The Impact of Using the "Go-Chemist!" App on Students' Motivation to Learn Atomic Structure in Chemistry

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***Abstract*—The purpose of this study is to analyze the effect of using the Go-Chemist! app on student motivation on the topic of atomic structure. In this study, we performed a quasi-experimental design. The sample was 71 tenth-grade students from two intact classes at a public high school in Jakarta, Indonesia. The control group was taught using a printed book, while the experimental group was instructed using the Go-Chemist! application. Student motivation in both groups was then evaluated before and after intervention using the science motivation questionnaire (SMQ). In order to examine the difference and increase in the scores of the two groups, independent and paired sample t-tests were employed. The results reflected that after treatment, students in the experimental group scored higher than students in the control group in terms of motivation. In addition, there was a significant increase in motivation among experimental group students compared to their counterparts. This suggested that the use of the Go-Chemist! is effective in improving students' motivation in atomic structure. As such, we recommend curriculum developers, policymakers, teachers, and students take advantage of Go-Chemist! app in the teaching and learning of chemistry.**

***Index Terms*—Chemistry motivation, atomic structure, mobile learning, Go-Chemist! app**

I. Introduction

The use of smartphones over the last few years has increased drastically. Recently, Statista [1] noted that in 2017 there were 4.4 billion smartphone subscriptions and by 2022 there were more than 6.6 billion smartphone users worldwide. This indicates that there is an increase in the number of smartphone users by around 50% in a 5-year period. In a study, Ozdamli and Cavus [2] also reported that smartphones were mostly used by people aged 18–34 years. Due to the high number of smartphone users, research related to the use of smartphones to support the learning process is very interesting to investigate.

It should be noted that learning is influenced by many factors and motivation is one of the important factors affecting student learning [3]. According to Feng and Tuan [4], motivation is related to students' willingness, need, desire, and drive to participate and succeed in learning chemistry. In other words, student performance is influenced by their motivation [5]. According to Pintrich and Schunk [6], motivation is an effort to achieve goal-directed results. In addition, Glynn *et al*. [7] define motivation as "an internal state that arouses, directs, and sustains science-learning behavior" (p. 2). Thus, motivation to study chemistry can be considered as a state within students that drives them to study chemistry [8].

The main reason why it is important to increase students' motivation is that motivation plays a significant role in their learning success [9]. More broadly, previous literature reveals that motivation toward science appears to be closely related to science, technology, engineering and mathematics (STEM) persistence and career choice [10–13]. Students with high motivation perform higher and show lower academic anxiety compared to students with those low motivation [14]. When students are motivated to learn, the learning objectives will be easily achieved. Thus, motivation is an essential factor influencing student success.

Unfortunately, in previous studies, it was found that student motivation tends to be low [14, 15]. In fact, there is a decrease in students' motivation with age [16–18]. Low motivation is one of the significant barriers to studying chemistry. Students' demotivation may be caused by a negative perception that chemistry is a difficult subject [19]. In addition, this decline may be related to the school curriculum [16]. Due to the positive correlation between motivation and academic achievement [7], decreased motivation can be associated with decreased achievement. In other words, there is a strong influence of motivation on students' success in chemistry. To increase students' motivation toward chemistry, innovation is needed in the learning process. Thus, there is a need to develop a learning media that is relevant to students' daily lives with the help of technology. This is because subject matter designed to be more attractive and relevant to students' lives is seen as more motivating for them to learn [20].

Educators believe that the lack of adequate teacher preparation to teach science often leads to less effective and meaningful science teaching [21]. In addition, Devetak and Glazar [22] stated that the low motivation of students to study chemistry is the use of teaching methods that are not in accordance with the needs of students. Given the rapid advances in technology today, the use of mobile learning in chemistry learning is seen as relevant. According to Ozdamli and Cavus [2], mobile learning is a learning process that utilizes technological tools in its activities. Meanwhile, Kukulska-Hulme and Traxler [23] conceptualized mobile learning as an educational activity in which the learner is not confined to a physical location. In essence, mobile learning is a learning method that makes it easier for students to get material through mobile devices. Thus, learning can be done anywhere and anytime.

There are many researchers who have investigated the

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application of mobile learning for science and chemistry learning in the last few decades. For example, Han and Shin [24] found that learning management system-integrated mobile learning can improve student understanding. In another study, Cahyana *et al*. [25] reported that the implementation of mobile learning had a positive effect on student achievement. Finally, Shoesmith *et al*. [26] explored the effect of implementing mobile application games on organic chemistry learning at the university level and they found that students found mobile learning an interesting and interactive learning resource. However, the use of mobile learning applications to promote motivation in chemistry has rarely been studied. In their study, Saedi *et al*. [27] suggest for future studies examine the effect of applications on students' learning motivation. In the current study, the researchers developed the Go-Chemist! app, a mobile learning to support student learning on atomic structure. This topic was chosen because it is considered one of the most difficult concepts in high school chemistry courses [28–30]. Xue *et al*. [31] also reported that the majority of students had difficulty understanding the relationship between the number and location of protons and electrons. In fact, the atomic structure is a basic concept that should be mastered by students to understand further chemical concepts.

Previous studies noted that mobile applications designed according to students' needs increased student performance [24] and contributed to positive learning outcomes [25, 26]. Given the increasingly massive development of technology, it is considered necessary to integrate mobile learning applications into traditional classrooms. Moreover, the spread of COVID-19 forced teachers and students to move from traditional face-to-face learning to technology-based learning. This new situation triggers educators to utilize mobile learning technologies as an effective tool to support student learning. Considering the importance of mobile technology, the Go-Chemist! app was developed and its impact on student motivation was then explored.

Based on the aforementioned problems, the purpose of this study is to investigate the effect of implementing mobile learning Go-Chemist! on the topic of atomic structure on student motivation. The research question posed included: "*Is there a significant difference in motivation scores between control and experimental group students before and after treatment?*"

II. Method

A. Design

In this quantitative study, a quasi-experimental pre- and post-test design was used. A quasi-experimental design is a procedure in which researchers test a hypothesis through the manipulation of independent variables so that the effect on the dependent variable is observed [32]. The independent variable in this study is the application of the Go-Chemist! application, while the dependent variable is chemistry motivation.

B. Participants

A total of 71 tenth-grade students were involved in the current study. They were from a public senior high school in Jakarta, Indonesia. Participants were between 15–17 years old. All students were selected using convenience sampling. According to Creswell [32], the sampling technique allows researchers to select participants because they are ready and available to be studied. All students in both groups had similar educational and socioeconomic backgrounds. They came from urban areas. In addition, they had similar midterm exam scores. To avoid instructor bias, both groups were taught by a chemistry teacher. They voluntarily participated in this study and could withdraw at any time. To ensure confidentiality, participant names were removed from all data collection forms [33].

C. Data Collection Tool

In this study, students' chemistry motivation was measured using the Science Motivation Questionnaire II (SMQ-II) developed by Glynn *et al*. [7] by replacing the word 'science' with 'chemistry'. The SMQ consisted of 25 statements with 5-point Likert scales (5 = always, 4 = often, 3 = sometimes, 2 = rarely, 1 = never). Overall, the minimum and maximum scores obtained by students were 25 and 125, respectively. The SMQ contained 5 indicators, namely Intrinsic motivation (e.g., I enjoy learning chemistry), Career motivation (e.g., My career will involve chemistry), Self-determination (e.g., I use strategies to learn chemistry well), Self-efficacy (e.g., I am sure I can understand chemistry), and Grade motivation (e.g., I think about the grade I will get in chemistry). Each indicator has 5 statements. The SMQ reliability coefficient in the current study was 0.90. Approximately 15 minutes were given to students to respond to the SMQ. In the study, this scale was administered before and after the treatment. A high score on the scale indicates that the motivation level is high.

D. Procedure

The design in this study was carried out in line with the Institutional Review Board (IRB). This research was conducted in August 2022 in the first semester of the 2022/2023 academic year. The topics and duration of learning time in both groups are the same. This research was conducted in four meetings with each 120 minutes per week. We involved two intact groups, namely the experimental and control groups. Each group was given a pretest to determine the students' initial motivation. In the beginning, the participants were informed about the purpose of the study. At the first meeting, both the experimental and control groups were given a pretest. After that, at the second and third meetings, the experimental group students studied the atomic structure using the Go-Chemist! application. The screenshots of the Go-Chemist! app are presented in Fig. 1.

The Go-Chemist! mobile application has 5 main menus: Competence, Instructions for Use, Learning Videos, Evaluations, and Games. Competence contains learning outcomes that must be achieved on the topic. Instructions for Use refer to information about how to use the application. The Learning Videos include explanations of the subjects. Evaluation allows the teacher to evaluate students' understanding of the topic because students earn points for each correct answer. When students have mastered a topic, they can challenge themselves on the Games menu.

In this setting, the teacher invited the experimental group students to discuss and encourage them to be actively involved in learning. Students were stimulated to exchange ideas, opinions, and thoughts during instruction. They then read the learning materials and took quizzes on the mobile learning app. Meanwhile, the control group students studied the same topic using textbooks. The learning process in the control group was carried out using lecture, discussion, and question-and-answer methods. After the intervention, each group was given a post-test. This aims to determine whether there is a difference in the effect of the different learning methods applied to the two groups.

E. Data Analysis

After the data was analyzed, the assumptions of parametric tests were not violated. The data was homogeneous and normally distributed ($p > 0.05$). To evaluate the effect of the implementation, descriptive statistics including the mean and standard deviation were used to display the data. Inferential statistics including *t*-tests were also performed to analyze sample information from a particular population [34]. To explain whether there was a difference in motivation scores between the experimental and control groups, an independent samples *t*-test was run. To determine whether there was an increase in learning motivation between the experimental and control groups, a paired *t*-test was used. In this study, data analysis was performed using SPSS 25 and the significance level was set at 0.05. To analyze how strong the effect of using the Go-Chemist! on student motivation, Cohen's *d* was calculated; small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$) effect sizes [35]. Standardized *d*-effect sizes for paired samples were computed to account for the significance of the observed differences. The higher the Cohen's *d* value is, the greater the effect of the intervention would be.

(a) (b) (c) (d) (e) (f)

Fig. 1. Mobile application screenshots: a) homepage, b) instructions for use, c) main menu, d) learning material, e) quiz, and f) score.

III. Findings

This section presents the results of quantitative data analysis. To compare the chemistry motivation of students using the Go-Chemist! application and their counterparts using conventional learning methods, an independent sample *t*-test was employed. The results of the SMQ are presented for pre- and post-administration in Table I.

As Table I shows, the mean scores on the posttest for the experimental and control groups are 88.257 and 84.666, respectively. It can be interpreted that the motivation of the experimental group students is higher than the control group students ($t = -4.049$, $p = 0.000$). In light of these findings, it can be concluded that there is a significant difference in the motivation to learn chemistry between students who study using the Go-Chemist! and students who use conventional learning.

TABLE I: THE COMPARISON OF MOTIVATION BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS

	Groups	Mean	*SD*	*t*	*p*
Pretest	Experimental	81.171	3.485	0.485	0.629
	Control	81.583	3.659		
Posttest	Experimental	88.257	3.814	−4.049	0.000
	Control	84.666	3.656		

Furthermore, a paired *t*-test was used to explain the change in pre- to post-test scores after the intervention. The changes in the pre- and post-test scores are played in Table II.

TABLE II: THE CHANGES IN PRE- AND POST-TEST SCORES

Groups	Paired Differences		*t*	*df*	*p*	Cohen's *d*
	Mean	*SD*				
Experimental	7.086	2.119	−19.778	34	0.000	1.94
Control	3.083	0.368	−50.218	35	0.000	0.84

Based on Table II, all participants in both groups increased their scores in the post-test. However, the mean score of the experimental group students was higher (M = 7.086, SD = 2.119) compared to the control group students (M = 3.083, SD = 0.368). This reflects that the experimental group students were more dominant than the control group. These results confirm that the use of the Go-Chemist! has a greater effect on increasing students' learning motivation (t = −19,778; p = 0.000) compared to conventional teaching. This is supported by the high effect size (d = 1.94), which indicates that the use of the Go-Chemist! had a great impact on motivating students to learn chemistry on atomic structure.

IV. DISCUSSION

The purpose of this study is to investigate how using Go-Chemist! can increase students' motivation to learn chemistry. The results show that there is a significant increase in motivation. This can be seen from the difference in pretest and posttest scores among the experimental group students. Although there was a significant increase in motivation among the control group students, the post-test scores of the experimental group students were higher than their counterparts. The increased motivation of students to study chemistry may be because they find learning chemistry more fun. This is because the subject matter in the mobile learning app has been linked to students' daily problems. A learning environment that increases the relevance of chemistry to students' everyday experiences has the opportunity to increase their motivation to learn [21]. When concepts become more familiar, student motivation begins to increase [36].

Interestingly, this study shows that students who use the Go-Chemist! app significantly outperformed students who received traditional learning in terms of chemistry motivation. Mobile learning applications are easy to use and have high flexibility, so students can learn anywhere and anytime. During the intervention, students also learn while playing and communicating with their peers. The interaction of students with their mates is seen as an important component in increasing motivation [36]. In addition, the use of mobile devices also encourages students to actively participate in learning activities, and in turn, increases their interest and motivation [37]. In other words, authentic experiences have the potential to prevent students from decreasing their motivation to study chemistry [38]. In other words, during gameplay students find that learning about atomic structure is interesting and relevant to their lives, which increases their motivation [39]. Thus, this study shows that the mobile learning app is seen as an important tool in increasing students' motivation in chemistry lessons.

The results of the current study are in accordance with the findings of Petritis *et al*. [40] who reported that the use of mobile applications on the topic of hybridization succeeded in increasing students' academic performance, confidence, engagement, and motivation to learn the topic. Similarly, Polakova and Klimova [41] found that students who used mobile applications in the language learning process achieved better results and expressed satisfaction than students who received traditional face-to-face instructions. In addition, Teri *et al*. [42] found that the use of mobile applications in science education has been shown to be effective in promoting positive student attitudes and perceptions regarding the use of these technologies for educational purposes. The use of mobile learning for educational purposes helps students increase their learning motivation. Another study conducted by Miller and Cuevas [43] also reported that the use of mobile learning can increase the motivation of sixth graders in social studies. The use of mobile devices offers an interactive classroom environment where students feel enthusiastic and eager to learn [43]. This indicates that motivation can be promoted by using interesting materials. By using the app to provide content and enhance students' motivation, teachers can improve students learning success.

V. CONCLUSIONS AND LIMITATIONS

This study evaluated the effectiveness of using Go-Chemist! application on students' motivation on the topic of atomic structure. The results showed that there were differences in students' motivation to learn chemistry after using the application compared to using conventional learning methods. This indicates that there is a statistically significant change in students' learning motivation after using the Go-Chemist! application. It can be concluded that this application is effective in motivating students and helping them to study atomic structure. Thus, chemistry teachers are advised to promote student motivation to a satisfactory level using this application.

The results imply that a well-designed mobile app can be a useful tool for teaching atomic structure. In other words, this application makes it easy for students to understand topics anytime and anywhere. This claim is based on the fact that the use of the Go-Chemist mobile application has proven effective in increasing students' motivation to learn chemistry. The current findings help chemistry teachers to understand the benefits of combining mobile learning with face-to-face learning. Therefore, it can motivate them to use digital technology more for teaching purposes.

Although the use of mobile learning is effective in increasing student motivation, this study has some potential limitations. First, this study involved only 71 tenth graders at a public high school in Jakarta, the capital city of Indonesia. Thus, future research needs to involve a larger sample. In addition, this study uses quantitative methods. Future research is recommended to use mix-methods to obtain comprehensive findings. Finally, the research was only conducted for four meetings. Thus, we recommend a longer intervention for further research. It is intended to study changes in student motivation over time.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Irwanto Irwanto prepared the literature review, edited the language used in the article, and managed the write-up of the whole article. Afrizal Afrizal was involved in the conceptualization, statistical analysis, and interpretation of the results. Isna Rezkia Lukman was involved in the interpretation of the results and reviewing the whole article. Dhika Putricia was involved in reviewing and editing the whole article. Rudi Suhartono Wijayako improved the paper writing. All authors were committed to reviewing the final manuscript.

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