E-module Newton's Law of Gravity based Guided Inquiry to Train Critical Thinking Skills

Deswita Elliya Sari[1*], Kartini Herlina[1], Viyanti[1], Doni Andra[1], and Ida Safitri[2]

[1]Physics Education Department, Universitas Lampung, Indonesia
[2] Sekolah Indonesoia Bangkok, Thailand

A R T I C L E   I N F O

A B S T R A C T

The study aims to develop an electronic module based on guided inquiry on Newton's law of gravity material that is valid, practical, and effective. The developed e-module aims to practice critical thinking skills in physics learning. This development research uses the ADDIE development method which consists of five steps, namely analysis, design, development, implementation, and evaluation. Student response questionnaires to guided inquiry e-modules and tests of critical thinking skills became research instruments. Data analysis presented with quantitative descriptive. The product validity was assessed by 3 experts with an average score of 3.63 with category very valid. The practicality of the product consisted of readability which was tested on 15 high school students in Grade X and the teacher's perception of the suitability of guided inquiry-based learning activities in e-modules by obtaining an average percentage of 90% in the category very practical. The effectiveness of the product is assessed based on students' responses of critical thinking skills are improve after using the e-module by obtaining a product effectiveness percentage of 87% with category very effective. Student response questionnaire showed a positive response to the developed e-module. Based on the analysis of the research results, it is stated that the guided inquiry-based e-module on Newton's law of gravity is valid, practical, and effective for practicing critical thinking skills.

Introduction

Learning in the 2013 curriculum aims to develop the talents, interest, and potentials of students to be characterful, competent, and literate. To achieve these result requires learning experiences that vary from simple to complex learning experiences (Wilatika & Yonata, 2022). In these activities, teachers must carry out learning and assessments that are relevant to the characteristics of 21st century learning.

Education of 21th-century is learning integrates knowledge, skills, and attitudes, as well as understanding of data information and skill off communication technology. All skills could be extended through kind models of activity-based learning activities by the characteristics of abilities and learning materials (Rasyid et al., 2022). Competencies that must be mastered by students include 4C abilities, one of which is: Critical Thinking Skills and Problem-Solving (Kembara *et al.*, 2019). Critical thinking is the skill to think analytically, logically, and reflectively from various sources in making decisions that have long-term benefits in the field of education. Howard *et al.*, (2015) define critical thinking skills as a thinking process that is carried out by making the most of one's knowledge and reflective experience.

Asmoro et al. (2020) view that critical thinking includes scientific thinking processes that extend to identifying and defining problems, gathering information to study problems in depth, analyzing

situations concerning these problems, and generating potential solutions to the problems being handled, and evaluate proposed solutions (Basilaia & Kvavadze, 2020). Based on research conducted improve and empower critical thinking skills, can use teaching material in the form of e-modules (Albert-Sangra et al., 2012).

E-modules are a collection of digital or non-printed learning media that are systematically arranged for independent learning purposes and are equipped with video tutorials, animations, and audio presentations as a learning experience for students. The standard e-module according to Sawitri (2014) divided into five types: self-instructional, self-contained, stand alone, adaptif, dan user friendly.

Research conducted by Fani & Mawardi (2022) it was found that flipbook-based interactive e-books can foster students' skills. One of the activities that can support student-centered learning is guided inquiry-based learning. The use of guided inquiry learning is a relevant way of collecting information and using logical analysis through several investigations as well as guiding the investigation of surrounding phenomena by guiding questions so that students solve problems based on the facts they find (Joyce et al., 2009). This guided inquiry invites students to make discoveries where they can combine several concepts from observing, classifying, guessing, explaining, measuring, and making conclusions with guidelines or directions from the teacher (Zekri et al., 2020).

Condition of pandemic is a challenge for all of point to keep group active even that schools have been closed, online learning by learning manajement based on online learning, mobile learning, web-based learning, and e-learning (Basilaia & Kvavadze, 2020). E-learning is defined as a natural development of distance learning, which always uses the latest tools emerging in the technological environment to build education (Albert Sangra et al., 2012). The main goal is to provide learning experiences that support the learning process for students that are personal, open, fun, and interactive.

One of the physics materials that must be mastered by students is Newton's law of gravity. Newton's gravitational law is a physics topic that makes students have difficulty understanding physics concepts. Liliawati et al., (2017) found that the topic of the celestial bodies motion was difficult to understand because students had difficulty imagining their motion in the sky. In addition, Madhuri & Goteti (2022) stated that the idea of the actual shape of the orbital trajectory and the details of the speed of moving objects have not been studied much. In line with this,

based on the results of interviews conducted by researchers, the teacher stated that students experienced difficulties in learning Newton's law of gravity because some students had an incorrect understanding of the concept in understanding the basic concept of Newton's law of gravity, as well as weak mathematical calculations mastered by participants.

The results of interviews conducted by researchers with Grade X physics teachers at SMA Negeri 1 Bandar Lampung and teachers in several schools in Bandar Lampung regarding the analysis of the needs of teaching materials in learning physics on Newton's law of gravity material, it can be seen that there are obstacles in teaching physics on Newton's law of gravity material. Several factors become obstacles, namely the teaching materials used by teachers and the limitations of tools in implementing Newton's law of gravity practicum material. The teaching materials used by teachers are still in the form of printed books and supporting learning media in the form of powerpoint (PPT) and have not held practicum on Newton's law of gravity material, when not holding practicum the teacher teaches Newton's law of gravity material using conventional methods so that learning activities to train skills critical thinking has not been achieved. In addition, the lack of visual representation of Newton's law of gravity material in the teaching materials used is also a factor in the difficulty in teaching Newton's law of gravity material.

The presentation of the problems from the results of teacher interviews, learning physics on Newton's law of gravity requires teaching materials that can train critical thinking skills. With the current conditions that require teachers to carry out online learning. Therefore, the researcher intends to carry out development e-module of guided inquiry-based on Newton's law of gravity material to train critical thinking skills.

Methods

The type of research is Research and Development using the ADDIE model which has 5 steps, namely: (1) Analysis; (2) Design; (3) Development; (4) Implementation; (5) Evaluation. The steps of developing the ADDIE model, the first step is analysis (Aldoobie, 2015). The analysis step is the step for analyzing needs by identifying problems, expectations, and solutions that can be applied in the field. The analysis carried out is regarding the factors of difficulty in learning physics on Newton's law of gravity material and limitations related to teaching

materials or tools used during the physics learning process. The analysis step is also supported by gathering information through literature studies, as well as the internet.

The second step, namely design is the step of designing the concept of the product to be developed based on the analysis that has been carried out. In the product design steps, this design is based on an analysis of student characteristics and material characteristics to develop a flowchart. The third step is development. At this step, the development of the e-module is carried out by the design which consists of three parts, namely: the initial part, the contents, and the closing. The beginning, it consists of core competence, achievement indicators, learning objectives, and concept maps. The content section consists of orientation, conceptualization, simulation, drawing conclusions, reflection, material description, summary, sample questions, and competency test. The closing section consists of a glossary, bibliography, and author profile. Furthermore, the e-module will be assessed for validity. Validation was carried out by third experts. The mean validity is calculated on Equation 1.

$$r = \frac{obtained\ average}{\Sigma amount} \qquad (1)$$

The average score obtained is converted with the criteria on Table 1.

Table 1
E-Module Validity Criteria

Score Interval Rating Results	Criteria
3.25<score<4.00	Very Valid
2.50<score<3.25	Valid
1.75<score<2.50	Invalid
1.00<score<1.75	Not Valid

(Ratumanan & Laurent, 2015)

The next step is implementation at this step a practicality and effectiveness test is carried out by testing the product on a small group consisting of 15 students from SMA Negeri 1 Bandar Lampung who have received material on the gravity law. The evaluation step is carried out at the end of each development step. The evaluation in question has the aim of improving the e-module at each step. It is intended that the developed e-module is said to be valid and suitable for use in learning.

Result and Discussions

The results of guided inquiry-based e-modules on Newton's law of gravity material. This product was developed with the aim of training students' critical thinking skills. The full results of the validity analysis by material experts and design experts can be seen in Table 2 and Table 3.

Table 2
Average Results of Material and Construct Expert Validation

No.	Rated Aspect	Average Score	Category
1	Appropriateness of Material Content	3.53	Very Valid
2	Construction	3.62	Very Valid
Average		3.57	Very Valid

Table 3
Average of Design Expert Validation Results

No.	Rated Aspect	Average Score	Category
1	Cover section	3.81	Very Valid
2	Contents section	3.57	Very Valid
Average		3.69	Very Valid

The average score of each aspect of the validity test, the aspect that has the highest rating is the cover section. In this case, it shows that the guided inquiry-based e-module that has been developed has an appropriate cover point of view, a balance of elemental composition, layout (title, author, illustration, logo, etc.). The layout elements in the cover are appropriate, the cover design of the e-module is aligned, the color of the e-module title and the background color is aligned, the combination of typefaces on the cover of the e-module is balanced, the illustrations presented are following the material, shape, size, and objects the illustration is proportional and follows reality, and the color of the object illustration is by reality.

Table 4
Product Practicality Average Percentage Results

No.	Aspect	Achievement (%)
1	Legibility	92
2	Teacher Perception	89
Overall average		90
Category		Very Practical

The practicality of the product is assessed based on the readability and teacher perception aspects. The results of the practicality analysis can be seen in Table 4.

The results of readability aspect, it can be stated that the highest assessment aspect is the benefits of the e-module with a percentage of 99%. This shows that the developed guided inquiry-based e-module has benefits in training students to think critically because in the developed e-module there are activities that are following the syntax of critical thinking skills, namely analysis, evaluation, inference, inductive reasoning, and deductive reasoning. The results of the teacher's perception assessment, it can be stated that the lowest assessment aspect is guiding student investigations with a percentage of 86%. In this case, it shows that the guided inquiry-based e-module that was developed, the activities of guiding students' investigations still have to be evaluated again.

Table 5
Product Effectiveness Results

Rated Aspect	Achievement (%)	Category
Internet, Android and Computer Skills	94	Very Effective
Readiness of Learners	82	Very Effective
Student Personality	84	Very Effective
Cultural Factors	76	Very Effective
Learning Style	75	Effective
Knowledge, Ability, and Application of Knowledge and Ability	87	Very Effective
Communication	90	Very Effective
Learn to be independent	91	Very Effective
Student Perceptions About Satisfaction	89	Very Effective
Student Perceptions About Interaction	92	Very Effective
Average	87	Very Effective

Activities guiding student investigations in e-modules that are being developed are still not optimal because the simulations and simulation menu buttons contained in e-modules are not easy to understand and the commands and objectives in carrying out simulations are also difficult for students to understand. Guided inquiry e-module is able to direct

students to study the material appropriately. In assessing product effectiveness, it is assessed based on the results of student responses. The results of the effectiveness analysis can be seen in Table 5.

The results of student responses, it can be stated that the aspect of the student response test assessment that has the lowest score is the learning style aspect with a percentage of 75%. This means that the learning styles possessed by students are not optimal in understanding the learning provided by the teacher. Each student has a different learning style, some students can understand by looking at objects and pictures, some students can easily understand by listening to the teacher's story, and some students can easily understand learning by practicing in class(Khoiri et al., 2020). Guided inquiry e-module provides direction to students to go through learning with guiding instructions gradually. The stages of the direction material make the guided inquiry e-module very effective. The achievement of students' critical thinking skills is presented in Figure 1.

Figure 1
Description of Critical Thinking Skill
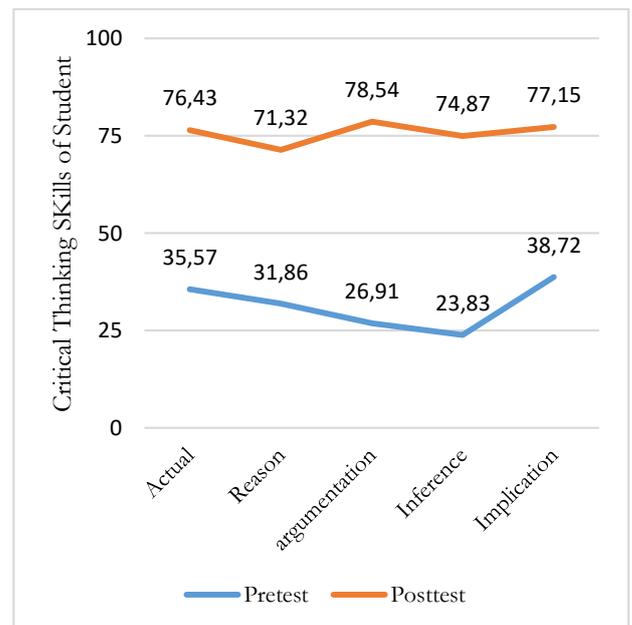
The advantages of guided inquiry-based e-modules are that they are interactive because the videos presented in the e-modules can be broadcast directly without having to open Youtube and there is a barcode to directly access the simulation and the Google form provided. The developed e-module has an attractive design and can be accessed easily using phones, computers, and laptops anytime and anywhere without having to have a paid account. In addition to the advantages of guided inquiry-based e-modules, it

also has disadvantages, including not having a simulation feature, so students must scan a barcode to switch platforms (Setyaningsih et al., 2019). In addition, students also cannot collect assignments directly in the e-module, so students need to access the Google form first to submit assignments.

The findings in the development research conducted apart from training critical thinking skills, guided inquiry-based e-modules can also train students' digital literacy abilities. The ability to use digital media, communication tools. Internet networks to find, use, evaluate, create, process information, and use it wisely is also called digital literacy (Sadikin *et al.*, 2019).

The use of guided inquiry-based e-modules requires students to access the e-module using a mobile phone that is connected to the internet. Accessed via the internet network. In orienting the problem, students use the internet to access and understand phenomena about satellites in video form. In organizing students, student's access video phenomena about satellites then students make predictions, problem formulation, and hypotheses. In this activity, students take advantage of searching for information that supports student's arguments in making predictions, problem formulation, and hypotheses.

Investigation activities, students carry out simulations through the physics simulation and edumedia science platforms, where in carrying out simulations students are required to access online simulation platforms. These three activities can support students in training student's digital literacy skills. The ability to made and use text and acquire data information through online reading and inquiry wit literacy of digital (Leu *et al.*, 2019). In carrying out activities in the e-module students also carry out simulations, search for information, and answer questions online. According to Setyaningsih *et al.*, (2019), the interests and attitudes for abilities digital literacy of individuals to make technology of digital and skill of communication instrument to access, manage, integrate, analyze and evaluate information, construction to new concept and funding, create communicate for data collect as participant more effectively and friendly society. E-modules can facilitate students in increasing digital literacy because more interactions with digital media are now a necessity for humans to facilitate life including learning in it coupled with interactive ways (Chairunisa & Zamhari, 2022).

The inquiry learning on e-modul as learning

experiences for special thema that emphasize the steps of process thinking and **analysis** to seen and find answers to a case in question. Inquiry for learning is designed persuasive students directly into the scientific process in several time with routine phase. Data inquiry exercises expanded scientific mastery are productive inovative in creative thinking and students become skilled in obtaining data and analyzing information (Susilawati et al., 2021). Students special plan in condition to conduct extensive self-practice in order to search what is experience happening, could to to do special something, list of questions, and found questions and answers for themselves, and connect one discovery with another. The teacher facilitated students in bring out experience by giving initial questions or instructions that can direct students into a discussion to find a solution to the problem. In the process of teaching and learning with the guided inquiry learning model, students are requset to found material through the necessary instructions from a teacher. These clues are not special in the list form of direction questions. In addition to questions, the teacher can also provide necessary explanations when students are going to do an experiment, for example an explanation of how to do an experiment. At the pre-steps of stage more is given direction for easy experience in learning by little the guidance is several reduced.

Guided inquiry is a teaching designed to learn material and interaction content and concepts. If making this learning set of model, the teacher ilustration examples to students, guides students when trying to find patterns in these examples and provides a kind of closing when students have been able to describe thema taught identified by the teacher (Al Mamun et al., 2022). The guided inquiry learning is inquiry learning with guidance from the teacher, which is a way of delivering lessons by studying something that is critical, analytical, and scientifically argumentative by using certain steps towards a conclusion (Rais et al., 2020). The teacher provides clear guidance or instructions to students. The steps in question are orientation, problem formulation, hypothesis formulation, and drawing conclusions on answers.

Conclusions

The development of guided inquiry-based e-modules on Newton's law of gravity material to train critical thinking skills is included in the very valid category with an average score of 3.57 on the material expert

test aspect and an average score of 3.69 on the design expert test aspect. The developed e-module is stated to be very practical with a percentage of 90% and very effective with a percentage of 87%. E-module of Newton's law based Guided Inquiry is able to improve Critical Thinking Skills which include the ability to reason, argumentation, inference and implementation in learning activities. Student responses obtained positive responses to Newton's law of gravity e-module.

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