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Development of Flipped Guided Inquiry Learning (FGIL) System Using Discord Application on Chemical Equilibrium

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Abstract: This study aims to develop and analyze the validity and practicality of the Flipped Guided Inquiry Learning (FGIL) system using Discord application on chemical equilibrium. The research method used was Educational Design Research (EDR) with the Plomp model. Chemistry lecturers and teachers were experts and 12 students of grade XI SMAN 8 Padang who became subjects in this development research. The instruments used were the validity sheet for content validity and construct validity tests which were then processed using Aiken's V formula. In contrast, the practicality test's teacher and student response surveys included a practicality percentage. Based on the analysis results, it was found that the V values for content and construct validity were 0.88; and 0.89, with a valid category. Practicality results showed a value of 92% for students and 93% for teachers with a practical category. Therefore, the learning system created is reliable and useful for teaching.

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Introduction

Facing the industrial revolution era, 4.0 causes changes in all areas of life, one of which is the field of education which results in the use and dissemination of IT (information and technology) (Rakhmawan et al., 2020). The industrial revolution 4.0 era causes educators to understand and apply technological developments to achieve a dynamic learning environment. As a result, digital-based online learning systems are among the learning requirements in the age of revolution 4.0 (Fani & Mawardi, 2022).

The goals of Indonesian education, which emphasize 21st-century skills, align with the development of the Industrial Revolution 4.0 era (Risdianto, 2019). Students must possess several skills, namely 4C skills (critical thinking, communication, collaboration, and creativity) (Indarta et al., 2022). Learning in the 21st century is a challenge for teachers to adjust teaching strategies, models and methods according to the characteristics of this generation (Rakhmawan et al., 2020). Implementing 21st-century learning based on a Merdeka Curriculum is carried out by considering students' readiness, interest, and learning needs to achieve learning objectives and national education goals optimally (Ibrahim et al., 2021).

A flipped classroom is a sub-model of the rotation model in blended learning (Watson et al., 2015). This educational approach can help pupils learn in a way that is comfortable for them while still achieving learning outcomes and providing convenience for teachers in learning (Ismail & Mawardi, 2021). Students who attend classes in a flipped method may learn more actively, support group work, replay learning videos anywhere and anytime, and set the learning pace (Herpika & Mawardi, 2021). The flipped classroom approach offers both synchronous and asynchronous learning opportunities. When instructors and students

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are present simultaneously, synchronous learning occurs; however, asynchronous learning occurs when instructors and students are present at various times and locations (Rakhmawan et al., 2020).

A set of exercises known as guided inquiry helps students learn and explore concepts methodically, critically, logically, and analytically. For the sequence of exploration and concept formation, and application is at the core of this design (Mawardi et al., 2016). The guided inquiry model involves learners' prior knowledge that is built through experiences followed in the learning cycle including exploration, concept formation, and application (Hanson, 2015).

The guided inquiry learning model and the flipped classroom learning method are combined to form the FGIL system is a suitable combination to be applied as a learning system. The combination leadable students to be more active during learning due to the emphasis on the process of concept discovery by students while the teacher is a facilitator. The flipped classroom system will facilitate learning activities to be more focused, effective, and practical (Waer & Mawardi, 2021).

To support the learning of the FGIL system in its implementation of Discord. It was first released in 2015 and is an application with the main target of the video game community to communicate directly with game players (Ardiyansah et al., 2021). Along with developing features in Discord to be applied in education (Muzaki & Hakim, 2022). Discord social media has advantages such as users can communicate through voice calls and even video calls, discuss, control students' activities, and provide feedback by teachers to students so that good collaboration is established (Dewantara et al., 2020).

Based on Lo & Hew (2017) research, learning with the flipped classroom approach encourages active learning that requires students to solve problems with what they learned before learning in the classroom. According to research by Lee & Wallace (2018), flipped classroom learning impacts students' final grades, which increase when compared to classes with conventional learning. Most learners are more active in classroom learning, and there is feedback between teachers and learners. By giving assignments before in-class learning, learners become more prepared to learn (Lee & Wallace, 2018).

Based on Nurcahyo's research (2020), learning using e-learning in the Merdeka Curriculum provides more opportunities for students to work flexibly wherever, whenever, and however. According to research by Dewantara et al. (2020), blended learning using Google Classroom and Moodle LMS can be replaced using Discord. Discord as a learning platform supports the emergence of a teacher's creative ideas, and learning becomes more interactive to raise students' interest in learning (Dewantara et al., 2020).

A solution for active and interactive learning on chemical equilibrium, according to previous research by Siregar and Mawardi (2022), which describes how the FGIL system is applied in learning chemistry, specifically on chemical equilibrium, using a Learning Management System (LMS) named Moodle in both asynchronous and synchronous learning. Other relevant research is the system of flipped classrooms based on guided inquiry learning on redox reactions and electrochemistry using Moodle on redox and electrochemical reactions (Insani et al., 2022). For XII grade SMA/MA, research is being done on creating a flipped classroom learning system based on guided inquiry on redox reactions and electrochemical cells (Winata & Mawardi, 2021). The outcome is that an application that can run synchronous and asynchronous learning on one system is required. Discord is a platform for learning that is entirely free to use and does not have any extra fees or premium subscriptions (Kruglyk et al., 2020). Students can benefit from using Discord in the

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classroom thanks to its reliable operation, excellent communication quality, and user-friendly design, making it ideal for users of all ability levels.

This research utilizes the learning system developed as FGIL system uses Discord in learning activities. Discord was chosen because it provides capabilities that support synchronous and asynchronous learning, including taking attendance, having voice calls, and video conferences, sharing screens, creating discussion rooms, and allowing professors to regulate student access. Using simple technology compared to other applications, the Discord application in synchronous learning creates a single-stream online classroom system while improving learning circumstances and lowering system challenges (Kruglyk et al., 2020). In addition, guided inquiry learning syntax can also be arranged on Discord. With Discord, learning will be more practical for both teachers and students. This research aims to analyze the validity and practicality of the FGIL learning system using Discord on chemical equilibrium.

Research Method

The research method used was Educational Design Research (EDR) which aims to design and develop an intervention as an innovative solution to a complex problem (Plomp & Nieveen, 2007). The Plomp model, created by Tjeerd Plomp, is the development model employed in this research. This Plomp model has three phases, namely (1) preliminary research (initial investigation), (2) development or prototyping (development and prototyping), and (3) assessment (trial and assessment) but is limited to the prototype IV stage. The first stage was preliminary research by conducting several activities: needs analysis, context analysis, literature study, and conceptual framework development. In the need analysis, interviews were conducted with three chemistry teachers in three different schools in Padang City, namely SMA Negeri 1 Padang, SMA Negeri 8 Padang, and SMA Pembangunan UNP. As for the context analysis, the curriculum, and Learning Outcomes (CP) were analyzed.

Furthermore, a literature study was conducted on several articles related to the problems found and attempted to discover solutions to issues that arise in the industry; the preliminary stage ends with developing a conceptual framework. Based on the literature studies conducted, the conceptual framework will describe the problems found at the need analysis and context analysis stages to provide solutions to overcome these problems. The analysis result conducted at the preliminary stage will then be used to design the development of the FGIL system using Discord on chemical equilibrium for grade XI SMA/MA.

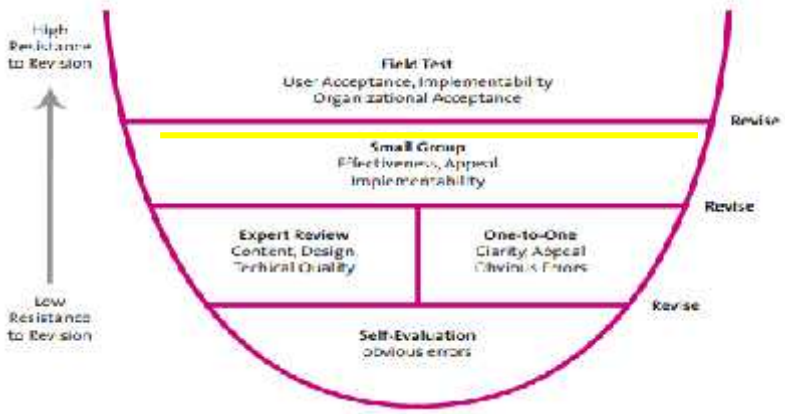

Figure 1. Layers of Formative Evaluation from Tessmer (Plomp & Nieveen, 2007)

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Based on Figure 1, the prototype development and formation stage align with the four stages of formative evaluation: self-evaluation, expert review, one-to-one evaluation, and small group test. The prototype development and formation stage begin with developing a product as an FGIL system using Discord as prototype I. In the second stage, the developed product (prototype I) underwent a self-evaluation by completing a self-evaluation questionnaire. Furthermore, the product will be revised to form prototype II.

Expert review and one-on-one evaluation of prototype II made up the third stage. Three chemistry lecturers from FMIPA UNP and two chemistry teachers from SMAN 8 Padang were subjected to an expert review. Experts act as validators who assess prototype II through evaluation questionnaires in the form of content and construct validity questionnaires. An individual evaluation will be carried out by conducting interviews with three students from grade XI of SMAN 8 Padang utilizing an interview sheet instrument after prototype II has been examined by experts during the expert review stage. The three students were selected with varying ability levels, namely high, medium, and low abilities recommended by the chemistry teacher. Prototype II will be revised based on all inputs to produce a valid prototype III. The last stage was the small group test which was conducted on nine students of grade XI SMAN Padang with varying levels of ability, namely students with high, medium, and low abilities selected based on the recommendation of the chemistry teacher. At this stage, the developed learning system was tested on several small groups of students for one learning cycle. Furthermore, students and chemistry teachers would provide suggestions and input on the developed learning system by completing a practicality questionnaire. Prototype III would be revised to produce a valid and practical prototype IV.

Data obtained through interviews would be presented in the form of conclusions. Meanwhile, Processing the data received from the validator using the Aiken V formula was used to see the validity of the product developed. The employed Aiken formula is as follows (Lewis R. Aiken, 1985):

$$V = \frac{\sum s}{n(c-1)}$$
$$s = r - Io$$

Information:
Io: The lowest validity assessment number (in this case = 1)
c: The highest validity assessment number (in this case = 5)
r: The number given by the validator
n: Many validators

The following are the validity assessment criteria based on the Aiken's V scale found in Table 1 below.

Table 1. Aiken Validity Index Criteria

Aiken's V Scale	Validity
V ≥ 0,80	Valid
V < 0,80	Invalid

Source: Lewis R. Aiken (1985)

Data obtained through small group tests in the form of responses from teachers and students, with the formula below, find the degree of product practicality (Purwanto, 2010):

$$NP = \frac{R}{SM} \times 100$$

Information:
NP: The percent value sought or expected

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R: Raw score obtained by students
SM: The ideal maximum score of the test concerned
100: Constant

In terms of how practical the guided inquiry based FGIL learning approach was using Discord, it can be seen from Table 2 below.

Table 2. Practicality Level Category

Value	Aspect Assessed
86% - 100%	Very Practical
76% - 85%	Practical
60% - 75%	Quite Practical
55% - 59%	Less Practical
≤ 54%	Not Practical

Source: Purwanto in Muharika & Agus (2019)

Results and Discussion

This study aims to create a FGIL learning system using Discord on chemical equilibrium material. Additionally, by assessing the generated learning system's level of practicality and validity criteria. The research described above was carried out following the stages of the Plomp model, which will be explained as follows:

Preliminary Research

Need analysis

Based on the results of structured interviews conducted with three chemistry teachers, the results are related to strategies for dealing with obstacles in learning using the Merdeka Curriculum, namely by carrying out learning with a scientific approach with a specific learning model. Besides that, the application of a learning system that has yet to adapt to learning 4.0 by applying technology, there is no application of social media with features that support learning; as a result, students are more engaged. According to an analysis of the interview data, one of the requirements of the Merdeka Curriculum is learner-centered learning, which can increase students' participation in classroom learning. The flipped classroom learning method and the guided inquiry model both attempt to aid students in developing concepts. At this stage, researchers interviewed three chemistry teachers in three different schools in Padang City, namely SMAN 1 Padang, SMAN 8 Padang, and SMA Pembangunan UNP.

Context analysis

The curriculum and learning outcomes (CP) are assessed during the context analysis step. This analysis aims to identify, detail, and place the various learning objectives in order, materials, and strategies that are systematically selected to develop a learning system. From the CP, it is then derived into TP and ATP on chemical equilibrium material that will be compiled in Discord. One of the chemical materials is chemical equilibrium material studied in eleventh grade, which has abstract concepts such as in the dynamic equilibrium subchapter, the difference between equilibrium and imbalance, and the application of Le Chatelier's principle (Raviolo & Garritz). When the forward reaction rate and the reverse reaction rate are equal, and the reactant and product concentrations remain constant throughout time, chemical equilibrium occurs (Chang, 2008).

Literature study

After going through the interview stage in the field, the researcher conducted a literature study of several scientific journals related to the problems found and try to devise

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solutions to the issues we run into in the field. These articles were used as reading sources that contain the source of research ideas. Therefore, an FGIL system development using Discord on chemical equilibrium material was designed, which is expected to increase learners' participation in their studies. In addition, through literature studies, the Plomp Model developed by Tjeerd Plomp is one of the appropriate development models for this research.
Based on research conducted by Bergmann & Sams (2012) and Hughes (2012), the implementation of the flipped classroom makes the flipped classroom learning system will have an impact on learning to make students more active; using technology facilities, the students do homework first, the activity of the class involves students in critical thinking in dealing with problems with good solutions, and helps students to understand better the concepts (Albert & Beatty, 2014).

Conceptual framework development

According to the literature study, the learning system used in the learning process is the FGIL system using Discord. The stages of guided inquiry learning relate to how the learning system is used. The following are the stages of the FGIL learning system in Figure 2.

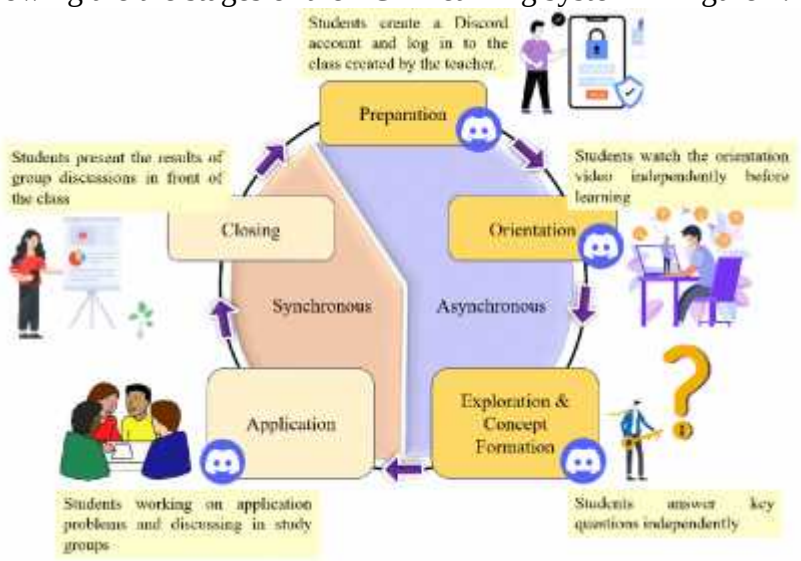

Figure 2. FGIL System Chart Using Discord

Development or prototyping phase

In the development or prototyping phase, prototyping will be carried out along with four stages of formative evaluation, including self-evaluation, expert review, one-to-one evaluation, and small group. Along with the formative evaluation of the developed product, revisions will also be made at each stage of the formative evaluation.

Prototype I

What was done in the prototype I stage was to design the FGIL learning system following the steps of guided inquiry learning. They include orientation, exploration and concept formation, application, and closure. The FGIL system consists of two learning conditions: asynchronous and synchronous. Asynchronous learning conditions are conducted at the orientation, concept exploration and formation, and application stages, while application and closure are conducted synchronously in the classroom. The two learning conditions will be run using the Discord application. After everything is well organized, the next step is to compile the results of the learning design into Discord. The learning begins with self-verification as a learner in

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the class and then continues with attending asynchronous learning on Discord. Figure 3 shows an illustration of self-verification and attendance taking on Discord.

a) b)

Figure 3. a) Self-Verification, b) Taking Attendance on Discord

The orientation video contains learning directions, learning outcomes, learning objectives, apperceptions, and a brief introduction to the material to be learned. An example of an orientation video display on Discord can be seen in Figure 4.

Figure 4. Orientation Video View on Discord

After determining the learning system to be used, the next stage is to find a model that fits the learning objectives for the chemical equilibrium material. The contested model consists of animated pictures, graphs, and data tables. Furthermore, some models include multiple chemical representations. Create appropriate key questions from the presented model to effectively guide students in discovering concepts and learning objectives they are expected to attain. The model and key questions were presented using multiple chemical representations with three levels of multiple representations: macroscopic level, sub-microscopic level, and symbolic level. The three levels help students understand abstract

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concepts. Key questions are organized from low difficulty to higher difficulty (Piawi et al., 2018). Examples of model displays and key questions are in Figure 5.

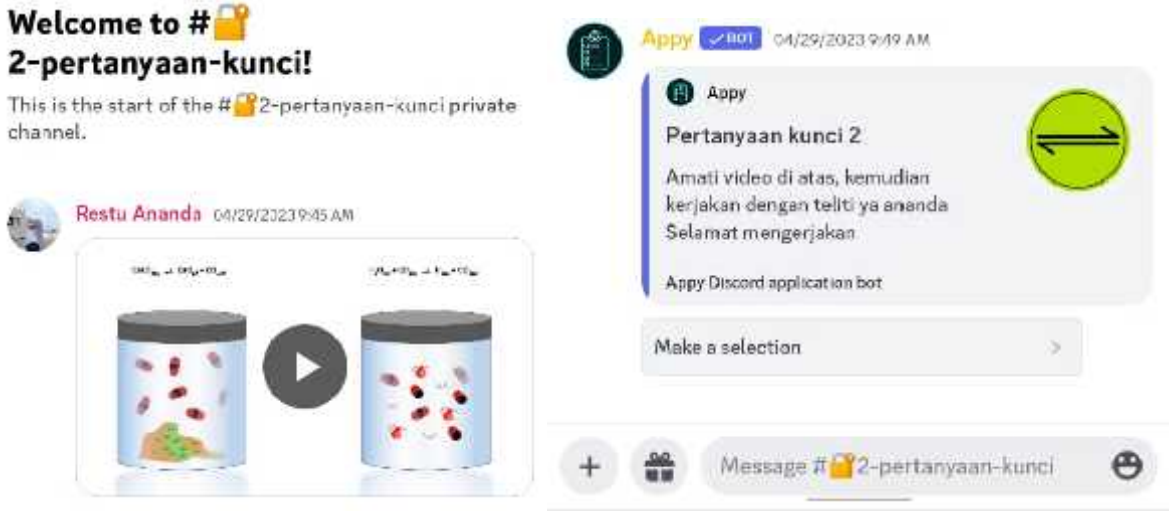

Figure 5. Model View and Key Questions on Discord

During the exploration and concept-formation phase, students will analyze the presented model on Discord. The concept formation stage establishes the teacher's responsibility for helping students discover their notions. It is the responsibility of teachers to create essential questions that will let pupils explore concepts on their own (Khairunnisak et al., 2023). Then students will answer key questions based on the model given by analyzing the model.

Next, the task is to generate evaluation questions that can be utilized as a platform for students to apply the concepts they have acquired and gauge their proficiency in chemical equilibrium. The questions were modified following the previously established learning objectives. The application phase continued synchronously using Discord in the classroom for 2 hours of learning. The first 1 hour is used to work on application questions on Discord. Each student discussed in a study group to answer the questions in the application stage. An example of the application display on Discord is in Figure 6.

Figure 6. Display of Application Questions on Discord

The closing stage was carried out directly in front of the class. Students presented the results of their discussion and confirmed the learning at the meeting with the teacher. After the learning design was completed, the prototype I was formed.

Prototype II

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The results of prototype I will then be carried out at the self-evaluation stage of the prototype I. In this self-evaluation stage, an instrument in the form of a checklist was given. The self-evaluation checks the FGIL system's completeness before submitting it to Discord. After filling in the self-evaluation sheet, the next step was to revise and complete the FGIL system components uploaded to Discord. After the revision of the improved components following the self-evaluation sheet was completed, prototype II was formed.

Prototype III

The stages in producing prototype III were through expert review and one-to-one evaluation first. Two chemistry teachers from SMAN 8 Padang and three chemistry academics from FMIPA UNP participated in the expert assessment stage. In this case, experts acted as validators who assessed prototype II through evaluation questionnaires in the form of content and construct validity questionnaires. Determine the degree of validity concerning the content, presentation, language, and graphics using expert assessment. After the data was processed, the content validity analysis result is shown in Figure 7 and construct validity in Figure 8.

After prototype II was examined by experts through the expert review stage, then an individual evaluation would be carried out by conducting interviews with three students of grade XI SMAN 8 Padang. This stage aims to find out how students respond to the learning developed. Based on the outcomes of this stage, it was discovered that the orientation video on Discord had a very clear appearance and sound, and the language used was simple to grasp; the usage of Discord was not a barrier for students to carry out learning because the instructions and models were very clear, making it easy for them to respond to the questions. After that, revisions were made to prototype II, which aims to improve the quality of prototype II. After the revision of prototype II, it resulted in a valid prototype III.

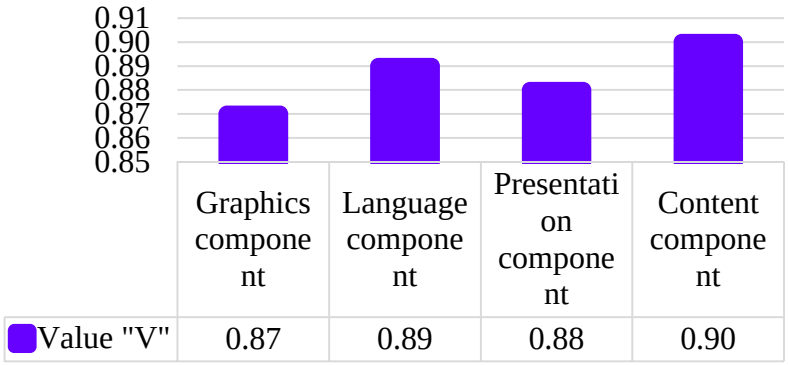

Figure 7. Diagram Showing the Content Validity Analysis Results

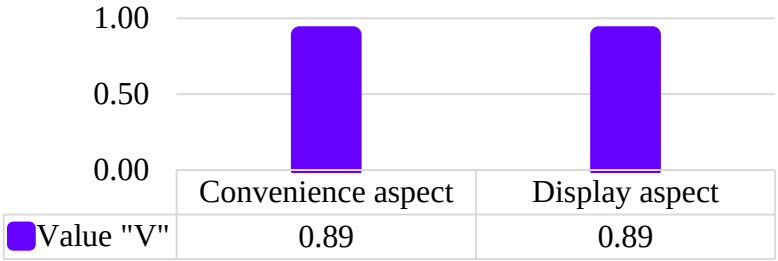

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Figure 8. Diagram Showing the Construct Validity Analysis Results

Based on the validity scores given by five validators, each component in the FGIL learning system using Discord was valid. The model used was scientifically correct and followed the material taught, so students could explore the model to answer key questions (Kardena & Mawardi, 2021). It means that the learning system developed as the FGIL system using Discord has met the criteria in the validity questionnaire to be applied in learning.

Prototype IV

Nine students from grade XI SMAN 8 Padang divided into three small groups would participate in a small group trial after developing prototype III to ascertain the practicality of the created product. After that, learning would begin according to the FGIL system designed using Discord. Additionally, students would be required to complete a practicality questionnaire, the results of which would be used to gauge the degree of practicality. The level of practicality, with a very practical category, was 92% after the data from the practicality questionnaire was evaluated. At this stage, data were also collected from two chemistry teachers by filling out a practicality questionnaire to determine the level of practicality. After data processing, the practicality level was 93%, with the category of very practical. The practicality data analysis result can be seen in Figure 9

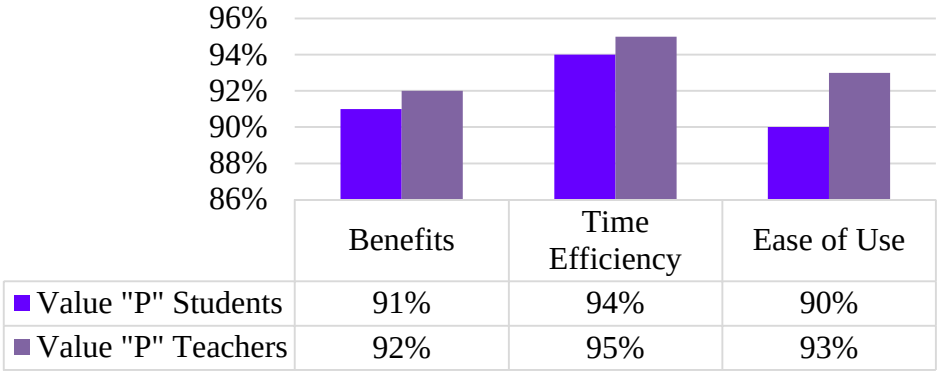

Figure 9. The Results of Small Group and Teacher Practicality Analysis

Based on how practical the FGIL learning system using Discord is, the category was extremely practical regarding benefits, ease of use, and time efficiency. The practicality data analysis result showed that the designed prototype IV was good quality and was undoubtedly valid and practical as a tool for learning.

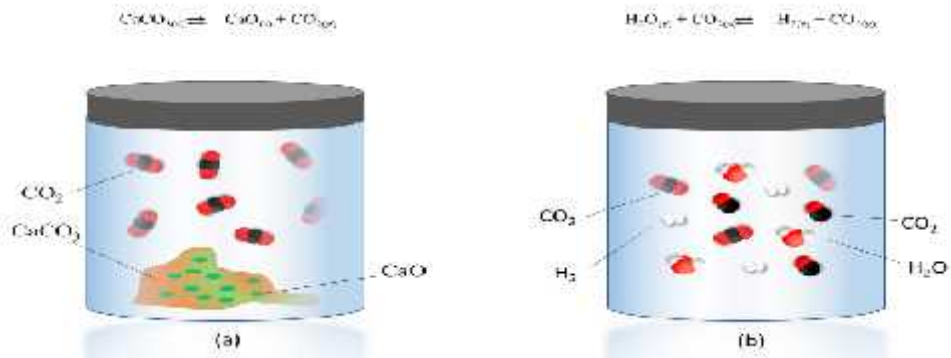

Figure 10. Homogeneous and Heterogeneous Equilibrium

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One of the models utilized in the key questions that students must respond to is Figure 10. Students were asked to explain the concepts of homogeneous equilibrium and heterogeneous equilibrium. Based on the results of student interviews, homogeneous equilibrium was an equilibrium where reactants and products were in the same phase. In contrast, heterogeneous equilibrium was an equilibrium where reactants and products were in different phases. Submicroscopic images of homogeneous and heterogeneous equilibrium, which have each phase of reactants and products being different for heterogeneous equilibrium and the same for homogeneous equilibrium, can be used to detect this.

Based on Figure 10, students were required to answer the key question correctly, not only with macroscopic images that can be observed directly but also with more detailed sub-microscopic images. When students were given macroscopic images, they could not show more detailed symptoms, so they had difficulty finding problem-solving ideas. Sub-microscopic images helped depict compounds that were important in concept discovery. Therefore, using macroscopic, sub-microscopic, and symbolic images is good for better and directed depiction, so learning is focused. Additionally, the Discord application has the following features, according to research by Kruglyk et al. (2020), including the ability to create an unlimited number of servers, configure general server information, create an unlimited number of text and voice communication channels, share invitations for new users via links, set user roles, control who can access the channel, and broadcast live (Kruglyk et al., 2020).

The guided inquiry model typically used is different from this FGIL learning system. Students can now work on the Discord application without paper if they often complete questions on student worksheets. Using this FGIL technique is undoubtedly more useful than having students do worksheets. It is distinct from learning with the FGIL system utilizing the Discord application if pupils typically practice the questions on the worksheet at school. The guided inquiry learning process consists of three stages: orientation, exploration, and concept formulation. The Discord app completed the application step, and the final stage took place in a classroom. The teacher presented an orientation video that includes an opening, motivation, perception, and the relationship between the chemical phenomena presented in the video, which was different from the typical presentation of pictures and descriptions on student worksheets. The film showed chemical animations with models that refer to chemistry textbooks' content, particularly regarding chemical equilibrium. Before classroom instruction begins, the process of working on the orientation, exploration, and concept creation stages will be carried out.

The goal behind conducting numerous steps before learning in class is to allow students to explore the model and respond to crucial questions available on Discord before suggesting them. Students always have access and locations. It makes it simpler for students to talk in organized study groups. As a result, before learning in class, students built and discovered concepts and understanding independently. It prepared them for the application and closing stages, which were carried out in the classroom, by enabling them to quickly connect the concepts they had previously learned with questions at the application stage to make it simpler for the students to discuss the outcomes with the teacher and come to a conclusion at the end of the lesson.

Conclusion

The FGIL system was developed for chemistry learning on chemical equilibrium material by analyzing its validity and practicality. Content and construct validity had been carried out

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with the results of 0.88 and 0.89, respectively, in the valid category. Then the practicality showed a value of 93% with a very practical category. Both point to the validity and practicality of the FGIL approach employing Discord for educational purposes.

Recommendation

This study can help teachers adjust to a Merdeka Curriculum that requires a student-centred learning approach and uses advancements in school digitalization consistent with instruction during the industrial revolution 4.0 era. This research can be utilized by students as a learning tool that aids in concept discovery. This research is limited to the small group test, which resulted in prototype IV, which has been valid and practical for use in learning. However, there is a need for large-scale testing by further researchers of the FGIL system using Discord through testing its effectiveness and influence on student learning outcomes.

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