

Effectiveness interactive digital modul physics (IDMP) based interactive lecture demonstration of concepts vector

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Abstract

Keywords:

Digital Modul
Physics;
Interactive Lecture
Demonstration;
Vector;

This research explores the effectiveness of Interactive Digital Module Physics (IDMP) for additional teaching materials in vector concepts. The IDMP which was developed according to the ADDIE model and its implementation uses the Interactive Lecture Demonstration (ILD) learning model. A total of 65 participants were students enrolled in a Basic Physics course at a university in a special area in the central district of Indonesia. The instrument used to validate the IDMP uses a scale of 1-5 and has a scoring rubric and processing effectiveness data using technique Cohen's D formula. The intervention group was given training assignments in using ILD-based IDMPs while the control group was given ILD-based assignments only. The results of this study obtained data that the intervention group was significantly better than the control group, found there was no significant increase. Cohen's D score in the intervention group had a large impact on the control group of 1.17 with a 95% confidence interval. Furthermore, they get learning experience by providing feedback that the course material using ILD-based IDMP can challenge students to learn independently.

To cite this article:

Wibowo, F C., et al. (2023). Effectiveness interactive digital modul physics (IDMP) based interactive lecture demonstration of concepts vector. *Thabiea : Journal of Natural Science Teaching*, 6(2), 118-131.

Introduction

The trend of technological and pedagogical development towards active learning approaches has been very popular in recent years (Abramovich et al., 2019). Learning using digital interactive technology in the form of modules is a demand in the era of fast Education 4.0 (Mamun et al., 2020; Rajabalee & Santally, 2021). Especially if this module is implanted using the Interactive Lecture Demonstration (ILD) model to build student understanding it is important to do so that students are enthusiastic about learning (Awaliyah et al., 2022; Sokoloff et al., 2012). ILD During class hours, focus on active exercises such as problem solving, discussion and laboratory practice. In other words, it is this approach that allows the student to

understand and focus on the topic, thereby providing an opportunity to consolidate the information collected on the topic being studied. The Interactive Lecture Demonstration learning model is carried out by raising initial ideas or student hypotheses as a starting point for learning so that students can directly compare theory and reality, which encourages students to be active and able to think critically (Delgado-Gómez et al., 2020; Sharma et al., 2010). ILD is designed to contradict students' misconceptions to produce a process of conceptual change. ILD is also used to explore the effects of the process of conceptual change and the interactive learner's role in this process (Uwamahoro et al., 2021; Wibowo et al., 2022). Interactive lecture demonstrations are also designed to improve students' conceptual skills and has improved students' conceptual learning regarding physics concepts (Ebner et al., 2020; Marwanti et al., 2020).

Efforts to encourage students to actively use lecture demonstration models to make conceptual changes or with the Interactive Lecture Demonstration method. In this method, students are asked to predict the results of demonstrations and write down their predictions and explanations, and therefore commit to an explicit model (Mubarak et al., 2020). Peer discussions follow, with students discussing their predictions in small groups – again, they must discuss the existing model explicitly (Hew et al., 2020; Zimrot & Ashkenazi, 2007). The instructor engages the class, asking for predictions and highlighting common predictions. A demonstration is then conducted, and the instructor discusses the results of the demonstration given the students' previous predictions, emphasizes the conflict and provides a consensus way to resolve the Science.

The basic physics course includes some material that is abstract in nature (Stankova et al., 2016) so that if the explanation is not supported by good media, students will experience obstacles due to differences in the ability to think abstractly and the power of imagination of each student. The physics learning system only focuses on memorization, not on the concept, so students tend to forget easily. Some of these things cause physics to be considered difficult by students. Understanding of a material basically requires a good understanding of the concept (Gong & Ribiere, 2021). To improve student conceptualization, the learning model must be packaged in the form of interesting teaching materials for use by students, such as using modules (Lämsä et al., 2021).

Digital modules are units of planned learning activities designed to help student complete certain goals by organizing subject matter that is tailored to the individual's own personality so that they can maximize their intellectual abilities (Abidin & Wulandari, 2022; Carney, 2021). The purpose of using the module is for students to understand physics concepts to improve their cognitive abilities (Desnita et al., 2022). In an era like today where technological developments are very rapid, the contents of modules can be displayed using electronic equipment with the same layout and appearance as books and are known as electronic modules or Interactive Digital Modules (IDM).

IDM is a print module development in digital form that adapts a lot of print modules. The advantages of IDM compared to print modules are that it is interactive, makes it easy to navigate, allows displaying/loading images, audio, video, and animation and is equipped with formative tests/quizzes that allow immediate automatic feedback (Hadianto & Festiyed, 2020; Moradi et al., 2018). IDM is intended to ease the understanding of users and enable them to focus. Another advantage of IDM in the learning process lies in the stages of problem-based

learning, namely student orientation to problems, organizing students to learn, guiding individual and group investigations, developing, and presenting work, as well as analyzing and evaluating problem-solving processes. IDM teaching supported by technology can help students understand lessons in an effective and more interesting way (Nurlaily et al., 2019; Simanjuntak et al., 2021).

The IDM is more attractive to students and easily accessible using a cellphone, making it easier to carry anywhere and be owned by anyone (Conradty et al., 2020). Students are allowed to use their personal devices such as cellphones, tablets and laptops which enable an interactive lecture style like technology (Mills et al., 2020; Osman & Lay, 2022). However, in fact, based on the results of a needs analysis that has been carried out by researchers on several students, it shows that the use of teaching materials at one tertiary institution obtained information that was still not valid, especially during the Covid 19 pandemic, which required the learning process to be carried out online and independently. Based on the results of the survey, it was shown that 89% of students considered it necessary to have modules that could be used as independent teaching materials and were easy to access anywhere (Awaliyah et al., 2022).

However, many IDM or E-Modules have been developed, including the use of IDM to make students interested in the learning process, because it can be accessed anytime and anywhere, supported by adequate tools, and does not complicate students (Rahayu & Sukardi, 2021). IDM is easy to carry out teaching activities even though the place is different from the students. IDM as a learning evaluation tool is designed to be practical so that it attracts students' learning interest (Sidiq & Suhendro, 2021). IDM allows students to learn independently and is a realization of individual differences. However, IDM, the implementation of IDM preparation using Interactive Lecture Demonstration, has not been developed by other researchers. In addition, IDM on the concept of Vector Concepts is also rarely found on Google or digital learning media providers.

Based on the understanding of the various research results and facts mentioned above, with the aim of finding solutions to existing problems, this study aims at the effectiveness of Interactive Digital Module Physics (IDMP) with ILD for additional teaching materials in vector concepts. The reason for choosing the Vector concept is because there is not yet or at least IDM discusses Vectors. In addition to these reasons, from the results of the needs analysis conducted it is known that the currently available IDMPs are not optimal in helping students understand vector concepts. Therefore, explores the effectiveness of Interactive Digital Module Physics (IDMP) for additional teaching materials in vector concepts.

Method

The IDMP which was developed according to the ADDIE (Analyze, Design, Development, Implementation, Evaluation) model and its implementation uses the Interactive Lecture Demonstration (ILD) learning model (Spatioti et al., 2022). In the Analysis Phase, the researcher conducted a needs analysis for students at one of the tertiary institutions in Jakarta regarding the needs of teaching materials in the learning process. Based on the results of the analysis that has been carried out, it can be concluded that the use of IDM can support learning activities in physics material. In addition, the use of electronic modules is in accordance with the characteristics of current students who frequently use cell phones and the internet. Researchers also found the fact that students had difficulty understanding vector material due

to the lack of application in their daily lives. Based on this, the development of electronic modules using the ILD approach so that physics learning can be more easily understood through interactive discussions between students. The complete research method is described in the following figure.

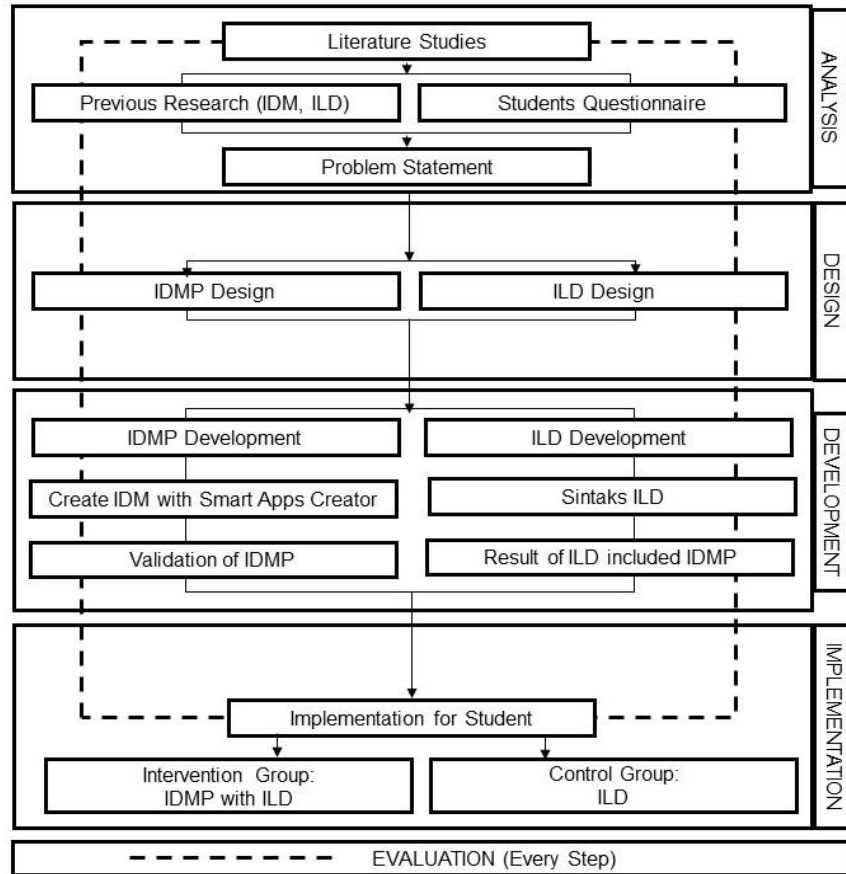


Figure 1. Method of Research ADDIE for IDMP with ILD

The second stage of Design, IDMP Components based on the literature review that has been conducted consists of the title, introduction (objectives, basic competencies, core competencies, concept maps), material review, summary, and finally the glossary, the final project. The third stage, Development, namely the IDMP development process is carried out using the ILD approach on vector material. In the initial menu there are several options. Then there is an introduction that contains objectives, core competencies, basic competencies, and concept maps. There will be materials, discussions, and evaluations to test students' understanding. The fourth stage of implementation is that at this implementation stage everything that has been developed is installed or set in such a way according to its role or function so that it can be implemented and then tested for validity by learning experts, media experts and material experts. Three people became Learning experts which consist of evaluate the accuracy, clarity, and depth of the content, Assess the alignment of the content with learning goals and objectives, Evaluate the effectiveness of the learning activities and assessments, Provide feedback on the pedagogical approach and instructional design. Three people became media experts which consist of evaluate the quality of the visual and audio elements, Assess the usability and accessibility of the resource, provide feedback on the overall design and layout, ensure that the media elements are engaging and effective. Three people became material experts which consist of Evaluate the accuracy and technical correctness of the

information, Assess the relevance and currency of the content, provide feedback on the organization and structure of the material, ensure that the material is free from factual errors and bias.

The product will be declared valid based on the score obtained using the Guttman scale. After that, revisions will be carried out in accordance with the suggestions of experts. In this stage a practicality test will also be carried out by students and lecturers supporting basic physics courses. The last stage is Evaluation namely: In each stage of ADDIE development involves formative evaluation. In this study the evaluation was carried out at the analysis, design, development, and implementation stages. Evaluation is carried out by analyzing qualitative data, namely processing data in the form of input, criticism, and suggestions from experts for further revisions to be carried out in stages for better media development. Furthermore, quantitative data analysis will be carried out through the assessment of respondents in the form of instrument test. This stage is carried out to determine the feasibility of the developed module in terms of the scope of the material, media, and learning. The research instrument used in the implementation stage to test the effectiveness of the IDMP used the learning outcomes instrument of vector concepts consisting of C1, C2, and C3. The number of pretest and post-test is the same, a total of 20 test on vector concepts. The types of tests given to students consist of cognitive skills C1, which measures the students' ability to recall information about vector concepts. C2 cognitive skill tests measure students' ability to understand information about vector concepts. Cognitive skill C3 measures students' ability to apply information that has been learned in new situations related to vector concepts. The learning outcomes of the lecture that want to be achieved in the application of the IDMP on vector concepts are mastering basic vector concepts, including notation, vector algebra operations, and vector spaces. Mastering vector function concepts, including derivatives and integrals of vector functions. Mastering vector application concepts, such as in geometry, mechanics, and physics. For complete instruments for IDMP media validation, click [Digital media validation instruments](#).

A total sample implementation of IDMP with ILD is 65 participants who were students enrolled in a Basic Physics course at a university in a special area in the central district of Indonesia. The intervention group was given training assignments using ILD-based IDMP while the control group was given ILD-based assignments only. The IDMP with ILD implementation design drawing is shown in the figure below.

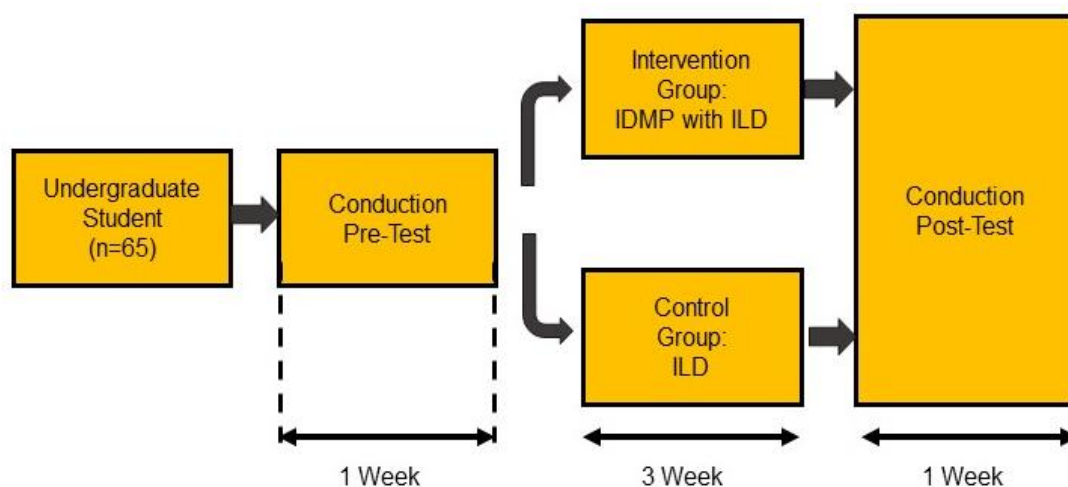


Figure 2. Design Implementation IDMP with ILD

The data analysis validation test by media experts aims to determine the validity of the IDMP vector concept developed as a learning medium made using the Interactive Learning Demonstration approach for students. Furthermore, to measure the effectiveness of IDMP with ILD for learning using ANCOVA to test the difference between the pre-test and post-test scores of the intervention and control groups related to vector concepts. By retaining the pre-test in the intervention and control groups, this eliminates the possible effect of the post-test results. For its implementation, this check is carried out to verify whether the ANCOVA hypothesis is fulfilled. Effect size or effectiveness is calculated using Cohen's D (Lovakov & Agadullina, 2021). The calculate Cohen's D – Formulas is computed as:

$$D = \frac{M_1 - M_2}{S_p}$$

The description M1 and M2 represent the sample means for groups 1 and 2, and Sp represents the combined estimated population standard deviation. Based on the calculation results, it can be concluded that the effect of learning with IDMP and ILD shows its effect (Wilson, 2022). The interpretation results are taken from the table below.

Table 1. Effect Size Category

Effect Size	Description
0,00 < ES < 0,20	Ignored
0,20 < ES < 0,50	Small
0,50 < ES < 0,80	Moderate
0,80 < ES < 1,30	Large
1,30 < ES	Very Large

Results and Discussion

Descriptive IDMP with ILD

The product being developed is an Interactive Digital Module Physics (IDMP) based Interactive Lecture Demonstration of Concepts Vector as teaching material in the form of an android application. Products are created using the Smart Apps Creator application and the ADDIE research carried out in this research at the evaluation stage was carried out at each stage. At the needs analysis stage, an evaluation of each stage activity is carried out based on the results of the needs analysis. At the Design stage, the results of the IDMP design are always evaluated to obtain maximum results. The development stage is in the form of IDMP development using the Smart Apps Creator application software, the results of IDMP development are evaluated at each stage to obtain an IDMP that is close to perfect. Meanwhile, at the implementation stage, IDMP is applied to students to see the effectiveness of its implementation. The IDMP contains vector material in basic physics lectures in tertiary institutions using the Interactive Learning Demonstration method. Starting from prediction, experience, and reflection. This IDMP is also equipped with video examples as well as explanations and practice test. The design of the module and its parts is described below. IDMP with Interactive Lecture Demonstration (ILD) Approach has the components shown in the figure below.

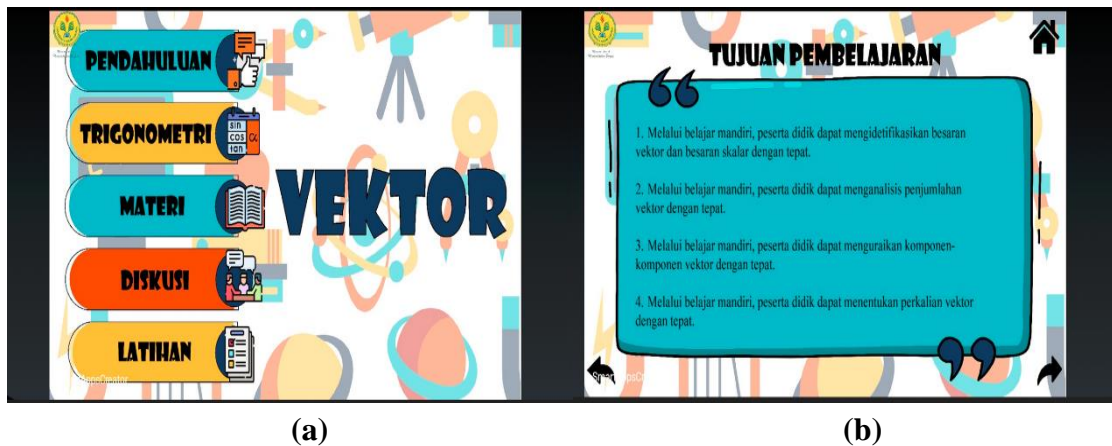


Figure 3. (a) Menu List Display & (b) Learning objectives IDMP

Figure 3 shows that the IDMP vector concept consists of an introductory menu, Trigonometry, Material, Discussion and Exercise. These five menus are the main menu found in this IDMP. The IDMP development process is based on the ILD model syntax which has been validated by the syntax expert before being implemented in IDMP products. Next, the concept map display is shown in the following figure.

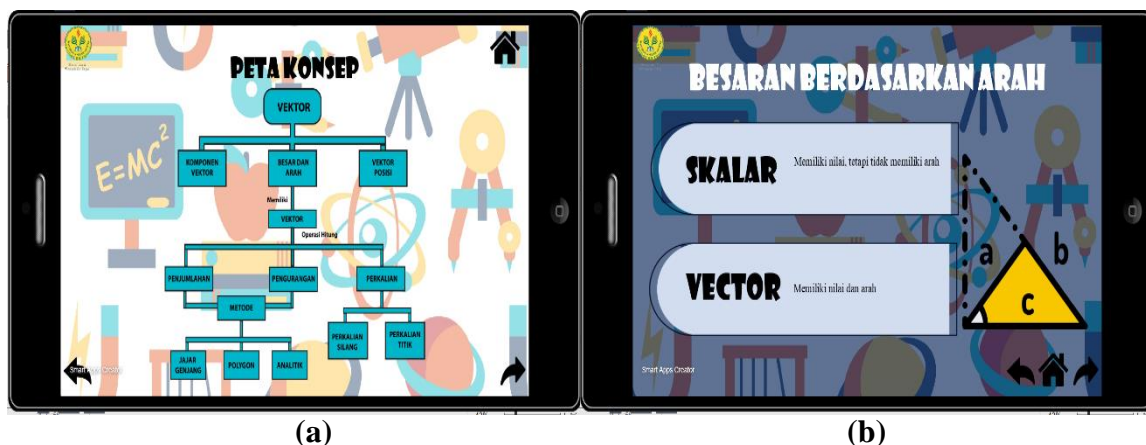


Figure 4. (a) Vector Concept Map Display IDMP & (b) Vector Concept

Figure 4. Describes a vector concept map consisting of vector components, magnitude and direction, and position vectors. In addition, vector arithmetic operations consist of addition, subtraction, and multiplication. While Figure 4b explains that the scalar and the vector itself. While the ILD stages implemented in IDMP are shown in the following figure.

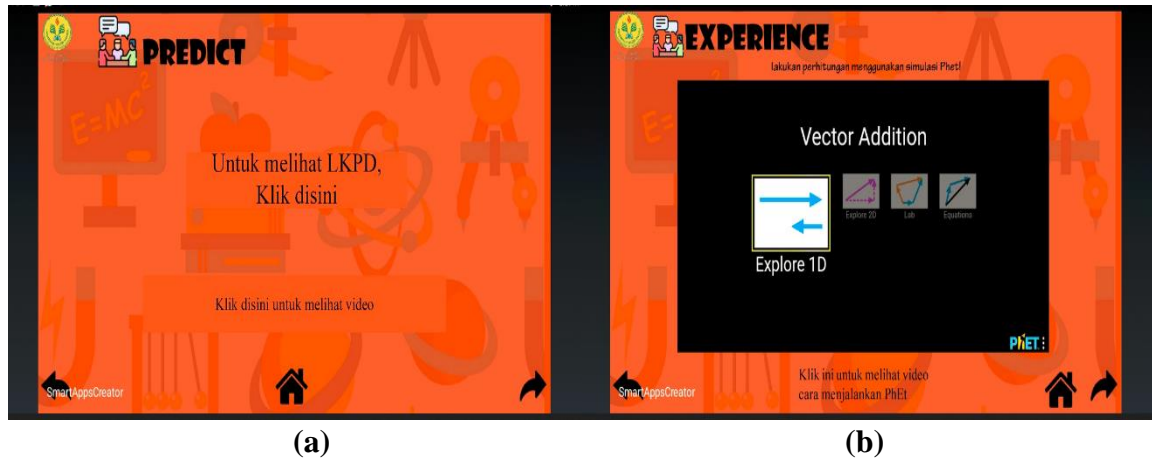


Figure 5. (a) ILD First Stage: Predict & (b) ILD Second Stage: Experience

Figure 5. Describes the first stages of ILD, namely Predict and Experience. At the Predict stage, students are asked to view the Student Worksheet (SW) by downloading it from the IDMP application. After downloading students are asked to predict from the phenomena presented from SW. In the second stage of experience, students are asked to pay attention to the simulation shown in the IDMP which is related to the concept or vector depiction. If students have done these two stages, then students have half learned vector concepts with ILD. The third stage of this ILD is reflected which is shown in the following figure.

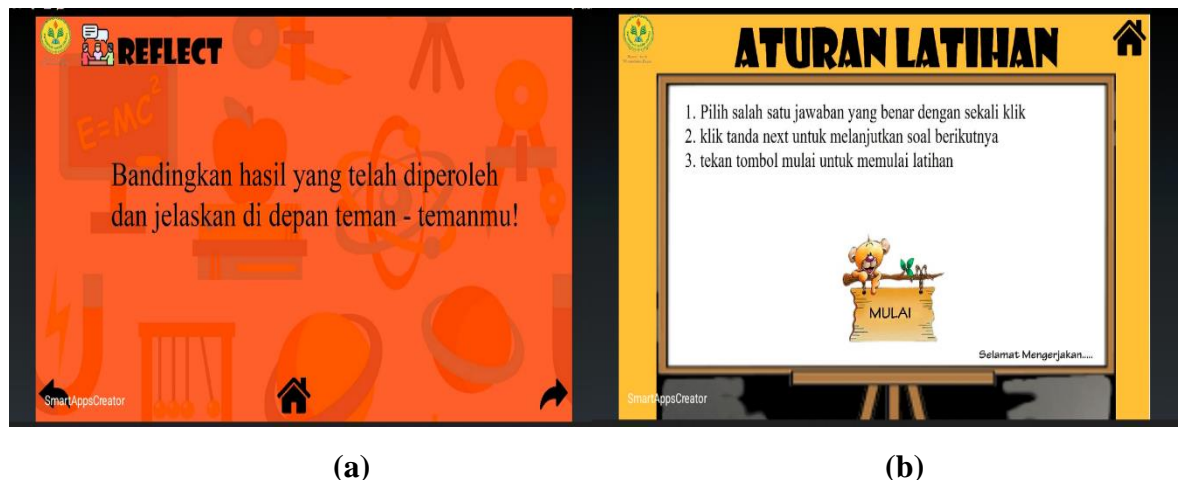


Figure 5. (a) ILD Third Stage: Reflected & (b) Display Concept understanding exercises

Figure 5 shows the last stage of ILD which is reflected, students identify the differences between what they predicted and what happened in the demonstration and explain how their understanding is changed. In other words, comparing the results obtained compared to other students. Furthermore, to strengthen the understanding of vector concepts, this IDMP is also equipped with practice test which are sent directly to each student's e-mail. IDMP validation is carried out to test the validity and reliability of the IDMP that has been developed. Validation with [Digital media validation instruments](#) by material experts, learning experts and media experts. IDMP product validation is carried out to determine the validity of the products developed before testing. The results of the assessment are then used as material for media analysis which is developed so that it becomes a product that is valid for use in student learning.

Total Validity statements for material experts are 15 indicator statements. Based on the validation results of the assessment scores obtained, the average percentage of IDMP products for material validation obtained a score of 83.3% which was categorized as very valid. So, it can be said that the electronic module for vector material with the ILD approach has a "valid" interpretation to be used as teaching material in physics learning.

The IDMP validation assessment was carried out using a media expert questionnaire consisting of 3 components, namely the electronic module component with 16 indicator statements. Based on the assessment score obtained, the average percentage of IDMP products for media validation gets a score of 80.75% which is categorized as valid. So, it can be said that the electronic module for vector material with the ILD approach has a "valid" interpretation to be used as a learning medium in physics learning. While the IDMP validation assessment was carried out using a learning expert questionnaire consisting of 2 components, namely the Module component with 7 statements and the Interactive Lecture Demonstration Approach component with 3 statements. Total statements for material experts are 10 statements. Based on the results of the validity assessment, the assessment score obtained from the validation of learning experts, the average percentage of IDMP products for learning validation obtained a score of 83.33% which was categorized as valid. So, it can be said that the electronic module for vector material with the ILD approach with a valid interpretation for use in learning physics is in accordance with the established ILD learning approach.

Effectiveness Statistical Test

The statistical effectiveness test was carried out using pre-test and post-test data and was calculated using the Cohen's D equation. The goal Effect Size is a statistical concept that measures the strength of the relationship between two variables on a numerical scale. The effect size data is shown in Table 2.

Table 2. Overall Effect Size IDMP

Group	n	x	S	S ²	Cohen's D
Intervention (IDMP+ILD)	33	81	8.85	72.94	1.17
Control (ILD)	32	71	8.07	65.20	

Table 2 provides an explanation that the intervention group had a large impact on the control group of 1.17 with a 95% confidence interval. This is because the ILD model combined with the IDMP media has a high influence on student achievement. This finding also revealed that the significant difference between the effect sizes was caused by students who felt challenged to learn with new media in physics courses. The thing that causes IDMP and ILD to have a big impact on students' understanding is that based on the results of interviews, it was found that after trying IDM students can easily learn physics, especially in vector material. Furthermore, vector learning using simulation in IDMP is attractive to students. Most students stated that IDMP helped me in independent learning, and they also liked learning using IDMP because it was interactive. Most of the students using IDMP found it easier to understand the concept of vectors. Furthermore, students felt that the presentation of material in the electronic

module was arranged logically and systematically and was easy to understand and electronic IDMPs anywhere and anytime. The results of this study obtained data that the intervention group was significantly better at the post-test through the implementation of ILD-based IDMP, meanwhile, the control group found there was no significant increase in the post-test.

IDMP when combined with the Interactive Lecture Demonstration model can enhance conceptual learning. ILD has improved students' conceptual learning regarding physics concepts (Moradi et al., 2018). So, with that in this study there is an ILD approach in which students are required to make predictions about the problems presented in video form, then pour them into the form of a PhET simulation, after which it is continued with discussions to solve the problem (Conradty et al., 2020). For this reason, in helping the learning process to be better, effective learning media is needed so that students can understand the material being studied anywhere and anytime by using electronic module media.

This reason leads to the development of an electronic module produced in this study, namely in the form of an Android application that can be installed by students using an Android cell phone, then accessed using the internet to open the video features contained therein (Awaliyah et al., 2022; Mamun et al., 2020). The features in the application are made in such a complete way as to make it easier for students to learn this vector material. IDMP is used as a learning tool that includes material, methods, and learning evaluations are also provided that are designed practically so that it attracts students' learning interest and electronic modules can be in the form of documents or articles whose format is not printed, so that it is not a hassle for students when traveling, because e-modules can be accessed via student electronic devices anywhere and anytime the user needs. Apart from the advantages possessed, there are disadvantages, namely this e-module application can only be installed on an Android, not for iOS, but can also be accessed using the HTML that has been created. but not all features contained in the application can be played if using HTML. And e-modules are also made so that they can keep up with the times which can be made to look like a book but are more complete because they can display video, sound, or other features. With the rapid development of technology, the contents of the module can be displayed using electronic equipment with the same layout and appearance as the book (Osman & Lay, 2022). The advantages of e-modules compared to print modules are that they are interactive, make it easy to navigate, allow displaying/loading images, audio, video, and animation and are equipped with formative tests/quizzes that allow immediate automatic feedback. So, with the IDMP it is hoped that it can make the learning process of students even more effective, and help students understand the material they are studying.

The advantages of the IDMP being developed include there are explanatory videos regarding the application of vectors in everyday life, video examples and discussion of questions, then students can carry out PhET simulations without having to search for them first through Google, and students can immediately do the exercises. along with immediately knowing the score they get, in accordance with the development of information technology that is easily accessible anywhere and anytime by students, the use of the ILD approach and is equipped with appropriate and contextual features, simulations and videos that can make students happy and active in their learning (Desnita et al., 2022; Rahayu & Sukardi, 2021). Meanwhile, the various shortcomings of this module include not being able to run smoothly if accessed via HTML, lack of implementation in everyday life, and cannot be installed on iOS,

not accessible to students who do not have Android. With these various advantages and disadvantages, this electronic module is declared valid to be used as a learning medium in accordance with the formulation of the problem that has been determined. The learning media developed can meet the time and space of student learning, so that students can access electronic modules anywhere and anytime independently or in groups.

The novelty of the research carried out contributes to the development of digital modules that can display cognitive aspects and vector concepts which are usually depicted in one dimension in IDMP. This is capable of being depicted in 2 dimensions. This is the latest claim from IDMP that has been developed. Research results for the development of the field of science, especially in terms of developing digital media for physics learning. The advantages of IDMP include: (1) Interactive and interesting, Digital media can make learning more interactive and interesting for students. This is because digital media can use various kinds of multimedia elements, such as video, animation, and audio. (2) Flexible and accessible, Digital media can be accessed easily and flexibly. (3) Students can access digital media anytime and anywhere if they have a compatible electronic device. This can make it easier for students to learn according to their individual needs and pace. (4) Adaptive and personal Digital media can be adapted and personalized according to student needs. For example, digital media can be equipped with features that can help students to track their learning progress, or to provide feedback tailored to each student's needs. (5) Efficient and cost-effective Digital media can save learning time and costs. This is because digital media can be used to present learning material more concisely and effectively. Apart from that, digital media can also be accessed at a more affordable cost compared to traditional learning methods, such as face-to-face. The following are some examples of the application of digital media in learning: Tutorial video Learning videos can be used to present learning material visually and interactively. Learning videos can be used to explain concepts that are difficult to understand, or to provide a real picture of a phenomenon. Animation can be used to explain abstract concepts visually. Animation can help students understand these concepts more easily.

The limitation of this research is that students tend to learn individually because IDMP was developed for independent learning. Apart from that, the limitation of IDMP is that it is not equipped with instructions for using IDMP, so that during implementation the lecturers provide many instructions for students. The sustainability of this research will be enhanced by implementing IDPM to train 21st century skills in students and developing IDMP on other microscopic physics concepts.

Conclusion

The IDMP includes the ILD model, so it will give a large effect size of 1.17 if this number is interpreted as a high category. This means that the IDMP which is developed by applying the IDMP model in it has a big impact on student understanding. Because the ILD stage consists of Predict, Experience and Reflected. At the Predict stage, students are asked to view the Student Worksheet (SW) by downloading it from the IDMP application. After downloading students are asked to predict the phenomena presented from SW. In the second stage of experience, students are asked to pay attention to the simulation shown in the IDMP which is related to the concept or vector depiction. If students have carried out these two stages, then students have half learned vector concepts with ILD. The third stage of ILD is reflected,

in which students identify the difference between what they predicted and what happened in the demonstration and explain how their understanding was changed. Furthermore, they get learning experience by providing feedback that the course material using ILD-based IDMP can challenge students to learn independently. The results of this questionnaire also indicated that students agreed with the implementation of IDMP as additional material for lectures in class.

Credit Authorship Contribution Statement

Firmanul Catur Wibowo: Conceptualization, Writing Original Draft, Review Editing, and Initial Data Analyzation. **Siti Rubihatul Awaliyah:** Design IDMP, Implementation and Data Collection. **Hadi Nasbey:** Conceptualization, Translation, and Editing. **Cecep E Rustana:** Review Draft and Editing. **Dina Rahmi Darman:** Conceptualization, Methodology, Formal Analysis, and Translation. **Nur Jahan Ahmad:** Conceptualization, Methodology, Review, and Editing. **Bayram Costu:** Review Draft, Research Adviser, and Supervision. **Binar Kurnia Prahani:** Visualization and Formal Analysis. **Achmad Samsudin:** Formal Analysis, and Review Draft.

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