EJSIT

Development of E-Modules Discrete Math Learning Multimedia for *Discovery Learning*

Ni Nyoman Supuwiningsih[1], Ida Bagus Ketut Surya Arnawa[2], Ni Putu Linda Santiari[3],
I Made Ari Santosa[4], Joko Santoso[5], Edwar[6]
[1,4]Computer System, ITB STIKOM Bali, Indonesia
[2,3,5]Information System ITB STIKOM Bali, Indonesia
[6]Informatic Management ITB STIKOM Bali, Indonesia

ABSTRACT

The purpose of developing learning multimedia for Discrete Mathematics courses based on discovery learning is to provide interactive, in-depth, and interesting learning experiences for students. Through the discovery learning approach, the main goal is to encourage students to be actively involved in the learning process, so that they can develop a deeper understanding of discrete mathematics concepts. Multimedia learning provides opportunities for students to explore these concepts through various media, such as videos, simulations, and direct interaction, which help them internalize the material better. The research subjects were ITB STIKOM Bali students who took the Discrete Mathematics course in the intermediate semester with a population of 35 students. The method used in multimedia development is MDLC (Multimedia Development Life Cycle) which consists of the stages of *Concept, Design, Material Collecting, Assembly, Testing and Distribution*. This e-module design applies use case diagrams, activity diagrams, sequence diagrams and storyboards. Testing includes blackbox with the results of all functions in the application running well; the second test of user trials using interviews with limited result is that overall students can accept the application well; the third test is a user trial using a Likert scale questionnaire, and the results of the Likert scale score are analyzed using the feasibility percentage formula with a value of 89.6 declared e-modules very feasible to use as discrete mathematics learning media.

Keywords: Learning Multimedia, Discrete Mathematics, Discovery Learning, MDLC

INTRODUCTION

Discrete mathematics is a branch of mathematics that studies distinct and separate objects and the relationships between these objects (Cahyani, 2019). Concepts in discrete mathematics have a crucial role in the development of information technology, computer science, and various other fields, but learning discrete mathematics is often considered difficult by most students because it is abstract and not easily understood. To overcome this obstacle, an innovative learning approach is needed to improve students' understanding and interest in discrete mathematics. Discovery Learning-based learning approach offers an interesting solution to improve students' understanding of Discrete Mathematics concepts. Discovery Learning allows students to be actively involved in the learning process, they are given the opportunity to discover and understand concepts independently through exploration, experimentation, and reflection, thus, students not only understand concepts more deeply, but also develop critical thinking skills and essential problem-solving abilities.

Discovery Learning is an effective learning approach but its implementation in discrete mathematics learning is often constrained by the availability of appropriate learning resources (Marisya & Sukma, 2020). In particular, the lack of interactive materials relevant to the learning context is often an obstacle in implementing this approach, therefore the development of discrete mathematics learning multimedia can be an effective solution to overcome these

obstacles. Learning multimedia offers various advantages in presenting learning materials, including the ability to present content visually, interactively, and engagingly. Multimedia-based discrete mathematics concepts can be conveyed in a more concrete way and easily understood by students. In addition, multimedia also allows variations in the presentation of material, so that it can be adapted to the learning style and individual needs of students.

The development of discrete mathematics learning multimedia based on Discovery Learning is an effort to provide interactive and interesting learning resources for students. Through this multimedia, students are given the opportunity to explore discrete mathematics concepts independently, thus strengthening their understanding of the learning material. In addition, learning multimedia can also increase student motivation in learning discrete mathematics, because it presents material in a more interesting way and is relevant to the context of everyday life. The development of discrete mathematics learning multimedia, effective multimedia design and in accordance with the principles of Discovery Learning are important. A good multimedia design must pay attention to the characteristics of Discovery Learning, such as presenting material in the context of real problems, providing challenges that are appropriate to the level of student understanding, and providing constructive feedback.

This research aims to develop Discovery Learning-based discrete mathematics learning multimedia that is effective and efficient in improving concept understanding and student learning motivation. This research method uses MDLC (Multimedia Development Life Cycle). The development of discrete math learning multimedia uses adobe animate software, image editing using canvas, audio editing software and so on. The results of this study are expected to make a significant contribution in the development of innovative and effective discrete mathematics learning methods.

MATERIALS AND METHODS

The research method used in this research uses MDLC (Multimedia Development Life Cycle) which consists of several stages (Kumala et al., 2021). The stage of creating a concept, the stage of application from starting to determine who the application user is (audience identification), identifying a problem with data collection techniques, the purpose of the application, media and determining specifications (Mustaghfaroh et al., 2021).

1. *Design*

   The stage where making a theme, idea, design appearance that will be made into an application later. At this stage, specifications are made of program architecture, style, appearance, and material requirements for the educational media to be created (Fauzan Febriansyah & Sumaryana, 2021).

2. *Material Collecting*

   The material collecting stage is the stage of having to select and determine the materials used and needed as material for making this educational application. This stage is the stage of collecting materials as needed (Rizal, Mursalim, & Kamaruddin, 2019).

3. *Assembly*

   The assembly stage is a process of implementing the previous stages processed and made into a combination that produces an application that has been designed (Sumaryana & Hikmatya, 2020).

4. *Testing*

   The testing stage is the stage where the results of the previously created application will be tested with the aim of knowing whether the application that has been made can run properly and properly, and also looking for errors and discontinuities in the application (Borman & Purwanto, 2019).

5. *Distribution*

The distribution stage is the stage where after the testing process is carried out, it will be published so that users can use it (Arpiansah et al., 2018).
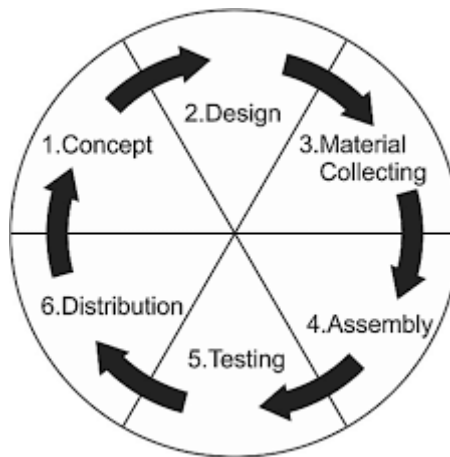
Figure 1. MDLC (*Multimedia Development Life Cycle*)

RESULTS AND DISCUSSION

Concept

At the concept stage, the research began with the identification of problems in learning discrete mathematics that required innovative solutions. The first step is to conduct a careful literature review to understand the theoretical basis of discrete mathematics learning, existing teaching methods, and the specific needs of students in understanding these mathematical concepts. This stage formulated clear research objectives based on the results of the literature review and identified the target population of students who would be the subject of the study. The next step is to plan appropriate data collection tools to measure the feasibility of e- modules discrete math with interviews and questionnaires. Discovery Learning is a learning approach that provides opportunities to discover and understand new concepts actively through exploration, experimentation, and self-discovery. The role of the lecturer is not as the main source of knowledge, but as a facilitator who guides students in the process of exploration and discovery. The main principle of *Discovery Learning* is that students learn more effectively when they are actively involved in constructing their own understanding through direct experience and reflection on that experience. This stage is an important foundation that will guide the development process of the next learning multimedia in this research.

Design

Use Case Diagram

A Use Case Diagram is a visual representation of the interaction between one or more actors (users or other external systems) and the system being developed or created (Fauzan et al., 2021). This diagram can help in modeling the functions that exist in the system and identifying who is entitled to use these functions. This research uses 1 actor, namely students as system users. This actor can access several functions, namely the main page function, learning objectives page, material menu page, material page, assignment page and quiz page. Students first before entering the material page read the learning objectives, the next step is to be able to access the can material that be selected, after studying the material, the exercise and quiz buttons will be active for students to do as shown in Figure 2 uses case diagram access to multimedia learning applications for Discrete Mathematics courses. *Use Case*

Diagram is a very useful tool in software development as it helps in planning, designing and communicating system functionality effectively among all stakeholders involved in the project.
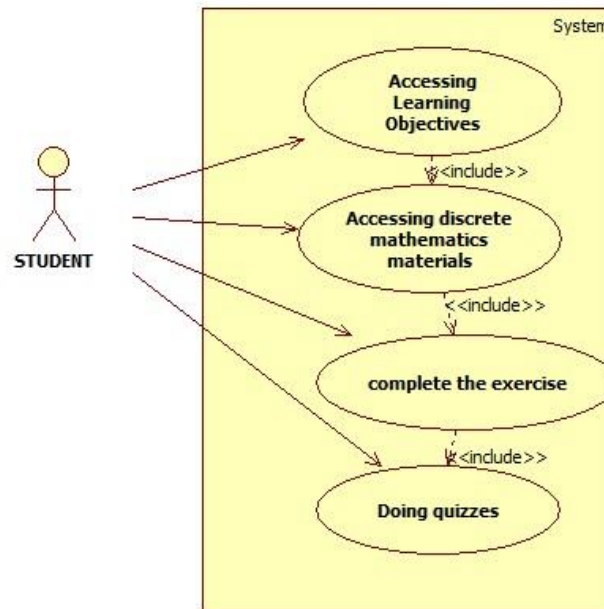
Activity Diagram
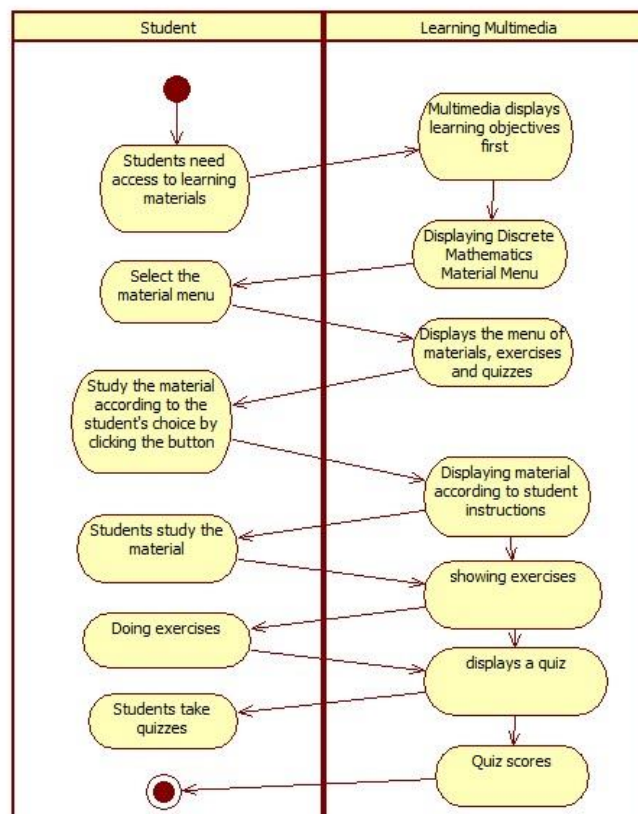

Figure 2. Use Case Diagram


Figure 3. Activity Diagram

The second is an activity diagram, this diagram is used to model the workflow or activity in a process or system as shown in Figure 4 to describe the workflow of students in accessing multimedia learning applications design ranging from accessing material to doing exercises and quizzes for Discrete Mathematics courses.
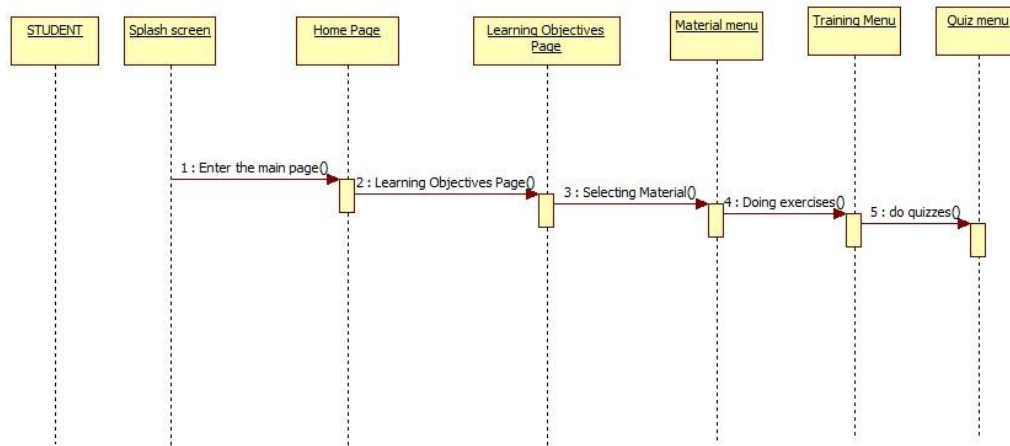
Figure 4. Sequence Diagram

The third is the design sequence diagram seen in Figure 4 which is used to describe the interactions between objects in a system in a certain time sequence. Its usefulness is very important in modeling and visualizing how objects interact with each other in a particular scenario or process,

Storyboard
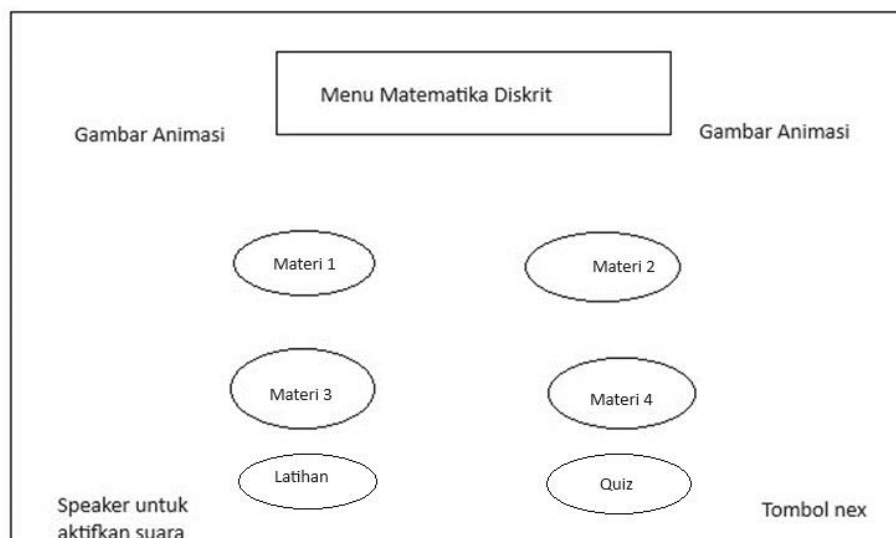
Figure 5. Material Menu *Storyboard*

Figure 5 is one of the storyboards for the Discrete Mathematics course learning multimedia application. Storyboard is a very useful tool in the development of visual content, audio, animation, or interactive user experience (Kunto et al., 2021). Its usefulness lies in its ability to depict the visual sequence of a story or process in a clear and concise manner. detailed before actual production or development begins.

Material Collecting

With case studies provided in the e-modules Based Discrete Mathematics Learning Multimedia Development research *Discovery Learning*, the material collecting process plays an important role in ensuring the availability of relevant and useful content for the development of learning multimedia *discovery learning* based. The first step is to identify key concepts in discrete mathematics that will be taught through the learning multimedia which includes concepts such as combinatorics, graph theory, logic, functions and relations.

Assembly

This stage is to convert the design or design that has been made previously to be developed into multimedia software which can be seen in Figure 6, the main page of discrete math learning multimedia.

Figure 6. Multimedia Home Page

Figure 7 is a picture of multimedia learning that displays the material menu, exercise menu and quiz menu for Discrete Mathematics course.

Learning multimedia is a technology media equipped with text, audio, video, animation and so on which contains learning content that is delivered interactively and interestingly based on multimedia (Supuwiningsih, 2024).
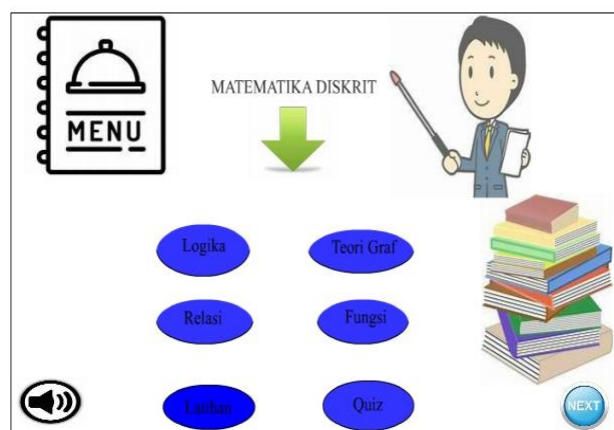

Figure 7. Discrete Math Material Menu Page

Figure 8 is an image that displays one of the materials in the menu list selected by students to learn. The material displayed contains narration, audio in the form of soft music to stimulate cognitive work in receiving learning, animation, text and so on
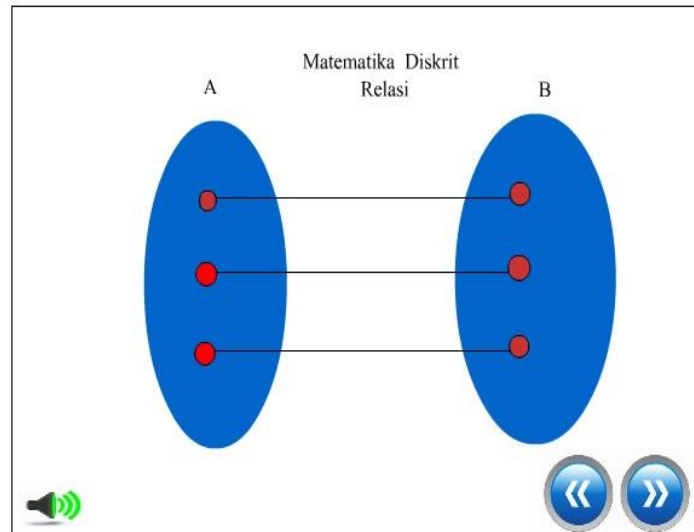
Figure 8. Relationship Material

Testing

The first test used in this research is *blackbox testing,* with the test results contained in Table 1.

Table 1. Blackbox Testing Result

No	Multimedia Features tested	Testing	Testing Result
1	Multimedia interface navigation	Completeness and functionality of navigation buttons and navigation between pages	All navigation buttons work well, and navigation between pages is smooth
2	Availability of learning materials	Availability and accessibility of learning materials such as text, images, and videos	Learning materials are fully available and easily accessible to participants.
3	Interactivity and compliance with Discovery Learning principles	Active involvement of students in exploring and discovering discrete math concepts	Students were actively involved in the process of discovering discrete math concepts and showed a good level of understanding.
4	Visual and audio quality	Quality of images, videos, and audio used in multimedia	Images, videos, and audio are of good quality and support the understanding of learning materials.
5	Quiz and exercise functionality	Effectiveness of interactive quizzes and exercises in testing student understanding	Interactive quizzes and exercises are effective in testing students' understanding of discrete math concepts.

Second Testing

Users in this learning multimedia application are ITB STIKOM Bali students who take Discrete Mathematics courses in the intermediate semester, a sample of limited students is 5 students who are taken randomly to provide answers to 5 questions given by researchers as can be seen in Table 2.

Table 2. Student Interview Results

No	Questions	Student Answer 1	Student Answer 2	Student Answer 3	Student Answer 4	Student Answer 5
1	What is your experience in using right multimedia learning?	I feel that my experience was very positive. The multimedia really helped me understand the concepts of discrete math.	I found it a little difficult at first, but after a while, I got used to it and found that this multimedia was very helpful in my understanding.	I found this multimedia easy to use and interesting. It makes learning discrete math more enjoyable.	I enjoyed the experience of using this multimedia. I feel more involved and active in the learning process.	I feel that this multimedia makes it easier for me to understand the material. I can learn at my own pace and find solutions in a shower.
2	Did you find the multimedia helpful in improving? What is your understanding of discrete math?	Yes, I find this multimedia very helpful in improving my understanding. I can learn the concepts better than before.	That's right, it provides clear visualization and explains difficult concepts in an easy-to-understand manner.	I feel that my understanding of the material has improved significantly after using this multimedia	This multimedia helps me to overcome the difficulties. I face in understanding discrete math concepts.	I feel more confident in understanding the material after using this multimedia.
3	Did you face any particular difficulties or challenges while using this multimedia?	I had a little trouble navigating the interface at first, but after a few uses, I got used to it.	No, it's actually, quite intuitive and easy to use. I didn't experience any significant difficulties.	I had a few technical issues at first, but after that everything went smoothly.	There were no major issues that I faced. A few initial difficulties that were soon resolved.	I didn't experience any significant difficulties.
4	What do you think about the interactivity of this multimedia in supporting principles of Discovery Learning?	I think this multimedia is very effective in supporting the principles of Discovery Learning. I feel more active and involved in learning.	This multimedia gives me the opportunity to explore concepts independently, which is an important aspect of Discovery Learning	I feel like I have control over my own learning, and that makes me more excited to learn.	The interactivity of this multimedia helped me to really understand the concepts of discrete math concepts better.	I feel engaged and challenged by this multimedia
5	Do you have any suggestions or recommendation for improvements or enhancements to this multimedia?	The only thing that might need improvement is the explanations in some sections that could be a little more detailed.	I think the addition of some practical examples or additional exercises could make this multimedia more complete.	I don't have many complaints, but there could be room to add more interactive content.	I think this multimedia is good enough, but some additional hints might help students who are having difficulties.	I would suggest adding features to facilitate collaboration between students, such as discussion rooms or online forums.

Based on the results of interviews with five students, it can be concluded that the Discovery Learning-based discrete mathematics learning multimedia received a positive response from users. The majority of students felt that the multimedia helped improve their understanding of discrete mathematics concepts and supported the principles of *Discovery Learning* with the interactivity provided. A small number of students faced some initial technical or navigational difficulties, but these were quickly resolved. Suggestions for improvement or enhancement emphasized adding additional content or collaborative features to improve the overall learning experience. Overall, the interview results indicate that this learning multimedia has great potential to improve the learning of discrete mathematics.

Third Testing

The third test is giving a Likert scale questionnaire (1-5) to students with a population of 35 students by giving 11 questions adapted from (Agustini, 2014). The results of the e-module feasibility testing can be seen in Table 3.

Likert Scale

1: Very poor; 2: Less good; 3: Fair; 4: Good; 5: Very good

Table 3. Result of Answers Student

Respondents	Score	%	Category
Student 1	41	75	Good
Student 2	53	96	Very Good
Student 3	53	96	Very Good
Student 4	53	96	Very Good
Student 5	52	95	Very Good
Student 6	48	87	Very Good
Student 7	48	87	Very Good
Student 8	44	80	Good
Student 9	51	93	Very Good
Student 10	54	98	Very Good
Student 11	55	100	Very Good
Student 12	55	100	Very Good
Student 13	45	82	Good
Student 14	53	96	Very Good
Student 15	47	85	Very Good
Student 16	50	91	Very Good
Student 17	54	98	Very Good
Student 18	55	100	Very Good
Student 19	45	82	Good
Student 20	50	91	Very Good
Student 21	51	93	Very Good
Student 22	52	95	Very Good
Student 23	54	98	Very Good
Student 24	55	100	Very Good
Student 25	39	71	Good
Student 26	47	85	Very Good
Student 27	55	100	Very Good
Student 28	39	71	Good
Student 29	42	76	Good
Student 30	36	65	Simply
Student 31	55	100	Very Good
Student 32	45	82	Good
Student 33	50	91	Very Good
Student 34	50	91	Very Good
Student 35	49	89	Very Good

Maximum Value: 55
Minimum Value: 11
Maximum-Minimum = 44
Interval = 44/5 = 8.8

Table 4. Categories and Frequency of E-Module Trial

Likert Scale	Interval %	Category	Frequency
5	86%-100%	Very Good	27
4	70%-85%	Good	7
3	54%-69%	Simply	2
2	37%-53%	Not Good	0
1	<=36%	Not Very Good	0

Based on Table 4, it turns out that the very good category has more frequency, namely 27 students, this proves that this e-module can be well received by students as a discovery learning-based learning media by presenting case studies.

Analysis of answers from respondents regarding the feasibility of Discrete math multimedia e-modules as learning media using the feasibility percentage technique adapted from (Sari & Suswanto, 2017):

$$P = \frac{\sum x}{\sum y} \; x \; 100$$

Description:
P   : Percentage of Feasibility
$\sum$x   : Total Member Answers
$\sum$y   : Total Maximum Score

Table 5. Eligibility Criteria

Percentage	Criteria
84 % < P ≤ 100 %	Very Feasible
68 % < P ≤ 84 %	Worth
52 % < P ≤ 68 %	Decent enough
36% < P ≤ 52 %	Less feasible
20 % ≤ P ≤ 36 %	Not worth it

P = 1725/1925 *100 = 89,6 %

The value of the calculation of the percentage of feasibility is 89.6% when viewed based on table 5 of the feasibility value criteria is "very feasible" meaning that this discrete math e-module is very feasible to use as a learning medium.

Distribution

Distribution for Discovery Learning Based Discrete Mathematics Learning Multimedia Development can involve several channels to reach the target audience effectively by integrating the learning multimedia into the existing e-learning platform at ITB STIKOM Bali campus which can be accessed through https://elearning.stikom-bali.ac.id/ is an effective way to reach students allowing easier and structured access to learning content, allowing students to learn independently and lecturers to monitor progress.

CONCLUSSION

The development of Discovery Learning-Based Discrete Mathematics Learning Multimedia offers an innovative approach in enriching students' learning experience, through the use of multimedia technology and the approach of *Discovery Learning*. This method provides opportunities for students to be actively involved in the learning process, exploring discrete math concepts through independent exploration.

This application gives students more control over their own learning, this method not only improves their understanding of the material, but also motivates them to study more intensively. In addition, learning multimedia provides flexibility in material access, allowing students to study anytime and anywhere according to their preferences. Through the combination of strong visualization, interactivity, and instant feedback, learning multimedia also helps to improve the effectiveness of material delivery and learning evaluation. Thus, Discovery Learning Based Discrete Mathematics Learning Multimedia Development promises an important role in improving the quality and learning experience of students in the field of discrete mathematics. Based on the results of interviews with students, they stated that the e-module helps improve their understanding of discrete mathematics concepts and supports the principles of *Discovery Learning* with the interactivity provided. The feasibility test results for e-modules used as learning media with a value of 89.6% stated that this e-module is very feasible to use as a Discrete Mathematics learning media so that it can foster creativity in learning and discovering new knowledge (discovery learning).

ACKNOWLEDGEMENT

REFERENCES

Agustini, K. (2014). *Matrik BluePrint dalam Desertasi Pengembangan Media Ajar Berteknologi Hypertext untuk Perkuliahan Komunikasi Data dan Jaringan Komputer Berbasis Kearifan Lokal Konsep Subak*. Jakarta: Universitas Negeri Jakarta.

Arpiansah, R., Nurdiana, D. & Suryadi, A. (2018). Game edukasi vr pengenalan dan pencegahan virus covid-19 menggunakan metode MDLC untuk anak usia dini. *Jurnal Petik*, *3*(2).

Borman, R. I. & Purwanto, Y. (2019). Implementasi Multimedia Development Life Cycle pada Pengembangan Game Edukasi. *Jurnal Edukasi dan Penelitian Informatika*, *5*(2).

Cahyani, L. (2019). Analisis Kesulitan Belajar Matematika Diskrit Mahasiswa Teknik Informatika. *Prisma (Prosiding Seminar Nasional Pendidikan Program Pascasarjana Universitas PGRI Palembang)*.

Fauzan Febriansyah, M. & Sumaryana, Y. (2021). Pengembangan Aplikasi Media Pembelajaran Sekolah Dasar Menggunakan Metode Multimedia Development Life Cycle (MDLC). *Informatics and Digital Expert (INDEX)*, *3*(2). doi: 10.36423/index.v3i2.838.

Fauzan, R., Siahaan, D. et al. (2021). A Different Approach on Automated Use Case Diagram Semantic Assessment. *International Journal of Intelligent Engineering and Systems*, *14*(1). doi: 10.22266/IJIES2021.0228.46.

Kumala, F. N. et al. (2021). MDLC model for developing multimedia e-learning on energy concept for primary school students. *Journal of Physics: Conference Series*. doi: 10.1088/1742-6596/1869/1/012068.

Kunto, I. et al. (2021). Ragam Storyboard Untuk Produksi Media Pembelajaran. *Jurnal Pembelajaran Inovatif*, *4*(1). doi: 10.21009/jpi.041.14.

Marisya, A. & Sukma, E. (2020). Konsep Model Discovery Learning pada Pembelajaran Tematik Terpadu di Sekolah Dasar Menurut Pandangan Para Ahli. *Jurnal Pendidikan Tambusa*, *4*(3).

Mustaghfaroh, K. S. et al. (2021). Pengembangan Media Pembelajaran Interaktif dengan MDLC Untuk Materi Benda dan Perubahan Sifatnya. *Journal Automation Computer Information System*, *1*(2). doi: 10.47134/jacis.v1i2.22.

Rizal, M., Mursalim, M. & Kamaruddin, K. (2019). Rancang Bangun Game Edukasi Vocabulary English Menggunakan Metode MDLC. *Inspiration: Jurnal Teknologi Informasi dan Komunikasi*, *9*(1). doi: 10.35585/inspir.v9i1.2488.

Sari & Suswanto. (2017). Pengembangan Media Pembelajaran Berbasis Web Untuk Mengukur Hasil Belajar Siswa Pada Mata Pelajaran Komputer Jaringan Dasar Program Keahlian Teknik Komputer Dan Jaringan. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, 1008–1016.

Sumaryana, Y. & Hikmatyar, M. (2020). Aplikasi pembelajaran siswa sekolah dasar menggunakan metode multimedia development life cycle (MDLC). *TeIKa*, *10*(2). doi: 10.36342/teika.v10i2.2381.

Supuwiningsih, N, N. (2024). *E-Modul Multimedia Pembelajaran untuk Self Directed Learning*. Klaten: Idebuku.