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Usability of WebMath-Kit as an Educational Platform for the topic Network in Graph Theory Among Grade 11 pupils in South Malaysia

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Abstract

The primary aim of WebMath-Kit is to address the challenges pupils face in understanding complex mathematical concepts by providing interactive, engaging, and visually appealing learning materials for the topic Network in Graph Theory. The platform includes components such as a learning kit, assessments, and a chatbot to facilitate comprehensive learning experiences. To evaluate its usability and effectiveness, a sample consists of 39 Grade 11 pupils were chosen in one of the high schools located in South Malaysia. Results indicated high reliability and validity, with Cronbach's Alpha $\alpha = 0.95$ demonstrating strong internal consistency. About 92% strongly agree that usability of the WebMath-Kit as a teaching and learning platform and the average mean score across all items is 3.926, with an average standard deviation of 0.176. Usability assessments revealed that pupils found the platform user-friendly, engaging, and helpful in enhancing their understanding of Network in Graph Theory. The WebMath-Kit features interactive elements, gamification, and Dual Language Programme (DLP) options to cater to diverse student needs and preferences. Expert feedback and pilot study outcomes suggest further improvements in navigation, visual content, and interactive features. Overall, WebMath-Kit represents a significant advancement in mathematics education, providing a robust and adaptable tool for teaching and learning complex mathematical concepts.

Keywords: Network in Graph Theory, Canva Website Design, Technology Education

INTRODUCTION

Graph theory, an integral part of discrete mathematics, is increasingly included in high school curriculums due to its applications in various fields such as computer science, biology, and social sciences. Networks in graph theory, which involve the study of graphs as representations of pairwise relationships between objects, can be particularly challenging for students. This literature review aims to identify and discuss the common problems faced by high school pupils in learning network concepts in graph theory. Mathematics education is essential in developing critical thinking, problem-solving, and logical reasoning skills among pupils. Integrating technology into the mathematics curriculum has the potential to enhance learning experiences and outcomes significantly. This study focuses on the usability of WebMath-Kit, an innovative educational platform designed to teach Network in Graph Theory to Grade 11 pupils by utilising Canva website design. The platform aims to address the challenges pupils face in understanding complex mathematical concepts through interactive and engaging learning materials. The integration of technology in education has revolutionised teaching and learning methods. One such innovation is the WebMath-Kit, designed to

enhance the understanding of Network in Graph Theory for Grade 11 pupils. This study evaluates the usability of WebMath-Kit, utilising Canva website design, to address challenges in grasping complex mathematical concepts. Research indicates that integrating technology into mathematics education enhances visualisation and problem-solving capabilities [1]. Traditional curriculum often struggles to keep pace with technological advancements, highlighting the need for innovative educational tools (Ahmad, 2020). WebMath-Kit, guided by the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), incorporates constructivist learning and inquiry-based approaches. It aims to make abstract concepts tangible through interactive and engaging materials [2-3]

OBJECTIVES AND RESEARCH QUESTIONS

The main objective to be obtained through the implementation of this study is to determine the usability of WebMath-Kit as an educational platform for the topic Network in Graph Theo-ry by utilizing Canva website design among Grade 11 pupils. In line with it, the two specific ob-jectives that researcher want to lead are to determine the validity of the WebMath-Kit as a learning and teaching platform for the topic Network in Graph Theory among Grade 11 pupils and to evaluate the usability of the WebMath-Kit as a learning and teaching platform for the topic Network in Graph Theory among Grade 11 pupils. Within the purpose of this research, the subsequent inquiries are addressed:

1. What is the validity of the WebMath-Kit as a learning and teaching platform for the top-ic Network in Graph Theory among Grade 11 pupils?
2. What is the reliability of the WebMath-Kit as a learning and teaching platform for the topic Network in Graph Theory among Grade 11 pupils?
3. What is the reliability of the WebMath-Kit as a learning and teaching platform for the topic Network in Graph Theory among Grade 11 pupils?

LITERATURE REVIEW

Graph Theory and Network Theory are important parts of math education. They help students understand relationships and functions [4]. Countries like Germany, the United States, Indonesia, and Malaysia include these topics in their school programs, showing their importance in real-life situations like social networks, transportation, and computer networks [5].

The abstract ideas in graph theory can be hard for high school students to understand. Concepts like vertices, edges, paths, and cycles need a level of thinking that students may not have developed yet. Students often come to graph theory classes with misunderstandings, like mixing up graphs with charts or not knowing the difference between directed and undirected graphs. An older article by Dubinsky & Harel (1992) talks about how these misunderstandings can affect learning advanced math concepts and suggests that fixing these misunderstandings early can help students learn better [6]. A study by Bouzid, Khelladi, & Chanchary (2020) shows that students struggle with abstract graph theory concepts, and traditional teaching methods often do not help [7]. Goos, Galbraith, & Renshaw (2020) discuss how student disengagement affects learning in math, highlighting the need for interactive teaching methods to keep students interested [8]. To address these issues, several solutions have been proposed. The use of digital tools and resources, like math websites and educational tools, has changed the learning experience [9]. These platforms provide interactive experiences, personalized learning, and chances for collaboration. Research shows that using technology in math education can greatly improve student engagement, motivation, and understanding of complex concepts. Rodríguez, Nussbaum, & Dombrovskaia (2021) look at how dynamic geometry software and other visualization tools help teach graph theory, finding that these tools improve students' understanding and engagement [10]. A study by Ke (2021) examines how gamification affects student motivation and learning in graph theory, concluding that gamified learning can significantly boost motivation and understanding [11]. More advanced methods include virtual and augmented reality technologies that offer immersive learning experiences to help students understand abstract graph theory

concepts better. A study by Parong & Mayer (2021) evaluates how effective virtual reality is in teaching complex math concepts, including graph theory, finding that VR can improve spatial reasoning and understanding [12].

Recent studies suggest that technology can help high school students learn network concepts in graph theory. Interactive software, gamification, online learning platforms, virtual and augmented reality, and adaptive learning technologies are useful tools that can improve understanding, engagement, and motivation. Ongoing research and investment in these technologies, along with proper teacher training, are crucial for maximizing their benefits in math education. This article focuses on creating a webpage called WebMath-Kit to address some of the challenges high school students face in learning network concepts in graph theory. Interactive software, gamification [13], online learning platforms, virtual and augmented reality, and adaptive learning technologies are valuable tools that can enhance understanding, engagement, and motivation, and even a simple webpage design can help solve this problem.

METHODOLOGY

The study involved 39 Grade 11 students from a high school in South Malaysia. The students were chosen using stratified random sampling, which means dividing the population into groups with similar traits and randomly selecting from each group. This method ensures that different parts of the population are fairly represented. Graph Theory and Network Theory are key topics in math education. They help students understand relationships and functions. Countries like Germany, the United States, Indonesia, and Malaysia include these subjects in their school programs, showing their relevance in real-life situations like social networks and transportation.

Graph theory can be challenging for high school students. Concepts like points, lines, paths, and cycles require advanced thinking that students may not have developed yet. Many students enter graph theory classes with misconceptions, such as confusing graphs with charts or not understanding directed versus undirected graphs. An older article notes that these misunderstandings can hinder learning advanced math concepts and suggests addressing them early to improve learning. Research indicates that students often struggle with abstract graph theory concepts, and traditional teaching methods may not be effective. Another study highlights how student disengagement can impact math learning, emphasizing the need for interactive teaching methods to keep students engaged. It also points out that teachers often lack the necessary training to teach complex math concepts and calls for better training programs. To tackle these challenges, several solutions have been proposed. The use of digital tools and resources, such as math websites and educational tools, has transformed the learning experience. These platforms offer interactive experiences, personalized learning, and opportunities for collaboration. Research shows that incorporating technology in math education can significantly enhance student engagement, motivation, and understanding of complex concepts. Another study examines how dynamic geometry software and visualization tools aid in teaching graph theory, finding that these tools enhance students' understanding and engagement. A study investigates how gamification influences student motivation and learning in graph theory, concluding that gamified learning can greatly improve motivation and comprehension. Additionally, another study explores the role of online courses in teaching graph theory, noting that these platforms provide high-quality content and interactive learning that can complement traditional classroom teaching. More advanced methods include virtual and augmented reality technologies that offer immersive learning experiences to help students grasp abstract graph theory concepts better. A study assesses the effectiveness of virtual reality in teaching complex math concepts, including graph theory, finding that VR can enhance spatial reasoning and understanding. The research used various tools, including need analysis questionnaires, usability questionnaires, reliability questionnaires, and validation questionnaires, to collect data on the platform's effectiveness.

The data collection process began with obtaining permission from the Education Planning and Research Division (EPRD) under the Malaysian Ministry of Education. This step was essential as it allowed

the research to be conducted in schools with students as participants. The application for EPRD permission included submitting a completed form along with supporting documents such as a confirmation letter of student status from the university, a detailed research proposal, and the instruments to be used in the study. After receiving EPRD approval, permission was sought from the State Department of Education (JPN) for the relevant states where the study would take place. Once both EPRD and JPN permissions were secured, the researcher approached selected schools to request permission from the headmaster or principal, explaining the study's purpose and procedures. The study location was chosen to ensure easy access for researchers and minimize costs. Finally, respondents were selected using a stratified random sampling method to ensure fair representation of the population. The selected respondents completed questionnaires, providing the necessary data for the study. This organized approach ensured compliance with regulations, systematic data collection, and the generation of reliable and valid data.

RESEARCH DESIGN

The study employed a mixed-methods approach, utilising both quantitative and qualitative data to evaluate the usability of WebMath-Kit. The research design was guided by the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), which provided a structured framework for developing and assessing the educational platform [14-15].

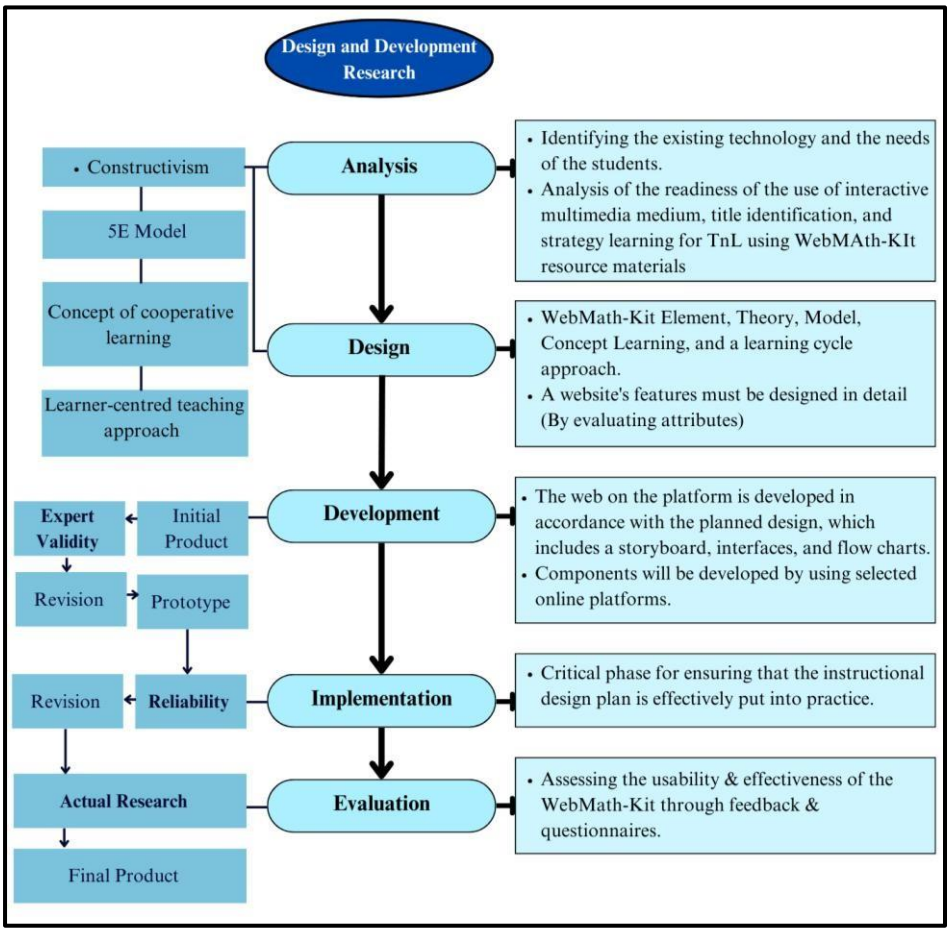

Figure 1. ADDIE Model

ANALYSIS

The analysis phase gives an overview of a platform designed to improve the learning experience for Grade 11 Mathematics students, especially on the topic of Network in Graph Theory, which is important in the Malaysian High School Mathematics syllabus. According to Ahmad Zamzuri (2019) [16], there are six key components to consider: objectives, users, content, methods, platform, and software.

1. Objective:
The main goal is to help Grade 11 students understand Network in Graph Theory and how it applies in real life. The platform aims to make difficult math concepts easier and more interesting, which should help improve students' grades and interest in the subject.

2. User
The platform is made for Grade 11 Mathematics students, usually aged 15 to 17. This age group was chosen based on the curriculum and their development stage, making sure the content is suitable and helpful.

3. Content
The content is carefully created based on the needs of Grade 11 Mathematics students. It includes the existing WebMath-Kit and other resources made by students. The WebMath-Kit aligns with the KSSM syllabus, covering key topics in Network in Graph Theory. The topics are selected to meet the learning goals from the survey, ensuring they fit the students' needs and interests. The content has explanations, examples, and interactive parts to help with learning.

4. Method
The platform uses different teaching methods to support various learning styles.

5. Platform
The platform uses interactive multimedia to create a fun and engaging learning experience. An analysis of teachers' readiness to use multimedia in their teaching was done, showing the need for training. The platform is available online, so students can use it on computers, laptops, and mobile devices. This allows students to access learning materials anytime and anywhere, promoting ongoing learning.

6. Software
The development of the platform leverages several software tools to create a robust and user-friendly learning environment:

- Canva: A tool for creating attractive educational content easily.
- Writesonic: An AI tool that helps make content quickly and efficiently.
- YouTube: A platform for sharing lesson videos, making it easy to host instructional content.
- Quizizz, Kahoot, Mblock, Makar, Genially, and Wordwall: Tools for fun quizzes and interactive learning activities.
- Padlet, Mantee meter, and Jamboard: Tools for working together online.
- Google: A service for storing and managing files. It can hold videos, textbooks, and worksheets. Google Forms can also be used to check students' understanding quickly.

DESIGN

The design phase incorporates elements from various learning theories and models, such as constructivist learning, inquiry-based approaches, and the 5E instructional model. The WebMath-Kit website was designed with three main components: Learning Kit, Assessment, and Chatbot. A draft of the website was created to serve as a guide, including essential components like the front page, introduction, table of contents, and detailed sections for each major component. This draft helped ensure that the final website would be

well-structured and comprehensive. Nevertheless, the flowcharts are the brief descriptions of navigation or sequence of the activities.

DEVELOPMENT

During development, designs from the earlier phase are turned into a working website (https://cikguzurina.my.canva.site/webmath-kit) using Canva. The WebMath-Kit includes interactive elements like text, images, animations, audio, and video to make learning fun. It also uses AI tools like Writesonic for creating content and Canva for design. QR codes help users easily access parts of the WebMath-Kit, such as manuals, teaching videos, and lesson slides. A diagram shows how the main parts of the WebMath-Kit work together, including user management, lessons, assessments, and chatbot features.

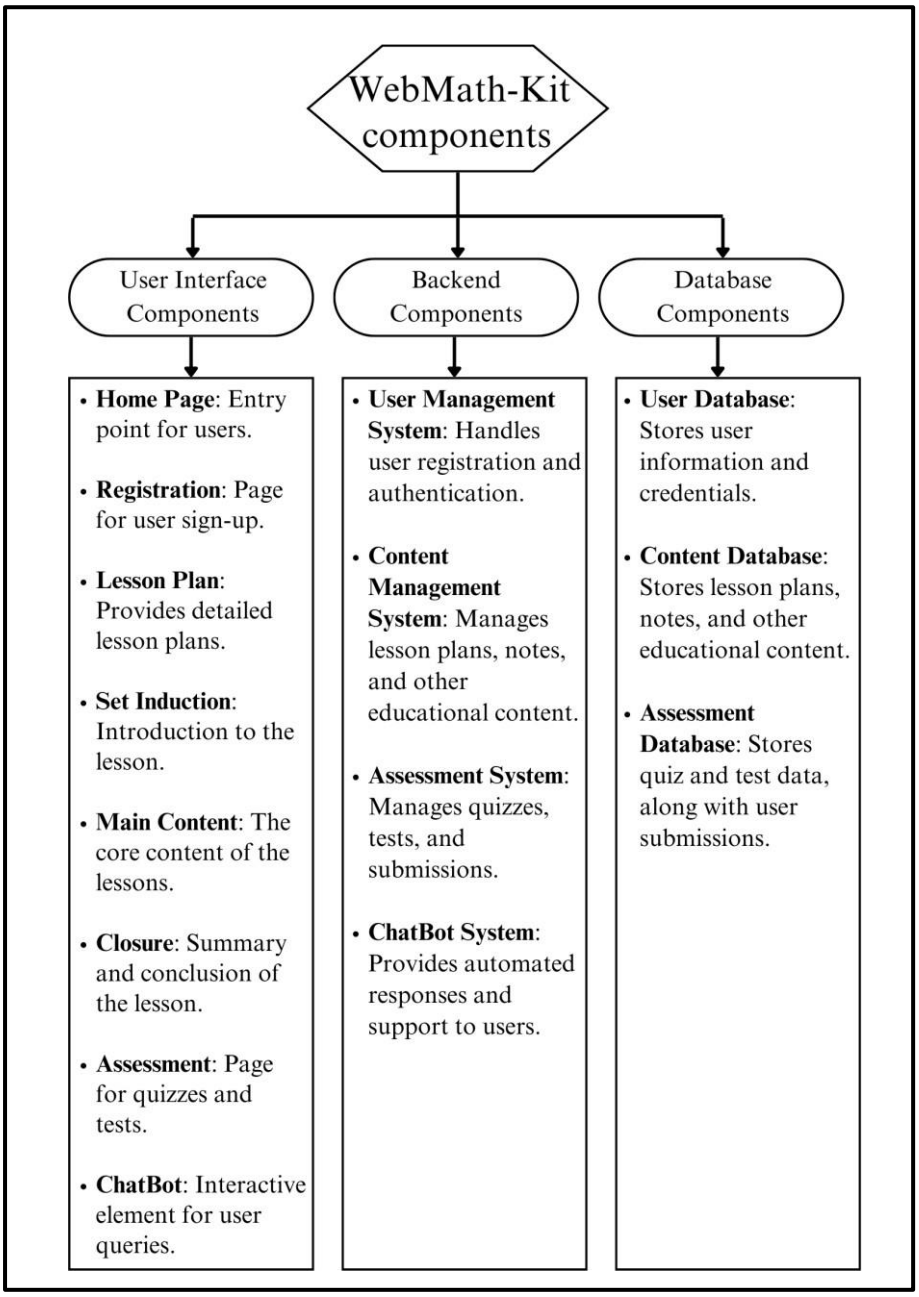

Figure 2. Main components and their interactions

Ensuring the validity of the data collected during this phase was essential to accurately identify the needs and challenges [16]. The instrument's validity was first confirmed by three experts during the development phase. Also referred to as this phase also seeks to conduct a more comprehensive examination of the platform that has been developed from a variety of perspectives, such as its functionality, its ability to captivate pupils, and its compliance with the requirements, which include the utilisation of WebMath-Kit.

IMPLEMENTATION

The implementation phase involves the practical application of the WebMath-Kit in a real educational setting. A pilot study was conducted at one of the high schools in South Malaysia using stratified random sampling to select participants. This phase aimed to test the reliability of the WebMath-Kit and gather formative feedback from pupils. During the pilot study, the Reliability Questionnaire was tested to ensure that it not only measured what it was intended to measure (validity) but also provided consistent results (reliability). Despite initial validations by experts, the pilot study revealed some navigation issues, leading to necessary modifications before the actual study commenced.

EVALUATION

The evaluation phase focuses on assessing the usability and effectiveness of the WebMath-Kit. Pupils used the platform during tutoring sessions and provided feedback through the WebMath-Kit Usability Questionnaire. This evaluation aimed to measure how well the WebMath-Kit facilitated learning and whether it met the educational objectives. The data collected was analyzed using the average score value method to determine the mean usability score, ensuring that the WebMath-Kit effectively supported student learning. Ensuring the validity of the evaluation process was crucial to accurately assess the effectiveness of the WebMath-Kit in achieving its educational goals.

RESULTS AND DISCUSSION

The research findings on the WebMath-Kit, an educational platform developed to enhance the learning experience of Grade 11 pupils in the topic of Network in Graph Theory. The study aimed to evaluate the WebMath-Kit's validity, reliability, and usability through expert assess-ments and student feedback.

Validity Analysis

The WebMath-Kit was reviewed by three experts: two math teachers and a lecturer from Universiti Pendidikan Sultan Idris (UPSI). They looked at five areas: content, design, interactivity, user-friendliness, and suitability. Each expert rated the items from 1 (Not Relevant) to 4 (Highly Relevant). The results showed that all content items got a perfect score of 1.00, meaning all experts agreed the content was relevant to learning goals and suitable for the audience. Most design items also scored high, with font size, background, graphics, and colors getting a score of 1.00. However, the type of writing and ease of accessing links had lower scores. The interactivity of the WebMath-Kit was mostly positive, with audio interactivity and overall features scoring 1.00, while the menu and clickable options scored lower. All user-friendliness items scored 1.00, showing that the WebMath-Kit was easy to use. Items about the platform's suitability for teaching and learning also scored 1.00, indicating it is effective for helping teachers and engaging students.

Reliability Analysis

The reliability of the WebMath-Kit was evaluated using Cronbach's Alpha, a measure of internal consistency. The study involved 39 Grade 11 pupils who used the WebMath-Kit and completed a reliability questionnaire. The overall Cronbach's Alpha value for the WebMath-Kit was 0.95, indicating very high

reliability. Individual constructs such as usefulness, content, and satisfaction also exhibited high reliability, with Cronbach's Alpha values ranging from 0.853 to 0.908.

Usability Analysis

The usability of the WebMath-Kit was assessed through a questionnaire distributed to 39 Grade 11 pupils. The questionnaire consisted of 25 items divided into three constructs: satisfaction, content, and usage.
Usability of WebMath-Kit

	Usefulness	**Contents**	**Satisfaction**
Percentage (%)	98	99	99
Mean	3.926	3.953	3.966
Standard Deviation	0.176	0.181	0.113

The results indicated a high level of satisfaction among pupils, with an average mean score for satisfaction items of 3.966 and a standard deviation of 0.113. Lower standard deviation means in usability data indicate that students generally find the learning tools or environments effective and engaging. This suggests that most students are experiencing positive interactions, which can lead to enhanced learning outcomes. Items such as the platform's ability to attract interest, improve mastery, and overall satisfaction achieved perfect scores of 4.00. The content of the WebMath-Kit was also highly rated, with an average mean score for content items of 3.953 and a standard deviation of 0.181. Pupils found the platform useful for understanding the topic content and the effectiveness of exercises, which received high scores. The usage construct also showed positive results, with an average mean score of 3.926 and a standard deviation of 0.176. The platform was deemed useful for learning and problem-solving in Network in Graph Theory, with items related to ease of use and user-friendliness achieving perfect scores of 4.00. Together, these metrics suggest a strong overall engagement level, where students not only appreciate the usability of the tools but also benefit from them in a similar manner, fostering a cohesive learning experience.

Impact on Learning

The implications of the research on the WebMath-Kit as a learning and teaching platform for the topic Network in Graph Theory among Grade 11 pupils are significant and multifaceted. These engaging learning platforms leverage interactive tools, visualization, and gamification to enhance the learning experience for high school pupils studying graph theory. By providing dynamic and interactive environments, these platforms help students grasp abstract concepts more effectively and maintain their interest and motivation in the subject.

CONCLUSION

The findings from the study confirm that the WebMath-Kit is a valid, reliable, and user-friendly educational platform for teaching Network in Graph Theory to Grade 11 pupils. The platform's content, design, interactivity, and overall usability were highly rated by both experts and pupils. The high reliability scores further validate its effectiveness as a teaching and learning tool. The WebMath-Kit has the potential to significantly enhance pupils' understanding and engagement with the subject matter.

DECLARATION OF INTEREST

There is no conflict of interest with this study.

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