Development of an Interactive Learning Kit for Basic Polygons as a Teaching Aid for the Topic of Basic Polygons in Form One

Nur Haizatul Ummi Awang Jalihi[1], Nurul Akmal Mohamed[1]*, Nurul Huda Mohamed[1], Nur Fadhilah Ibrahim[2], Nurul Hila Zainuddin[1]

[1]Department of Mathematics, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, Malaysia

[2]Faculty of Computer Science and Mathematics, Universiti Malaysia Terengganu, Malaysia

**Corresponding author: Nurul Akmal Mohamed (akmal.mohamed@fsmt.upsi.edu.my)*

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ABSTRACT

Students often face difficulties in understanding basic polygon concepts due to the abstract nature of geometry and the continued reliance on conventional, teacher-centred instructional approaches. The lack of interactive and structured teaching aids further limits students' ability to visualise and internalise geometric properties effectively. The purpose of this study is to develop an Interactive Learning Kit for Basic Polygons as a teaching aid for the Basic Polygons topic for Form One and to test the validity and usability of the Interactive Learning Kit for Basic Polygons among Form One students for the Basic Polygons topic. The Form One Interactive Learning Kit for Basic Polygons, developed based on the ADDIE model, was designed and developed using the Development Research Design (DRD). This study involved 30 Form One in a secondary school in Kuala Penyu, Sabah, through convenience sampling. A questionnaire instrument was used to evaluate the validity and usability of the Interactive Learning Kit for Basic Polygons in this study. The validity of the Interactive Learning Kit for Basic Polygons was assessed using the Content Validity Index (CVI) through evaluations by three experts in the field of Mathematics, while the usability aspect of the kit was analysed based on descriptive statistics for the mean values and standard deviations obtained from the data analysis conducted using the Statistical Package for the Social Sciences (SPSS). The CVI value obtained is 1.00, indicating that this Basic Polygon Interactive Learning Kit has satisfactory validity. Furthermore, the overall average of the usability for the Basic Polygon Interactive Learning Kit is 3.90. Therefore, this Basic Polygon Interactive Learning Kit has a satisfactory level of validity and usability, reflecting the constructs of usefulness, ease, and satisfaction, achieving a high level of agreement among respondents. This study proves that the Basic Polygon Interactive Learning Kit has the potential to improve students' understanding through an interactive learning approach.

Keywords:
Basic Polygon; Interactive learning kit; Validity; Usability; ADDIE model

Introduction

Mathematics is a pillar subject that is critical in instilling logical, systematic, and critical thinking among learners, especially in secondary school (Maine et al., 2021). Nevertheless, there are still weaknesses in mathematics education, and some students struggle with mastering basic concepts, particularly geometry (Kit & Mahmud, 2023). Such challenges are particularly evident in subjects such as polygons, where students commonly struggle to understand the various types of polygons and their defining features, resulting in poor learning outcomes (Nurhakim et al., 2023).

Geometric concepts are abstract, and this aspect requires students to engage in higher-order thinking and conceptualisation, which may be extremely challenging when the teaching process relies on conventional methods (Halil & Mahmud, 2022). Traditional approaches that focus on lectures and textbook-based instruction are less effective at fostering meaningful interaction and in-depth learning of geometry concepts (Cai et al., 2024). The absence of the interactive components of such methods also restricts students' ability to explore themselves and acquire independent learning (Prestiani et al., 2021).

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Past research has also reported a lack of interactive learning modules specifically designed to support the instruction of fundamental geometry concepts, such as polygons (Putri et al., 2021). Although the application of visual and multimedia-based instructional materials has been demonstrated to improve students' conceptual knowledge in geometry, their use in classroom practice remains underdeveloped (Afifah & Kusuma, 2021).

Geometry has continued to be among the challenging topics in secondary mathematics education in Malaysia. National and local research studies always indicate that students have problems with mastering basic geometrical lessons, especially in recognition, categorising, and visualisation of shapes. According to Malaysian-based research, it was found that students tend to have poor conceptual knowledge and memorise instead of using meaningful reasoning when learning geometry subjects (Ali et al., 2024). These problems are also reflected in the trends of the national performance when the geometry-related items remain at a lower level of achievement compared with other fields of mathematics (Udin et al., 2024). This is clearer in some areas, such as Sabah, Malaysia. Research carried out in Malaysia indicates that students in rural and semi-urban schools have extra difficulties because they cannot access teaching aids and do not get exposure to manipulative-based or interactive forms of teaching (Hashim et al., 2023).

It is also reported by teachers that students have difficulties relating the definitions of polygons, including the number of sides, angle properties, and regularity, with their visual images. This leads to confusion, especially in the different types of quadrilaterals and the interpretation of convex and concave polygons. This research indicates that teaching aids aimed at teaching geometry at secondary schools in Malaysia, especially in Sabah, are necessary and must be contextually meaningful and interactive. Sequential development of structured instructional aids, including interactive learning kits, has been suggested as one of the pragmatic interventions to facilitate conceptual learning and student interest in geometry learning (Shaimi et al., 2023). This has led to the necessity to create instructional resources that will help in filling the gap between abstract mathematical concepts and the concrete learning experiences of students.

To overcome these challenges, a Basic Polygon Interactive Learning Kit is presented as an alternative teaching aid to facilitate the teaching and learning process of the Basic Polygon topic at the Form One level. The kit aims to encourage participation and support the development of concepts through interactive learning processes (Putri et al., 2021). The main objective of the research is the creation of an interactive learning kit and the testing of its validity and usability regarding the topic of the Basic Polygon, which will be used as a teaching tool. Based on this, the following research questions will guide the study:

1. Does the Basic Polygon Interactive Learning Kit demonstrate satisfactory validity as a teaching aid for the Basic Polygon topic in Form One?
2. Does the Basic Polygon Interactive Learning Kit demonstrate satisfactory usability as a teaching aid for the Basic Polygon topic in Form One?

The study aims to contribute to the growing research on the design of interactive instructional materials that can enhance students' understanding of basic geometry concepts in secondary mathematics.

Literature Review

The abstract nature of geometry and the need to use spatial reasoning make it always one of the most difficult subjects in secondary mathematics (Halil & Mahmud, 2022). In a few studies, it is reported that students have acute difficulties recognising geometric shapes, their properties, and using geometry to solve problems (Nurhakim et al., 2023). Specifically, the polygon subject, including quadrilaterals and their properties, remains problematic for Form One students, with misconceptions and poor performance often leading to misconceptions (Baharudin and Abdullah, 2024). Conventional teaching practices, with a strong emphasis on lectures, textbooks, and memorisation of concepts, have since been found inadequate to address students' conceptual challenges in geometry (Cai et al., 2024). Such methods do not tend to offer the possibility to engage, visualise, and explore, which are essential in learning geometrical concepts (Akmal, 2022). Therefore, students are more likely to be passive learners, which limits their capacity for higher-order thinking and self-learning (Prestiani et al., 2021).

There has been interest in multimedia-based interactive learning kits and teaching aids as an alternative to traditional teaching strategies in mathematics education. The previous literature suggests that interactive kits may motivate and engage students and improve their conceptual learning by making abstract mathematical concepts real through experiential learning (Fitriyah et al., 2025). Studies on educational kits in geometry and algebra have consistently shown successful results in terms of usability, learning satisfaction, and teaching satisfaction (Zulkiflee et al., 2025). In addition, the potential of interactive learning tools has been further expanded by the future of educational technology, including artificial intelligence (AI) and learners' digital environments. Learning systems supported by AI can provide highly personalised scaffolding and adaptive feedback, allowing students to study at their own pace and receive relevant guidance (Riastuti & Suryadi, 2023). Though these technologies may be more actively discussed in the context of higher education, their principles (scaffolding, learner-centred design, and so on) are highly applicable to the teaching of mathematics in secondary schools today.

Despite developing an interest in interactive teaching aids, there is still a need for systematically developed and empirically evaluated learning kits that align with curriculum standards and student ability levels. Validity and usability are important aspects that facilitate the success of an instructional tool in a classroom context (Lynn, 1986). Hence, gap identification in geometry teaching at the secondary level requires the design and testing of a Basic Polygon Interactive Learning Kit that is valid and practical to use.

Methodology

Research methodology refers to the procedural or methodological way in which a researcher plans, conducts, and analyses a study. The research methodology is relevant to the research process to ensure the study is conducted in an orderly, valid, and reliable manner.

Research Design

The research used a quantitative design within the framework of Design and Development Research (DDR), which emphasises the systematic creation and testing of educational products. This study aimed to create a Basic Polygon Interactive Learning Kit and test its validity and applicability as a teaching tool for Basic Polygons in Form One Mathematics. This has followed the ADDIE instructional design model, with five stages: Analysis, Design, Development, Implementation, and Evaluation. The DDR framework in this research was applied to the overall research process, whereas the ADDIE model was used to organise systematic design and development of the learning kit. The ADDIE model was chosen because it is a structured, iterative model that can be successfully applied to the development of instructional materials in an educational setting.

Population and Sample

The sample for this research comprised Form One students at a secondary school in Kuala Penyu, Sabah, who were studying the topic Basic Polygon in Mathematics. The target population was 96 students. A total of 30 students in this population were selected as the study sample using convenience sampling. Convenience sampling was selected because respondents are readily available and feasible in studies involving education, which are conducted with limited time and resources (Taherdoost, 2016). Kadam & Bhalerao (2023) confirm that quantitative pilot studies can be done with a sample of 15 participants. Thus, it can be stated that the sample size employed in the study was sufficient to assess the usability of the developed learning kit. Also, three educationists in Mathematics were chosen to test the validity of the learning kit. The sample of three experts is also in line with Lynn's (1986) recommendation, which indicates that three experts are sufficient to conduct a content validity assessment. Every specialist had at least 5 years of teaching mathematics education.

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Table 1
Profile of Experts Involved in the Content Validity Evaluation

Expert	Academic Qualification	Area of Specialisation	Current Position	Teaching Experience (Years)	Curriculum / Assessment Experience
E1	Bachelor of Education in Mathematics (Hons.)	Mathematics Education	Mathematics Teacher	30	Serving as an exam committee member
E2	Bachelor of Education in Mathematics (Hons.)	Mathematics Education	Mathematics Teacher	11	Involved in curriculum planning at the department level
E3	Bachelor of Education in Mathematics (Hons.)	Mathematics Education	Excellent Teacher (Guru Cemerlang)	25	Serving as Mathematics head of panel

Research Instruments

As the key research tools, two sets of questionnaires were utilised. Validity Evaluation Instrument. The initial questionnaire was developed to provide the face and content validity of the Basic Polygon Interactive Learning Kit. This tool was divided into two parts:

1. Section A: This section was used to gather demographic data on the experts, including education, area of specialisation, and years of teaching experience.
2. Section B comprised questions assessing the appropriateness, intelligibility, precision, and applicability of the information, language, presentation, and instructions in the learning kit, as an interactive pedagogical resource for the subject of Basic Polygon.

Usability Evaluation Instruments

The second questionnaire was administered to students to evaluate the usability of the developed learning kit. The usability instrument measured three constructs commonly used in educational technology research, namely usefulness, ease of use, and satisfaction.

The usability questionnaire consisted of 15 items organised into three constructs: usefulness, ease of use, and satisfaction. Each construct was measured using five items. Section A assessed the usefulness of the Basic Polygon Interactive Learning Kit, Section B evaluated its ease of use, and Section C measured students' level of satisfaction after using the kit. All items in both questionnaires were measured using a four-point Likert scale, ranging from strongly disagree (1) to strongly agree (4).

Data Collection Procedure

The data collection process was conducted in two stages. First, the developed learning kit was evaluated by the selected experts to assess its face and content validity. Feedback and suggestions provided by the experts were used to refine and improve the learning kit. Subsequently, the revised learning kit was implemented with the selected student participants during a learning session on the Basic Polygon topic. After completing the learning session, students were required to complete the usability questionnaire to provide feedback on their learning experience using the interactive learning kit.

Data Analysis

All data collected in this study were quantitative in nature and analysed according to the type of instrument used. Data from the validity evaluation were analysed using the Content Validity Index (CVI). A CVI value of 1.00 was considered acceptable for instruments evaluated by three experts, in accordance with the guideline proposed by Lynn (1986). Data obtained from the usability questionnaire were analysed descriptively using the Statistical Package for the Social

Sciences (SPSS). Descriptive statistics, including mean scores and standard deviations, were used to determine students' perceptions of the learning kit across the three usability constructs. Higher mean scores indicated greater usability and positive acceptance of the learning kit.

Ethical Considerations

Ethical approval and permission to conduct the study were obtained from the school administration. Participation in the study was voluntary, and informed consent was obtained from all participants. Students' anonymity and confidentiality were maintained throughout the data collection and analysis.

Results

Validity of the Basic Polygon Interactive Learning Kit

Three Mathematics teachers with a minimum of 5 years of experience in the field determined the validity of the Basic Polygon Interactive Learning Kit using a questionnaire that measured face and content validity. The responses were rated on a 4-point Likert scale (1 = Strongly Disagree to 4 = Strongly Agree) and measured using the Content Validity Index (CVI), where CVI = 1.00 indicated acceptable validity for 2 to 4 experts.

Face Validity

The seven face validity items all had a CVI of 1.00, indicating that the layout, instructions, terminology, typography, spelling, and grammar used in the kit were appropriate and easily comprehensible to Form One students.

Table 2
Validity of the Basic Polygon Interactive Learning Kit Face

Validity of the Basic Polygon Interactive Learning Kit Face					
No.	Criteria	Expert 1	Expert 2	Expert 3	CVI Value
1	The layout of the learning kit is appropriate	1	1	1	1
2	The instructions for using this learning kit are clear	1	1	1	1
3	The terms used in the learning kit are appropriate	1	1	1	1
4	Type of writing suitable for use in the kit	1	1	1	1
5	The spelling in the learning kit is correct	1	1	1	1
6	The grammar used is good	1	1	1	1
7	The words used in the learning kit are common words	1	1	1	1
	Overall Average CVI Value				1.00

Content Validity

The nine content validity items also had a CVI of 1.00, which proves that the kit is acceptable to the Form One Mathematics KSSM curriculum alongside the learning standards on the topic of Basic Polygon, which is suitable for the ability of students.

Table 3
Validity of the Basic Polygon Interactive Learning Kit Content

No.	Criteria	Expert 1	Expert 2	Expert 3	CVI Value
1	The content of the Basic Polygon Interactive Learning Kit aligns with Form 1 Mathematics KSSM	1	1	1	1

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2	The content of the Basic Polygon Interactive Learning Kit meets the learning standards for the Basic Polygon topic	1	1	1	1
3	The Basic Polygon Interactive Learning Kit content meets the standard content of the Basic Polygon topic	1	1	1	1
4	The Basic Polygon Interactive Learning Kit content is suitable for the ability level of Form 1 students	1	1	1	1
5	The content of this Basic Polygon Interactive Learning Kit has the potential to improve students' achievement in the Basic Polygon topic for Form 1.	1	1	1	1
6	The content of this Basic Polygon Interactive Learning Kit has the potential to increase students' motivation towards learning the Basic Polygon topic in Form 1.	1	1	1	1
7	The contents of this Basic Polygon Interactive Learning Kit provide questions for the Basic Polygon topic, containing questions of various levels.	1	1	1	1
8	The content of the Basic Polygon Interactive Learning Kit is able to strengthen students' understanding of the concept of Basic Polygons.	1	1	1	1
9	Students can use this Basic Polygon Interactive Learning Kit to reinforce their understanding of the Basic Polygon concept.	1	1	1	1
Overall Average CVI Value					1.00

Usability of the Basic Polygon Interactive Learning Kit

The Basic Polygon Interactive Learning Kit was tested at Sekolah Menengah Kebangsaan St. Peter Bundu, Kuala Penyu, Sabah, with a pilot study involving 30 Form One students. The measure was done on three major constructs, which included usefulness, ease of use, and satisfaction, using a four-point Likert scale. These constructs are also well-known in educational technology research as important factors in assessing the practicality and effectiveness of a learning tool for classroom application (Cen et al., 2023).

Findings on Usability Constructs

As shown in Table 4, the results were as follows:

Table 4
Average Mean Score for Each Usability Aspect of the Basic Polygon Interactive Learning Kit

Construct	Number of Item	Mean Score	Interpretation
Usefulness	5	3.80	High
Ease of Use	5	3.93	High
Satisfaction	5	3.96	High
Overall	15	3.90	High

All three constructs were rated positively by the students, indicating that the kit is viewed as effective, easy to use, and fun for learning the basic concepts of polygons.

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The high scores in the usability category highlight a few key aspects concerning the effectiveness of the kit as an education tool:

1. Usefulness (3.80)
   The students found the kit useful in advancing their knowledge of polygon concepts.

2. Ease of Use (3.93)
   The ease-of-use score was high, indicating that the kit is user-friendly and intuitive, reducing unnecessary mental burden.

3. Satisfaction (3.96)
   Student satisfaction was rated highest, indicating a positive learning experience.

Discussion

The face and content validity unanimous CVI of 1.00 shows that all the experts agree that the Basic Polygon Interactive Learning Kit is suitable in the proposed learning environment. This implies that the design, terms, and structure of instructions of the kit are aligned to the needs of the Form One Mathematics KSSM curriculum. It is also an essential process in the development of instructional material because it is through expert validation that learning material is found to be sound pedagogically and in accordance with the standards of the curriculum before it can be put into practice in the classroom. The same studies have also pointed out that instructional resources reviewed by experts are more likely to exhibit better quality and effectiveness in facilitating conceptual learning in mathematics education (Musikin et al., 2023; Sutomo and Turmudi, 2024). The high validity scores thus give preliminary evidence that the kit can be used to support the teaching and learning of polygon concepts among the Form One students.

The scores of usability are high in terms of usefulness, ease of use, and satisfaction, which shows that the students are positive about interactive learning aids. This implies that the kit promotes active learning, enhances engagement, and promotes self-exploration of geometry concepts, which is in line with previous research (Sharova et al., 2024; Zulkiflee et al., 2025).

The findings indicate that the kit is highly useful in supporting students' understanding of polygons, as it helps translate abstract geometric concepts into more concrete learning experiences. In terms of ease of use, the high scores suggest that the kit is user-friendly and effectively minimises cognitive load, making it accessible to students with varying levels of digital literacy (Cen et al., 2023). Additionally, students reported high levels of satisfaction, reflecting positive learning experiences that can motivate them to continue engaging in learning activities (Nahar & Sulaiman, 2024).

In general, the results justify using student-centred and interactive methods of teaching geometry in high schools. The kit can be especially useful in rural or under-resourced regions, including Sabah, Malaysia, where the availability of traditional teaching aids is low (Hashim et al., 2023). The findings of this research prove that the Basic Polygon Interactive Learning Kit is a valid and useful teaching tool that can be used by the students of Form One learning the topic of the Basic Polygon. The Content Validity Index (CVI=1.00) of both face and content validity is unanimous, which proves that the kit is expert-approved in terms of clarity, layout, terminology, compliance with the KSSM curriculum, and applicability to the target student population. The result is consistent with the earlier studies that indicate that properly organized, curriculum-based, and reviewed instructional resources have a positive impact on conceptual knowledge and motivation in students (Musikin et al., 2023; Sutomo and Turmudi, 2024). The high validity suggests that the kit is efficient in closing the gap between abstract geometric concepts and the tangible learning experiences of the students, which is essential in the case of geometry, where it is essential to have high spatial reasoning abilities (Halil & Mahmud, 2022).

Regarding usability, the high ratings of usefulness (3.80), ease of use (3.93), and satisfaction (3.96) indicate that the kit is a positive and effective learning experience. The results indicate that the kit facilitates student-centred learning, which is active and allows students to discover the concept of polygons by themselves with guided instructions. The usefulness score is high, which means that students find the kit useful to improve their knowledge of the properties of

polygons, which is consistent with the previous research pointing to the significance of interactive learning aids in converting abstract knowledge into coherent and interesting information (Sharova et al., 2024; Zulkiflee et al., 2025).

The findings of the ease-of-use indicate the significance of the intuitive design in educational technology. The kit enables students with different digital literacy levels to concentrate on the learning of mathematical concepts instead of being frustrated with the interface by reducing cognitive load and making it easier to navigate (Cen et al., 2023; Pambudi et al., 2023). In the meantime, the high satisfaction score indicates that students are positive about the learning tool, which is a key element in creating motivation, engagement, and long-lasting interest in mathematics learning (Nahar and Sulaiman, 2024).

Collectively, these results contribute to the idea that interactive learning kits could be used to improve conceptual learning, engagement, and motivation in secondary mathematics learning, especially in traditionally challenging areas, like polygons. The findings also indicate the possibility of such kits being used in under-resourced environments, including rural areas in Sabah, Malaysia, where the availability of manipulative-based and interactive teaching aids is low (Hashim et al., 2023). In general, the research shows that the Basic Polygon Interactive Learning Kit has both pedagogical and practical advantages. Its inclusion in the classroom practice can help to create more meaningful, interactive, and student-centred learning experiences and, therefore, lead to better learning outcomes in geometry. Future research might consider the assessment of several schools, academic performance indicators, and improvements through the use of augmented reality (AR) or AI-based capabilities to further improve student engagement and comprehension.

Conclusion

Overall, the proposed study developed the Basic Polygon Interactive Learning Kit as a teaching resource for the Form One topic of Basic Polygons. Assessment of the kit has shown it has a high level of validity, and the expert ratings yield a Content Validity Index (CVI=1.00) for face and content validity. Also, a pilot study with 30 students showed high usability, and the mean scores for usefulness, ease of use, and satisfaction totalled 3.90, which is above the recommended minimum.

The results indicate that the Basic Polygon Interactive Learning Kit could be used as an effective and engaging teaching method, promoting active student interaction and improving knowledge of polygon principles. Its implementation supports student-centred learning, and learners can be exposed to mathematical concepts on their own, with structured guidance. This research, however, has several limitations. To begin with, the pilot study was limited because it was conducted in a single school and involved a sample of 30 students, which restricted the generalisability of the results. Secondly, the usability testing was based solely on questionnaires and did not include classroom observation or direct analysis of academic performance, which could provide a broader view of the kit's effectiveness. To conduct further studies, it is suggested that the kit be evaluated in more schools with higher- and more mixed-student groups. The mixed-methods assessment, which involves observation in the classroom, the assessment of academic performance, and an interview with students and educators, would give more insight into its efficiency. It is also possible to conduct further studies to explore the integration of augmented reality (AR) or AI-based learning applications to boost students' interactivity and learning experiences. Finally, this paper identifies that the creation of the Basic Polygon Interactive Learning Kit not only facilitates more interactive teaching of mathematics but also sets the stage for future advancements in STEM education in secondary schools, specifically by improving students' understanding of abstract concepts such as geometry.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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