Development and Usability of A 3D Projection Kit for Mathematics Teacher Trainees on the Topic of Plans and Elevations

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ABSTRACT

This study aims to develop and evaluate the validity of the content and usability of the 3D Projection Kit for the topic of Plans and Elevations among Mathematics trainee teachers. The topic of Plan and Elevations in the primary school syllabus requires high spatial visualization skills to understand the relationship between three-dimensional objects and two-dimensional projections such as plans, forward Elevations, and side Elevations. Mathematics trainee teachers need visual, interactive, and systematic teaching aids (PA) to support the teaching of the concept. This study uses a Development Research Design (DRD) approach guided by the ADDIE Model. A pilot study involving 10 respondents showed a very high level of instrument reliability with an Alpha Cronbach value of 0.941. Next, the actual study was carried out in phases: the needs analysis phase involved 30 Mathematics trainee teachers, the content validity assessment phase involved three experts in the field of Mathematics, and the usability assessment phase involved 43 Mathematics trainee teachers. Quantitative data was analyzed using descriptive statistics (mean and standard deviation), while content validity was analyzed using the Content Validity Index (CVI) and the Scale Content Validity Index (S-CVI/Ave). The study findings showed that the needs analysis was at a very high level with an overall mean of 4.78 (SP = 0.34). The evaluation of the validity of the content by the expert panel recorded a very high level of validity with a value of S-CVI/Ave = 1.00. Furthermore, the assessment of the usability of the 3D Projection Kit among Mathematics trainee teachers was also at a very high level with an overall mean of 4.78 (SP = 0.38). Overall, the 3D Projection Kit has proven to have excellent validity and usability and has great potential to be an effective digital, visual, and interactive teaching aid in supporting the teaching training of trainee teachers on abstract geometry topics.

Keywords: 3D Projection Kit, Plans and Elevations, Design and Development (DRD), Trainee teachers, Usability.

INTRODUCTION

Mathematics is a fundamental field of knowledge in the national education system because of its critical role in shaping logical thinking, analytical reasoning, creativity, as well as fostering systematic problem-solving skills among students. In line with this desire, the integration of 21st century approaches such as flipped classrooms has been found to have a positive impact in improving mathematics learning performance as well as actively nurturing students' creative thinking skills (Ramli et al., 2024a). Under the implementation of the Secondary School Standard Curriculum (KSSM) introduced by the Ministry of Education Malaysia, the Mathematics curriculum has gone through a drastic transformation phase to ensure that students can compete in facing the challenges of the digital era and the Industrial Revolution 4.0. In line with these aspirations, Mathematics teaching is now required to move from the memorization methods of conventional calculation procedures to a more visual, interactive, and student-centered approach to learning (Dilling et al., 2024; Firmanti et al., 2024). The integration of aspects of Science, Technology, Engineering, and Mathematics (STEM) requires a deep mastery of concepts, the placeability to interpret dynamic visual representations, as well as the skills to connect abstract mathematical ideas with physical applications in everyday life. However, in the reality of the classroom, there are certain sub-topics that are often considered very challenging for students to master and taught by teachers, especially those involving three-dimensional geometry (3D) and visual-spatial reasoning.

One of the geometry topics in the Form Three Mathematics curriculum that requires high spatial visualization skills is the topic of Plan and Elevations. Under this topic, pupils are required to analyse concrete 3D objects and translate them into two-dimensional (2D) orthographic projection drawings from various points of view, namely plan (top view), front Elevations, and side Elevations (right or left). Mastering the concept of orthographic projection is a very important foundation for the development of students' spatial thinking, as these spatial skills have been shown to have a very strong correlation with academic achievement in mathematics as well as excellent abilities in engineering and physical science subjects at a higher level (Harris, 2023; Lowrie et al., 2020). However, the process of interpreting this orthographic projection is not an easy task. It involves complex mental operations that require the ability to perform simultaneous mental rotation to imagine a change in visual form from a dense 3D object shape to a static 2D line drawing (Ozcakir & Cakiroglu, 2021). This challenge exposes students to great conceptual difficulties if the teaching relies only on conventional methods.

The main difficulty in learning the topic of Plans and Elevations stems from the weakness of the visualization of the students' space as well as the limitations of the teaching materials used in the class. Conventionally, Mathematics teachers rely heavily on static drawings on whiteboards or 2D illustrations in textbooks to explain dynamic 3D geometric relationships. This kind of static teaching approach embodies what researchers' term as a cognitive filter (Alcañiz et al., 2010; Shelton & Hedley, 2004). This cognitive filter refers to the mental barriers that pupils experience as they try to imagine 3D objects from a flat 2D projection display on a computer screen or textbook. Due to the material is stationary and cannot be manipulated, pupils have significant difficulty distinguishing between the function of the real line and the hidden lines that represent the projected shielded surface (Khong & Lim, 2019; Fuadiah et al., 2019). This phenomenon leads to serious geometric misconceptions, in which pupils often simply copy answers, guess the dimensions of the projection at random, or fail to correctly translate the position of the inclined surface.

This problem of misconception also poses a great pedagogical challenge for the mathematics trainee teacher. As prospective teachers who are still building teaching experience, they often lack the confidence and skills to effectively explain abstract spatial geometry concepts to students (Herman et al., 2025; Yang, 2025). Trainee teachers are in dire need of teaching aids (TA) that are not only visual and interactive, but also systematic and practical to be used in real teaching situations. Based on the highlights of past studies, there are many visual technologies developed such as 3D modeling software and augmented reality (AR) that have proven to be effective in improving the mastery of pupil spatial concepts (İbili et al., 2020; Topraklıkoğlu & Öztürk, 2021; Voulgari et al., 2024). However, most of these applications are very complex to operate, require high-performance computer devices, and are not specifically designed based on trainee teacher training modules that are in line with the local Mathematics Curriculum and Assessment Standard Document. Hence, there is a real gap for a simple, cost-effective, visual, interactive, and easily mobilized TA innovation to support trainee teachers in explaining the concept of Plan and Elevations visually and concretely. To bridge this gap, the 3D Projection Kit was systematically developed through this study.

Research Objectives

The main objective of this study is to draft the development and product evaluation of the 3D Projection Kit. Specifically, the objectives of this study are to:

1. To identify the level of need for the development of 3D Projection Kits among Mathematics trainee teachers for the topic of Plan and Elevations.

2. Evaluate the validity of the content of the 3D Projection Kit developed based on the evaluation of the expert panel.

3. Evaluate the usability of the 3D Projection Kit in terms of design, interest, and usability among Mathematics trainee teachers.

Research Questions

To achieve the objectives of the study, a total of four research questions were formulated to guide this research, namely:

1. What is the level of need for the development of 3D Projection Kits among Mathematics trainee teachers for the topic of Plan and Elevations?

2. What is the level of validity of the content of the 3D Projection Kit developed based on the evaluation of the expert panel?

3. What is the level of usability of the 3D Projection Kit in terms of design, interest, and usefulness among Mathematics trainee teachers?

LITERATURE REVIEW

Space visualization skills play a very important role in geometry learning. According to some cognitive models, spatial visualization is defined as the cognitive ability to manipulate, rotate, and translate mental representations of 3D objects spatially in the absence of physical assistance (Maier, 1996; Lohman, 1993). This low achievement problem due to difficulty translating visual coordinates can be overcome by diversifying student-centered teaching strategies such as Problem-Based Learning which has been shown to improve mathematical critical thinking skills, especially in the ability to identify conceptual information and evaluate evidence logically (Ramli et al., 2024b). Past studies have shown that poor levels of visual-spatial skill mastery are often directly associated with conceptual difficulties in understanding geometry, while improvements in spatial skills can drastically boost students' overall mathematics achievement (Harris, 2023; Lowrie et al., 2020). The topic of Plan and Elevations is an ideal platform to hone these skills. However, this orthographic projection demands the mental ability to assimilate the relationship of inclined surface position, insulated corners, and scale retention. Pupils' inability to translate visual coordinates from 3D angles to static 2D projection planes often ends in frustration reactions, mathematical anxiety, as well as low achievement (Barroso et al., 2021; Khasawneh et al., 2021). Therefore, efforts to train pupils should be supported by the provision of concrete visual manipulatives.

Development in digital education technology offers a high-potential geometry learning alternative to overcome these cognitive filters. The integration of visual digital tools such as augmented reality (AR) and 3D modeling software allows pupils to dynamically explore geometric structures from various points of view, thus allowing orthographic projections to be concretized (İbili et al., 2020; Topraklıkoğlu & Öztürk, 2021). Geometry learning based on visual technology has also been found to be able to minimize the cognitive load of spatial cognition through dynamic manipulation of 3D models (Ozcakir & Cakiroglu, 2021). However, most past studies have only focused on the impact of the application of this visual technology on the academic achievement of school students alone, while the aspects of digital competence and pedagogical readiness of Mathematics trainee teachers who will teach the topic have received less attention (Dilling et al., 2024; Firmanti et al., 2024). Teacher trainees need a PA that allows them to integrate geometry content and teaching strategies effectively in a practical way (Chai et al., 2023). Therefore, the development of this 3D Projection Kit is designed to support the training domain of trainee teachers.

Theoretical Framework of Study

The development of the 3D Projection Kit in this study was guided by a combination of three intact theoretical frameworks, namely Constructivism Learning Theory, Mayer Multimedia Learning Theory (2009), and Technological Pedagogical Content Knowledge (TPACK) framework. First, Constructivist Learning Theory emphasizes that knowledge should not be passively transferred from teacher to student, but rather that students actively build their own understanding through concrete experiences and interactions with the learning environment (Kaufmann, 2004). Through the use of the 3D Projection Kit, pupils can physically interact with the 3D model, rotate it, and see firsthand how two-dimensional shapes result from projections of certain surfaces. This active manipulative experience helps pupils to transfer spatial visuals concretely into the mental picture of the projected plane.

Second, the Multimedia Learning Theory expressed by Mayer (2009) explains that the human mind processes information through two separate channels, namely visual/pictorial channels and oral/auditory channels. Multimedia learning will be most effective when information is delivered simultaneously through a combination of dynamic visuals, concise text, as well as meaningful interactive feedback (Mayer, 2009; Hedley, 2003). The 3D Projection Kit combines 3D dynamic visual representations with 2D line drawings side by side to reduce the cognitive load of spatial cognition, allowing pupils to process geometric transformations without experiencing mental barriers. Third, the TPACK framework introduced by Koehler and Mishra (2009) emphasizes the importance of trainee teachers building a balanced understanding of how technology, pedagogical strategies, and the content of the mathematics curriculum respond in an integrated manner. The 3D Projection Kit serves as a training medium that allows trainee teachers to practice the TPACK domain holistically while designing a visual and student-centered daily lesson plan.

METHODOLOGY

This study uses systematic research methods to ensure that the products developed meet Scopus' high-quality standards. This study uses the Development Research Design (DRD) approach to build, test, and evaluate the applicability of 3D Projection Kits empirically. The DRD approach is very suitable to be used in educational innovation development studies as it involves an organized data collection process at each phase to guarantee the quality and suitability of the final product with the needs of the actual users (Plomp, 2013).

Study Design based on ADDIE Model

The development framework of the 3D Projection Kit is systematically guided by the instructional phases in the ADDIE Model (Branch, 2009), which include the Analysis, Design, Development, Implementation, and Evaluation phases. Each of these phases uses a specific methodological design to ensure the accuracy of the data and the effectiveness of the kit:

1. **Analysis Phase**: Using a Descriptive Survey Research Design to identify the level of development needs of the 3D Projection Kit. The survey design was chosen because it allows the researcher to gather comprehensive, detailed, and generalizable feedback on the current teaching practices, constraints, and fuel needs of trainee teachers before the product is developed (Creswell & Creswell, 2018; McKillip, 1987). A sample of 30 Mathematics training teachers were involved in this phase.
2. **Design Phase:** Using the Instructional Design approach to translate analysis phase data into a systematic visual structure and content framework (Cheung, 2016). In this phase, the visual layout of the kit, the integration of geometric visual concepts, the selection of interactive elements, as well as the draft of the Daily Lesson Plan were drafted based on the national curriculum learning standards. The justification for this design is to guarantee the alignment of PA with the learning outcomes of the official curriculum.
3. **Development Phase:** Involves Prototype Prototyping Design to produce physical and digital materials of 3D Projection Kits that can be manipulated interactively. The researcher arranges the physical items of the geometric model (such as planes, prisms, pyramids, cylinders) and completes a visual digital module to concretize the visual projection and address the issue of geometric cognitive filters (Ozcakir & Cakiroglu, 2021). The justification for this design is to produce products with high concept integrity before field testing.
4. **Implementation Phase:** Using the Pilot Study Design approach involving 10 Mathematics trainee teachers (outside of the actual sample) to test the internal consistency of the questionnaire instruments. Next, field testing of the 3D Projection Kit was conducted to the target group of UPSI Mathematics trainee teachers during the micro-teaching session to provide direct exposure. The justification for this pilot study was to measure the reliability of the item (Alpha Cronbach) and the suitability of the operation of the kit in a controlled class (Hair et al., 2019).

5. **Evaluation Phase:** Involves two main approaches, namely (i) Expert Evaluation Design to determine the validity of the content of the kit evaluated by 3 Mathematics experts using the content validity index, and (ii) Usability Survey Study Design involving 43 UPSI Mathematics training teachers. The justification for this evaluation is to objectively assess the quality of the final product from the technical aspects, aesthetics, pedagogical usefulness, as well as user satisfaction before the kit is widely used (Polit & Beck, 2006; Wan Mohd Zaid & Mustafar, 2024).

Sampling Procedures and Respondent Groups

This study used purposive sampling techniques to select all groups of respondents involved. The justification for the use of targeted sampling is strongly supported by research scholars who state that this technique is particularly appropriate when researchers want to obtain in-depth, rich, and relevant data from subjects who have specific knowledge, experience, or background that is directly related to the purpose of the study (Creswell & Creswell, 2018; Krejcie & Morgan, 1970). In this study of the development of PA geometry, the mathematics trainee teachers were selected on a purposeful basis because they have undergone specific academic training related to spatial geometry at the university, will teach the topic of Plans and Elevations during teaching training, as well as are able to provide professional feedback on the quality of the design and practicality of the kit in the classroom. Based on Table 1, four groups of selected respondents were used according to the methodological phase of the study.

Table 1: Study Participants Involved by ADDIE Development Phase

ADDIE Phase	**Methodology & Specific Design**	**Target Groups / Respondents**	**Sample Size (N)**
Phase 1: Analysis	Descriptive Survey Study	UPSI Mathematics Teacher Trainees	30 people
Phase 4: Implementation	Pilot Study	UPSI Mathematics Teacher Trainees	10 people
Phase 5: Assessment (Validity)	Expert Evaluation	Field Specialist / University Lecturer in Mathematics	3 people
Phase 5: Evaluation (Usability)	Usability Survey Study	UPSI Mathematics Teacher Trainees	43 people

Research Instruments

This study used three main types of questionnaire instruments adapted from instruments that have been validated by previous scholars to ensure the reliability of the data collected:

1. Needs Analysis Questionnaire: Adapted based on the theoretical principles of needs analysis by McKillip (1987) and Kaufman (1992), this instrument was modified to align with the context of teaching the topic of Plan and Elevations in national Mathematics classrooms. The questionnaire included a total of 20 items divided into four main constructs: (i) practice during teaching, (ii) problems and constraints in teaching, (iii) the level of need of trainee teachers for the development of visual PA, and (iv) the priority of the need for kits.

2. PA Content Validity Assessment Form: Adapted from the content validity framework by Polit and Beck (2006), Polit et al. (2007), as well as the index calculation method by Yusoff (2019). This form contains quantitative and qualitative evaluation criteria to enable a panel of experts to assess the suitability of the product based on four main constructs: (i) the accuracy of the mathematical content, (ii) the beauty and quality of the physical design, (iii) the level of interactivity, and (iv) the practicality of the kit's usability during geometric learning.

3. 3D Projection Kit Usability Questionnaire: Adapted from the PA usability instrument by Wan Mohd Zaid and Mustafar (2024), this questionnaire is specifically tailored to the features of the 3D Projection Kit to assess the perception of the target user. The instrument includes 15 items that measure three main usability constructs: (i) kit design, (ii) interest and motivation, and (iii) kit usefulness in aiding the teaching process.

The procedure for conducting the pilot study to measure the internal consistency of this instrument is parallel to the method carried out in the development of the module by Ramli et al. (2024c), where the initial pilot study on the target group also showed a high Cronbach's alpha reliability value above 0.90. All these instruments use a five-point Likert scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. The use of this five-point Likert scale follows the standards of the construction of cognitive measuring instruments that allow the level of attitude tendency to be measured in detail. Before the instruments were distributed, a pilot study was conducted on 10 Mathematics trainee teachers to test the reliability value of the instruments. The results of descriptive statistical analysis showed that the Alpha Cronbach value of the usability instrument reached 0.941. This value is excellent and is within a very high range of internal consistency (alpha > 0.90) referring to the criteria of Hair et al. (2019), providing scientific authorization for this instrument to be distributed for the actual study.

Data Analysis Methods

The data were analyzed using descriptive statistical methods and the calculation of the validity index according to the data type:

1. **Needs and Usability Analysis: Analyzed** using descriptive statistics involving frequency, percentage, mean score, and standard deviation. The interpretation of the level of the mean score is based on Landell's (1997) classification: a mean score of 1.00 to 2.33 indicates a low level, a mean score of 2.34 to 3.66 indicates a moderate level, and a mean score of 3.67 to 5.00 indicates a high level.
2. **Content Validity Analysis:** Analyzed using the Content Validity Index (CVI) at the item level (I-CVI) and the Scale Content Validity Index (S-CVI/Ave). In accordance with the classification guidelines of Polit and Beck (2006) and Yusoff (2019), for studies involving a panel of experts of less than five people, the S-CVI/Ave value must reach a value of 1.00 to be declared to have excellent and very high content validity.

4. Study Findings & Data Analysis

The findings of this study are presented in an orderly manner according to the sequence of quantitative study questions to provide strong empirical evidence analysis related to the necessity, validity, and usability of the 3D Projection Kit.

Research Question 1: Analysis of the Development Needs of 3D Projection Kits

The first research question tested the extent to which Mathematics trainee teachers needed the development of a 3D Projection Kit to support the teaching of the topic of Plans and Elevations. Quantitative data from 30 UPSI Mathematics trainee teachers were collected and analyzed in a descriptive statistical manner. A summary of the results for this phase of needs analysis is shown in Table 2.

Table 2: Summary of Findings of Analysis of the Development Needs of 3D Projection Kits (N = 30)

Construct No.	Construct Requirements	Min Score	Standard Deviation (SD)
1.	Practice during the teaching of the topic of Plan and Elevations	4.56	0.47
2.	Problems and constraints in the teaching of the topic of Plan and Elevations	4.77	0.41
3.	Requirements for the development of 3D Projection Kits	4.91	0.26

4.	Priority requirements for 3D Projection Kits	4.89	0.23
Overall	**Average Requirements Analysis Mean Score**	**4.78**	**0.34**

Based on the results of the analysis in Table 2, it was found that the entire construct in the needs analysis phase recorded the interpretation of the mean score at a very high level with an overall mean average of 4.78 (SD = 0.34). In-depth, the construct of requirements for the development of the 3D Projection Kit recorded the highest mean score of 4.91 (SD = 0.26), closely followed by the specific priority of kit design with a mean of 4.89 (SD = 0.23). Furthermore, the practice during teaching (mean = 4.56, SP = 0.47) and the teacher trainee's awareness of problems and constraints in conventional teaching (mean = 4.77, SD = 0.41) were also at a very high level. These findings are a very strong empirical indication that the conventional teaching of Plans and Elevations faces severe pedagogical problems, and there is a very urgent need gap for the development of visual and interactive teaching kits to address these issues among Mathematics trainee teachers.

Research Question 2: Analysis of the Validity of the Content of the 3D Projection Kit

The second research question assessed the content quality, design, interactivity, and usability of the 3D Projection Kit based on an independent assessment by three panels of Mathematics experts. For this purpose, the feedback provided was evaluated using the Content Validity Index (CVI) at the item level and analyzed descriptively to obtain the Scale Content Validity Index Average (S-CVI/Ave). The results of this expert content validity analysis are presented in Table 3.

Table 3: Summary of the Validity Assessment of the Content of the 3D Projection Kit by the Expert Panel (N = 3)

No.	Construct Assessment	Expert 1	Expert 2	Expert 3	I-CVI / S-CVI
1.	Mathematics Content	4.20	5.00	4.20	1.00
2.	Physical & Digital Design	4.33	4.50	4.17	1.00
3.	Interactivity Level	5.00	5.00	4.75	1.00
4.	Practicality of Usability	4.00	4.50	4.00	1.00
Overall	**Scale Content Validity Index Average (S-CVI/Ave)**				**1.00**

Based on the results of the expert analysis in Table 3, all constructs consisting of content (I-CVI = 1.00), design (I-CVI = 1.00), interactivity (I-CVI = 1.00), and usability (I-CVI = 1.00) have achieved maximum item index value of 1.00. Thus, the overall calculation of the S-CVI/Ave value was recorded as 1.00. According to the guidelines for content validity analysis by Polit and Beck (2006) and Yusoff (2019), for studies using an expert panel of three to five people, an S-CVI/Ave value of 1.00 proves a very high, excellent, and satisfactory level of content validity. These findings provide strong scientific justification that the 3D Projection Kit developed is highly relevant, accurate in terms of mathematical science content, has excellent aesthetic visualization, as well as practical to test in real teaching processes.

Research Question 3: Usability Analysis of 3D Projection Kit

The third research question assessed the level of usability of the 3D Projection Kit from the perspective of UPSI Mathematics trainee teachers. This usability assessment includes three main constructs, namely kit design, interest, and usefulness of the kit in assisting the teaching process of the concept of Plan and Elevations. The results of the descriptive analysis of the usability of the kits are shown in Table 4.

Table 4: Summary of the Usability Assessment of 3D Projection Kits among Mathematics Trainee Teachers (N = 43)

Construct No.	Usability Construct	Min Score	Standard Deviation (SD)
1.	Kit Design	4.78	0.38
2.	Interest	4.80	0.40
3.	Usability	4.77	0.36
Overall	**Average Mean Usability Score**	**4.78**	**0.38**

Based on the results of the quantitative analysis in Table 4, it was found that the evaluation of the usability of the 3D Projection Kit among Mathematics trainee teachers was at a very high level with an overall mean average of 4.78 (SD = 0.38). More specifically, the construct of interest recorded the highest mean score of 4.80 (SD = 0.40), closely followed by the design aspect of the kit with a mean of 4.78 (SD = 0.38), as well as the usability of the kit with a mean of 4.77 (SD = 0.36). Based on the classification of mean interpretation by Landell (1997), the overall mean score which is in the range of 3.67 to 5.00 proves that the 3D Projection Kit has an excellent level of usability in the real teaching field. The trainee teachers fully agreed that the kit is very practical, effectively attracts students' attention and active engagement, as well as facilitates their efforts to translate abstract geometric orthographic projection concepts during teaching exercises.

CRITICAL DISCUSSION

The excellent results recorded for each phase of the development of the 3D Projection Kit require a critical discussion review to unravel the why, how, and why aspects of these findings are produced under the framework of the educational theory studied.

First, the question of why the usability level of the 3D Projection Kit is rated so high (overall mean = 4.78) can be explained through the effectiveness of the aesthetic aspects and dynamic visual design of the kit in reducing the cognitive load of students (Mayer, 2009). Kit designs that allow pupils to physically manipulate 3D models and view matching 2D projections simultaneously can stimulate their interest (interest = 4.80) and active engagement (Awang et al., 2024; Wan Mohd Zaid & Mustafar, 2024). Mayer's Multimedia Learning Theory (2009) proves that spatial information is more easily processed in working memory when visual elements and verbal descriptions are meaningfully integrated (Mayer, 2009; Hedley, 2003). In traditional geometry teaching, this absence of dynamic visual coordination creates cognitive filters that burden the pupil mentally (Alcañiz et al., 2010). Therefore, by designing a clear and interactive visual projection kit, the 3D Projection Kit manages to reduce the mental processing load of pupils, thus facilitating visual-spatial understanding and increasing interest in learning.

Besides, the debate on how the 3D Projection Kit can solve the misconception of students' geometric projections relies on the process of mental rotation and visualization of inclined surfaces. Using this kit, students are no longer just passively looking at a stationary diagram on a whiteboard (Jerry & Jamaludin, 2021). Instead, they are actively guided to conduct exploration guided by the Theory of Constructivism (Kaufmann, 2004). When students hold a 3D model, rotate it in the direction of view (plan, front, and side), and compare it with a 2D orthographic projection grid drawing, the plane projection is directly concretized in their thinking (Lowrie et al., 2020; İbili et al., 2020). This process of transferring spatial concepts is very helpful for students to relate the functions of real lines and shielded lines logically, thus eliminating the misconceptions of geometric projections that often occur in traditional learning (Khong & Lim, 2019; Fuadiah et al., 2019).

Thirdly, the question of why the integration of the TPACK framework has proven to be effective in stimulating the teaching abilities of Mathematics trainee teachers has a very close relationship with their professional training at university. Through a design and development (DRD) process based on the ADDIE Model, the 3D Projection

Kit has been carefully adapted to the curriculum needs and pedagogical readiness of the trainee teachers (Branch, 2009; Richey & Klein, 2007). These findings are in line with the findings of other recent Mathematics PA development studies such as the SLEQ Kit (Chai et al., 2023), the Dolphin Jump Number Line Kit (Jamaludin et al., 2023), and the Algebra Wheel (Foo & Mohd Yaini, 2025), all of which conclude that the development of instructional products based on ADDIE's systematic design will always result in an excellent level of validity and usability in the real teaching field. The use of this kit empowers the TPACK skills of the trainee teachers by enabling them to harmoniously integrate content knowledge (projection geometry), pedagogical knowledge (constructive interactive visual method), and technological knowledge (use of digital visual PA), thus increasing their confidence and teaching efficiency in the classroom (Koehler & Mishra, 2009; Firmanti et al., 2024).

CONCLUSIONS, LIMITATIONS & RECOMMENDATIONS

Overall, the Development Research Design (DRD) study of the 3D Projection Kit has successfully achieved all the research objectives that have been set. First, the needs analysis conducted showed that there is a very urgent need for kit development (mean = 4.78, SD = 0.34) to support trainee teachers in teaching the topic of Plan and Elevations. Besides, the development process of the 3D Projection Kit has been successfully completed systematically guided by the instructional design framework of the ADDIE Model. Furthermore, the evaluation of the validity of the content by the expert panel recorded a very high value with the acquisition of an excellent validity index value, S-CVI/Ave = 1.00. Finally, the level of usability of kits among UPSI Mathematics trainee teachers was found to be at a very high level with an overall mean average of 4.78 (SD = 0.38). Thus, this 3D Projection Kit has proven to be theoretically sound, valid in terms of mathematical science content, and very practical to be integrated as a fuel for teaching projection geometry in secondary schools.

However, several limitations of this study should be acknowledged. Firstly, this study only involved respondents who were Mathematics trainee teachers at a local public university (UPSI), so the generalization of the findings needs to be interpreted carefully for the context of teaching training at other institutions. Secondly, this study only measured perceptions of kit usability and content validity but did not test the effectiveness of kits directly on pupils' performance, academic achievement, or emotional dealing in a real secondary school classroom. Next, the implementation of micro-teaching using these kits is limited in terms of time, resulting in the full potential of long-term kits not being fully explored.

Based on these limitations, several recommendations are highlighted for further study. First, the 3D Projection Kit is proposed to be tested for effectiveness in the actual classroom of secondary schools by directly involving school Mathematics teachers and Form Three students (Jamaludin et al., 2023). Future studies should use experimental or quasi-experimental designs (pre-tests and post-tests) to scientifically assess the impact of kits on students' academic achievement and spatial skills. Besides, these kits are proposed to be digitally improved by integrating interactive augmented reality (AR) technology that can be accessed through students' smartphones (Ozcakir & Cakiroglu, 2021; Voulgari et al., 2024). Third, qualitatively advanced studies (such as classroom observations and focus group interviews) should be conducted to analyze how pupils interact with the kit directly to document the operational challenges and visual learning of geometry more holistically.

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