TEM Journal. Volume 12, Issue 3, pages 1638-1644, ISSN 2217-8309, DOI: 10.18421/TEM123-45, August 2023.

Go-Chemist! App and Its Impact on Students' Attitudes Toward Chemistry

Irwanto Irwanto [1], Afrizal Afrizal [1], Isna Rezkia Lukman [2], Darius Agung [1], Rudi Suhartono Wijayako [3]

[1] *Department of Chemistry Education, Universitas Negeri Jakarta, Jakarta 13220, Indonesia*
[2] *Department of Chemistry Education, Universitas Malikussaleh, Aceh 24351, Indonesia*
[3] *Indonesian National Agency for Research and Innovation, Jakarta 12230, Indonesia*

***Abstract* – The current study aims to explore the impact of using the Go-Chemist! app on students' attitudes toward chemistry on colligative properties. This pretest-posttest quasi-experimental design study involved 71 twelfth-grade students in Jakarta, Indonesia. One class was randomly assigned to a treatment group which was taught using a mobile application and another class was assigned to a comparison group which was taught using e-books. The Attitude Toward Chemistry Lessons Scale (ATCLS) was administered before and after instruction to both groups. To analyze the data, we employed independent and paired sample *t*-tests. The results indicated that after the intervention, the gap in attitude scores between the two groups was statistically significant in favor of the intervention group. Students in the treatment group also showed a statistically significant improvement in average scores from pre- to post-administration with a large effect size. This reflected the use of the Go-Chemist! app effectively increases students' positive attitudes toward chemistry lessons on the topic of colligative properties.**

***Keywords* – Attitudes toward chemistry, colligative properties, Go-Chemist! app, mobile learning.**

DOI: 10.18421/TEM123-45
https://doi.org/10.18421/TEM123-45

Corresponding author: Irwanto Irwanto,
Department of Chemistry Education, Universitas Negeri Jakarta, Jakarta 13220, Indonesia
Email: irwanto@unj.ac.id

Received: 07 April 2023.
Revised: 16 July 2023.
Accepted: 25 July 2023.
Published: 28 August 2023.

1. Introduction

Nowadays, developing attitudes toward chemistry among high school students is an essential goal for countries around the world [1], [2]. More broadly, attitude is considered an important dimension that should be improved in the chemistry curriculum for all levels of education. This is because students who have a positive attitude are seen as more interested in scientific arguments and enhance their scientific understanding [3]. In the literature, there are many definitions of attitude have been proposed. Attitude is the emotional aspect that drives a person's behavior toward an object or subject [4]. In addition, attitude is conceptualized as a person's psychological tendency which is the result of an evaluation of something and is shown through a statement of liking or disliking [5]. Attitudes are also viewed as associations in memory between attitude objects and their evaluation [6]. Supportively, Zanna and John [7] define attitude as "the categorization of a stimulus object along an evaluative dimension". More specifically, the attitude toward chemistry itself can be interpreted as a student's positive or negative feelings toward chemistry lessons.

The main reason why developing positive chemistry attitudes among students is important is that attitudes toward a subject are closely related to academic achievement [8], [9], [10]. Students who have good academic achievement also report high levels of liking for related subjects [10]. Chi et al. [11] through their research conducted in 29 junior high schools in Shanghai, showed that a high correlation emerged between academic achievement and interest. Eighth-grade students who have a positive perspective on the usefulness of the natural sciences get higher academic achievement than students who have a negative view of the usefulness of the natural sciences [9]. Finally, most students who expressed low levels of liking for chemistry also scored lower on exams [8].

Although developing students' attitudes toward science in a positive direction is essential, unfortunately, attitudes toward science of students tend to decline with age [12], [13], [14]. This may be due to the dominance of conventional learning methods that do not utilize interesting learning media; thus, it might lead to negative views and attitudes of students toward science [15]. In addition, a decrease in students' positive science attitudes may occur when learning is teacher-centered and there is a lack of use of ICT in science lessons [16]. Therefore, interactive learning media is needed to elevate students' attitudes toward chemistry. One of them is mobile learning.

With the advent of mobile technology, the use of mobile devices in distance education, for example, tablets and smartphones, is increasingly popular nowadays because it allows people to stay in touch and provides easy access to information anywhere and anytime [17]. Over the past two decades, smartphones have become an inseparable part of everyday life. This is because of the ease and practicality of its use. It was recorded that in 2022, there were 6.5 billion smartphone users worldwide and 210 million smartphone subscriptions in Indonesia [18]. This means that 77% of the Indonesian population owns and uses smartphones in their daily life and this number is predicted to continue to increase. In another study, most students in Brunei Darussalam also spend most of their time (up to 24 hours) using their smartphones [19]. Thus, the use of smartphones is beneficial in catalyzing and enhancing student learning. The high number of smartphone users makes the application of smartphones to support the learning process an interesting topic to research.

Theoretically, Gary [20] defined mobile learning as a learning process that utilizes mobile technology or mobile phones. Kukulska-Hulme [21] proposed mobile learning as an educational activity in which the learner is not confined to a physical location. Meanwhile, mobile learning is an intermediary medium that provides educational content and supporting materials through wireless devices [22]. So in general mobile learning can be interpreted as a learning process where students use mobile technology as an intermediary tool. In the literature, mobile learning is believed to have several advantages in the educational context. By combining several digital technologies, mobile learning offers students the opportunity to actively engage in their ubiquitous and asynchronous learning. These advantages include making it easier for learners to access learning materials and also making it easier for teachers to evaluate learning outcomes [23].

In addition to enabling flexible access to rich digital resources, the application of mobile learning gives students the freedom to learn according to their abilities [24] and makes them more active by making it easier for students to communicate and collaborate [25].

In the last few decades, there has been a lot of research related to the application of mobile learning in chemistry. For example, the effect of implementing Organic Fanatic, a mobile application game, on learning organic chemistry at the university level is explored [26]. The results indicate that students feel Organic Fanatic is an interesting and interactive learning resource. Lok and Hamzah [27] explore the learning experiences of matriculation students who use educational apps when studying chemistry. They reported that the use of mobile apps helped students in understanding the concepts being studied. In addition, students also stated that the application helped them visualize abstract concepts. Apart from student learning experiences, existing literature has also observed the impact of implementing mobile apps on motivation. Mobile learning applications were effective in increasing students' motivation in studying chemistry [28].

In this research, we developed Go-Chemist! app, a mobile learning application to help students learn colligative properties easily. The unit of colligative properties was chosen in this study because this topic is relatively difficult because it requires complex reasoning [29]. In a study, Zikovelis and Tsaparlis [30] analyzed the kinds of errors made by eleventh-grade students in Greece and found that out of 141, a total of 26 errors in solving problems related to colligative properties and their laws were found. According to the aforementioned issues, the usage of the mobile application is expected to help students more easily understand colligative properties and increase students' positive attitudes to a satisfactory level. Therefore, this current research aimed to scrutinize the effect of using Go-Chemist! app on attitudes toward chemistry lessons of high school students on colligative properties. Accordingly, the research questions (RQs) directing the present study were:

RQ1: Is there a statistically significant mean difference in attitudes toward chemistry scores between treatment and comparison group students prior and subsequent to learning activities?

RQ2: Is there a statistically significant improvement in attitudes toward chemistry scores of the treatment and comparison group students from pre- to post-administration?

2. Method

This section presents the research method in detail as follows.

2.1. Design

This study employed a quantitative data collection method. The quantitative form utilized a quasi-experimental design. In this study, we adopted a non-equivalent pretest/posttest control group design. A quasi-experimental design is a procedure in quantitative research where researchers test a hypothesis through the manipulation of independent variables so that their effect on the dependent variable is observed [31]. In this study, the independent variable is the use of the Go-Chemist! application, while the dependent variable is the students' attitudes toward chemistry. Quasi-experimental research is a unique research methodology in which the research subjects were not likely to be assigned randomly [31].

2.2. Participants

The study encompassed a total of 71 12th-grade students, ranging in age from 17 to 19 years. These students were enrolled in a public upper-secondary school located in Jakarta, Indonesia. Participants in this study were recruited using the simple random sampling method. The control and treatment groups were then randomly assigned. To avoid instructor bias, a female teacher taught both groups for the same length of time. This study was done at the beginning of the first semester of 2022/2023.

2.3. Data Collection Tool

To gather the data, the Attitude Toward Chemistry Lessons Scale or ATCLS was employed as pre- and post-tests. This scale was designed by Cheung [32] to evaluate students' chemistry attitudes.

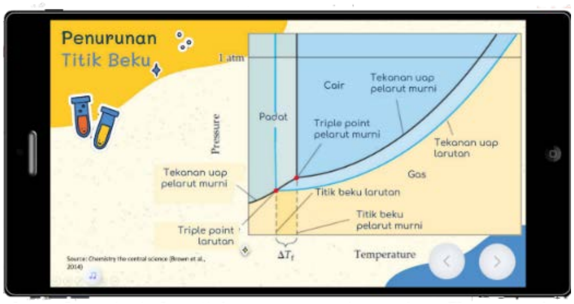
The instrument consisted of twelve items with seven Likert scales (ranging from "strongly disagree" to "strongly agree"). There were four indicators, such as liking chemistry lessons, liking chemistry experiments, evaluative beliefs about chemistry, and behavioral tendencies to study chemistry. Each indicator has three statements. Overall, the minimum and maximum scores that can be obtained by each student were 12 (negative attitude toward chemistry) and 84 (positive attitude toward chemistry). The scale has been face-validated by three expert judgments in chemistry education. After being analyzed, the reliability value of ATCLS was 0.85.

2.4. Procedure

In total, the learning process in both classes lasted for 4 meetings and each meeting lasted 40 minutes. The topic was colligative properties. At the beginning of the first meeting, a pre-test was carried out and then continued with learning, while the post-test was carried out at the end of the fourth week. During the learning process, students in the treatment group learned colligative properties using the Go-Chemist!. Figure 1 shows screenshots of a mobile learning application. The teacher explains how to use the Go-Chemist! app to ensure that all students can use the app well. Furthermore, students were encouraged to study the topic through the application. After the self-study session, students were divided into small groups for discussion. In the last meeting, the teacher directed students to work on the questions provided in the application. Finally, the teacher provided reinforcement and students reflected on their learning.

Meanwhile, the control group students studied the same topic using e-books for 4 meetings. During learning, the teacher as a content transmitter explained the learning content in front of the class and students listened and took notes. In the last meeting, the teacher invited all students to conclude the lesson and then gave them homework.

(a) (b)



(c)

(d)

Figure 1. Four screenshots of Go-Chemist! scene: (a) starting appearance, (b) main menu, (c) learning content, and (d) quiz

2.5. Data Analysis

Because the data obtained were homogeneous and normally distributed ($p > 0.05$), parametric tests were used. Quantitative data analysis was performed in terms of descriptive and inferential statistics to obtain the results. Descriptive statistics were presented as average scores (M) and standard deviations (SD). Further, inferential statistics consisted of independent and paired *t*-tests. An independent *t*-test was conducted to compare the attitude scores between the treatment and comparison groups. Additionally, a paired *t*-test was utilized to compare the mean scores of the pre-test and post-test within both groups. The significance level was accepted as 0.05. In addition, to analyze the effect size, we also computed Cohen's *d* [33]. It should be noted that quantitative data were analyzed in SPSS 25 package program.

3. Findings

This section expounds on the results of independent and paired *t*-tests. Differences in attitudes between treatment and comparison group students were checked using an independent *t*-test. Table 1 summarizes the results. It can be observed that the gap between the two groups was not significantly different (t = -0.260, p = 0.795). This shows that both groups have similar attitudes toward chemistry before intervention. After the learning process, we re-measured students' chemistry attitudes in both groups after participating in learning using different methods. Based on the analysis, a statistically significant mean difference between the two groups of students in chemistry attitudes existed subsequent to intervention was provided (t = -3.302, p = 0.002). It suggested that the average scores appeared to be greater for the treatment group compared to their counterparts. This shows that learning using Go-Chemist! Is more effective in promoting students' attitudes toward chemistry than conventional teaching using textbooks.

Table 1. The comparison of attitudes between two groups

		Mean	*SD*	*t*	*p*
Pretest	EG	61.257	8.279	-0.260	0.795
	CG	60.722	9.013		
Posttest	EG	69.628	7.907	-3.302	0.002
	CG	63.138	8.626		

In addition, to determine whether there was an increase in attitude scores after instruction, we run a paired sample *t*-test. Table 2 demonstrates the findings of the *t*-test.

Table 2. The changes in students' pre/post-test scores

	Paired Differences		*t*	*df*	*p*	Cohen's *d*
	Mean	*SD*				
EG	8.371	1.456	-33.993	34	0.000	1.03
CG	2.416	1.480	-9.792	35	0.000	0.27

As listed in Table 2, it can be clearly expressed that the gap between pre- and post-scores in both groups was statistically significant. This reflects that in both groups, there is an increase in positive chemistry attitudes subsequent to instruction. However, the mean difference between pre-post scores was greater for the intervention group (M = 8.371; SD = 1.456) than for the comparison group (M = 2.416; SD = 1.480). This shows that learning using Go-Chemist! provided a greater impact (Cohen's d = 1.03) on increasing students' positive attitudes toward chemistry compared to learning using textbooks (d = 0.27).

4. Discussion

In this study, it was found that the application of the Go-Chemist! app was more effective in promoting positive attitudes toward chemistry than traditional learning using textbooks. This is in accordance with the findings of Damo and Prudente [34], who reported that the usage of educational applications was effective in encouraging students' positive attitudes toward chemistry.

Similarly, Heflin et al. [35] also linked the application of mobile learning to the formation of positive student attitudes. The increase in positive attitudes among students may be due to the advantages of mobile apps. For example, there is a claim that mobile app is an interesting and interactive learning resource for students [26]. Thus, it is not surprising that students in the treatment group were more interested in studying colligative properties in general than the control group. Textbooks were also found by previous researchers to cause boredom in students because they could not attract students' attention [36], [37], [38]. A previous study [39] revealed that students who use mobile devices like tablets and smartphones are more satisfied and enjoy their learning activities than students who use other devices. This is because the participants in this study were at an age called "digital natives" [40].

In brief, the mobile learning app designed in this study makes it easier for experimental group students to understand chemistry. This is due to the fact that by using mobile apps, students can access learning materials and carry out independent learning without space and time restrictions; thus, they can learn according to their abilities and own pace [41]. It also allows students to easily interact and discuss learning topics with their peers and teachers. Thus, the interactions created by involvement in group activities among students increase their attitudes. Mobile learning also offers convenience for students to access materials [23]. This is because the applications available on smartphones can be used as learning media to study material effectively and efficiently [42]. By utilizing this application in chemistry learning, it enriches students learning [43], motivates them to learn [44], and makes students feel enthusiastic [45]. This may promote students' attitudes toward chemistry on colligative properties in the current study.

5. Conclusions and Limitations

This study examines whether the Go-Chemist! app can elevate students' attitudes toward chemistry on colligative properties. After four meetings using a mobile learning app, students reflected more positive chemistry attitudes than their counterparts who studied using e-books. Thus, the implementation of the Go-Chemist! app was effective because the treatment group students performed better scores than the comparison group students. The results indicated that if learning is implemented properly, the use of mobile app is effective and efficient in increasing twelfth-grade students' attitudes toward chemistry. Therefore, we recommend the wider use of Go-Chemist! app.

Although the current study was successful in promoting students' chemistry attitudes, some limitations should be taken into account. First, the respondents in the present study are still relatively small, which is only one public high school in Jakarta. Future studies should involve a larger number of participants so that the results can be generalized. Second, although the results show that four meetings are sufficient to promote students' attitudes toward chemistry, further research is suggested to involve a longer duration of time. It aims to study changes in student attitudes over time.

Acknowledgment

This study was supported by Universitas Negeri Jakarta under Grant Number: 40/KN/LPPM/III/2023.

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