Investigation of Teacher Candidates' Skills in Creating Knowledge-Based Life Problems Based on STEM Lesson Plan and Suggesting Solution

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ABSTRACT

STEM is becoming widespread as an education model in many countries today, and it has been included in the curriculum in our country, and the need for teachers trained in this field has emerged. The purpose of this study, in which the case study method, one of the qualitative research methods, is used, is to examine the skills of Physics-Chemistry teacher candidates to create real-life knowledge-based problems covering the achievements in the high school curriculum and propose solutions for these problems. For this reason, 4 Physics and 2 Chemistry teacher candidates who took formation training and participated in the study voluntarily were studied for five weeks in the research. The data of the study were collected through semi-structured written documents given to teacher candidates and face-to-face interviews. The collected data were evaluated with the content analysis approach. According to the results obtained, it was concluded that the teacher candidates had difficulties in associating the problems they created with the achievements of the STEM discipline and physics-chemistry discipline, and they were successful in terms of their ability to propose solutions such as product development and testing.

Keywords: Physics teacher candidate, chemistry teacher candidate, STEM lesson plan, life-based problem

INTRODUCTİON

With the rapid and effective introduction of scientific and technological developments, the need to train teachers who have the knowledge and skills to contribute to this development in education has emerged. The STEM education model, which is one of the educational approaches that will meet this need, has become widespread. Roehrig, Moore, Wang and Park (2012) stated that the rapid development of technology in the 21st century caused changes in the workforce and needs in general. Accordingly, the expectations of teachers and students changed. In addition, this model is seen as the key concept of countries' technical and economic progress today. Bell (2016) emphasizes the importance of training qualified teachers for STEM education, which is presented as a way forward. According to Siekmann & Korbel (2016), one of the most important practitioners of STEM education is teachers and educators who can integrate and successfully apply STEM knowledge and skills. In this context, it is important to provide teachers with sufficient professional knowledge to implement STEM education. In most research reports, it is seen that teachers have difficulties in STEM practices (Jho, Hong, & Song, 2016). When the literature on STEM applications is examined, it is emphasized that it is important to enabling teachers to apply the knowledge they have learned in the classroom environment (Johnson & Fargo, 2010).

According to Çepni (2017), teachers in STEM education have to design learning environments that will enable their students to use the research methods of scientists and perform quality STEM activities that will enable them to gain experience in solving real-life problems.

Although there is no single definition of STEM education, considering that the definition of STEM includes “the application of knowledge to real-life problem solving”, it follows that effective STEM-oriented teaching should include a pedagogy that focuses on real-life issues, problems or questions (Dass, 2015).

The Taskforce Report STEM (2014) adopts the view that STEM education is much more than a proper integration of the four disciplines and expresses this view as “it encompasses real-world, problem-based learning”. Indeed, there are knowledge-based life problems at the center of the STEM education program. Dealing with such problems takes them out of the classroom and enables them to perceive the real world.

Moore et al. (2014) defined the connection of STEM education with world problems as "an effort to bring together some or all of the four disciplines of science, technology, engineering and mathematics" and "a class or course based on connections between subjects and real-world problems". It is seen that STEM education practices in the world emphasize the understanding of solving problems in daily life through an engineering design using science, mathematics and technology (Chalmers, Carter, Cooper, & Nason, 2017; DeFreitas

et al., 2017; English, 2017). According to Margot and Kettler (2019), STEM education is both a curriculum and a pedagogy. The curriculum includes cross-curricular real-world challenges for students to solve. In addition to choosing the content in STEM education, it is also necessary to create a lesson plan suitable for STEM education, to apply and evaluate the created lesson plan.

Corlu (2012) stated a need for mathematics and science teachers equipped with the knowledge to implement STEM education in Turkey and that reforms in Turkish STEM education could be successful if mathematics and science teachers are trained with programs that facilitate STEM education with innovative and integrated thinking. Due to the emergence of the need to train STEM teachers today, some researchers have developed programs. There are some projects carried out in Turkey as well. The purpose of the Integrated teaching project, which is one of them, provides a roadmap for teaching developed based on different information and data sources for STEM practitioner teachers, teacher educators and researchers (Aşık, Doğança Küçük, Helvacı & Corlu, 2017). Another is the STEM Teacher Institutes Education Model (STIEM), a model in which teachers will provide their professional development for STEM education (Yıldırım, 2020).

There are some studies conducted to investigate STEM education in pre-service teacher education in Turkey. These studies generally focused on candidates' attitudes and awareness about STEM education. (Altun, Yalçın & Yalçın, 2018; Bakırcı & Karışan, 2018; Hacıoğlu, Yamak & Kavak, 2017; Kızılay, 2018; İnançlı & Timur, 2018). There are also STEM-oriented studies carried out during undergraduate education. In these studies, teacher candidates' various skills in the 21st century, their attitudes towards STEM practices and their awareness about STEM were examined (Bozkurt, 2014; Çetin & Kahyaoğlu, 2018; Hacıoğlu, 2017). In addition to these studies, Ercan (2016) examined the professional development of teacher candidates regarding STEM education. There are also some studies in which teachers or teacher candidates actively participate in the STEM education design or implementation process (Bozkurt-Altan & Ucuncuoglu, 2019; Eroğlu & Bektaş, 2016; Han, Yalvac, Capraro & Capraro, 2015; Ryu, Mentzer & Knobloch, 2019).

Corlu (2017) created a cycle consisting of two successive structures, namely the cognitive process and the social product, which he named "STEM Learning Cycle and Line" for teachers and students. According to this, "at the center of the STEM learning cycle," *There is a knowledge-based life problem focusing on 21st-century life, allowing the analysis of the dynamic and complex structure of more than one variable, thus not directing students to a predetermined single correct solution, but well-defined with limitations.* . At the beginning of the cycle, he defined three steps: life-based problem followed by knowledge acquisition, idea development, and limitations. After these three steps, product development and testing steps are defined. In the study, it is aimed to contribute to the literature by

analyzing the difficulties experienced by the physics-chemistry teacher candidates in this process by using the STEM learning cycle suggested by Corlu (2017).

Purpose Of The Study

The main purpose of this study is to create a knowledge-based life problem based on the STEM lesson plan suitable for the high school curriculum (KBLP) of the physics-chemistry high school teacher candidates and their ability to propose solutions.

For this reason, answers to the following questions were sought in the study.

1. What are the skills to create knowledge-based life problem which is suitable to the curriculum?
2. How do the knowledge-based life problems which teacher candidates created relate to the achievements of the related subjects in the high school curriculum?
3. What kind of solutions did teacher candidates propose for knowledge-based life problems aimed at stem applications?
4. Have teacher candidates been able to create suitable products within the scope of the solution proposal for knowledge-based life problems?

METHOD

Research Model

The study uses a case study design as a qualitative research methodology. A case study; is a type of ethnographic research study that focuses on a single unit such as an individual, a group, an organization or a program (Ary, Jacobs, Sorensen, & Walker, 2013). In the case study, one or several situations are analyzed holistically within their boundaries (environment, time, etc.) (Yıldırım & Şimşek, 2016). In this study, in which the holistic single case design, which is one of the case study designs, was used, it was aimed to reveal the skills of physics-chemistry high school teacher candidates in creating knowledge-based life problems (KBLP) and suggesting solutions according to the STEM lesson plan suitable for the high school curriculum.

Study Group

The study group of the research consists of 6 teacher candidates (4 girls, 2 boys), 4 physics-2 chemistry, who studied pedagogical formation at a state university in the fall semester of the 2018-2019 academic year and took the special teaching methods course. Criterion sampling (Yıldırım & Şimşek, 2016) method, one of the purposeful sampling methods, was used in the selection of the sample. In the study, it was determined as a measure that teacher candidates took courses of STEM.

Data Collection Tools

Semi-structured written documents (STEM plans) created by the researchers were used as data collection tools in the study. While creating the STEM lesson plan, literature research was conducted, and the STEM lesson plan, which was created by using the lesson plan prepared by Corlu (2017), was applied. This plan includes the following stages:

1- Objectives (Science, Engineering and Mathematics)
2- Materials used
3- Sources
4- Creating a knowledge-based life problem (KBLP)
5- Course content (Idea development, product development)
6- Testing the developed product

Before starting the study, the STEM lesson plan was applied to a teacher candidate as a pilot study, and it was determined that the candidate was able to implement the plan. During the face-to-face interview, voice recording, and note-taking methods were used together. Each interview lasted approximately 10-15 minutes. The work schedule for the applications that lasted five weeks is given in Table 1.

Table 1. *Work Schedule*

Week	Content
Week 1	Information about the Stem lesson plan
Week 2	Establishing KBLP compatible with high school program achievements
Week 3	Creating solution proposals according to the stem lesson plan
Week 4	Preparation of solution-oriented designs
Week 5	Creation and presentation of products

Since the teacher candidates who participated in the research had comprehensive knowledge about STEM within the scope of the formation program they attended, information was given about the STEM lesson plan prepared by the researchers in the 1st week, as indicated in Table 1. They were asked to prepare knowledge-based problems related to life, including the subject's achievements they will choose following the high school curriculum. In the second week, the suitability of the problems prepared by the teacher candidates with the acquisitions related to the subject in the high school curriculum was examined. In the 3rd week, stem lesson plans for the solution proposals prepared by the

teacher candidates concerning the real-life problem they identified were evaluated. In the 4th week, the products (prototypes) that the researchers created by making sketches and drawings of the solution-oriented designs required by KBLP were examined. In the 5th week, each researcher made a presentation using the final versions of the product they created. After the presentations, evaluations were made, and the scientific accuracy of the final versions of the products, how many solutions they bring to the problem and their suitability for the level of students were discussed.

Teacher candidates were given a STEM lesson plan form and were asked to answer the following questions:

1- What are the STEM achievements of your chosen subject?
2- Create a knowledge-based life problem for the topic you have chosen.
3- What are the ideas developed for the KBLP solution?
4- Were you able to develop a prototype for the KBLP solution? Were you able to implement your prototype?

Data Analysis

As a qualitative data source in the research, STEM plans, which are semi-structured written documents developed by (Corlu, 2017), were used. Qualitative data were created as a result of interviews with physics-chemistry teacher candidates. The main purpose of interviewing is to obtain in-depth, detailed and multidimensional qualitative information on the subject (Glesne, 2014). In this study, a 65-minute audio recording was created as a result of the interview with the teacher candidates. After the STEM plans prepared by the students and the audio recordings obtained from the interviews were written down, the analysis of the data was started. The analysis of the obtained data was made by content analysis. At the last stage, the data were interpreted by turning them into tables. In order to keep their identities confidential, the teacher candidates in the study group were given codes from S1 to S6. For the reliability of the research, the reliability formula suggested by Miles and Huberman (1994) was applied, and the reliability of the research was calculated as 91%. To ensure external validity, all stages of the study were clearly stated.

Limitations of the Study

The study is limited to the fact that it was conducted with high school teacher candidates who received formation education at a state university in Bursa; the data obtained were collected with qualitative data tools, and the study period was five weeks.

FINDINGS

KBLP for the subjects chosen by the teacher candidates from the Ministry of National Education(MONE) High School curriculum, the achievements of the problem, the development of ideas, the product developed for the solution of the problem and the test of the product are given in the tables below for each teacher candidate with their own words. While the problem statement and achievements for each teacher candidate are shown in a table, the ideas developed for the solution of the problem and the testing of the product, and the product are given in another table.

Table 2. *S1 Teacher Candidate's problem statement and achievements about 10th-grade Electricity and Magnetism*

Life-based Problem statement	**Achievements**		
	Achievements Of Physics Course	*Mathematics Achievements*	*Engineering Achievements*
"It is known that thousands of people pass through the bus terminals a day, and it is a crowded environment. Everyone must have heard that an announcement was made at least once while waiting at the terminal. However, this announcement is often not understood due to the crowded environment, the loud noise, the speakers' incorrect position, and the use of insufficient speakers. In physics, the necessary basic physics knowledge of the propagation and reflection of sound waves, as well as the internal structure of a loudspeaker, is studied in electricity and Magnetism. Try to solve	Analyzes the relationship between electric current, resistance and potential difference. Analyzes the variables that affect the strength of the magnetic field formed around a flat wire with current flowing, at the center of the ring and in the center axis of the current reel. Makes calculations about the magnetic field around a flat wire with current flowing, at the center of the ring and in the center axis of the current reel. Makes calculations about magnetic current and induction current. Explains the reason for the formation of self-induction current.	It performs operations by creating area and volume relations of the sphere, right circular cylinder and right circular cone.	The student identifies the processes involved in an engineering project. Explains stages such as planning, prototyping, design, execution, quality control and reporting.

this problem with the physics infrastructure you have acquired.”	Makes inferences about the causes of electromotive force. Compares alternating and direct current.		

Table 3. *S1 Teacher candidate's idea about the subject of 10th grade Electricity and Magnetism, the developed product and the testing status of the developed product*

Idea Development	**Developed Product**	**Test Status Of The Developed Product**
The students are asked, “If you were to design a loudspeaker, what would you pay attention to have a good volume and clarity of sound?”.	Using the following materials A speaker has been designed. Plain cardboard plate. (1 piece) (Necessary for diaphragm) Cardboard (1 piece) (Necessary for the floor) Fine polished copper wire (0.5 mm x1m) Cylindrical Neodymium magnet (1 piece – 2,5cm in length, 2cm in diameter) Scissors Cardboard (4 pieces of 12,5cm x 4cm) (For Bellows) Hot glue gun Cylindrical silicone (1 piece) Audio amplifier circuit Solder, Soldering iron 	Tested The speaker was made ready for testing by connecting to the signal amplifier and the computer. 

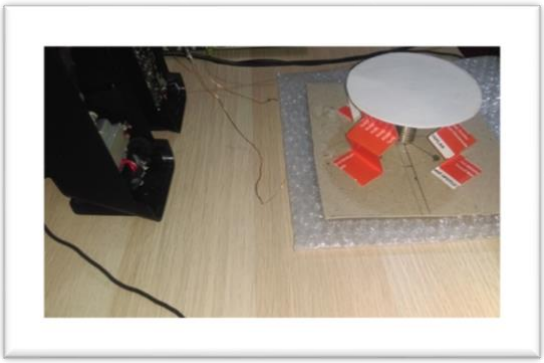
	Side view of the loudspeaker, showing the magnet, coil and bellows.  Side view of the speaker, wires connected to the audio amplifier  Signal amplifier	

Table 4. *S2 Teacher candidate's Grade Chemistry lesson, Nature and Chemistry unit, problem statement and achievements for Environmental Chemistry*

Problem Statement	**Achievements**		
	Achievements of Chemistry course	*Mathematics achievements*	*Engineering achievements*
"In a restaurant with a lot of customers, 5kg of frying oil is used daily. The kitchen cooks of the restaurant say that they clean the used frying oil by pouring it into the sink. After a while, it was observed that this	Explain the chemical pollutants that cause air, water and soil pollution. As air pollutants, nitrogen oxides, carbon dioxide and sulfur oxides are emphasized.	The student uses different mathematical concepts and methods while	The student identifies the processes involved in an engineering project. Explains stages such as planning, prototyping, design,

situation caused clogging of the sinks and the pipes going to the sewers. The manager of the restaurant thinks that a solution should be found regarding the treatment of waste oils. He asks a chemist and engineer to design a device for them to get information on the separation of oil and water."	Emphasis is placed on plastics, detergents, organic liquids, heavy metals, batteries and industrial waste as water and soil pollutants. It offers solutions to reduce the effects of chemical pollutants that harm the environment. The vital importance of the atmosphere for living things and the necessity of being sensitive to living things and the environment are emphasized when choosing and using consumer goods. It is ensured that students collect and share information about research, studies and results on reducing the harm of chemical pollutants to the environment by using information technologies.	analyzing the problem.	execution, quality control and reporting. The student examines research topics in engineering fields. The student investigates the principles and elements of design and demonstrates their use in the design process.

Table 5. *S2 Teacher Candidate's Status Of Chemistry Lesson, Nature And Chemistry Unit, Developing An İdea About Environmental Chemistry, The Developed Product And The Testing Status Of The Developed Product*

Idea development	*Developed product*	*Test status of the developed product*

Students are asked "What can we do for our environment? How can we separate our waste oils from water? And What are the properties of hydrophilic and hydrophobic substances? To enable students to think more easily, they are asked to think of experimental systems that they can easily do in the laboratory.	The liquid-liquid extraction method is applied. In this, acetone solution, which is easily available everywhere and has a low cost, is used as a solvent, and the solidified waste oils are separated.  Then taking into account the density difference between oil and water, it is proved that the underlying phase is water.	Not tested .

Table 6. *S3 Teacher Candidate's Problem Statement And Achievements On The 10th And 11th Grades Subject Of Magnetism*

Problem Statement	**Achievements**		
	Achievements Of Physics Course	*Mathematics Achievements*	*Engineering Achievements*
"A metal recycling factory wants to collect metal wastes used in daily life in the environment as well as the high tonnage metal wastes it collects from the industry. For this, s/he wants to establish various areas in the city. However, s/he wants to collect metals in the appropriate collection area with simple directions that citizens who do not know about the subject can use. It has been observed that these are thrown in a	Students will examine the magnetic field by conducting experiments or using simulations. It is emphasized that the magnetic fields of magnets are represented by magnetic field lines. Mathematical calculations related to the push-pull forces of magnets are not included. Students will be able to determine the variables that affect the magnetic field by	The student uses different mathematical concepts and methods while analyzing the problem.	The student identifies the processes involved in an engineering project. Explains stages such as planning, prototyping, design, execution, quality control and reporting. The student investigates the principles and elements of design and

mixed manner in areas such as plastic, glass and paper collection boxes that we are accustomed to seeing. Therefore, they want to develop a system that will allow only metal products to be thrown into the box where metals are to be collected. Try to solve this problem with the physics infrastructure you have acquired.”	conducting experiments or using simulations. The right-hand rule is established for the students. Mathematical calculations related to the direction and magnitude of the magnetic field are not addressed. The effects of the magnetic fields created by high voltage lines on living things in areas they pass through are addressed. Electromagnets are introduced, and examples of their usage are provided.		demonstrates their use in the design process. The student examines research topics in engineering fields. The student uses different mathematical concepts and methods while analyzing the problem.

Table 7. S3 Teacher Candidate's Status Of Developing An İdea On The Subject Of 10th And 11th Class Magnetism, The Developed Product And The Testing Status Of The Developed Product

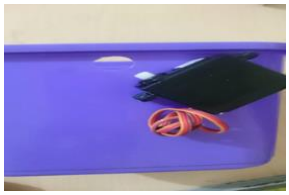
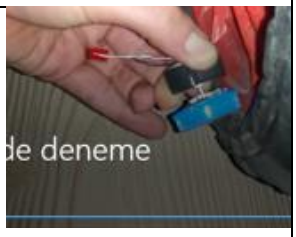
Idea Development	*Developed Product*	*Test Status Of The Developed Product*
The students are asked, "Do you have sufficient knowledge about recycling, if any, do you have experience on the subject?" and "Where can metals be used again after recycling?".	The design was made using the materials given below. Inductive sensor, Capacitive sensor Infrared sensor Led, Connection cables Cardboard, Bucket, Silicone, Tape, Screw, Adhesive Paper, Scissors, Staple Arduino Auxiliary materials in general  Inductive sensor  Infrared sensor  The servo that will make the device move Engine  Arduino to execute commands 	Tested  Material designed for recycling

Table 8. *S4 Teacher Candidate's Problem Statement And Gains On The Subject Of Class Electricity And Magnetism*

Problem Statement	**Achievements**		
	Cognitive Process Achievements	*Mathematics Achievements*	*Engineering Achievements*
"Due to the increase in fuel prices in our country and the high prices, a store employee commutes to work by bicycle. However, there are some problems on the way home in the evenings since there is no lamp on his/her bike. S/he has been in danger of an accident several times and travels uneasily because his/her home is in a deserted area. S/he thinks it would be good for him/her to design a lamp by making use of the rotation of the wheels to create an induction current."	Makes inferences about the causes of induction current. Makes calculations about magnetic current and induction current. Explains the behavior of charged particles in magnetic and electric fields. Makes deductions for the causes of the electromotor force.	Solves problems with the cosine theorem Solves problems with the theorem of sines Knows the basic elements of the circle.	The student identifies the processes involved in an engineering project. Explains stages such as planning, prototyping, design, execution, quality control and reporting. The student uses different mathematical concepts and methods while analyzing the problem. The student examines research topics in engineering fields. The student investigates the principles and elements of design and demonstrates their use in the design process.

Table 9. *S4 Teacher Candidate's Status Of Developing An İdea On The 11th Grade Subject Of Magnetism, The Developed Product And The Testing Status Of The Developed Product*

Idea Development	*Developed Product*	*Test Status Of The Developed Product*
It is aimed to provide convenience in the product creation process by telling the		

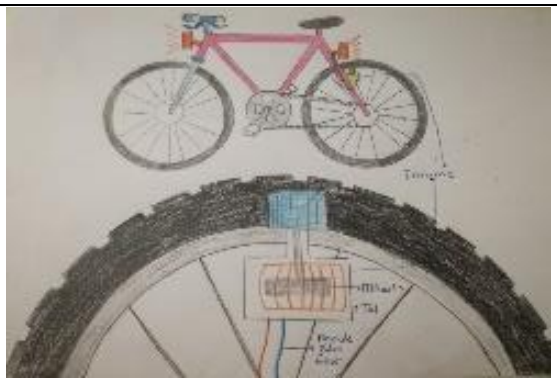
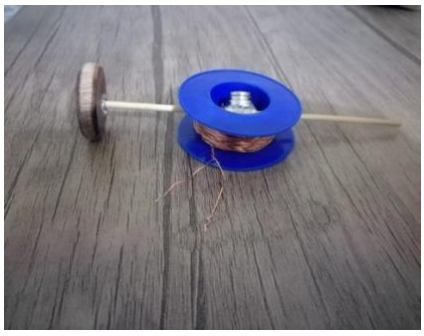
students, "Take a picture to have better knowledge about the product you will make and to imagine how to make it". “Think about the conditions under which the commands that the product will fulfill will take place. The question "What kind of equation solution do you need to deal with to fulfill the desired commands and achieve the desired and establish the relationship between solving the equation and the solution steps of the product you will make" is asked.	 Expected product  A bobbin was wrapped around the neodymium magnets, and when the magnets rotate, an induction current occurs.  Using a motor with more voltage than the simple motor above, it was mounted on the wheel of the bicycle, and with the rotation of the bicycle, the blue cap began to rotate, so an induction field began to form, and the bulb gave light when the field was cut off.	

Table 10. *S5 Teacher Candidate's Problem Statement And Gains For The 10th Grade Subject Of Chemistry Everywhere*

Problem Statement	**Achievements**		
	Achievements Of Chemistry Course	*Mathematics Achievements*	*Engineering Achievements*
"An olive oil production factory located in Gemlik releases a large amount of olive pulp (pomace) in their production, and since the amount is high, it has become difficult to control and has begun to harm the environment. The company wants to use pomace in an area that can contribute to nature. S/he asks a factory that recycles plastic materials to design a product using pomace. Design a product for the firm."	Gives examples of usage areas of common polymers. Explaining the phenomenon of polymerization - monomer and polymer concepts are emphasized. The main usage areas of rubber, polyethylene (PE), polyethylene terephthalate (PET), kevlar, polyvinyl chloride (PVC), polytetrafluor ethene and polystyrene (PS) are mentioned without going into the structural details. The positive and negative properties of polymers regarding their use in different fields are emphasized. The harms of toys and textile products in which polymer materials are used are mentioned. Explains the contribution of recycling of polymer, paper, glass and metal materials to the national economy. It is ensured that students collect and share information about research, studies and results on reducing the harm of	The student uses different mathematical concepts and methods while analyzing the problem.	The student identifies the processes involved in an engineering project. Explains stages such as planning, prototyping, design, execution, quality control and reporting. -The student investigates the principles and elements of design and demonstrates their use in the design process.

	chemical pollutants to the environment by using information technologies.		

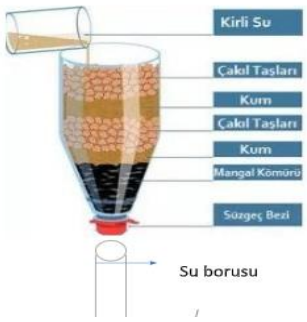
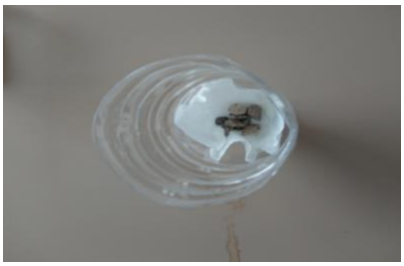
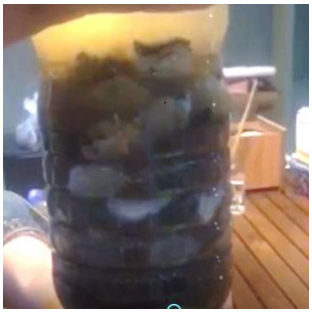
Table 11. *S5 Teacher Candidate's Status Of Developing An İdea About The 10th Grade Subject Of Chemistry Everywhere, The Developed Product And The Testing Of The Developed Product*

Idea Development	*Developed Product*	*Test Status Of The Developed Product*
Students are asked "Is there any student who knows what pomace means? and "What kind of product would you develop using olive pomace and waste plastic bottles?" .	 There are small pieces of olive seeds in the pomace, so it is sifted.  Pet bottle particles  Pet bottle particles and pomace are combined with hot water to form a dough.  The mixture of pet bottle particles and pomace is poured into the mold.	Tested Product designed as a flowerpot. 

Table12. *S6 Teacher Candidate's İdea About 9th-Grade Water And Life And 10th-Grade Mixture Separation Techniques, The Developed Product And The Testing Status Of The Developed Product*

Problem Statement	**Achievements**		
	Achievements Of Chemistry Course	*Mathematics Achievements*	*Engineering Achievements*
"Due to an earthquake that took place last week, all infrastructure was destroyed, and natural water resources were polluted. You work as a volunteer chemist in the 'solution generation' section of one of the accommodation camps created after the earthquake. Design a treatment system to purify the utility water and bring it to the functional level."	Explain the importance of water for living beings. The importance of water resources and protection is explained. Develops solutions for water saving and protection of water resources. The fact that it is the responsibility/duty of every citizen to his/her country and the world to use water sparingly is highlighted. Classifies mixtures according to their properties The characteristics that are decisive in distinguishing homogeneous and heterogeneous mixtures are explained. It is emphasized that homogeneous mixtures are called solutions, and examples of solutions from daily life are given. Separation by a magnet, as well as by utilizing the difference in particle size (sieving, filtration, dialysis), density (separation funnel, flotation), melting point, boiling point (simple distillation, fractional distillation) and solubility (extraction, crystallization, fractional crystallization) techniques are emphasized.	The student uses different mathematical concepts and methods while analyzing the problem.	The student identifies the processes involved in an engineering project. Explains stages such as planning, prototyping, design, execution, quality control and reporting. The student examines research topics in engineering fields. The student investigates the principles and elements of design and demonstrates their use in the design process.

Table 13. S6 Teacher candidate's idea about 9th-grade water and life and 10th-grade mixture separation techniques, the developed product and the testing status of the developed product

Idea Development	**Developed Product**	**Test Status Of The Developed Product**
Students are asked "What is purification?" They are asked to plan their filtration systems by giving plastic bottles, coffee filters, activated carbon, sand and gravel.	  Activated carbon, gravel, coffee filter, sand, bottl  Stones are added to the filter. 	Tested   

	Stone and sand are added to the activated carbon, respectively.  The muddy water is purified.	

CONCLUSION AND DISCUSSION

The main purpose of this study is to examine the physics-chemistry high school teacher candidates' ability to create a knowledge-based life problem based on the STEM lesson plan suitable for the high school curriculum (KBLP) and their ability to propose solutions.

For the first research question of the study, teacher candidates were asked to prepare knowledge-based problems related to real life, including the achievements in the program related to the subject they would choose under the high school curriculum. Since the candidates were informed about STEM education during the formation education process, it was seen that they did not encounter any difficulties at this stage. In addition, it has been determined that the problems they create are related to daily life and that they can produce solutions by using their physics and chemistry knowledge.

Knowledge-based life problems created by teacher candidates are given in tables 2,4,6,8,10, and 12. The striking situation in the research is that the candidates working independently of each other focused on similar subjects. Teacher candidates mostly preferred the subject of Magnetism for the physics lesson and environmental chemistry subjects for the chemistry lesson, and they produced different knowledge-based life problems for these subjects. The problems created by the candidates S1, S3, S4, S5 cover all four disciplines, and they are successful in practice. However, innovation in the product developed by the candidate S3 besides the candidates S1 and S4, innovation and art in the product developed by the candidate S5 can be seen. When the problems created by candidates S2 and S6 are examined, it is understood that although the problems include four disciplines, they cannot use the engineering and technology dimensions in practice. The results obtained from the candidates numbered S2 and S6 in the study coincide with the finding that there are problems in integrating mathematics, engineering, and science fields in the STEM lesson plans determined by Yıldırım (2020).

As the second research problem, the relationship between the knowledge-based life problems created by the teacher candidates and the relevant subjects and achievements in the high school curriculum was examined. The data are given in tables 2, 4, 6, 8, 10 and 12. When the data were examined, it was seen that the teacher candidates associated the problems they created with all the achievements in the unit they chose without considering the limitations. Therefore, it was understood that the candidates had difficulties in determining the related acquisitions related to the problem topic. For example, The achievements such as "Analyzes the relationship between Electric Current, resistance and potential difference." by S1, "As air pollutants, nitrogen oxides, carbon dioxide and sulfur oxides are emphasized." by S2 and "The effects of the magnetic field formed in the areas where high voltage lines pass on living things are mentioned." by S3 were found unrelated to the problems posed by the candidates.

A different situation was encountered in determining the mathematics and engineering achievements. While the achievements of the units are specified in detail in the physics and chemistry textbooks, the engineering and mathematics achievements are not specified for each unit but are stated in more general terms. For this reason, it has been seen that the candidates tend to write the achievements for their problems, regardless of their relationship with their problems. For example, it has been seen that the achievements "The student examines the research topics in the fields of engineering." by S2, S3, S4 and S6 are not an achievement for problems. There is a similar situation for mathematics achievements, and the candidates could not write the achievements related to the problems they chose. For example, the S2 candidate was expected to write an achievement such as "The student uses mathematical relations by considering the density calculations of substances with different densities while analyzing the problem". , S3 such as "The student realizes the mathematical relations related to the push-pull forces of magnets while analyzing the problem" and S6 was expected to be able to associate them with achievements such as "Performs data collection, classification and evaluation of substances according to their particle retention qualities". Only two candidates (S1 and S4) could make the correct association, as seen in Table 2 and Table 8. Özçelik and Akgündüz (2017), in their study, drew attention to the fact that the solution proposals prepared by the teacher candidates for KBLP are based on science and mathematics achievements and require engineering skills.

For the third and fourth research questions of the study, knowledge-based life problems created by teacher candidates were examined in terms of Physics - Chemistry content, Mathematics relationship, compatibility with Engineering-Design processes, product (prototype) development and testing processes. As seen in Table 3, S1 developed a loudspeaker in accordance with the content of the problem s/he posed. Here, s/he focused only on the use of insufficient speakers due to the problem of "crowded environment, loud

noise, the inaccurate position of the speakers and using insufficient speakers" for its connection with the unit s/he chose and thus provided a connection with the problem s/he created. When the materials and tools and products s/he has used are examined, it is seen that they are suitable for the level of the student. The candidate has also successfully carried out the testing process in the classroom environment.

As shown in Table 5, S2 suggested the liquid-liquid extraction method, explained that it could be done using a separating funnel in the classroom environment, and talked about the techniques he researched, but could not use engineering and technology dimensions could not develop a product. S/he also stated that the materials required for the candidate product are high cost. For this reason, it is important for candidates to consider features such as cost, feasibility and material access while designing problems for product development. Candidate S3 wanted to develop a system for collecting metal wastes in workplaces for Magnetism, which would enable the disposal of only metal waste. As can be seen in Table 7, a metal waste collection box has been designed and demonstrated that it could work in a classroom environment. When the materials used by the candidate are examined, it is seen that the cost is expensive, and the materials are not easily available. However, they are tools that should be in accordance with the subject and problem content due to the ability to detect the presence of metal objects with the help of the magnetic field created by the inductive sensor and the ability to detect all metal or non-metal objects with the help of the electrical field created by the capacitive sensor. The candidate has successfully created and presented an innovative solution to the problem s/he has created. S4 candidate has demonstrated the effect of electromagnetic induction on converting mechanical energy into electrical energy by using simple and easily accessible materials. As shown in Table 9, s/he has designed a lamp system by creating an induction current due to the rotation of the bicycle wheels according to the magnetism issue and demonstrated its operability. As seen in Table 11, candidate S5 has designed a product (pot, vase, etc.) by using pomace to recycle plastic materials and showed that the product s/he designed is usable in the classroom environment. Since the candidate has done both the evaluation of waste materials and a detailed literature review on polymer chemistry, s/he has combined his/her knowledge in both fields to realize the product and added the artistic dimension. As seen in Table 13, candidate S6 has designed a treatment system to purify the polluted water and bring it to a usable level and showed that it is successful by doing it in the classroom environment. Water treatment methods are one of the most widely used methods today. Therefore, the candidate could solve this by examining water treatment methods and the role of activated carbon. For the solution, s/he investigated the properties of the absorbents used for environmental pollution control and used the knowledge on this subject. The results obtained from the study are also compatible with the study conducted with teacher candidates by Kennedy and Odell (2014). In their studies, Kennedy and Odell (2014) showed that candidates can successfully develop prototypes, test situations, and STEM

design processes for the problem they have created. Bozkurt-Altan, Yamak, and Discovery Kırıkkaya (2016) revealed that they have difficulties in engineering design process steps such as developing possible solutions, making a prototype, determining the best solution, defining the problem in their study in which they aimed to evaluate the STEM education approach design and implementation process by science teacher candidates, in the application process of the teacher candidates. In this study, it was determined that high school teacher candidates generally did not experience difficulties in the implementation phase. Still, they had difficulties in determining the achievements of the disciplines.

RECOMMENDATIONS

Regarding STEM applications, training can be given to teacher candidates to prepare lesson plans suitable for different grade levels and associate them with disciplinary achievements and provide them with the skills to create up to date KBLP compatible with the curriculum, including STEM disciplines. In addition, the candidates may be allowed to present their practices more in the classroom environment. Similar studies can also be done with science teacher candidates within the scope of special teaching methods courses.

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