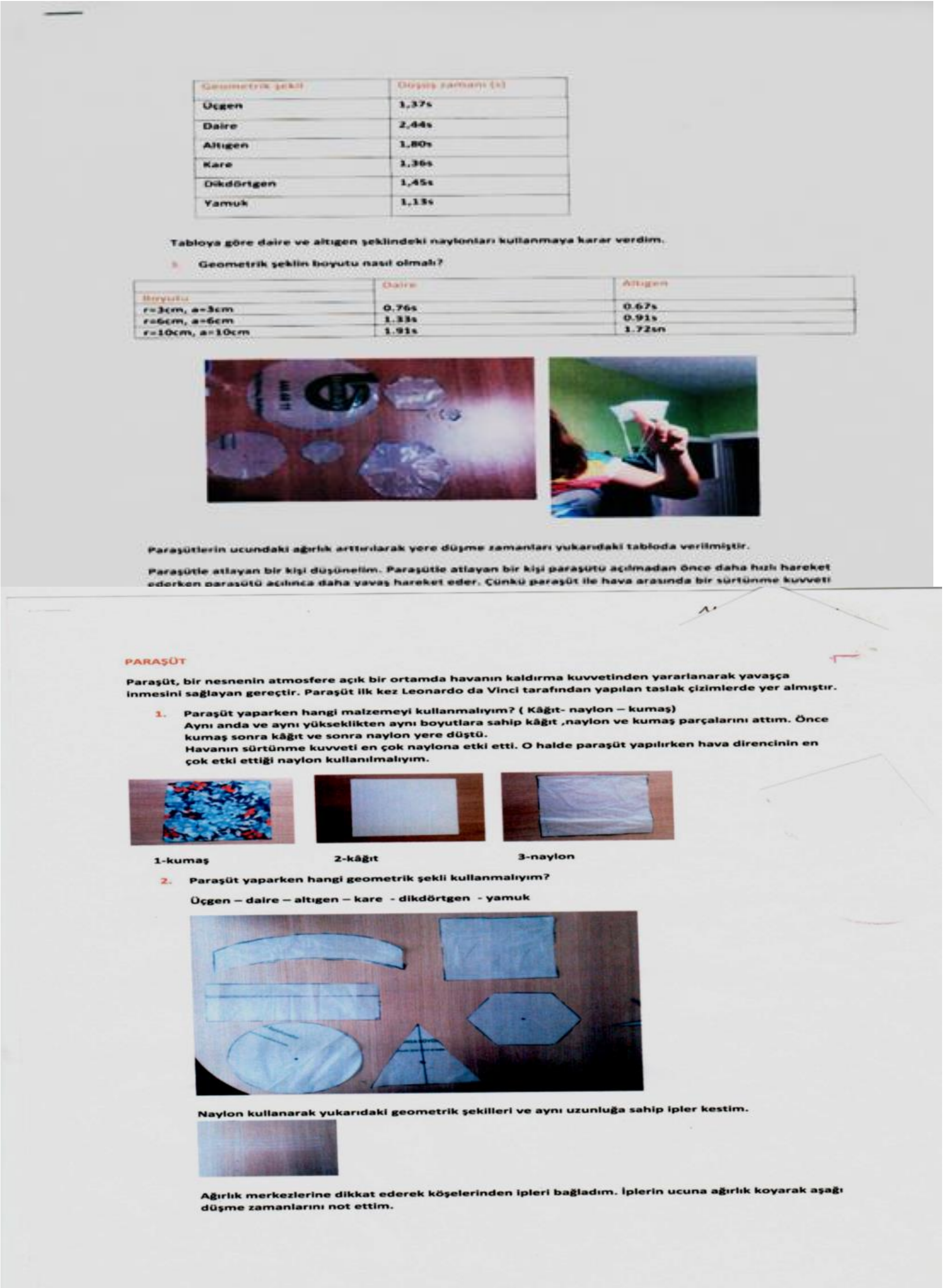
Table 6. *Mathematical reasoning competency belonging to G2*

Theme	Category	Number of Students	%
Mathematical reasoning competency	Being competent	21	35.59
	Having incompetences	7	11.87
	Being incompetent	31	52.54

Table 7. *Using Physics-Math Knowledge competency belonging to G2*

Theme	Category	Number of Students	%
Using Physics-Math Knowledge competency	Being competent	14	23.73
	Having incompetences	24	40.68
	Being incompetent	21	35.59

Below are also some examples of reports belonging to G1, G2 groups.



Geometrik şekil	Düşüş zamanı (s)
Üçgen	1,37s
Daire	2,44s
Altıgen	1,80s
Kare	1,36s
Dikdörtgen	1,45s
Yamuk	1,13s

Tabloya göre daire ve altıgen şeklindeki naylonları kullanmaya karar verdim.

3. Geometrik şeklin boyutu nasıl olmalı?

Boyutu	Daire	Altıgen
r=3cm, a=3cm	0.76s	0.67s
r=6cm, a=6cm	1.33s	0.91s
r=10cm, a=10cm	1.91s	1.72sn

Paraşütlerin ucundaki ağırlık arttırılarak yere düşme zamanları yukarıdaki tabloda verilmiştir.

Paraşütle atlayan bir kişi düşünelim. Paraşütle atlayan bir kişi paraşütü açılmadan önce daha hızlı hareket ederken paraşütü açılınca daha yavaş hareket eder. Çünkü paraşüt ile hava arasında bir sürtünme kuvveti

PARAŞÜT

Paraşüt, bir nesnenin atmosfere açık bir ortamda havanın kaldırma kuvvetinden yararlanarak yavaşça inmesini sağlayan gereçtir. Paraşüt ilk kez Leonardo da Vinci tarafından yapılan taslak çizimlerde yer almıştır.

1. Paraşüt yaparken hangi malzemeyi kullanmalıyım? (Kâğıt- naylon – kumaş)
Aynı anda ve aynı yükseklikten aynı boyutlara sahip kâğıt ,naylon ve kumaş parçalarını attım. Önce kumaş sonra kâğıt ve sonra naylon yere düştü.
Havanın sürtünme kuvveti en çok naylona etki etti. O halde paraşüt yapılırken hava direncinin en çok etki ettiği naylon kullanılmalıyım.

1-kumaş 2-kâğıt 3-naylon

2. Paraşüt yaparken hangi geometrik şekli kullanmalıyım?
Üçgen – daire – altıgen – kare - dikdörtgen - yamuk

Naylon kullanarak yukarıdaki geometrik şekilleri ve aynı uzunluğa sahip ipler kestim.

Ağırlık merkezlerine dikkat ederek köşelerinden ipleri bağladım. İplerin ucuna ağırlık koyarak aşağı düşme zamanlarını not ettim.

Figure 2. *The report example belonging to the G1 (Sufficient) group.*

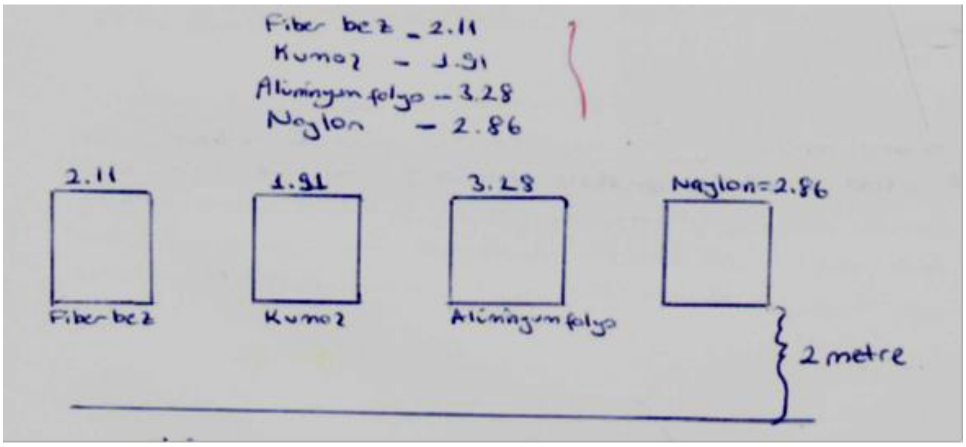


Figure 3. *The report example belonging to the G2 group*

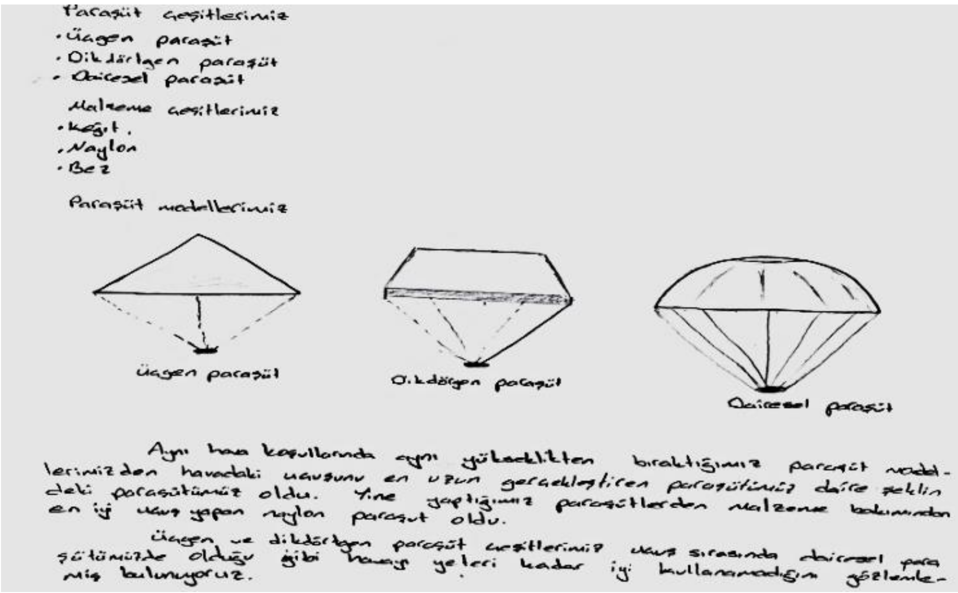


Figure 4. *The report example belonging to the G2 group*

CONCLUSION AND DISCUSSION

In general, it seems that the results do not supplied the expectations. The result reached in terms of the competencies taken into consideration indicates that only 4.38% of the preservice teachers obtained sufficient success in all the themes. The obtained results clearly make us reach the finding that most of our students did not possess the STEM competencies. The students included in G1 group used figure, mathematical symbol, etc. as a communication language and, moreover, prepared a sufficient written report. In Figure-2 below, some parts from the report example belonging to G1 group were given.

As it is seen in the example, the students understood the problem in accordance with the steps suggested by Funke (2012). While making this evaluation, the suggestion stated by Dörner and Funke (2017) as “CPS should not be reduced only to the result of a solution process. When the process going toward the solution, including the deviations and the mistakes made along the way, is examined, a more different impression can be achieved about preservice teachers’ problem-solving abilities and competencies” was taken into consideration. Therefore, the process was followed clearly. The preservice teachers determined the first independent variable by using different materials; at the second stage, they determined the second independent variable by selecting the parachute geometry. They determined time as the dependent variable and performed a controlled experiment. In the meantime, they supported the designs which they thought as necessary via drawings as well. For example, they thought different geometries (hexagon, circle, square, triangle, trapezoid, rectangle, etc.) for the parachute surface and, for every different material (nylon, paper, fabric, etc.), they tested different parachute models having surfaces in these geometries. They interpreted the experiment results which they obtained via their knowledge of physics. For example, some students reached the following results:

- *Student 78: “In the experiment, I saw that the material which had the highest air resistance force was nylon”.*
- *Student 2: “As the size of the geometric shape increased, so did the air resistance affect the parachute”.*
- *Student 154: “In the experiment, I decided to use the nylon material because the air resistance affecting nylon reduced the speed and allowed for a safe landing”.*
- *By evaluating all the obtained data, they formed evidence for the most appropriate solution to the problem. For example, some students made the following comments:*
- *Student 82: “As a result of the obtained data, I saw that the use of a surface with an octagonal surface was more appropriate. For, the greatness of the surface area had an effect”,*
- *Student 83: “While I was deciding about the geometric surface, I took into account the resistance force and time and, hence, I decided about the circle surface”,*
- *Student 132: “I made a parachute by using paper, nylon and piece of cloth; I understood that less air filled inside the fabric parachute as a result of free fall”.*

Hence, as it was explained by the Australian Mathematics Curriculum (ACARA, 2017), they were observed to use the mathematical reasoning skills.

In conclusion, they made the geometric measurements required for each material and geometry, measured the endurances of the models which they made and gave the results which they obtained in tables and determined and created their parachute models by putting forward some evidence in accordance with the given problem. Based on these findings, it can be stated that the preservice teachers had the required competencies. However, although the skills of creative thinking or generating an idea were very limited, efforts to improve an existing situation were observed.

When we examine the students in G2 group, we see in the evaluation made in terms of complex problem-solving competency that only 3% of the students in G2 group became successful. When the students in this group are evaluated by taking the steps suggested by Funke (2012) for complex problem-solving process into consideration, it was observed that they generally turned to make a parachute by taking in hand the given problem unidirectionally, but they did not take into account the desired feature of the best hang-in-the-airtime and, hence, they had some problems understanding the problem. For example, they mostly obtained data by making measurements depending on a single parameter for the parachute design, but they could not make a decision about making the best parachute or draw a design plan based on the data or release a product. Some students planned experiments in relation to design, but they did not give any information about what they did or aimed to do and put forward any evidence related to the results, either. Moreover, some students included their experiment findings by specifying their aims and what they did, but they did not make any contributions and comments based on these results in their designs. For example, when we look at an example of group G2 in figure 3, it is seen that in this report, they formed a range of appropriate questions in relation to the student parachute design, made a selection of materials to answer the questions, determined a single geometric surface and used a statement “I dropped it freely from a height of 2 meters". Along with the use of knowledge of physics, it is not certain what he did and how he reached the result as a procedure and according to what data he designed the best parachute. When the report of another student in G2 group were examined shown in Figure 4, we understand that this student determined three different types of geometric surfaces and materials and decided that the best one is the circle surface. However, data such as how he made this decision and what evidence he based on is not available.

When the reports of the students in the last group G3 were examined, it was observed that what the students did was not clear. In these examples, the students gave very short theoretical information about how to make a parachute and mentioned about their experiments. However, they wrote results without any kind of data, that is to say, without being based on evidence. In the interviews held with the students, too, it was observed that the students did not use the concept of variable.

As it is seen in the study, too, some skills are nested in and support one another. That is to say, it is not possible to distinguish these via precise borders. For example, according to Fielding-Wells (2013), mathematical inquiry has the potential to develop important competencies of the 21st century and helps students adapt their knowledge to other situations by developing their problem-solving skills and mathematical thinking. According to Herde, Wüstenberg and Greiff (2016), there is an increasing demand for CPS; for this reason, students’ CPS skills should be measured, and they should also be provided with learning environments developing CPS skills in order to prepare them for the difficulties of the 21st century. Science education can be developed via adopting the engineering design approach; for, it creates an opportunity for scientific research process and implementation, and, at the same time, mathematical reasoning provides an important context in order to make conscious decisions in the design process (Kelley and Knowles, 2016).

If the findings are evaluated as a whole, we see some results which require taking into consideration. When the effect of the STEM approach on a nation's intellectual and competency-based needs in future years is taken into consideration, it can be stated that this need should be taken into account and attached importance in the training of preservice teachers. Since the mentioned competencies can be developed via quality education understanding, necessary arrangements should be made in relation to this target.

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