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The Development of a Moodle-Assisted Guided Inquiry Model for General Biology E-Learning to Enhance the Student' Critical Thinking Dispositions

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Abstract: Critical thinking disposition is a component of higher-order thinking skills required to meet 21st-century challenges. This research aimed to develop a Moodle-assisted Guided Inquiry model (GI-Moodle) for General Biology e-learning and to enhance university students' critical thinking disposition. Fenrich's instructional model was used in this development research. Meanwhile, a quasi-experimental study was conducted at the implementation stage. This study was carried out at the Faculty of Applied Science and Engineering, Undikma. The data were collected using validation sheets and the California Critical Thinking Disposition Inventory. Descriptive quantitative analysis and ANCOVA were done. The results revealed that: the general biology e-learning developed was reliable and valid; students' critical thinking disposition increased from the pretest to the posttest, where the GI-Moodle students achieved better than the WhatApp Group-assisted Guided Inquiry students (GI-WAG) and WhatApp Group-assisted Structured Inquiry students (SI-WAG); the implementation of GI-Moodle and GI-WAG E-learning did not have a significant effect, but it was significantly different compared to the SI-WAG class. In conclusion, GI-Moodle is a viable option for enhancing college students critical thinking disposition through General Biology e-learning. It can be a reference for development in other learning.

Keywords: Critical thinking dispositions; E-learning; General biology; Guided inquiry; Moodle

Introduction

Higher-order thinking skills (HOTS), specifically skills or procedures used for critical thinking (Gunawan et al., 2019; Tong et al., 2022), are required to meet the problems of the 21st Century (Afandi et al., 2018; Irwanto, 2023; Sumarwati et al., 2020). Critical thinking is analytic and evaluative thinking with the purpose of reaching conclusions. It involves the process of deductive and inductive reasoning (Alismaiel, 2022; Facione, 2015; Shaw et al., 2020), which demands a superior level of reasoning to attain the desired outcome (Wechsler et al., 2018). Ennis (1996) describes critical thinking as the process of reasonable determination of what to believe or do. College students face a variety of challenges in daily life. Therefore, they should be able to solve their own problems through the process of learning.

According to Ennis (1996) and Facione (2015), critical thinking consists of two dimensions (aspects): cognitive and affective. The cognitive dimension of critical thinking is critical thinking skills, while the affective dimension is critical thinking disposition. Critical thinking disposition is a tendency to employ critical thinking skills in a situation (Facione et al., 1994; Robillos, 2022). Critical thinking disposition influences

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decisions regarding whether to utilize critical thinking in a situation and enables one to become a superior critical thinker (Syahfitri et al., 2019; Syahfitri & Firman, 2022). This highlights the significance of critical thinking disposition in the learning process.

The cognitive component of critical thinking is insufficient to make a student a critical thinker, so the critical thinking disposition needs to be taught in the classroom (Ennis, 1996; Sendag et al., 2015; Syahfitri & Firman, 2022). Critical thinking disposition is a constant intrinsic urge to engage with challenges and make judgments through critical thinking (Facione, 2015; Fitriani et al., 2018). Critical thinking disposition consists of seven components, namely: 1) inquisitiveness, 2) self-confidence, 3) truth-seeking, 4) open-mindedness, 5) analyticity, 6) systematicity, and 7) maturity (N. C. Facione et al., 1994; Gunawan et al., 2019; Robillos, 2022). In short, critical thinking disposition refers to one's awareness to think critically, so it is essential for students and needs to be empowered in learning activities.

Empowerment of students' critical thinking dispositions in Indonesia has yet to be done optimally. Most educators rarely apply to teach designs that develop higher-order thinking skills (Fauzi & Sa'diyah, 2019), so it has an impact on student learning outcomes, including critical thinking dispositions. This is evident from the research results, which prove that most students show a low level of critical thinking disposition (Fitriani et al., 2018; Temel, 2014). Students have low critical thinking because they lack a thorough understanding of analyzing essential data and managing scientific resources (Jaganathan & Subramaniam, 2016).

One of the efforts to enhance students' critical thinking disposition in the classroom is to involve students in investigative activities (Gunawan et al., 2019; Sendag et al., 2015). Guided Inquiry (GI) learning, for instance, can facilitate investigative activities through student-centered instruction (Margunayasa et al., 2019; Setyawan et al., 2020). The GI learning model places emphasis on strengthening students' skills, students' understanding, and confidence in science-related activities (Eichenholtz & Bellard, 2017). In addition, the scientific labor featured in this learning model enables students to directly observe, generate concepts, and draw conclusions about newly acquired knowledge (Khoiri et al., 2020; Putra et al., 2018). This explains that, besides emphasizing the skills, the GI learning model also emphasizes the achievement of other learning outcomes. Previous research indicates that GI has a positive effect on students' learning outcomes and critical thinking (Ibnusaputra et al., 2023; Putra et al., 2018; Verawati et al., 2020).

Due to the COVID-19 pandemic, the GI learning model has to be implemented online and offline. Therefore, the use of information and communication technology (ICT), such as the Modular Object-Oriented Dynamic Learning Environment (Moodle), is important. Moodle is a learning platform developed as a dependable and secure integrated system to build a learning environment that is suitable for every user (Aikina & Bolsunovskaya, 2020; Utari et al., 2023) and to enable lecturers and students to communicate at any time using communication tools (Makruf et al., 2022; Schettini et al., 2020). Moodle can assist lecturers in generating and administering online learning, in addition to offering a variety of elements that can be incorporated into learning, such as learning materials, quizzes, discussion forums, and assignments (Sumarwati et al., 2020). This proved the significance of the use of Moodle in education, particularly overcoming the restricted frequency of face-to-face encounters between students and lecturers (Almusharraf & Khahro, 2020; Nurwahidah et al., 2022; Schettini et al., 2020).

Moodle-assisted Guided Inquiry (GI-Moodle) is presented as e-learning. It may be implemented in online and offline courses and can be easily accessed. Because GI-Moodle learning involves students in research activities (Eichenholtz & Bellard, 2017; Khoiri et al., 2020), the courses that can utilize GI-Moodle are those that integrate investigative activities. The review of the curriculum of the undergraduate program at the Faculty of Engineering and Applied Science, Undikma, revealed that General Biology is a subject equipped with research activities. According to the Biology Education Curriculum Undikma, the objective of General Biology is for students to be able to comprehend and explain the concepts of biology as a prerequisite for advanced biology courses. This objective can be accomplished if students actively seek information without relying on the lecturer's content. Through e-learning-based inquiry activities, students will be more engaged and independent in pursuing knowledge sources using the GI-Moodle learning model.

The developed GI-Moodle e-learning is an interactive mobile technology that can facilitate communication between students and lecturers. In GI-Moodle e-learning, lecturers followed students in their investigation activities. The function of lecturers in assisting students is necessary for the optimal results of the learning process. The current study aimed to develop a Moodle-assisted guided inquiry model (GI-Moodle) for general biology e-learning and enhance the student's critical thinking.

Method

Research Design

This study was a part of a Research and Development study that aimed to generate a Moodle-assisted Guided Inquiry model for General Biology e-learning. The e-learning model was developed using Fenrich's instructional development model (Figure 1). There were six phases conducted during the development of the product, namely: Analysis, Planning, Design, Development, Implementation, Evaluation and Revision. Each of the phases is explained in the following sections.

The objective of the *Analysis* phase is to discover and analyze classroom issues and to establish the desired learning outcomes. Utilizing a requirements analysis questionnaire, problems were identified through observation and interviews. The needs analysis questionnaire was completed by students who had taken General Biology as well as the course lecturers. The subsequent stage was *Planning*. During this phase, learning activities were details planned, along with performance objectives and assessment systems. This *Design* phase focused on preparation, the adoption of the original design of the instructional tools, and the development of the e-learning portal. After the Analysis, Planning and Design phases, instructional tools will be produced, which is an E-learning prototype.

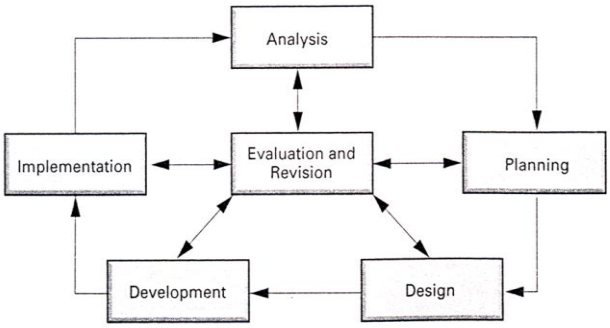

Figure 1. Fenrich's instructional development model (Fenrich, 2005)

The Development stage followed the preceding stages. During the Development phase, an evaluation of the e-learning prototypes was conducted through a validity test to examine the feasibility of the learning materials, the accuracy of the concepts, and the feasibility of the learning media. The validity test was conducted by three experts, one for each factor evaluated. In the classroom, valid and improved e-learning was then deployed. The *Implementation* phase was a quasi-experimental research phase in which produced e-learning was applied in the classroom. The *Review and Revision* phase was a continuous process that occurred at each stage of the development cycle (Fenrich, 2005).

The pretest-posttest non-equivalent control group design was used in the quasi-experiment (Cohen et al., 2018). The experimental research design is presented in Table 1.

Table 1. Quasi-Experimental Research Design

Pretest	Treatment	Posttest
O1	X1	O2
O3	X2	O4
O5	X3	O6

Notes:
O1, O3, O5: pretest scores; O2, O4, O6: posttest scores
X1: Guided Inquiry-Moodle (GI-Moodle)
X2: Guided Inquiry-WhatsApp Group (GI-WAG)
X3: Structured Inquiry-WhatsApp Group (SI-WAG)

The quasi-experimental study involved three treatment groups, namely: the experimental, positive control, and negative control groups. The experimental group (X1) was taught using the GI-Moodle learning model, the positive control group (X2) was taught using the GI-WAG learning model, and the negative control group (X3) was taught using the SI-WAG learning model. The learning activities were conducted online and offline. The first meeting of each discussed subject was conducted online, while the second meeting was offline. The General Biology course covered five topics, including Cytology, Reproduction, Photosynthesis, Ecosystems, and Biodiversity. During the online session, students were directed to identify subject-related problems, select learning tools and resources, and develop the investigation procedure (GI), while the lecturer designed the investigation procedure (SI). During the offline meeting, students conducted investigations based on the investigation procedures set beforehand. The investigation's findings served as the basis for students' conclusions. Due to the pandemic conditions, it was not possible for this learning activity to take place entirely offline.

Research Sample

The sample was determined using a cluster random sampling technique. This technique commenced with an equivalency test (ANOVA test) utilizing the SPSS program, the results of which indicated that all population members possessed equivalent academic abilities. Then, three classes were randomly selected as the research sample: X1 as the experimental group (consisting of 31 students), X2 as the positive control group (consisting of 32 students), and X3 as the negative control group (consisting of 27 students). Thus, the research participants consisted of 90 students enrolled in the General Biology course during the 2021/2022

academic year at the Faculty of Engineering and Applied Science, Undikma, Indonesia.

Research Instrument and Data Collection

This study used validation sheets and The California Critical Thinking Disposition Inventory as instruments (CCTDI). The validation sheets were used to examine the validity of the generated product, whereas the CCTDI was used to identify the students' critical thinking dispositions. This investigation utilized an adapted version of the CCTDI developed by Facione et al. (1994). Prior to its usage in the study, the validity and reliability of the research instruments were examined and confirmed. The critical thinking dispositions of the students from the three treatment groups were measured with a pre- and post-test, administered before and after all learning sessions, respectively.

Data Analysis

Using qualitative descriptive analysis, the findings of the validity test of the e-learning components were studied, specifically by averaging the scores obtained from the three validators. The findings of the average score are stated according to the criteria presented in Table 2 (modified from Ratumanan & Laurens (2011)).

Table 2. Validity category

Interval	Category	Notes
1.0 ≤SV≤ 1.5	Poor	Cannot be used, needs to be considered carefully
1.6 <SV≤ 2.5	Fair	Can be used with major revision
2.6 <SV≤ 3.5	Good	Can be used with minor revision
3.6 <SV≤ 4.0	Very Good	Can be used without revision

Using parametric statistical techniques, notably Analysis of Covariance (ANCOVA), data on the student's critical thinking disposition were evaluated to demonstrate an increase (difference) in the critical thinking dispositions of each treatment group. The normality and homogeneity tests were performed before conducting the ANCOVA test. The One Sample Kolmogorov Smirnov test was utilized for the normality test, while Levene's Test of Equality of Error Variances was utilized for the homogeneity test. The LSD (Least Significant Different) test was used for the ANCOVA findings that indicated differences between the treatment groups. With a significance level of 0.05 (5%), SPSS was used to conduct the parametric statistical analysis.

Result and Discussion

Results

The development of e-learning GI-Moodle in this study consisted of six (6) phases: Analysis, Planning, Design, Development, Implementation, as well as Evaluation and Revision (Fenrich, 2005). The needs analysis results indicated that the instructional activities often involved lecture, discussion, question-and-answer, and assignment delivery methods for the subject matter. Moreover, throughout practicum activities, students utilized a simple practicum manual (already equipped with problems, work procedures, and tools and materials). Consequently, a Learning Management System (LMS) is essential for supporting online learning activities to meet learning objectives effectively. WhatsApp Group (WAG) was the most popular medium for online education. The needs analysis determined that measuring students' critical thinking dispositions were rarely conducted, even though 87.8% of students stated they needed critical thinking dispositions as prospective educators. Based on the needs analysis results, learning outcomes must be adapted to meet the needs of the 21st Century, namely, to develop student competencies related to higher-order thinking skills, including the disposition critical thinking.

Planning was the process that followed the needs analysis and consisted of the following activities: designing learning activities, establishing performance objectives, and building evaluation systems. Based on the results of the problem analysis and the desired learning objectives, the Guided Inquiry learning model was implemented in the classroom. The pandemic required learning activities to take place online, so the application of the GI learning model was assisted by LMS-Moodle. Considering this, the projected performance objective was to provide e-learning that employed the Guided Inquiry learning model supported by Moodle and enhanced students' critical thinking dispositions. This research employed an assessment technique to evaluate the product's validity and create a field test design for use in the implementation phase. In this instance, the tested components comprised a validation tool for evaluating the practicability of the General Biology e-learning prototype built during the Design phase.

The Design phase focused on developing the instructional tools (e-learning prototypes) and the e-learning portal. The instructional tools were organized in accordance with the Guided Inquiry learning model and the subjects discussed in the classroom, including cytology, the reproductive system, photosynthesis, ecology, and biodiversity. This initial design stage yielded prototypes of the General Biology instructional

tools, including a syllabus, lesson plans, student worksheets, PowerPoint, a critical thinking disposition questionnaire, and validation sheets. Next, an LMS-Moodle portal was created. The e-learning portal required a server that serves as a repository for e-learning content and applications that may be accessed via a specific URL. The location (URL) of the e-learning portal developed for this study is http://saidil.ikip-mataram.ac.id/. The e-learning portal was inputted and developed based on the expected requirements.

In the Development phase, the prototypes of the General Biology instructional tools (e-learning components) were evaluated in a validity test by three experts. The validity test measured the feasibility of the instructional materials and media as well as the correctness of the biology concepts integrated in the tools. Figure 2 illustrates the validity test findings.

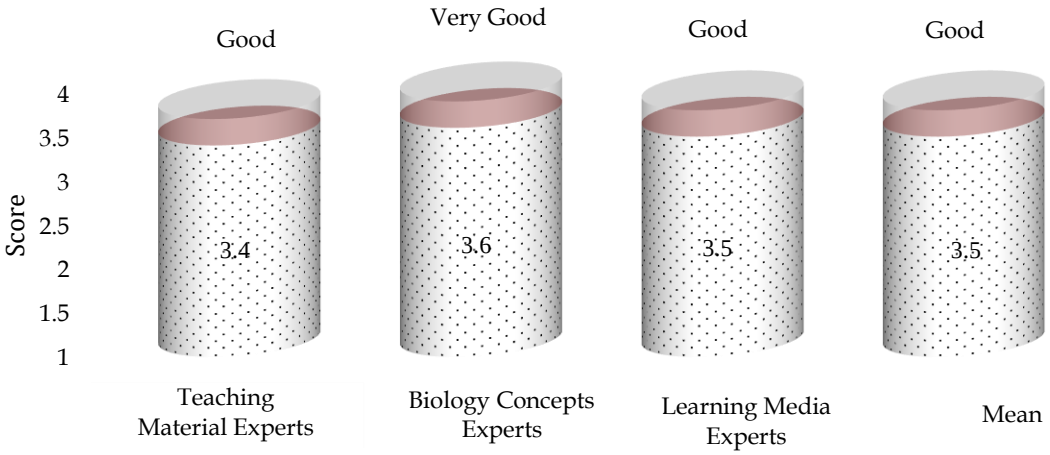

Figure 2. The results of the prototypes' validity test

Figure 2 shows the results of the validity test. Based on the validity test findings, the developed teaching materials achieved a score of 3.4 (good), the correctness of the biology concepts scored 3.6 (very good), and the feasibility of the media scored 3.5 (good). The three experts who also served as validators suggested adjusting the operational verbs used to formulate course learning outcomes and learning indicators, correcting typographical errors in the texts, improving the formulation of learning steps in lesson plans to make learning more student-centered, and improving the formulation of problems given to students in both lesson plans and student worksheet. Experts also recommended incorporating summarizing activity at the end of each lesson, as well as providing general instructions on how to operate the e-learning platform. In addition, problems discussed in the classroom should be more contextual. Some formulations of practice questions or exams must be modified so that students can comprehend them better. The name of the editor must be written on the front cover of the student worksheet, and the visuals on the PowerPoint slides must correspond to the topic being explained. Generally, the prototype of each instructional tool received a respectable average rating of 3.5. Therefore, the prototypes of the instructional tools must be updated in accordance with the validators' recommendations prior to their implementation in the classroom.

The validated and improved e-learning components contained instructional tools such as video, audio, and student data, which had been integrated into the created e-learning portal. In order for e-learning to be implemented in the classroom, the e-learning portal with LMS-Moodle was designed according to the specified requirements.

In the Implementation phase, students' critical thinking dispositions were identified using CCTDI. The data were then evaluated to establish the critical thinking dispositions of students from each treatment group. Figure 3 illustrates the results of the analysis. According to Figure 3, the mean pre- and post-test scores of students' critical thinking dispositions taught through e-learning GI-Moodle, GI-WAG, and SI-WAG experience different levels of increase. The largest increase was observed in the GI-Moodle e-learning group (11.1%), followed by the GI-WAG group (9.3%), and the SI-WAG group (6.8%).

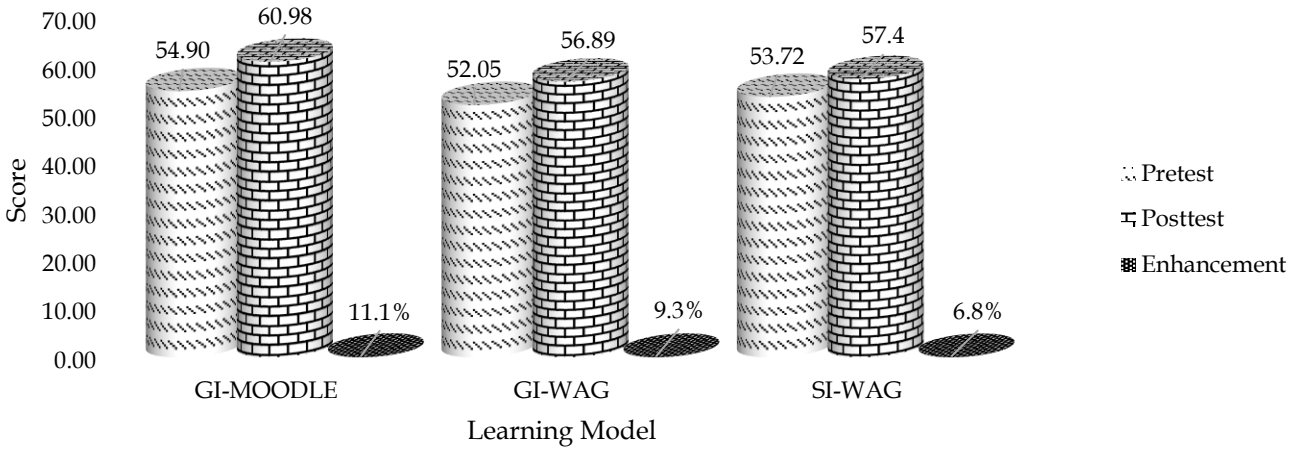

Figure 3. The mean pre- and post-test scores of students' critical thinking dispositions

In addition, data on students' critical thinking dispositions were assessed using parametric statistics, resulting in more precise data regarding differences in student competency between treatments. The test of parametric statistical significance with ANCOVA was preceded by normality and homogeneity tests. The purpose of the normality test was to assess whether the data were normally distributed. The normality test result is presented in Table 3. Table 3 shows that both the pre- and post-test data were normally distributed (Sig. pretest = 0.676 > 0.05, and Sig. post-test 0.558 > 0.05). The homogeneity test sought to assess whether the distribution of both pre- and post-test study data was homogeneous. Based on the Table 3, the pre- and post-test data had homogeneous variances (Sig. pretest = 0.152 > 0.05, and Sig. posttest 0.569 > 0.05).

Table 3. The results of the normality and homogeneity tests

Data	Sig. Normality	Sig. Homogeneity	*a*
Pretest	0.676	0.152	0.05
Posttest	0.558	0.569	0.05

Based on the results of the normality and homogeneity tests, it was stated that the pre- and post-test data were distributed normally and had homogeneous variances. The assumption tests' results indicated that the data in this study fulfilled the requirements for the parametric statistical analysis of ANCOVA. The ANCOVA results are presented in Table 4.

Table 4. The Results of ANCOVA

Source	*df*	*Mean Square*	*F*	*Sig. (p)*
Learning Model	2	40.208	6.445	0.002

Table 4 shows an F-calculated of 6.445 and a p-value (0.002) smaller than the alpha (0.05), meaning that there was a difference in the critical thinking dispositions between students in the GI-Moodle, GI-WAG, and SI-WAG groups. Furthermore, an LSD test with 5% of significance was done to determine which learning model had the most significant effect on students' critical thinking dispositions. The LSD test results are depicted in Table 5.

Table 5. The Students' Mean Score Significance Difference Based on the LSD Test

Group	Pretest	Mean Posttest	Mean Corrected	Enhancement	LSD Notation
GI-Moodle	54.895	60.980	59.591	11.085%	a
GI-WAG	52.045	56.888	58.397	9.306%	a
SI-WAG	53.719	57.396	57.203	6.845%	b

Based on the LSD test results displayed in Table 5, it was known that the mean score of students in the GI-Moodle group did not differ substantially from that of students in the GI-WAG group. The same LSD notation was recorded by both groups, confirming this finding. In contrast to the SI-WAG students, the GI-Moodle group achieved a significantly higher mean score of critical thinking dispositions, as evidenced by the disparity between the LSD notations received by the two groups.

Discussion

This study resulted in the development of e-learning for General Biology utilizing the Guided Inquiry (GI) learning approach supported by Moodle. The use of technology in e-learning in the form of

Moodle is an adaptation to the implementation of learning, which has switched from offline (face-to-face) techniques to online learning (Almusharraf & Khahro, 2020; Chootongchai & Songkram, 2018; Makruf et al., 2022). E-learning can overcome the spatial and temporal limits of offline learning, allow students and lecturers to connect and communicate at any time and from any location (Herayanti et al., 2018; Schettini et al., 2020). Moodle is one of the LMS that may build a digital-based learning environment, hence facilitating the online learning process (Aikina & Bolsunovskaya, 2020; Makruf et al., 2022; Nurwahidah et al., 2022). A technology-supported online learning system is highly recommended for higher education (Antón-Sancho et al., 2023; Bekteshi et al., 2023; Zidoun et al., 2016) since it can promote critical thinking skills (Ninghardjanti & Dirgatama, 2021), as well as foster creativity and motivation in the classroom (Yu et al., 2018).

General Biology e-learning based on the Moodle-assisted Guided Inquiry has been deemed valid and appropriate for usage in educational settings. Figure 2 depicts the results of the validity test demonstrating this. Validity testing is crucial for determining the quality or viability of the developed product (Cynthia et al., 2023; Quinto, 2022; Sutiani et al., 2021). E-learning feasibility was evaluated based on three factors: characteristics of learning (teaching materials), aspects of the veracity of concepts/materials, and aspects of learning medium (Sutiani et al., 2021; Syahfitri et al., 2019). The results of the feasibility test were deemed satisfactory; thus, it was necessary to amend the instructional tools in accordance with the validators' suggestions. The amended e-learning components were then entered and developed into a portal that had been established in accordance with the required criteria to produce e-learning that is suitable for implementation in learning activities. In the implementation phase, the effectiveness of e-learning in enhancing students' critical thinking dispositions was evaluated.

The experimental study conducted during the implementation phase revealed that GI-Moodle-based e-learning was helpful in fostering students' critical thinking dispositions. Figure 3 depicts the mean pre- and post-test scores of students' critical thinking dispositions in the three treatment groups, which increased after the implementation of the GI-Moodle, GI-WAG, and SI-WAG models. The rise in each class varied, with the GI-Moodle e-learning class showing the greatest increase, followed by the GI-WAG group, and the SI-WAG class showing the smallest gain. In addition, the results of the ANCOVA test in Table 5 indicated that the mean dispositions of students' critical thinking differed between GI-Moodle, GI-WAG, and SI-WAG implementations of e-learning. Previous research has shown that the GI learning model is successful at enhancing students' critical thinking skills, which supports the findings of this study (Indawati et al., 2023; Miftakhurrohmah et al., 2023; Pursitasari et al., 2020; Sutiani et al., 2021; Verawati et al., 2020).

The student's critical thinking dispositions in this study were improved because of the GI model's emphasis on student activity (Margunayasa et al., 2019; Putra et al., 2018), in which students were asked to establish investigative procedures, collect data, and make conclusions (Llewellyn, 2013; Sutiani et al., 2021). Beginning with research questions (problems) given by the lecturers, students collaborated to design the procedure, data collecting, data analysis, formulate conclusions, and communicate their findings (Indawati et al., 2023; Miftakhurrohmah et al., 2023; Yuliati et al., 2018). Consequently, GI is student-centered, collaborative, and problem-based (Khoiri et al., 2020; Pedaste et al., 2015; Setyawan et al., 2020).

The lecturer's role in GI-based learning is to guide students through a series of questions designed to promote concept exploration. The lecturer is also responsible for directing students to do investigation activities and create arguments based on the gathered evidence (Artayasa et al., 2018; Pursitasari et al., 2020). Lecturers ask questions to direct students to their tasks, namely to develop investigation procedures (Irwanto, 2023; Khoiri et al., 2020). Students in groups develop procedures by identifying their own sources of the necessary information and actively interacting with one another, for instance by working together and exchanging opinions among friends (Setyawan et al., 2020; Yuliati et al., 2018). The students will enhance inquisitiveness, self-confidence, analytical, and systematic skills through these learning exercises.

The procedure developed by students is then consulted with lecturers and presented so as to produce appropriate investigative procedures (Llewellyn, 2013). Online consultation activities and presentations provide the students with valuable feedback. These exercises will cultivate student self-confidence, open-mindedness, and maturity. At the subsequent offline meeting, the students complete an investigation based on a technique approved by the lecturers (Llewellyn, 2013). These investigative activities will encourage students to prove or truth-seeking using field-based evidence (Turner et al., 2018). Students are also encouraged to organize their findings in tables, diagrams, or graphs to draw conclusions based on the gathered data (Pursitasari et al., 2020; Verawati et al., 2020). These learning activities can encourage students' critical thinking, so training and enhancing their critical thinking dispositions (Weinstein, 2017).

In GI-Moodle, Moodle is utilized to facilitate online GI instruction. The primary advantage of electronic-based learning in the form of Moodle is that it enables

students to connect electronically during learning activities with both fellow students and lecturers (Aikina & Bolsunovskaya, 2020; Herayanti et al., 2018). Moodle also enables lecturers to manage learning and exchange information with students swiftly and flexibly (Makruf et al., 2022) and enables lecturers and students to communicate utilizing communication tools whenever and wherever (Anggraeni & Sole, 2022; Schettini et al., 2020; Sumarwati et al., 2020).

In addition, according to another finding of this study, GI-Moodle was not significantly different from GI-WAG in enhancing the students' critical thinking dispositions. Several factors, including differences in the intensity of inquiry and the use of Moodle, may contribute to this finding. Previous research demonstrated that the two levels of inquiry, namely SI and GI, have distinct effects on learning outcomes (Bunterm et al., 2014). GI is a more complicated investigation level than SI (Artayasa et al., 2018; Bunterm et al., 2014; Yanto et al., 2019). In GI, students must independently construct investigation processes, whereas, in SI, the investigation procedures are established by the lecturer (Artayasa et al., 2018). Therefore, students enrolled in GI learning have greater latitude to undertake inquiries than those enrolled in SI courses (Yanto et al., 2019).

Participation in learning assists students in acquiring the knowledge or comprehension necessary to investigate a topic. In accordance with this, Eichenholtz & Bellard (2017) stated that GI is a learning paradigm that actively engages students in investigative activities, providing students with hands-on experience in solving problems relevant to the content they are studying under the supervision of the lecturers. This demonstrates that GI is student-centered, focuses on skill development, and can give students experiences in basic inquiry (Llewellyn, 2013). The experience obtained by implementing GI in the classroom can boost students' knowledge and confidence, hence impacting their critical thinking dispositions.

Using technology in the form of MOODLE can increase student activity in learning activities (Makruf et al., 2022; Schettini et al., 2020), thus affecting learning outcomes, including critical thinking dispositions. A technology-supported online learning system is widely suggested for student-centered learning (Bekteshi et al., 2023; Zidoun et al., 2016), since it may considerably enhance students' thinking skills (Chootongchai & Songkram, 2018; Setyawan et al., 2020). Moodle can increase the effectiveness of a learning process (Schettini et al., 2020) specifically by increasing direct interaction of students with learning materials, providing discussion facilities for students with their lecturers and other students, providing feedback and facilitating students to collaborate (Aikina & Bolsunovskaya, 2020).

In conclusion, Moodle can support GI learning in enhancing students' critical thinking dispositions. This is corroborated by the findings of earlier indicating that technology-based learning has a favourable effect on students' critical thinking dispositions studies (Gunawan et al., 2019; Robillos, 2022; Sendag et al., 2015). According to the findings of other previous studies, using Moodle to learn can enhance college students' thinking skills (Chootongchai & Songkram, 2018; Cynthia et al., 2023; Sumarwati et al., 2020). This study focused on enhancing critical thinking dispositions; hence, additional research is required to demonstrate the impact of e-learning on students' thinking skills and other learning outcomes. In addition, the development of e-learning was limited to General Biology classes; consequently, it is essential to build equivalent e-learning in other courses that demand a greater aptitude for critical thinking or other learning outcomes

Conclusion

This study has produced a product in the form of General Biology e-learning, which is valid, practical, and effective. The e-learning is based on the Guided Inquiry learning model supported by Moodle. The use of technology in the form of Moodle in e-learning is an adaptation to the application of 21st-century learning, where formerly face-to-face (offline) learning methodologies are beginning to be combined with online learning. Based on this research finding, it can be stated that the General Biology e-learning generated is legitimate and suitable for use in education and that General Biology e-learning using GI-Moodle can increase students' critical thinking dispositions. The study results also indicated that the implementation of GI-Moodle in e-learning did not differ considerably from that of GI-WAG in terms of enhancing students' critical thinking dispositions, despite the fact that the two models differed significantly from the SI-WAG model. Consequently, General Biology e-learning using GI-Moodle might serve as a means of enhancing students' critical thinking dispositions. The learning model can be applied to different topics of Biology learning and learning in general.

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