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Investigation of the GeoGebra-supported teaching material development process of pre-service physics teachers

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Abstract

In contrast to educational methods, which is using ready-made technology, in this study, activities were designed aiming at improving pre-service physics teachers' computer-aided material development skills. The study was realized in the "Teaching Technologies and Material Design" course at the Physics Education program of a state university in Ankara. During this process, pre-service teachers have been guided not only to use technology-based pre-made course materials but also to prepare their own course materials. For material designs, GeoGebra was preferred because it is free and multilingual dynamic software. During the evaluation phase, the product was handled together with the process taking into consideration material design criteria. As a result, it was determined that pre-service physics teachers gained the ability to develop their own course materials using GeoGebra. It was seen that pre-service physics teachers could be used GeoGebra in the physics classes as a supporting software, too.

Keywords: *Material development, physics teacher candidates, GeoGebra, instructional technologies.*

Fizik öğretmen adaylarının GeoGebra destekli öğretim materyali geliştirme sürecinin araştırılması

Öz

Bu çalışmada hazır teknolojinin kullanıldığı eğitim yöntemlerinden farklı olarak fizik öğretmen adaylarının bilgisayar destekli materyal geliştirme becerilerini geliştirmeye

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yönelik etkinlikler tasarlanmıştır. Çalışma Ankara'da bir devlet üniversitesinin Fizik Eğitimi programında yer alan "Öğretim Teknolojileri ve Materyal Tasarımı" dersinde gerçekleştirilmiştir. Bu süreçte öğretmen adaylarına sadece teknoloji temelli hazır ders materyallerini kullanmaları değil, kendi ders materyallerini hazırlamaları konusunda da rehberlik edilmiştir. Materyal tasarımları için GeoGebra ücretsiz ve çok dilli dinamik bir yazılım olması nedeniyle tercih edilmiştir. Değerlendirme aşamasında ürün, malzeme ve tasarım kriterleri süreçle birlikte ele alınmıştır. Sonuç olarak, fizik öğretmen adaylarının GeoGebra kullanarak kendi ders materyallerini geliştirme becerisi kazandıkları belirlenmiştir. Fizik öğretmen adaylarının GeoGebra'yı fizik derslerinde de destekleyici bir yazılım olarak kullanabilecekleri görülmüştür.

Anahtar kelimeler: *Materyal geliştirme, fizik öğretmen adayları, GeoGebra, öğretim teknolojileri*

1. Introduction

Determining the appropriate learning/teaching strategies and enriching the learning environment by bringing together various lecturing techniques are closely related with the knowledge and skills of the teacher. Teachers obtain the necessary knowledge during their professional training and they experience it by applying this knowledge in their professional lives. In this respect, the applications of material design with teaching technologies which is part of the teacher training programs, is highly significant in transforming knowledge into skill [1-3]. Moreover, with the changing student profile with the advancement of technology necessitates teachers to renew themselves. Employing technology in class both makes it more appealing for the student and contributes to effective learning. Thus, computer-aided teacher (CAT) has been used effectively in various fields such as mathematics, physics, engineering, and medicine [4-8]. There are studies which focus on the effect of using computers in learning environments for student success [9,10]. CAT provides an advantage not only for the students but also for the teachers. Teachers can keep students' attention longer so that they can create more effective learning environments [11]. Students may create learning environments with CAT outside of school anytime and anywhere. Lai and Smith [12] reported that the undergraduate students engaged in informal learning using digital and mobile technologies to support their formal learning. CAT is highly effective in enabling people to comprehend abstract concepts in such courses as mathematics and physics where there are many abstract topics [13-15]. In this respect, computer software is important, it can be used both in preparing course material and during the actual teaching of the course [16-18].

One of such software is GeoGebra which is compatible with different operating systems and mobile devices such as tablets. GeoGebra is free software where both algebraic operations and dynamic applications can be made. Merely a computer and internet connection suffice to access this software (https://geogebra.org)[19]. It is fairly easy to set up the program, and there is no need to be online once the setup is complete. GeoGebra can work algebraically, and one can also follow differences by making changes on variables. Hence, GeoGebra consists of both algebraic and dynamic characteristic. It is possible to have a grasp of the characteristics quite fast thanks to its easy-to-understand menu. Using GeoGebra is easier than other software such as Mathematica, Mapple, and Cabri Geometry because GeoGebra does not require a certain level of knowledge from its user. Anyone from primary school to higher education can use [20]. A dynamic software, GeoGebra can be found especially in mathematics education [21-25]. In their study, Takaci, Stankov and Milanovic [26] concluded that using GeoGebra in mathematics education creates an effective learning environment and that students' learning success is positively influenced. GeoGebra software increases students' interest in mathematics [27]. In addition to studies on the use of mathematics and mathematics education with GeoGebra, there are studies in the field of physics education, albeit fewer in number. In their review of the literature in 2021, Solvang and Handlung stated that research on the use of GeoGebra software in physics teaching and learning is quite limited. They aimed to support the physics teachers who want in this regard [28]. In 2019, Kolar conducted a study on how GeoGebra's simulation preparation tools could be used in physics lessons, with the thought that it could be useful in teaching physics [29]. Computer simulations prepared using GeoGebra in physics education are also found in other studies [30,31]. In their study realized with 12 pre-service teachers in 2014, Malgieri, Onorato and Ambrosis used interactive simulations prepared with GeoGebra based on quantum optics in "Introduction to Quantum Physics" class [32]. At the end of the study, significant improvement was achieved in terms of pre-service teachers' comprehension of conceptual topic and problem solving. Singh, Sampath and Sivaswamy (2009) handled GeoGebra as a multi-platform, dynamic, free-access software in order to prepare a virtual physics laboratory in 2009 [33]. Rodriguez, Santana and Mendoza (2013) used GeoGebra applications in the teaching of geometric optics in 2013 that would develop students' both practical and basic theoretical knowledge. Hence, they realized activities in which computers are not merely computer devices but are utilized as teaching tools [34]. This and similar studies show that GeoGebra applications can be used effectively in teaching the topics in physics education.

Active class participation is an important factor in effective learning [35,36]. When students perceive abstract concepts by making them concrete by using the materials in education environment, they can have active class participation and this contributes to their permanent learning [37]. In this respect, having the skills for designing course material and the skills for using them is an important quality that pre-service teachers have.

Taking into consideration that being aware of information technologies and using them in class is a must of the time, this study planned activities on designing materials in computer environment. Since mathematics is the language of physics, what needs to be concretized is not only the concepts of physics in its teaching and learning. Mathematical expressions should also be concretized so that a more meaningful learning can be achieved since these expressions have a role in the comprehension of subjects. Thus, in this study, GeoGebra was preferred as it is free, has an easy-to-understand menu, and is a dynamic mathematical software [38]. In this respect, activities with a richer content were realized through both algebraic operations and various animations.

When literature on physics education is examined, it can be seen that studies done with GeoGebra focus more on the effectiveness of the course materials prepared by experts [39]. In this study, however, the focus is on pre-service teachers' designing new computer-aided course materials, because one of the aims of this study is to develop pre-service teachers' skills of designing course material that aims to visualize topics of physics, which contains abstract concepts. In this respect, within the context of the course entitled "Teaching Technologies and Material Design," students were asked to design their own material after they were informed about GeoGebra and how it can be used, and then the process was observed by the educators, who also acted as moderators. Evaluation was not only done focusing on the end product, but by following the developmental steps during the process. In addition, evaluation was done not only by the instructor; rather, feedback from the whole group was taken into consideration. Thus, pre-service teachers focused not only on their own product but they contributed by focusing on other products as well.

The aim was to bring pre-service physics teachers at a level, at the end of the study, where they could easily design their own material with only one computer and a free software installed to this computer, independent of the facilities provided by the schools they are posted at. Thus, it was aimed to contribute to an effective and permanent learning in physics classes (independent of where and under which circumstances one is posted). Another aim of the study is to make sure all physics teachers and pre-service physics teachers can access the materials prepared within the context of this study.

In this study, the content was determined in such a way that it would cover general physics topics like mechanics, electricity, and optics in order to design supportive materials that physics teachers and pre-service physics teachers can use in class. In this respect, GeoGebra, a dynamic program used especially in mathematics education, was applied in physics education. Basic research questions of this study are as follows:

- How much extend pre-service physics teachers can develop their own course materials using GeoGebra?
- What are the views and suggestions of pre-service physics teachers regarding the material development process during when they used GeoGebra?

2. Method

2.1. Research design

This study was carried out according to qualitative research methods. During the study, the material development process of the physics teacher candidates was followed in detail by the researchers. For the analysis of the developed materials, the evaluation form created by the researchers was used. At the end of the study, the opinions of pre-service physics teachers about the material development process with GeoGebra were obtained by semi-structured interview technique.

2.2. *Study group*

10 pre-service physics teachers who are enrolled at the Department of Physics Education of a state university taking the “Teaching Technologies and Material Design” course participated in the study. It is a compulsory course and 6 of the students enrolled in the course are women and 4 are men. Purposive sample selection was made by paying attention to the fact that the teacher candidates included in the study had not developed computer-aided materials before.

2.3. *Data gathering tools*

Data gathering tool in the study was developed taking into consideration the qualities that a material should have [36]. According to this, an evaluation form that consists of three categories, namely, Visual Design Evaluation, Multiple Environment Evaluation, and Evaluation of General Characteristics, was used (Appendix 1). In the creation of evaluation forms, it was aimed to increase the external reliability of the study and to increase the objectivity of the expert evaluations. In order to increase the internal validity, each category was divided into sub-categories according to its characteristics by taking expert opinions.

In this respect, subcategories of Visual Design Evaluation are use of figures, color, font, and font size in the material; subcategories of Multiple Environment Evaluation are screen design of the material, ease of use, and technical quality; subcategories of Evaluation of General Characteristics are appropriateness of the material for outcomes, material being life-based, scientific correctness, being away from prejudices and misconceptions, having a clear language, contribution to teaching the related subject, and keeping motivation alive. The designed material was evaluated by grading it from 1-5, from weak to good according to these characteristics. At the end of the evaluation participants were asked what they think the weak and strong points of the material are, and they were asked what they suggest for the further development of material. After the completion of peer review, expert views on materials were taken on the same forms, and they were reported.

2.3.1. *Semi-constructed interview form*

At the end of the semester, a semi-constructed interview that consists of six questions was realized with pre-service teachers who evaluate their GeoGebra-aided material development design (Appendix 2). Opinions were received with this form, which was also submitted to expert approval during the development phase. These interviews took approximately 15-20 minutes, and all interviews were transcribed.

2.4. *Data analysis*

Points obtained from evaluation forms were added up, and an evaluation result for each material was achieved by taking their average. For each subcategory was given between 1-5 points in the evaluation, and totals were turned into points over 100. Data obtained from the expressions of pre-service physics teachers about the weak and strong points of each material were evaluated with content analysis. Content analysis is one of the approaches used in data analysis in qualitative research. This approach is appropriate especially used for the analysis of documents that contain answers to open-ended questions [40,41]. While developing the evaluation form, it was aimed to increase objectivity and consistency between raters with the determined sub-criteria.

In the second half of the study, data obtained from semi-constructed interviews were interpreted in detail by using content analysis, and they were turned into a report.

2.5. *Application*

It was determined through the interviews conducted at the beginning of the process that in general pre-service physics teachers do not have an idea about such software and have never used one. In this respect, pre-service physics teachers were given information about GeoGebra. It was emphasized that GeoGebra is not only algebraic software but is open-access and have a widespread using. Thus, it was aimed that students learned the content of software, that they comprehended to what subjects it could be applied, and understood why GeoGebra was selected for this study. Then, they were informed about how to download and install the program. After the completion of installation, how to use the GeoGebra menu was shown by simple demonstrations. After these activities, which took two class hours, sample GeoGebra applications were examined all together as a group.

Then, pre-service physics teachers were asked to design their own materials on a topic that includes one or two outcomes from the secondary school physics education program. Six of the pre-service physics teachers opted to work individually, four of them wanted to work in pairs. Thus, a total of eight material subjects were determined. Pre-service physics teachers were free to choose any topic they want so that they could have a more intense and alive motivation during the study material design process. Educators served as moderators during the design process and directed students. Where each student is at the material design process, what each student plans to do at the next phase were discussed and necessary suggestions were made in order to increase the contribution of the end product to the teaching of that particular topic. Moreover, a close Facebook group was formed so that pre-service physics teachers could contact one another as well as the instructors after class hours and get support. Two weeks before the material submission deadline, all pre-service physics teachers made a pre-presentation and presented their material in class. Pre-service physics teachers got information about other materials and they continued with the process taking into consideration the critique and suggestions.

After the materials took their final shape, each material was evaluated by the students and educators by using evaluation forms (Appendix 1). It was repeatedly emphasized that evaluation forms have nothing to do with their passing grade. It was expressed that their performance in this study will return to them only as bonus points. Thus, without being anxious about their grades, their objectivity was ensured. Evaluation of the process was done by conducting semi-constructed interviews with pre-service physics teachers. Interviews were done in approximately 15-20 minutes as planned. Each material developed by pre-service physics teachers was revised by a group of experts that consists of three educators from material physics and physics so that these materials are free of scientific mistakes and misconceptions.

To enrich the content of the page each year and keep the results of the study active, it was aimed to add related materials obtained through same methods in material development classes in the following years.

3. Findings

3.1. Findings obtained from material evaluation form

Total number of materials designed by pre-service physics teachers is eight. Findings obtained from the evaluation of each material were coded as M1, M2 etc. The changes of physical relations used in materials according to parameters were visualized by using GeoGebra animation technique. The following results given in the table were obtained from the analysis of the evaluation forms.

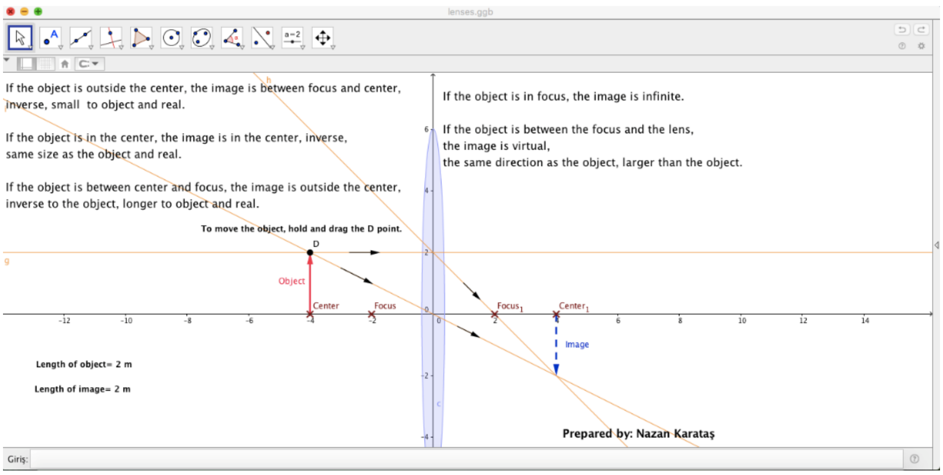
Table 1. Material evaluation form results (over 100 full points)

Material	Visual Design Evaluation	Multiple Environment Items Evaluation	Evaluation of General Characteristics
M1 (Free fall)	76.7	96.7	89.5
M2 (Colors of light and paint)	81.7	86.7	80.0
M3 (Reflection on plane mirror)	89.4	83.3	89.3
M4 (Convex lens)	90.6	90.0	83.2
M5 (Coulomb law and Gauss surface)	93.1	94.2	86.4
M6 (Relative velocity)	85.7	76.2	75.5
M7 (Gravitational force)	78.6	85.9	72.2
M8 (Rectilinear motion)	82.5	84.4	83.3
Average	84.8	87.2	82.4

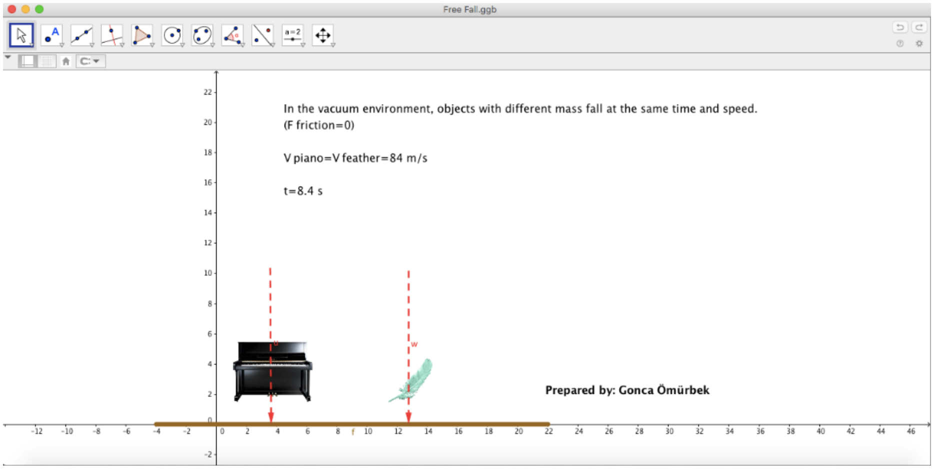
According to evaluation results, materials designed by pre-service physics teachers received the highest point (87.2) from the Multiple Environment Elements Evaluation section, and the lowest point (82.4) from the Evaluation of General Characteristics. However, there is no significant difference between the points of categories, and the average is approximately 80 points.

Findings of pre-service physics teachers' and educators' critique and suggestions for each material documented in evaluation forms are given in Table 2. In the evaluations made by pre-service physics teachers, only for M8 (Rectilinear Movement) did not include critique or suggestion concerning the weak points of the material. Strong points of this material were evaluated to be its use of figures and its visuals. Other materials were evaluated in term of strong and weak points depending on the subject of the material, and suggestions were made for the strengthening of weak points.

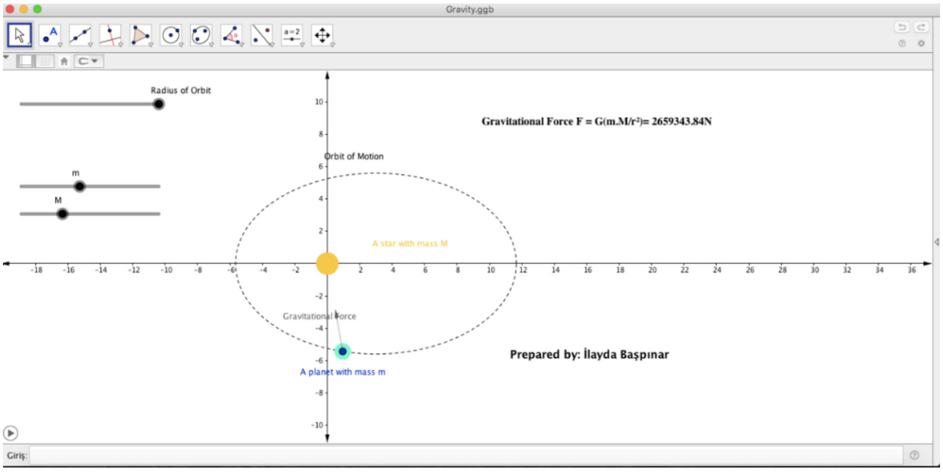
Examples for some of the materials prepared by pre-service physics teachers are given in Figure 1.



(a)



(b)



(c)

Figure 1. Example materials prepared by pre-service physics teachers. a) Lenses b) Free fall c) Gravitational force.

In Figure 1-a), lenses were handled, and the outcomes concerning the visual characteristics of the object on the lens were the focus point. Theoretical information about the visual characteristics was given in a short text form in the material so that the person who is going to use the material will have a reminder of the conceptual information about the topic. By employing animation technique, how such characteristics as the place of the object – the place of its image, its size – and the size of its image change were visualized.

In Figure 1-b), the topic was mechanics, and the movement in vacuum of free falling objects was examined. The free-falling movement of two objects dropped from the same height at the same time without initial velocity was examined. In the material, the aim was to correct the misconception that the object with more mass would fall in a shorter amount of time. In this respect, two objects with huge mass differences such as the piano and the feather (two frequently seen classical examples) were selected deliberately. The objects were allowed to fall freely by employing animation technique.

In Figure 1-c), the movement of two planets based on parameters of the gravitational pull law. Radius of the orbit and the numerical value of the gravitational pull which changes with the movement of the two planets with different masses on this orbit were given at the same time in the material so that both the orbital movement of planets and the change of the numerical value of the gravitational pull between them could be observed due to the parameters changing with live slides.

Table 2. Critique and suggestions for materials

Material	Strong Points	Weak points	Suggested operation
M1 (Free fall)	Visuality	Place of reference point	Moving the reference point to zero
M2 (Colors of light and paint)	Visuality, the fact that the difference between the colors of the paint and light is clear	The fact that you cannot write names of paints, the fact that it cannot be a more authentic study	Writing down the names of paints, making the material more authentic
M3 (Reflection on plane mirror)	Visuality, scientific correctness, the fact that it can be clearly seen that the arrival and reflection angles are equal	The fact that the normal line is not clear, the fact that there are no explanatory texts	Effective use of explanatory texts and re-forming the normal line
M4 (Convex mirror)	The fact that characteristics of object and image are given according to focus and center points	The fact that the size of the object and image are not given. Numerical values are not given on screen	Giving the sizes of the object and the image, showing numerical values as well
M5 (Coulomb law and Gauss surface)	The fact that it is target-oriented and three-dimensional increase comprehensibility; it is catchy and interesting	There are scientific errors. Font size is small	Frame can be added to explanations. Font size should be revised; formulae should be re-examined
M6 (Relative velocity)	Scientifically and visually very good. The topic is clear	It is not clear that the objects are, more text box can be added.	Explanatory texts can be added
M7 (Gravitational pull force)	Visually good, we can see the distance-based change	It creates the perception that the masses of the Sun and the Earth change. This can cause confusion. Units are not clear	Instead of the Sun and the Earth, two planets should be used as an expression. Units should be added to slides; values should be kept at certain intervals
M8 (Rectilinear movement)	Figures and visual quality	_	_

3.2. Findings obtained from semi-constructed interview

In the final phase of the study, pre-service physics teachers’ views on the course material design by using GeoGebra were asked. According to this,

“Do you think the GeoGebra menu and the content of this menu is clear and sufficient?”

Eight pre-service physics teachers answered this question indicating that they have found the menu and its content are clear and sufficient. One student criticized the menu saying that “As far as physics is concerned, some formula has the minus (-) at the beginning of the formula indicating the direction. When you reflect it to the program, there may be a problem between the formula and the image.”

“Have you had any difficulty during the material development process with GeoGebra? If you do, please explain.”

It was determined from the explanations of pre-service physics teachers that during the GeoGebra process, they had difficulties in representing it in three dimensions (one pre-service physics teacher), transferring a physics problem to GeoGebra (two pre-service physics teachers), in understanding the program in the beginning (two pre-service physics teachers), and in using the slide (four pre-service physics teachers). However, those pre-service physics teachers who indicated that they had difficulty in understanding the program also said that they got over the problem in time.

“What are the things you liked about using GeoGebra in material development? Explain.”

From their explanations, it was determined that pre-service physics teachers liked the visuality of the program (five pre-service physics teachers), the fact that it can be used in physics education (four pre-service physics teachers), the fact that formula can be entered into the program and that it uses Latin alphabet (one pre-service physics teacher). The most important finding obtained from this question is that it has a visuality and that it can be used in physics education.

“Do you think the materials developed by you and your friends would contribute to physics education positively? Explain briefly.”

From the answers given to this question, it was determined that all of the pre-service physics teachers believed that materials developed by using GeoGebra would contribute positively to physics education. Some of the answers given to this question are given below (Pre-Service Physics Teacher 1: PST 1)

PST1: “It is easier for students to learn and understand topics that are hard to understand or problems that students find difficult to solve by focusing on students’ visual intelligence instead of a rote learning.”

PST2: “Yes, I do. Explaining physics visually in a beautiful way makes it possible for the student to visualize it concretely.”

PST3: “Thanks to GeoGebra we can explain many of the topics of physics through animation. For example, preservation of energy, movement, optics etc.”

PST4: “I definitely do believe so. These materials were designed so that they would get rid of students’ confusions.”

“Do you think you can design new materials by using this program in your professional life in the future? Explain briefly.”

It was determined that almost all pre-service physics teachers (with the exception of one) believed that they could design new materials using GeoGebra. Below are given some of the views of pre-service physics teachers:
PST1: “Actually, no. I think teaching is a tiring enough profession, and I would not have time to deal with that. However, I can spare some time not on all subjects but on some, I mean, simple subjects.”
PST2: “Yes. I believe I can design a material after lecturing on the topic so that problem solving is permanent.”

PST3: “Yes. Using the program is rather fun and I can design new materials thinking that I can be helpful to my students.”

PST4: “Yes, I do. I would design materials in the future as well since it would draw my students’ attention more.”

“Please write down if you have any suggestions about this material development process!”

According to the interviews, pre-service physics teachers’ expressions on the material development process are learning GeoGebra better and sparing it more time (two pre-service physics teachers), having preparation for the material to be designed according to the theory (four pre-service physics teachers), keeping developing the designed material (three pre-service physics teachers), adding tools for physics to the GeoGebra menu (one pre-service physics teachers). Some of the suggestions by pre-service physics teachers are given below:

PST1: “It is necessary to have mastery over the subject while designing the material so that no theoretical mistakes are made. We have to do thorough research and then design the material. We have to have a draft before designing the material on GeoGebra.”

PST2: “We should work on the theoretical aspects of the subject of which we are going to design a material. GeoGebra codes should be learned and we should be proficient in the program by working with it through trial and error.”

PST3: “It is really fun to design materials. It doesn’t take much time depending on how well you know the program. However, the minus symbol can be a problem at some stages, and sometimes it does not accept executions. If these problems are solved, it can provide an easier and more successful material design process.”

PST4: “It would be better if the program were explained longer.”

4. Conclusions

In this study, there were course-material design activities from which pre-service physics teachers and physics teachers could benefit for a more effective learning-teaching environment. At the end of our study, materials were designed that could be used in physics education. At the same time, the skills of pre-service physics teachers to use the GeoGebra software were developed. According to the findings obtained in relation to material design process, it was determined that pre-service physics teachers can develop their course materials by using GeoGebra, which is a technological tool. In their study, Solvang and Haglung (2018) concluded that high school students learn better by using GeoGebra software in physics course [42]. In this sense, it will be beneficial for the future for pre-service physics teachers to start developing their own materials using software such as GeoGebra. Moreover, another result that came out after the interviews is that pre-service physics teachers think of GeoGebra as a material that supports learning during physics classes. This shows a similarity to previously conducted studies. GeoGebra is an effective tool in teaching and learning physics as it visualizes difficult-to-grasp topics [43-45]. In this respect, it can be said that the study reached its aims.

According to the findings of the peer reviews on the materials designed during the material design process, “Coulomb Law” got the highest point (93 points) in the Visual Design Evaluation. “Free Fall” received the highest points in the Multiple Environment Evaluation (96 points) and in the Evaluation of General Characteristics (89 points). Consequently, it was revealed that there is no material with the full points in all three categories. Looking at the averages of materials, it can be seen that all materials received over 80 points in subcategories. This result can be interpreted to be a highly good one since it is the first-time pre-service physics teachers have prepared a computer-aided material. In his thesis in 2008, Preiner concluded that the expression that GeoGebra can be used in visualizing mathematical concepts and preparing teaching materials can be applied to visualizing concepts of physics as well [46]. In this respect, it was suggested that pre-service physics teachers continue developing various materials in physics education by using this software.

According to the findings obtained from the semi-constructed interviews done with pre-service physics teachers concerning the evaluation of the material development phase, it was revealed that almost all of the participants liked the menu and the content of GeoGebra and that they found it clear and sufficient. It can be said that the most liked characteristic of GeoGebra during the material development phase is the fact that it is visual and that it can be adapted to physics education. In addition to that, it was also found out that pre-service physics teachers had difficulty especially with learning how to use the slider.

In brief, it can be said that pre-service physics teachers had the chance to improve themselves in information technologies by designing course materials within the context of this study, and that they could visualize the subjects of both mathematics and physics by using this program. It can be suggested that pre-service physics teachers make use of GeoGebra in order to be able to design computer-aided course materials in material design courses. Thus, this will contribute to raising teachers who can easily utilize technology.

When the suggestions of participants concerning the material development phase are taken into consideration, it can be concluded that it would be better to have tool related to physics on the GeoGebra menu. It is suggested that pre-service physics teachers should be given the chance to design materials by using GeoGebra on different fields of physics during their undergraduate studies so that they have the skills to use this technology more effectively in their own classes.

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Appendix

Appendix 1. Material Evaluation Form

MATERIAL
EVALUATION FORM
Name of Material:
Title of Subject: Date:
Prepared by:

Note: Please evaluate the form below giving it between 1-5 (1 being weak, 5 being the best)

A-Visual Design Evaluation	**1**	**2**	**3**	**4**	**5**
Use of figure					
Use of color					
Font					
Font size					
B-Multiple Environment Items Evaluation					
Screen design					
Ease of use					
Technical quality					
C-Evaluation of General Characteristics					
Appropriateness for aims					
Life-based quality					
Scientific correctness					
Being far away from prejudice/ misconceptions					
Having a clear language					
Contribution to teaching the related topic					
Keeping motivation alive					

Strong points		
Weak points		
Suggested operation		
Evaluated by		Date:

Appendix 2. Semi-Constructed Interview Form

1) Do you think the GeoGebra menu and the content of this menu is clear and sufficient?
2) Have you had any difficulty during the material development process with GeoGebra? If you do, please explain.
3) What are the things you liked about using GeoGebra in material development? Explain.
4) Do you think the materials developed by you and your friends would contribute to physics education positively? Explain briefly.
5) Do you think you can design new materials by using this program in your professional life in the future? Explain briefly.
6) Please write down if you have any suggestions about this material development process!

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