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GEOGEBRA-SUPPORTED IMPLEMENTATION OF THE ASSURE MODEL: OBJECT VIEWS FROM DIFFERENT DIRECTIONS

IMPLEMENTAÇÃO DO MODELO ASSURE COM SUPORTE DO GEOGEBRA: VISÕES DE OBJETOS A PARTIR DE DIFERENTES DIREÇÕES

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Abstract
The aim of this study is to develop and evaluate GeoGebra-supported instructional materials in accordance with the ASSURE instructional design model for the sub-learning area 'Views of Bodies from Different Directions' in the 'Geometry and Measurement' learning area of the 7th-grade mathematics course. It was conducted with a design-based research method. The study group consisted of 19 seventh-grade students from western Turkey, in the 2023-2024

Resumo
O objetivo deste estudo é desenvolver e avaliar materiais didáticos com suporte do GeoGebra, de acordo com o modelo de design instrucional ASSURE, para a subárea de aprendizagem "Vistas de Corpos a partir de Diferentes Direções", na área de aprendizagem "Geometria e Medidas" do curso de matemática do 7º ano. A pesquisa foi conduzida utilizando uma metodologia baseada em design. O grupo de estudo foi composto por 19 alunos do 7º ano da

academic year. Instructional materials developed in line with all steps of the ASSURE instructional design model were used in the teaching process. Data were collected through a drawing test developed to assess students' spatial skills and a semi-structured interview. Percentage and frequency analysis techniques were used in the analysis of quantitative data; descriptive and content analysis techniques were used in the analysis of qualitative data. As a result of the study, it was determined that the students were able to draw three-dimensional objects accurately from different directions and found the teaching process understandable, interactive, and fun. In line with the positive results obtained from the research, suggestions were made for the field, and academia.

Keywords: ASSURE Instructional Design Model. Spatial Skills. GeoGebra. Student Opinion.

região oeste da Turquia, no ano letivo de 2023-2024. Os materiais didáticos desenvolvidos em conformidade com todas as etapas do modelo de design instrucional ASSURE foram utilizados no processo de ensino. Os dados foram coletados por meio de um teste de desenho desenvolvido para avaliar as habilidades espaciais dos alunos e de uma entrevista semiestruturada. Técnicas de análise percentual e de frequência foram utilizadas na análise dos dados quantitativos; técnicas de análise descritiva e de conteúdo foram utilizadas na análise dos dados qualitativos. Como resultado do estudo, constatou-se que os alunos foram capazes de desenhar objetos tridimensionais com precisão a partir de diferentes direções e consideraram o processo de ensino compreensível, interativo e divertido. Em consonância com os resultados positivos obtidos na pesquisa, foram feitas sugestões para a área e para o meio acadêmico.

Palavras-chave: *Modelo de Design Instrucional ASSURE. Habilidades Espaciais. GeoGebra. Opinião dos Alunos.*

1 INTRODUCTION

In today's rapidly changing educational environment, the inclusion of instructional design models in educational processes is important in increasing the effectiveness of teaching and learning. An effective instructional design encourages active participation in the learning process by structuring instructional materials and methods in line with students' cognitive levels, learning styles, and individual differences, and supports conceptual understanding, meaningful learning, and retention. Research shows that structured instructional design models contribute significantly to student achievement in lesson planning and implementation processes. However, despite the growing interest in instructional design in education, there is limited understanding of how to effectively use specific models with innovative technologies. Indeed, there is a significant gap in the literature on how the ASSURE instructional design model can be integrated with dynamic mathematics software and how this integration can improve students' spatial visualisation skills. This study aims to fill this gap by examining how a lesson design based on the ASSURE model and supported by GeoGebra can improve students' ability to interpret and represent three-dimensional objects from different perspectives.

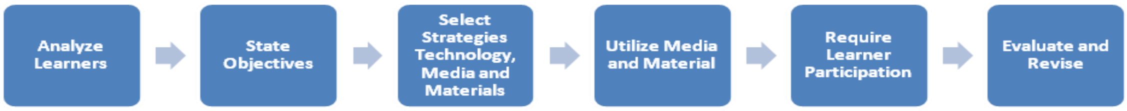
1.1 ASSURE instructional design model

The concept of instructional design, which states that learning systems need to be redesigned in order for society to achieve consistent success in education and training processes, has an important place in the literature (Akkoyunlu et al., 2008; Dijkstra, 2004; Reigeluth, 2005). It is emphasised that teachers should develop instructional design processes to make their teaching processes effective and efficient (Akkoyunlu et al., 2008). The main purpose of instructional design models is to guide designers by solving the problems encountered in the teaching process (Çakır et al., 2013; Molenda et al., 1996).

In the literature, there are instructional design models such as ASSURE, ADDIE, ARCS, Morrison, Ross, and Kemp, Smith and Ragan, and Dick, Carey, and Carey. Among these models, ASSURE provides a systematic approach that enables instructional designers to plan the use of materials and technology effectively and efficiently. ASSURE, developed by Heinich et al. (2002), is an instructional design model that involves the selection of methods, media, and materials in accordance with the characteristics of learners and instructional objectives. This model is classroom-oriented and includes the teacher's systematic planning of the instruction in advance, integration of technology and use of materials, thus aiming to realise the lessons at the desired level (Akkoyunlu et al., 2008; Özdemir & Uyangör, 2011). The ASSURE model has a linear flow chart and it is stated that the steps of this chart should be followed in order (Keleş et al., 2016). The steps of the ASSURE instructional design model facilitate its adaptability and applicability to different fields (Baran, 2010; Çetinkaya, 2017; Duman, 2015). These six steps are as follows (see Figure 1):

Figure 1

ASSURE Model Flow Diagram



Source: Authors

1.Analyze learners,

2.State standards, and objectives;

3.Select strategies, technology, media, and materials;

4.Utilize technology, media, and material;

5.Require learner participation; and

6.Evaluate and revise (Smaldino et al., 2015).

The ASSURE model is an instructional design framework that makes learning processes systematic and efficient. The first stage of the model is learner analysis, which evaluates factors such as socio-economic status, age, gender, prior learning, and learning styles of students (Akkoyunlu et al., 2008). The second stage includes the determination of goals and objectives and involves defining the proficiency levels that students should reach (Reigeluth, 1992). In the third stage, teaching methods, media and materials are selected and new materials are designed when necessary (Molenda et al., 1996). The fourth stage involves the use of the selected materials and the preparation of the learning environment (Smaldino et al., 2015). In the fifth stage, interactive materials are used to encourage and ensure active student participation in the learning process (Keleş et al., 2016). In the final stage, evaluation and revision, the media, materials, and methods used throughout the process are analysed and revised when necessary (Akkoyunlu et al., 2008; Reigeluth, 1992). The ASSURE instructional design model supports technology integration, and increases learning effectiveness by providing a systematic approach to the teaching process.

In the literature, there are various studies examining the effects of the ASSURE instructional design model at different levels of education. The model was found to increase academic achievement and positively affect student motivation in algorithm teaching (Durak, 2009) and science courses (Çetinkaya, 2017; Çetinkaya & Taş, 2016). In addition, it was found to support critical and creative thinking skills (Utama et al., 2022) and to enhance the effect of integration with Autograph software (Kristianti et al., 2017). While the model improves the quality of teaching (Uysal & Gürcan, 2004), it has been observed to enhance teachers' skills in lesson planning, using teaching tools (Adedapo & Opoola, 2021); and using technology-supported lesson plans to improve the process (Russel, 1994). It was determined that it supported teachers' competences in this field by increasing the use of instructional technologies (Tüy, 2003) and had positive effects on student attitude and self-efficacy but did not make a significant difference in academic achievement (Eren et al., 2010). Additionally, improved media literacy but was limited in perception change (Barut et al., 2016). It was found that the initiative contributed to the development of a new instructional design model called the ‘TREASURE Model’ as a solution to infrastructure deficiencies in Nigeria (Olayinka et al., 2018).

1.2 Use of ASSURE model in mathematics education

While the importance of innovative teaching approaches in mathematics education is increasing, the ASSURE design model offers an effective teaching framework in this field. Research has shown that the model plays an important role in increasing academic achievement, improving students' attitudes towards the course and supporting their cognitive skills. Sundayana et al. (2017) and Kristianti et al. (2017) stated that the ASSURE instructional design model is more effective in the development of mathematical communication and critical thinking skills compared to traditional methods. Karakış (2014), Liu and Chen (2011), and Keskin (2015) showed that the ASSURE model supported by GeoGebra and Cabri 3D software increased academic achievement and positively affected student attitudes in primary and high school mathematics courses. Adi et al. (2021) found that the model was effective in developing financial literacy skills.

1.3 Spatial skills

Spatial skill is a basic ability that enables individuals to comprehend the properties of two- and three-dimensional structures, to understand the relationships between these structures, and to mentally construct their views from different directions. This skill, which has an important place in mathematics education, plays a critical role in increasing student achievement (Kösa, 2011; NCTM, 2000; Van De Walle et al., 2014; Yıldırım-Gül, 2014). For geometry teaching to be effective, students need to have certain spatial skills. Therefore, many mathematics educators consider spatial reasoning to be an integral part of geometry curricula (Clements & Battista, 1992).

There is a need for teaching materials that enable students to develop their spatial skills. The importance given to instructional materials in the ASSURE instructional design model, which has attracted attention in recent years, shows, that the ASSURE instructional design model has the potential to improve the quality of teaching by providing technology integration in mathematics education (Keleş et al., 2016).

1.4 Technology supported mathematics teaching and GeoGebra

Rapid developments in technology necessitate the effective use of educational software for teaching mathematics. For this reason, countries today emphasise the use of information and communication technologies in their education programmes. Today, GeoGebra is one of the software programs used within the framework of computer-assisted mathematics teaching. GeoGebra is a dynamic mathematics software that includes computer algebra systems, enabling three-dimensional thinking and dynamic geometry software simultaneously. Birgin et al. (2020) stated that GeoGebra is the most widely known mathematics software by mathematics teachers.

GeoGebra enables students to develop their spatial visualisation skills, making it possible to examine three-dimensional (3D) objects from different angles (Hollebrands & Lee, 2012). Such software supports students' spatial skills such as mental rotation, orientation and working with multiple representations (Jones, 2006). By combining static and dynamic representations, GeoGebra enables students to better understand the relationships between 2D and 3D objects, to see objects from different angles and to make transformations (Christou et al., 2007). In addition, it is stated that such special software helps students to examine polyhedral objects from different perspectives and thus strengthen their spatial comprehension by mentally completing the invisible parts (Gutierrez, 1996). In this respect, the implementation of GeoGebra-supported activities within the framework of a conscious teaching plan contributes to the development of students' spatial thinking and visualisation skills and enables them to understand geometry concepts more deeply (Boytchey et al., 2007). In this context, evaluating the potential of GeoGebra to develop spatial skills and increasing the number of studies on its integration into educational processes will contribute to the provision of more effective and permanent learning experiences in geometry teaching.

When the studies on spatial skills at different levels of education are examined in the related literature, Geometer's Sketchpad (Boyraz, 2008), Google Sketchup (Uygan, 2011; Özçakır- Sümen, 2022), augmented reality, (Dünser et al., 2006; Topraklıkoğlu, 2018), and Cabri 3D (Baki et al., 2009; Güven & Kösa, 2008; Subroto, 2011; Uzun, 2013) are found to contribute to students' spatial skills. It is noteworthy that Cabri 3D was mostly used in these studies. On the other hand, it is thought that GeoGebra-supported teaching will contribute to students' spatial skills by enabling three-dimensional thinking, enabling students to learn by doing and experiencing, and making the subject more understandable by visualising it (Karakuş, 2008). In addition, when the related literature is examined, it is determined that mathematics teaching with the support of GeoGebra has a positive contribution to student achievement (Arbain & Shukor, 2015; Taş, 2016), provides retention (Birgin & Topuz, 2017; Taş, 2016), enhances conceptual learning (Öçal, 2017; Uzun, 2018), and contributes to spatial skills (Karaaslan, 2013; Sarpkaya-Aktaş & Erdoğan, 2024). When the related literature was examined, it was concluded that GeoGebra-supported teaching at secondary school, (Sarpkaya-Aktaş & Erdoğan, 2024), and high school (Chivai et el., 2024; Suprapto et el., 2021; Yulian et al., 2020) levels improved students' spatial skills. On the other hand, Suparman et al. (2024) analysed the studies conducted between 2010 and 2022, and observed that GeoGebra support had a strong and positive effect on spatial skills. On the other hand, the existence of a limited number of studies (Sarpkaya-Aktaş & Erdoğan, 2024) in which GeoGebra-supported teaching was carried out for teaching the 7th grade object's views from different directions is noteworthy.

On the other hand, the ASSURE instructional design model allows students to participate actively and find teaching fun (Karakış, 2014; Kim & Downey, 2016). However, there is no research in the literature on a GeoGebra-supported ASSURE instructional design for the acquisition of "Draws two-dimensional views of three-dimensional objects from different directions" in the 7th grade secondary school mathematics course, which may constitute an opportunity for future research. For this reason, in this study, preferring GeoGebra software for selecting materials developed based on the ASSURE instructional design model is of great importance for increasing the quality of the research. In this context, it is important to develop GeoGebra-supported instructional material in accordance with the ASSURE instructional design model, which enables the development of spatial skills for teaching 7th-grade students how to view objects from different directions. On the other hand, GeoGebra-supported instructional materials for teaching 7th graders how to view objects from different directions were developed and implemented in the real classroom environment. Taking students' feedback about the GeoGebra-supported teaching environment in accordance with the ASSURE instructional design model will enhance the evaluation of the learning environment. Considering these aspects, it is thought that this research is original and will benefit the scientific literature. In this context, the aim of this study is to develop instructional materials, GeoGebra-supported, based on the ASSURE instructional design model, to help 7th grade secondary school students acquire the skill of drawing two-dimensional views of three-dimensional objects from different directions, and to evaluate the students' views on this teaching process.

The purpose of this study is to design and evaluate teaching materials developed in accordance with the ASSURE instructional design model with the support of GeoGebra, focusing on the learning outcome in the sub-learning area of “Views of Objects from Different Angles” in the seventh-grade mathematics curriculum. The research aims to examine the effect of the developed teaching materials on students' spatial skills and their views on technology-supported teaching environments. In this regard, the study aims to provide significant contributions to the literature on how technology-supported instructional design can contribute to the development of students' spatial skills and their positive views on the learning environment. Based on this aim, the study addresses the following research questions:

1. How are the achievements of seventh grade students on the subject of the appearance of objects from different directions?
2. What are the seventh-grade students' views on the GeoGebra-supported learning environment based on the ASSURE instructional design model regarding the appearance of objects from different directions?

2 METHOD

2.1 Research design

This study aimed to develop and evaluate teaching materials for the sub-learning area of 'Views of Bodies from Different Directions' within the 'Geometry and Measurement' learning area of the seventh grade mathematics course in secondary school. Design-Based Research (DBR) is an approach that aims to develop innovative solutions by integrating theory and practice in education. Wang and Hannafin (2005) define this method as a flexible and context-sensitive research method in which the analysis, design, development, and implementation processes are carried out cyclically, in a real practice environment and in collaboration. DBR offers a framework that provides a continuous interaction between theory and practice, aiming to improve educational practices (Barab & Squire, 2004). In this context, the design-based research model was preferred in this study, since it aimed both to develop the teaching material and to continuously review and improve it in line with the data obtained during the implementation process.

2.2 Study group

The sample for this study consists of 19 seventh-grade students (9 girls, 10 boys) aged 12–13 who are enrolled in a public middle school in a province in western Turkey during the spring semester of the 2023–2024 academic year. Since the sample was selected according to specific criteria to serve the purpose of the study, purposive sampling was used. Purposive sampling is a qualitative sampling method that allows for the conscious selection of individuals with specific characteristics who are rich in information relevant to the study (Patton, 2002). In this study, the sample was selected considering that the students would be able to interact with both the GeoGebra-supported and ASSURE instructional design model-based learning environment and would encounter the relevant mathematical learning outcome for the first time. In this context, students provide suitable conditions for purposive sampling because they have prior learning and demonstrate academic and cognitive characteristics that can be observed during the study.

2.3 Instrument and procedures

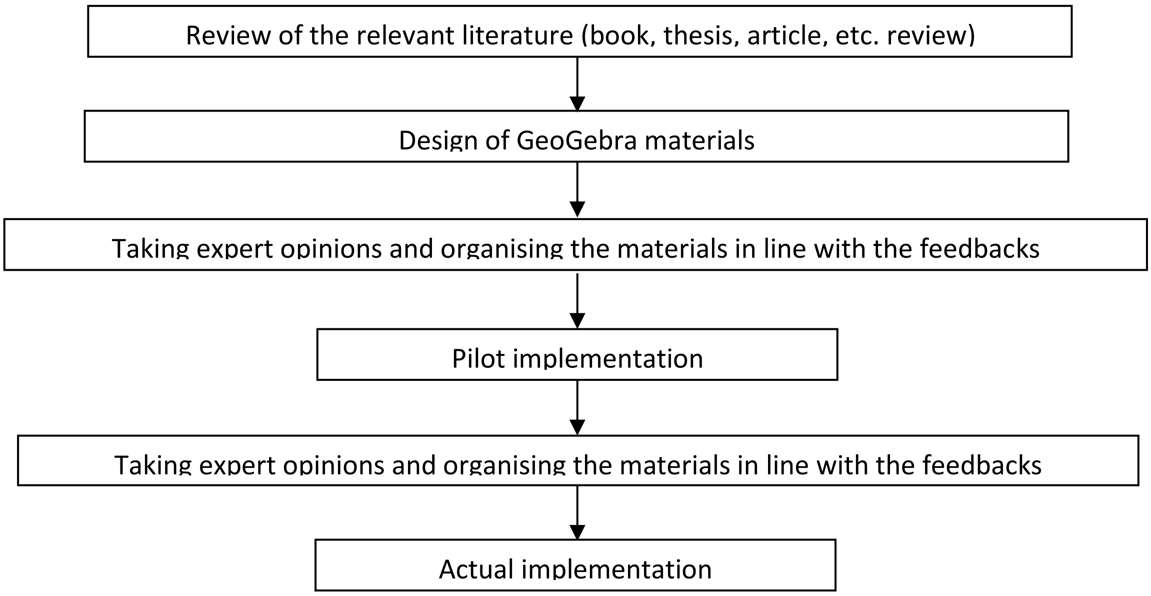
This study aimed to develop and evaluate instructional materials in accordance with the GeoGebra-supported ASSURE instructional design model for the sub-area ‘Views of Bodies from Different Directions’ in the area of 'Geometry and Measurement'’ within a seventh-grade mathematics course. The stages carried out for this purpose are presented below.

In the design of GeoGebra supported instructional materials and drawing test used in this study, related textbooks, articles, and graduate theses were examined. In the light of the reviewed literature, GeoGebra-supported instructional materials and a drawing test were designed, and the opinions of two mathematics experts and one mathematics educator were taken. To ensure that the language used in the GeoGebra-supported teaching materials and drawing test, developed in line with the opinions received, was understandable and to guide the actual implementation process, a pilot implementation process was started. The pilot application of this research was carried out with seventh-grade students of a state secondary school in Muğla province in the 2022-2023 academic year. After the pilot implementation, necessary arrangements were made in line with the feedback and the opinions of two mathematics experts and a mathematics educator, and the actual implementation process was initiated.

Before the actual implementation, GeoGebra software was introduced for one lesson because the students were encountering the software for the first time and did not know how to use it. Then, instruction supported by GeoGebra in accordance with the ASSURE instructional design model was carried out for 5 lesson hours. Then, the 'drawing test' developed to evaluate the students' spatial skills related to the acquisition of 'Draws two-dimensional views of three-dimensional objects from different directions' was applied to the students within one lesson hour. Finally, the self-evaluation form and semi-structured interviews were conducted during three lesson hours. Figure 2 shows the material development process, and Table 1 depicts the steps taken during the actual implementation process.

Figure 2

Material development process within the scope of the research



Source: Authors

Table 1

Actual implementation steps

Step No	Implementation	Duration
Step 1	GeoGebra Introduction	1 hour
Step 2	Teaching and Learning	5 hour
Step 3	Drawing Test	1 hour
Step 4	Semi-structured Interview and Self-assessment Form	3 hour

Source: Authors

In this study, worksheets for GeoGebra-supported instructional materials suitable for the ASSURE instructional design model were designed. GeoGebra-supported instructional materials, and the instructions in the worksheets were developed to enable students to gain spatial skills by exploring the appearance of objects from different places. Screenshots of the activities in GeoGebra teaching materials are presented in Figure 3-4.

In GeoGebra-supported teaching materials and worksheets, it was aimed to enable seventh grade students to discover the appearance of cubes, square prisms, rectangular prisms from different directions (Figure 3) and to discover the appearance of non-prism structures formed with unit cubes from different directions (Figure 4) with GeoGebra support.

Figure 3

View of a square prism from different directions material: GeoGebra screenshot for exploring View of a square prism from different directions

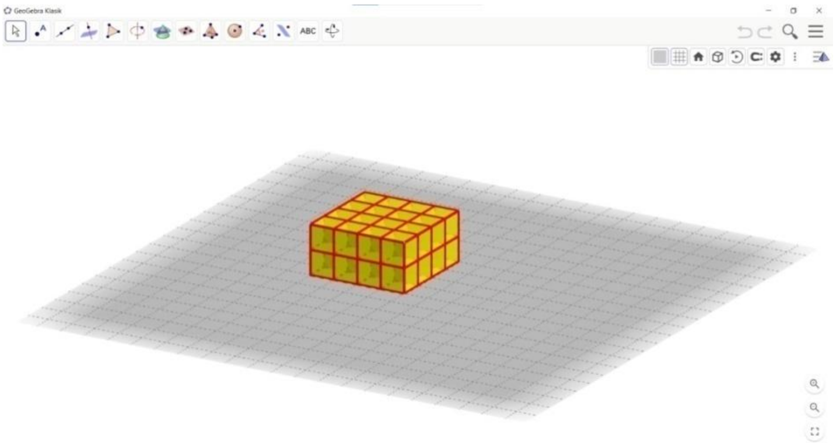


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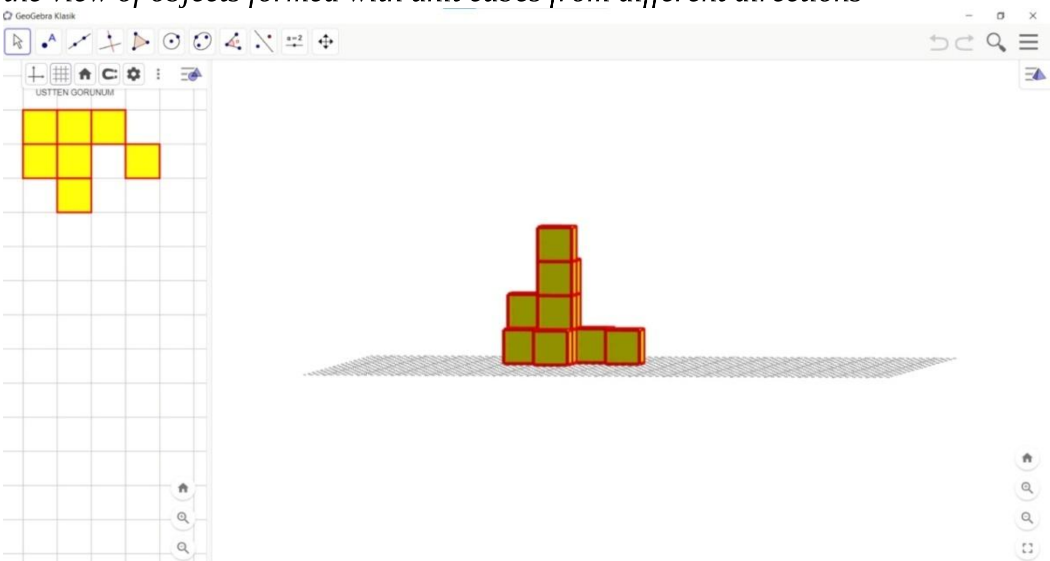
Figure 4

View of objects from different directions material: GeoGebra screenshot for exploring the view of objects formed with unit cubes from different directions



Source: Authors

2.4 Data analysis

The frequency technique was used to analyze the quantitative data obtained in this study, and content and descriptive analysis techniques were used to analyze qualitative data. Data are analysed in depth through content analysis, and themes and dimensions are revealed (Çepni, 2018). The data obtained from content analysis were reinterpreted according to codes, categories and themes. In descriptive analysis, data are presented by direct quotation (Hsieh & Shannon, 2005). In this study, the seventh-grade students' views on the GeoGebra-supported instructional materials and learning environment developed in accordance with the ASSURE instructional design model on the appearance of objects from different directions are given through direct quotations. Direct quotations obtained from the students in the qualitative data are presented with the codes S1, S2, ..., S19.

2.5 Validity and reliability

The answers given to the two open-ended questions in the section regarding opinions on the use of GeoGebra software within the self-assessment form were analysed by three researchers, and the similarity rate of the data set was calculated. The reliability of qualitative research is determined in this way. The reliability formula suggested by Miles and Huberman (1994) (Reliability = Agreement / (Agreement + Disagreement)) was used as a basis. The codes with 'consensus' and 'disagreement' were discussed by the researchers, and necessary arrangements were made. As a result of the calculations, the reliability of the research was found to be 0.96 for the first question and 0.94 for the second question. This result is relevant to the research.

Creswell (2021) mentioned five criteria for ensuring the validity principle of research. The first of these criteria is that the researcher should be in close and long-term communication with the learners. Another criterion is that all stages of the research are carried out under expert supervision and guided by expert opinions. In the third criterion, which is data triangulation, a drawing test and a self-evaluation form were used. In the fourth criterion, participant confirmation, the answers to the two open-ended questions in the opinions about GeoGebra in the self-assessment form were confirmed by the learners. Direct quotations from these answers were included to increase validity. The last criterion was presented by explaining all the steps of the ASSURE instructional design model in detail.

2.6 Ethics

This research was conducted in accordance with the ethics committee permission granted by the decision of the Kocaeli University Social and Human Sciences Ethics

Committee dated 17/01/2025 and numbered 10 in the meeting numbered 2025/01 and the scientific, ethical and citation rules specified to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive".

3 FINDINGS

The findings obtained from the scope of this research are presented below within the framework of ASSURE instructional design model steps.

1) Analyse Learners

- **General Characteristics:** This study included nineteen students (9 girls and 10 boys) aged 12-13 years studying in a public secondary school in Muğla province in the second semester of the 2023-2024 academic year**.** The majority of the students come from middle class families and more than half of them have personal computers, tablets, and smartphones, demonstrating their predisposition to technology.
- **Entry Skills:** Students will encounter the outcome 'Draws two-dimensional views of three-dimensional objects from different directions' in the sub-learning area 'Views of Objects from Different Directions' in the learning area 'Geometry and Measurement' for the first time. However, they have prior knowledge about this topic, thanks to the outcome 'Construct different rectangular prisms with a given volume with unit cubes' in the 6th grade mathematics programme.
- **Learning Styles:** Students are generally successful in achieving course objectives. Students who prefer to participate in active and fun activities prefer fast and dynamic progress in the learning process. This group of students, who prefer group work, enjoys activities aimed at structuring and discovering knowledge.

2) State Objectives

At the end of this instructional design, students are expected to achieve success in meeting the specified teaching objectives. At the end of the teaching process, the aim is for students to be able to draw the front, top, and side views of three-dimensional objects formed with unit cubes. This ability will enable students to develop their spatial skills. In the teaching process, students are expected to reach the target acquisition by following the systematic steps of the ASSURE model.

3) Methods, Media and Materials

The choice of teaching method was made by taking into consideration class size, the characteristics of the 7th grade students, the content of the learning outcome, and the foreseen time frame. Considering these factors, it is predicted that the combination of ‘lecture’ and ‘activity-based’ teaching methods will be effective. GeoGebra supported teaching materials and worksheets, with instructions for these materials, were developed by the researchers to support students' learning processes. At the same time, concrete materials (unit cubes) were preferred in addition to technology support to support students' learning by doing.

4) Utilize Media and Materials

Before starting the instruction, the teacher-researcher carefully prepared the teaching environment. In this process, GeoGebra software was first installed on the interactive board. This software enriches the learning process by enabling students to explore mathematical concepts interactively.

Then, GeoGebra-supported teaching materials were reproduced in sufficient numbers for each student. The class was organised in such a way that there were two students in each row. This arrangement encourages co-operation among students and supports individual participation. The teacher-researcher introduced GeoGebra software to the students, gave information about its basic functions and usage, after distributing the worksheets with instructions. Figure 5 below shows an example of the work done by a pair of students using unit cubes, while Figure 6 shows a student's visualization using GeoGebra materials on the smart board.

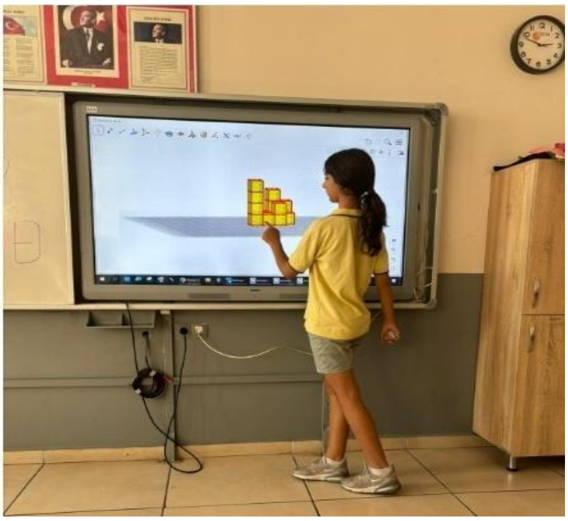
Figure 5

Student study group visualization

Source: Authors

Figure 6

Student visualisation for the use of for the use of tangible materials GeoGebra materials



Source: Authors

These preparations enable students to focus on the learning process by removing the difficulties they may encounter during the teaching process. Thus, by completing all the necessary preparations before teaching, a suitable environment was created for students to use course materials and technology effectively. With the completion of these preparations, the teaching process was ready to start.

5) Require Learner Participations

During the teaching process, the researcher-teacher and students used the media and materials effectively. The teacher used the interactive whiteboard for lectures and demonstrations while the students worked in pairs. This arrangement was planned to ensure students' active participation and to support activity-based teaching.

The teacher gave instructions to the students to follow the steps indicated in the worksheets . Students rotated three-dimensional objects to view them from various angles (top, right, left, front, and bottom) using GeoGebra-supported teaching materials. These activities were designed to develop students' spatial skills.

The research-teacher constantly observed the students' use of the GeoGebra software and worksheets and provided guidance to the groups when necessary. After each of the students completed the tasks in the teaching materials, the results obtained were discussed as a class. These discussions allowed the students to reinforce the learning outcomes and learn from each other.

GeoGebra-supported instructional materials and guided worksheets contributed to enriching and deepening students' learning experiences.

6) Evaluate and Revise

In the study, a special drawing test was developed to evaluate the spatial skills related to the target outcome of the students. Within the scope of this test, students were expected to draw the views of three-dimensional objects from different directions.

Afterwards, a self-assessment form was used to enable students to evaluate their own learning process and experiences. This form consists of three main sections: demographic information, self-evaluation and opinions about GeoGebra software. In the Demographic Information section, there is information about the gender of the students, their first semester mathematics course report card grades, their level of perceiving mathematics as important, and how successful they find themselves in mathematics. In the Personal Evaluation section, four open-ended questions were asked to the students to explain what they learned during the activity, in which areas they were successful, and at which points they had difficulties. Finally, in the Opinions on GeoGebra Software section, students were asked to express their opinions about the situations that they were particularly interested in and liked, and the situations that they did not want to do or did not like in the studies carried out with GeoGebra through semi-structured interviews.

The aforementioned drawing test and self-assessment form were designed to collect students' spatial skills as well as their thoughts and self-evaluations about teaching materials and methods. The results of the evaluation provide valuable information to determine the effectiveness of teaching processes and ways to increase student engagement.

3.1 Evaluation results obtained from the drawing test

In this study, it was determined that 89.5% of the students made successful drawings in the front view and 86% of the students made successful drawings in the top view in the four drawing questions in the drawing test, prepared to determine the seventh grade students' access to the targeted outcome. This was within the scope of GeoGebra-supported instruction based on the ASSURE instructional design model. In addition, it was observed that 68.4% of the seventh grade students made correct drawings in the right view and 68% in the left view. In line with these results, it can be concluded that seventh grade students are more successful in the frontal and top view than the right and left view.

3.2 Evaluation results obtained from semi-structured interviews

Two open-ended questions were asked through semi-structured interviews to obtain the opinions of seventh-grade students about the GeoGebra-supported teaching material and learning environment in accordance with the ASSURE instructional design model. The findings were presented as a result of the descriptive analysis of the data obtained. Codes, categories, themes, and student codes for the findings obtained are presented in tables. The descriptive analysis of the statements of the seventh grade students regarding the question "What are the situations that you especially like in the study with GeoGebra?" is presented in Table 2.

Table 2

Responses to the first open-ended question about GeoGebra software

Theme	Category	Code	Student Code
Cognitive	Dynamic	Movement	S4, S7, S8, S13, S16
	Content	Activity-based	S1, S19
		Having many activities	S3
		Detailed activities	S3
	Understandable	Easy finding	S17
		Better understanding	S18
	Visual	Visualisation	S5
	Transferable	Good transfer	S6
Affective	Positive	Fun	S9, S14, S17
		Enjoyment	S10, S11, S12
	Negative	Unwillingness to participate	S2
		Dislike	S15

Source: Authors

According to Table 2, cognitive and affective themes emerged when the seventh-grade students' expressions were analysed for the open-ended question, 'What are the situations that especially interest you and you like in the study with GeoGebra?'. In the dynamic category in the cognitive theme, five students (S4, S7, S8, S13 and S16) stated that they were interested in and enjoyed GeoGebra's ability to move. The student coded S16 expressed the opinion: 'I like that we can move three-dimensional objects.' In addition, in the content category in the cognitive theme, two students (S1 and S19) stated that GeoGebra was activity-based. The student coded S3 stated that he liked that the activities were numerous and detailed. Similarly, in the comprehensible category, the student coded S17 found GeoGebra easy, and the student coded S18 found it interesting, because he liked it and understood it better. The statement of the student coded S18 in this context is as follows: 'It helps us to understand the subject or view better from different directions.' In addition, the student coded S5 in the visual category stated that he was interested in GeoGebra because it was visual, whereas S6 in the transferable category stated that he liked GeoGebra because it effectively transferred concepts. On the other hand, in the positive category in the affective theme, it was seen that students coded S9, S14, and S17 found it fun, and students coded S10, S11, and S12 developed a positive attitude because they enjoyed it. Student expressions in this context are as follows: S18: 'It is very fun to draw the front, top, right and left views of various prisms with cubes'; and S11: 'I liked the view of three-dimensional objects from different directions.' On the other hand, in the negative category in the affective theme, it was observed that student S2 did not want to participate, and student S15 developed a negative attitude. These student expressions are as follows: S2: ‘There were no situations that I liked and that attracted my interest in the studies with GeoGebra,’ and S15: ‘I did not like it.’

Table 3

Responses to the second open-ended question about GeoGebra software

Theme	Category	Code	Student Code
Affective	Positive	Enjoyment	S4, S10, S13, S16, S18
		Fun	S14, S17
	Negative	Unwillingness to participate	S2
		Not wanting to do the activity	S9
		Dislike	S15
Cognitive	Student related	Difficulty with the activity	S3, S6, S8, S11, S12
	Related to the activity	Similarity of activities	S5
	Related to GeoGebra	Difficulty in use	S7
Drawing	Drawing related	Drawing the view of structures	S1, S19

Source: Authors

According to Table 3, cognitive, affective, and drawing themes emerged when the seventh grade students' expressions were analysed for the open-ended question: “What are the situations that you don't like or don't want to do in the study with GeoGebra?”. In the positive category of the affective theme, it was observed that five students (S4, S10, S13, S16, and S18) enjoyed the activity. Additionally, students coded S14 and S17 had a positive experience because they found it fun. The statement of the student coded S17 in this context is as follows: ‘Actually, most of the time there were no parts that I did not like, because the subject was very nice and fun.’ However, in the negative category in the affective theme, it was observed that the student coded S2 did not want to participate, the student coded S9 did not want to do the activity, and the student coded S15 did not like it. On the other hand, in the category related to the student in the cognitive theme, five students (T3, T6, T8, T11 and T12) stated that they had difficulty for the activities. The statement of the student coded S12 is as follows: ‘Sometimes there are very difficult shapes. I don't want to do them because I have difficulty in doing them.’ In addition, in the category related to the activity, it was observed that the student coded S5 did not like the similarity of the activities, the student coded S7 did not like GeoGebra, because he had difficulty in using it. In addition, in the drawing category, students coded S1 and S19 stated that they had difficulty in drawing the appearance of the structures, and did not like it. The statement of the student coded S1 is as follows in this context: ‘I didn't enjoy drawing the shapes. I had some difficulties.’ When Table 1 and Table 2 are analysed, in general, it can be concluded that seventh grade students generally enjoyed and had positive attitudes towards GeoGebra-supported instruction based on the ASSURE instructional design model.

4 DISCUSSION

The aim of this study is to develop and evaluate instructional materials for the sub-learning area of 'Views of Objects from Different Directions' within the 'Geometry and Measurement' learning area within the scope of the seventh-grade mathematics course in secondary school. These materials were developed with the support of GeoGebra, based on the ASSURE instructional design model. In this context, a lesson plan including the ASSURE instructional design model was prepared for the acquisition of 'Draws two-dimensional views of three-dimensional objects from different directions.'

In the research process, learner analysis, which is the first stage of the ASSURE model, was carried out for 7th grade students. Then, the other stages of the model were systematically applied, and the active participation of the students was ensured. At the end of the teaching process, the drawing test and the self-assessment form were applied to 19 students. As a result of the evaluations obtained, it was determined that GeoGebra-supported instruction, in accordance with the ASSURE instructional design model, in teaching the 7th grade view of objects from different directions subject, increased students' spatial skills. This approach also enabled students to make successful drawings. This finding is in line with the findings of various studies (Altıkardeş, 2018; Chivai et al., 2024; Elfa & Marwan, 2021; Karaaslan, 2013; Sarpkaya-Aktaş & Erdoğan, 2024; Suparman et al., 2024; Suprapto et al., 2021; Yulian et al., 2020). This finding overlaps with the result that the GeoGebra support contributes to spatial skills. In addition, these results coincide with the results of the studies in the literature (Adi et al., 2021; Aycan, 2024; Aydın, 2021; Çetinkaya, 2017; Durak, 2009; Gündüzalp & Yıldız, 2020; Karadeniz, 2021; Karakış, Karamete, & Okçu, 2016; Kaya, İnanç, & Çelik, 2020) which were conducted with ASSURE instructional design model, positively affecting academic achievement. From this point of view, it can be stated that GeoGebra support and the ASSURE instructional design model positively contribute to spatial skills.

When the learner opinions were analysed, it was concluded that the geometry teaching developed with the support of GeoGebra, based on the ASSURE instructional design model, provided a dynamic, understandable and fun learning environment. The finding that GeoGebra makes the learning process more fun overlaps with the results of Kutluca and Zengin (2011), Özçakır-Sümen (2017), and Yücel and Önal (2023); the finding that it is dynamic overlaps with the results of Çörekçioğlu (2019) and Çetin and Özgeldi (2018); and the finding that it provides more understandable teaching overlaps with the results of Yücel and Önal (2023). Similarly, the results of various studies (Aycan, 2024; Çetinkaya, 2017; Durak, 2009) align with the results of this study, indicating that learners have positive views towards the ASSURE instructional design model. On the other hand, studies conducted by Elmalı (2020), Göksu, Özcan, Çakır, and Göktaş (2014) and Özdemir and Uyangör (2011) suggest that the ASSURE instructional design model may be insufficient in mathematics teaching, especially in terms of learner analysis and evaluation processes. However, in the present study, it was observed that the model for teaching the topic of the appearance of objects from different directions fully met the content and offered an appropriate instructional design in this context.

5 CONCLUSIONS AND IMPLICATIONS

Despite the positive findings of this study, certain limitations should be acknowledged. The fact that it was conducted with only 19 secondary school students restricts the generalisability of the results. Moreover, as the research focused on a single instructional topic, it does not allow inferences about the long-term effects of the GeoGebra-supported ASSURE instructional design on students' skills. Likewise, the study's emphasis on spatial skills limits the evaluation of the model's applicability to other areas of mathematics.

Future studies with larger sample groups and diverse educational settings would enhance the external validity of these findings. Longitudinal research could further reveal the long-term effects of the GeoGebra-supported ASSURE model on students' spatial and mathematical performance. Examining the implementation of the ASSURE model in subjects beyond geometry would also contribute to understanding its broader pedagogical potential.

Another critical aspect for future research is teachers' professional development. Given the growing importance of technology integration in education, structured training programmes are needed to help teachers apply instructional design models effectively. Moreover, exploring how GeoGebra-based instruction interacts with innovative pedagogical approaches could provide insights into fostering student engagement and learning outcomes.

Overall, further studies in these areas could help validate and refine the ASSURE instructional design model as a comprehensive framework for integrating technology into mathematics education, thereby enhancing teaching and learning practices across varied contexts.

CONFLICT OF INTEREST STATEMENT

As the authors of this research, we declare that we have no conflicts of interest.

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Authors' Contribution

Both authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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