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Flipped Classroom Learning System with Digital Literacy Based on Guided Inquiry Using Discord Application on Thermochemistry for First-Year Chemistry Students

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Abstract: This study aims to develop a valid and practical learning system in addressing the need for an instructional design that fosters digital literacy in first-year chemistry students. Using the Educational Design Research framework, the learning system was developed on Discord and integrated flipped-guided inquiry learning models. The study involved lecturers and students from Department of Chemistry, Universitas Negeri Padang. The system was structured with a server and channels to facilitate each stage of the learning process. The evaluation assessed the validity and practicality of the system. The overall results indicated the system was highly valid with overall validity of 0.85 (construct validity 0.85 and content validity 0.86) and practical (student practicality 81% and lecturer practicality 83%). These findings suggest that a Discord-based, flipped-guided inquiry system is a highly viable and useful tool for teaching thermochemistry and student's digital literacy.

Keywords: Digital literacy; Discord; Flipped classroom; Guided inquiry learning, Thermochemistry

Introduction

The Industrial Revolution 4.0 has reshaped the educational landscape in fundamental level, shifting it from passive knowledge acquisition to the advent of critical 21st-century skills (Kennedy & Sundberg, 2020; Weise & Christensen, 2014). In this era, educators are now tasked with preparing students for a world that demands a strong ability in critical thinking, collaboration, and problem-solving **(Stobaugh, 2013)**. To meet these new demands, there has been a global change toward student-centered learning, where student is an active participant in their education rather than a passive receiver. This movement is exemplified by initiatives that has put forward by the government of Indonesia, such as the Merdeka Belajar Kurikulum Merdeka (MBKM) (Nizam & Partiwi, 2023). This newest curriculum reform emphasizes the previously mentioned student-centered learning as well as flexible and personalized learning experiences that prepare students for real-world challenges.

This paradigm introduces further challenge in effectively teaching abstract and rather complex topics, such as thermochemistry. Thermochemistry is one of the core topics for first-year chemistry students and is taught in General Chemistry courses. This topic largely related to thermodynamics, systems and environments, and practical applications of the theoretical laws (Petrucci, 2017). Didactic teaching methods that rely on a lecture-based approach often fall short at helping understanding the topics, leading to passive learning, low retention, and disconnection between theoretical and practical application (Tawfik et al., 2020). Thus, there's a clear need for a more dynamic and engaging

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instructional strategy that encourages students to actively construct the concepts and engage with the material.

To address these issues, the flipped classroom approach offers a compelling solution. This approach, as the name suggest, switches the traditional in-class activities, such as lecture or direct teaching, to outside of class via online instruction (e.g. video lectures or reading materials) (Divjak et al., 2022). This particular strategy frees up in-class time for various learning activities. Students also benefited from this approach as it's give the opportunities to progress their studies with their own pace. Moreover, flipped classroom particularly promotes students' engagement and understanding in learning (Al-Samarraie et al., 2020). As for teachers or lecturers, they can provide personalized support and guidance to their students.

Within the flipped classroom framework, the guided inquiry model is particularly effective for teaching abstract topics (Khairunnisak et al., 2023). Guided inquiry helps students actively construct their own understanding by exploring concepts, forming hypotheses, and reaching conclusions with given scaffolding and support (Syafei & Mawardi, 2022). Combined with flipped classroom, this approach could enhance student activity, critical thinking, and deeper understanding of complex topics like thermochemistry (Kurnia & Suyanta, 2024; Mukhlisa et al., 2021).

Furthermore, a successful implementation of such system lies on digital literacy skill. Belongs to information, media & technology skills, digital literacy is not a mere supplementary skill (Kids, 2019). Students have a strong ability in this in order to access, evaluate, and utilize online educational resources and digital environment (Falloon, 2020; Reddy et al., 2023). For a guided inquiry model, students must be able to critically assess the credibility of online materials to form valid conclusion and participate in collaborative tasks. Thus, this learning system not only utilizes technology but also intentionally develops students' digital literacy skills as a foundational element for academic success in the 21st century.

Lastly, to facilitate a guided inquiry-based flipped classroom in a technologically advanced era, a digital platform is essential. Discord emerges as one of the most potential online platforms, given rich, built-in features such as real-time communication, channels & servers, and compatibility in numerous operation system (OS) (Arifianto & Izzudin, 2021a; Kruglyk et al., 2020; Mazura et al., 2023). These features could both support the asynchronous and synchronous components of flipped-guided inquiry learning (Jannah et al., 2024). For the asynchronous component, Discord channels can host pre-class materials, key questions, and shared resources. As for synchronous component, its text, voice, and video (including screen-sharing) enable real-time class activities. It is important to consider that Discord is not commonly used among students compared to more popular apps like Instagram or TikTok (Yamtinah et al., 2023). However, students' often have positive perception and acceptance towards the use of Discord as an online learning platform (Arifianto & Izzudin, 2021b).

Hitherto, there are existed prior studies that developed Discord chemistry learning system for upper secondary school on reaction rates (Akmar et al., 2024; Tuti et al., 2023), thermochemistry (Delfianza et al., 2023) and chemical equilibrium (Ananda et al., 2023) and for college level chemistry on colloid (Handri et al., 2023) and the periodic system (Ismail et al., 2023). However, in these studies, the digital literacy aspects have not yet fully incorporated. Thus, by integrating the strengths of flipped classroom combined with guided inquiry, digital literacy aspects, and the well-quipped features of Discord, a cohesive and synergistic learning system can be designed. With not only specific challenges in teaching thermochemistry, it is also aimed to foster digital literacy skills among students.

Method

This research employed the Educational Design Research (EDR) framework as the main approach (Plomp, 2013). EDR comprises three phases: preliminary research, prototyping, and assessment (Nieveen & Folmer, 2013). In this study, however, the phase was curbed just until the fourth prototype achieved due to time and resource constraint (Figure 1).

Each phase consists of its own micro-research and evaluation that either done qualitatively or quantitatively (Plomp, 2013). The need and context analysis involved interviews with three lecturers to collect data on the current state of college-level chemistry teaching. This was followed by a literature study done by literature review which informed the development of a conceptual framework.

Self-evaluation was done using a checklist. Expert review was done with validation sheet and the obtained data was calculated with Aiken's V formula (Aiken, 1985). Initial user feedback was gathered through a one-to-one evaluation, which consisted of a brief trial and interview. Lastly, small group evaluation was done through trial with lecturers and student and used practicality sheet, with the data was analyzed using practicality percentage formula and category (Purwanto, 2020).

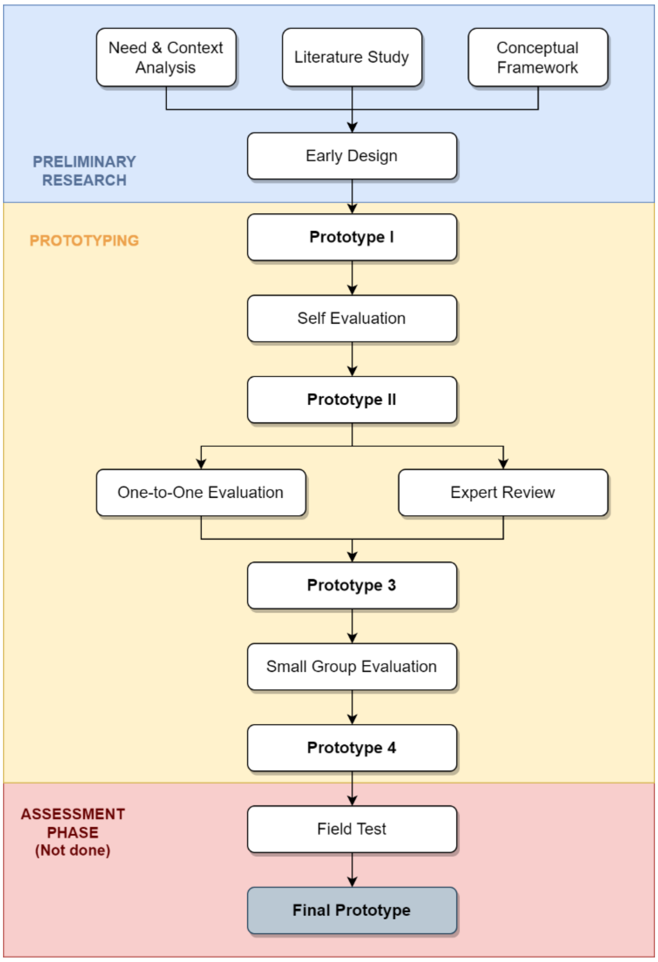

Figure 1. Flowchart of the research method

Result and Discussion

Preliminary Research

Based on interviews with three chemistry lecturers at Universitas Negeri Padang, it is known that the university had implemented MBKM. Lecturers are implementing student-centered learning approaches like group discussions, problem-based learning (PBL), and project-based learning (PJBL). While lecturers generally use social media like WhatsApp for learning, its features are limited. Many lecturers are aware of the Discord application but have yet to use it for teaching. The use of Discord in Indonesian education is still rare (Tjahjadi et al., 2021).

The interview results highlighted a gap: there are limited amount of specific teaching materials for thermochemistry that fully align with the MBKM's needs. Furthermore, besides Moodle and Zoom, few platforms are currently being used to support the entire guided inquiry process, track student activity, or automatically structure learning stages. This presents a clear opportunity to develop a new learning medium that leverages social media to increase student interest and better implement a student-centered approach.

A review of the literature shows that a combined flipped classroom and guided inquiry approach can enhance teacher-student interaction and improve cognitive abilities. Previous studies by Ananda et al. (2023); Delfianza et al. (2023); Tuti et al. (2023) demonstrated the high validity and practicality of similar educational interventions. Additionally, a study by Akmar et al. (2024) on the effectiveness of a Discord-based flipped guided inquiry system for reaction rate material showed a significant improvement in learning outcomes, with a t-count of 8.11 > t-table value of 1.99. With these findings, it is expected that a Discord learning system built on a flipped classroom and guided inquiry combination will be a valuable tool to aid student learning.

Prototyping Phase

The learning system was designed based on an established need and context and literary basis. The design followed guided inquiry syntax within flipped classroom framework with a server created as the main 'room' for all learning activities (Figure 2). Channels were subsequently created to host materials for and instruction for each syntax (Odinokaya et al., 2021). For instance, in orientation stage, a short, micro-lecture was presented right after students joined the Discord server. This video, which could be watched in the server without having to open external application, contained learning objectives, an apperception, learning instructions, and a brief introduction to the topics of thermochemistry (Figure 3a).

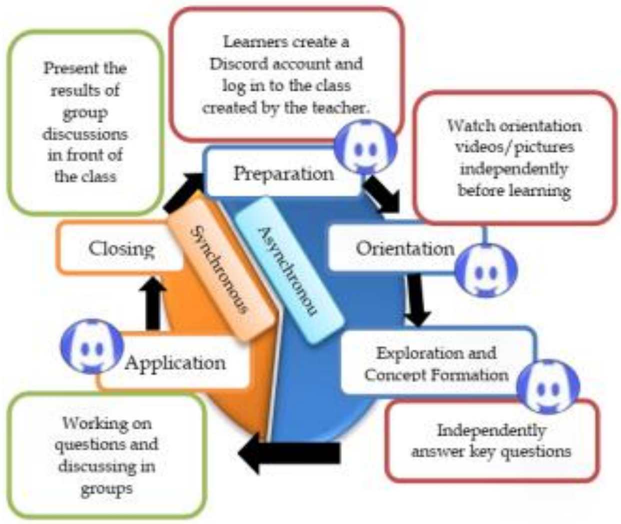

Figure 2. Cycle of flipped-guided inquiry learning

For exploration and concept formation, students could switch channel where they were presented with models (Figure 3b). These models included image, table or chart which are further equipped with chemistry multiple representation. These representations are paramount for students to begin inquiring about the concept (Gilbert & Treagust, 2009). A set of questions, called key questions, was also provided to help students build their own understanding. These questions were arranged from simple and straightforward to more complex and comprehensive (Moog & Farrell, 2015). After completing the questions, the asynchronous stage was finished, and students were free to review their learning or prepare for the following synchronous in-class activity.

Students were instructed to do group work in form of discussion in the application stage (Figure 3c). Harder and more challenging problems were given to promote critical thinking and problem-solving with their pre-conceptualized knowledge they had built in the previous stage (Hanson, 2006). With the teacher's guidance, students work their way out in solving the presented problems. And when they done, they are instructed to present their work in front of other students, promoting lively intra-group discussions (Figure 3d). This was done in closing stage synchronously, either face-to-face or in the video chat room. The closing stage, the teacher will give constructive feedback and conclude the learning process.

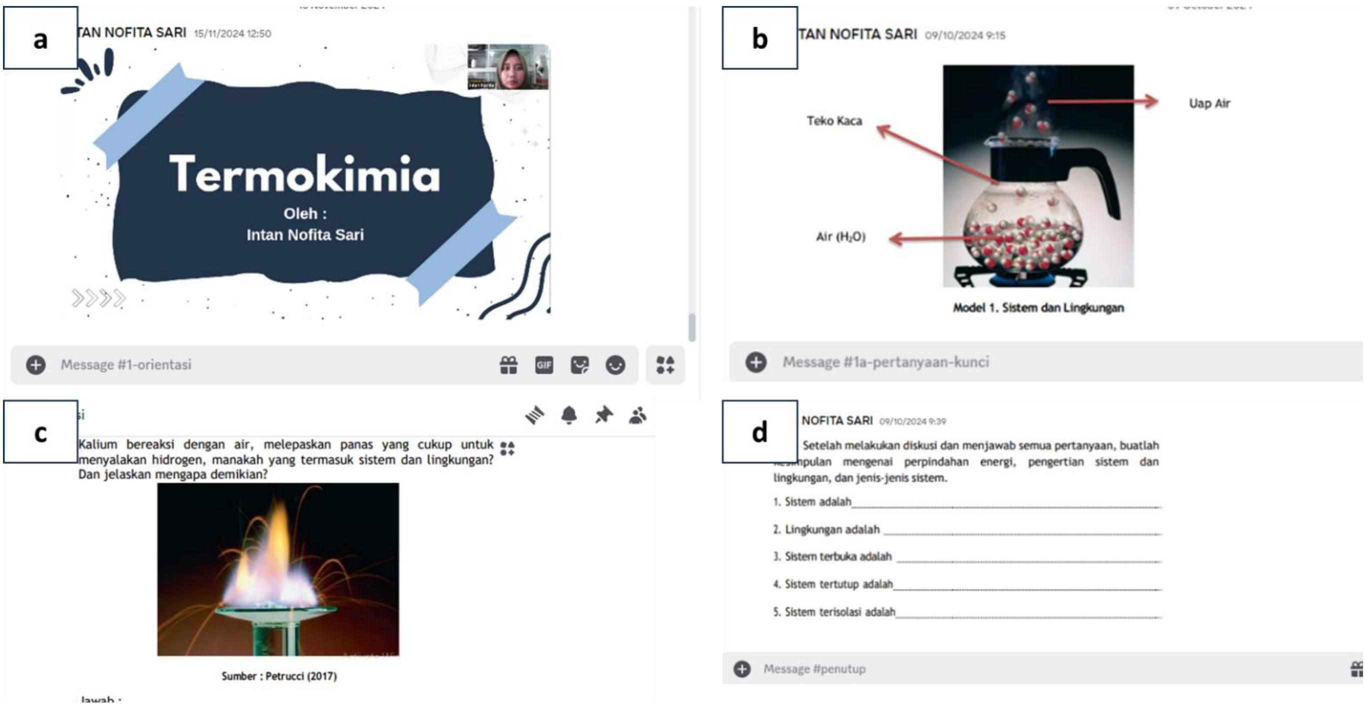

Figure 3. View of the developed learning system in each stage: a) orientation b) exploration and concept formation c) application and d) closing

Prototype I was obtained after all of the mentioned instruction are well-integrated in the Discord server and deemed fit for the first evaluation, self-evaluation. Self-evaluation was relatively short because it was a personal assessment and all of the components oftentimes already checked prior to evaluation. Some issues, nevertheless, were found, particularly in the automated bots for the key question, the attendances and the instruction language. These issues were fixed prior to the next evaluation.

In expert review, the content and construction of the learning system was thoroughly evaluated and scored using validation sheets. All of the evaluated aspects in the review exceed and meet the 0.80 threshold value for validity (Figure 4 & 5) with overall average of 0.85. The average value of content and construct validity is 0.83 and 0.85, respectively, meaning that the developed learning system is valid. Content-wise, the evaluated aspects consist of alignment, integration, cohesion, and compatibility. Alignment concerns with how suitable the designed instruction with guided inquiry principle, while cohesion with the presented material and the principle (Kosasih, 2021). Integration and compatibility, respectively, deal with how well the overall utilization of features and learning instruction within Discord server. These results agreed with previous studies on Discord learning system that emphasized the importance of accordance and adequacy of content in the design (Handri et al., 2023).

As for construct validity, it consists of content, presentation, language, and graphics (Jasmine, 2024). Content and presentation are in line with previously mentioned content validity aspects. Language concerns with how clear the instruction as it perceived and graphics deals with the graphical design aspects. In this evaluation, the presentation and language aspects scored lower than content. According to the reviewers' comments, the representations of the chemistry concepts were clear enough, albeit there are small inconsistencies or misrepresentation among them. The same can be said for the latter due to a substantial number of typos or incorrect use of grammar (in Indonesia). With all being said, the learning system was revised and scored enough for its validity claims.

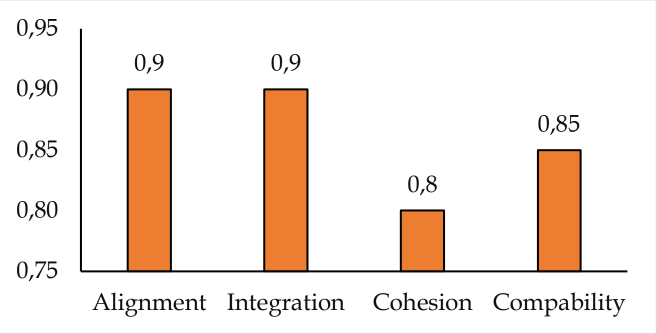

Figure 4. Analysis of content validation results

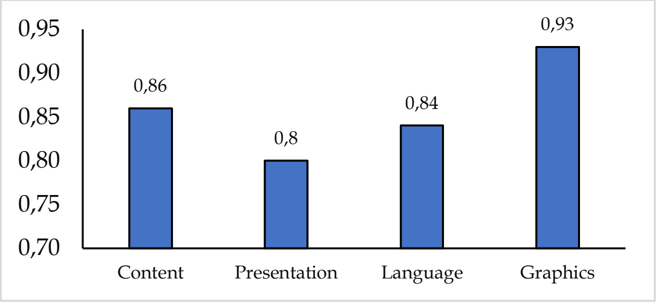

Figure 5. Result of construct validation

One-to-one evaluation, a relatively short evaluation, resulted in feedback from its potential users in short interview answers form. Three college chemistry students who ran quick trials considered the learning system as usable and easy to navigate. As usual, there was some minor issue found, such as lagging in the question bot, and fixed as a follow-up.

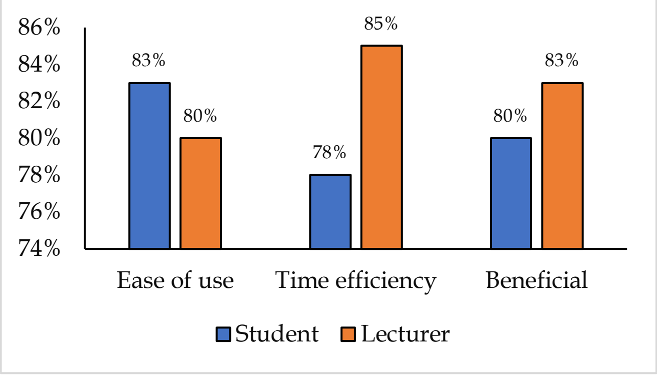

Figure 6. Result of practicality evaluation

For practicality, nine students and five lecturers assessed the developed learning system on three aspects: ease of use, time efficiency, and benefit. All of the aspect scored higher than 76% which can be categorized as practical (Figure 6) and the overall average practicality is 82%. In general, lecturers rated the learning system more favorably than the students, with the exception of ease of use. The results suggest that both students and lecturers found the system practical, but from different perspectives. The slightly higher score from students for ease of use likely reflects their familiarity with social media platform like Discord. This has implication that the system's interface and features felt intuitive to them (Wiles & Simmons, 2022). Lecturers, on the other hand, found the system to be more time-efficient and beneficial. It suggests that they perceived a greater reduction in workload, such as organizing materials or communicating with students (Uong et al., 2022). Similarly, the higher assessment from lecturers for benefits means that the system is valued and able to use as learning tool for guided inquiry with flipped approach (Ismail et al., 2023).

Conclusion

In conclusion, a Discord-based learning system that integrates the flipped classroom and guided inquiry models to teach thermochemistry has been developed. Overall, the quality criteria values are validity (0.85) and practicality (82%). This findings from the expert review and practicality evaluations confirmed that the system is valid, practical, and usable for its intended purpose. The positive feedback from both students and lecturers demonstrate the system's potential to address the challenges of creating a dynamic, student-centered learning environment and building digital literacy for first-year chemistry students. By leveraging the built-in features of Discord, the system provides a structured design for flipped-guided inquiry learning and serves as a device to build digital literacy skills. Further studies can be done on investigating the effectivity of the learning system when implemented on classroom scale.

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Author Contributions

Conceptualization, M.M. and A.U; methodology, M.M; validation, M.M., A.U., and O.S.; formal analysis, I.N.S. and R.A.; investigation, I.N.S.; resources, I.N.S.; data curation, R.A; writing—original draft preparation, I.N.S.; writing—review and editing, R.A; visualization, R.A; supervision, M.M.; project administration, I.N.S.; funding acquisition, M.M. and A.U.

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Conflicts of Interest
The authors declare no conflict of interest

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