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Investigation of Using Wiki to Facilitate Group Composition in Learning Engineering Knowledge: A Quasi-Experimental Study*

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The purpose of the study was to explore the effect of group composition by using wikis in classrooms. A wiki system was created for students to learn a chemical engineering theme. A quasi-experiment with pre-test and post-test design was adopted to fulfill the research question. The research participants were 116 eighth graders from three classes at a public junior high school in Taiwan. Students from three classes were divided into three types of group compositions: homogeneous, heterogeneous and natural selection groups. A criterion test defined as a learning achievement was developed to measure the students' understanding of chemical engineering knowledge. The educational experiment lasted for six weeks. 'Added contents directly related to the course' and 'modified contents from other groups' were two online behaviors defined as wiki performances. The results showed that the effect of group composition did not influence the students' learning achievements and wiki performances. Even though students, when engaging in wiki environments, in all homogeneous, heterogeneous, and natural selection groups achieved similar learning achievements of engineering knowledge, there were significant differences between their pre-tests and post-tests in all three groups. In particular, students in the heterogeneous group exhibited a better learning improvement than in the other two groups.

Keywords: group composition; wiki system; K-12 engineering education; chemical engineering

1. Introduction

1.1 Wiki as a learning tool

A wiki is one of the web-based learning platforms on which online users can easily access and edit digital contents [1]. An educational technology trend report, *Horizon*, listed a wiki as an emerging learning technology for changing classroom environments [2]. Social constructivists argued that a wiki could be viewed as a learning tool used to support student learning by constructing knowledge bases and engaging social networking [3]. From a teaching and learning perspective, a wiki serves in the role of collaborative writing, which allows students to collaboratively add their writing elements and actively modify peers' online works [4].

The use of wiki in classrooms is primarily based on two learning theories. First, the principle of constructive learning provides students with valuable opportunities to use wiki to construct their own learning (i.e. to generate knowledge through wiki entries). Unlike traditional lectures, under wiki instruction, an educational focus has shifted from teacher-based to student-centered learning. An instructor becomes a facilitator who engages students in wiki activities [5]. Second, the tenet of collaborative learning allows students to use a wiki to create a team-based learning environment in which peers collaboratively review the online contents and defend their ideas. Under this teaching model, learning becomes a community contribution rather than an individual performance showcase [6]. In wiki platforms, online edited contents are collaborative community assets via students' social negotiating.

While integrating wikis into classroom instruction, several past studies reported empirical evidence on positive outcomes in facilitating the students' learning process. For example, Raman et al. [7] found that a wiki platform enhanced college students' knowledge sharing processes. In Bold's [8] study, the findings showed that a wiki as supplementary learning materials in class supported graduate students' self-control learning. Martinsen and Miller [9] created a wiki system for college students to discuss writing issues and indicated that the wiki strengthened students' interaction with peers.

1.2 Group composition on wiki use

Although wikis exhibit some educational benefits, potential problems still influence classroom adoption. Hew and Cheung [10] reviewed literature

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about wiki implementation in K-12 and higher education settings and concluded that the social environment was one of the major factors affecting the students' willingness to use wikis. Chou and Chen [11] directly related such a social issue to the students' group composition. In their study, random assignment of student group members may reduce performances of wiki teamwork. Chou and Chen further suggested that future wiki research should focus on group composition.

Group composition is an instructional strategy aimed at optimizing student groups' performances in collaborative learning [12]. In the literature, students are often grouped into two types of compositions during classroom instruction: homogeneous and heterogeneous groups. Students' knowledge and skills are similar in homogeneous groups, while individuals' abilities are diverse in heterogeneous groups [13–14]. Since the use of wiki stresses the importance of collaborative learning [15], whether varied group compositions will influence wiki adoption in class, especially on student learning outcomes, is worthy of further exploration.

Hooper and Hannafin [16] examined the effect of group composition on computer-based math activities and found that no significant difference existed on students' learning achievements between homogeneous and heterogeneous groups. Brush [17] reviewed related studies and reported that heterogeneous group design was suitable for students completing computer-assisted activities. Even though these studies focus on group composition in a computer-assisted instruction setting, the impact of group composition using new emerging technologies, such as wikis, is still unknown.

1.3 Wiki use in engineering education

Due to the nature of collaborative learning in engineering topics, a number of past studies applied wikis to different engineering disciplines and yielded positive outcomes. Yalvac et al. [6] interviewed engineering instructors who used wiki in teaching and reported that professors were eager to use wiki to improve student collaboration. Abreu et al. [18] surveyed students and professors of computer science and electrical engineering regarding the use of wiki in educational contexts and found that participants would like to continue to use wiki for their professional development. Rubio et al. [19] surveyed students and instructors of industrial engineering about their familiarity with web 2.0 technologies and reported that most of the participants expressed a frequent use in wiki platforms. Nejkovic and Tosic [20] evaluated wiki teaching in an electronic engineering course and indicated that the wiki-based course increased students' motivation. Minocha et al. [21] introduced wikis into software engineering courses and found that wikis facilitated teamwork effectiveness. Boudet and Talon [22] used a mixed method to explore the use of wikis in postgraduate education and revealed that the wiki was a reflective learning tool for students. Forment et al. [23] reviewed the literature and proposed some didactical patterns for wiki use in learning activities. However, those past studies neither explored the concept of group composition nor employed an experimental design to collect and analyze research data.

K-12 engineering education is an emerging research theme for engineering educators [24]. In K-12 learning systems, a number of curricula include abundant engineering knowledge. Katehi et al. [25] asserted that K-12 education was an engineering seedbed in which elementary and high school students could develop their positive attitudes toward engineering by learning basic engineering concepts. Miaoulis [26] contended that K-12 courses related to engineering enriched students' problem solving skills, one of the core competencies in engineering domains. In the current study, the use of wiki was applied into a high school's engineering topic. Computer applications in K-12 engineering education may provide a valuable opportunity for high school students to employ technology tools to facilitate engineering learning.

Therefore, this study aimed to conduct an educational experiment to investigate the effect of group composition by using wikis. Two types of group structures were examined: homogeneous and heterogeneous groups. A wiki system was created for student groups to learn a chemical engineering theme. One hundred and sixteen students participated in the study. One major research question was as follows:

> Did significant differences exist for learning achievements and wiki performances for students in different group compositions (homogeneous and heterogeneous groups)?

According to the research question, the research null hypothesis of the study was:

> There was no significant difference on learning achievements and wiki performances for students in different group compositions (homogeneous and heterogeneous groups).

2. Research method

2.1 Research design

This study adopted a quasi-experimental role with pre-test and post-test designs to examine the aforementioned research question. The independent variable was the type of group composition (homo-

Table 1. Quasi-experimental design

Treatment	Pre-Test	Experiment	Post-Test	Wiki performance
Treatment 1 (Class A)	O_1	X_1	O_2	O_7
Treatment 2 (Class B)	O_3	X_2	O_4	O_8
Control Group (Class C)	O_5	X_3	O_6	O_9

X_1: Homogeneous group on wiki use.
X_2: Heterogeneous group on wiki use.
X_3: Natural selection group on wiki use.
$O_1 \sim O_6$: Criterion test on chemical engineering knowledge.
$O_7 \sim O_9$: Student groups' wiki performances.

geneous and heterogeneous groups). The dependent variables were students' learning achievements in chemical engineering and performances in wiki works. Table 1 lists the research design of the study.

According to mean scores on five sectional examinations in the Physics and Chemistry classes, students in three classes were divided into different groups. In Treatment 1 (Class A), a homogeneous approach was used to segregate student groups where team members' abilities were approximate. In Treatment 2 (Class B), a heterogeneous principle grouped students into several divisions in which individuals' capabilities were divergent. Based on common interests, in Control Group (Class C), students picked their classmates to form a team by themselves. Regardless of the type of group composition, each group had six students. One week before and one week after the experiment, students received the pre-test and post-test within one hour. On completing the experiment, the student groups' wiki performances were examined through wiki platforms' log files.

2.2 Experimental control

This study employed several experimental controls to minimize the threats to the internal validity of the quantitative research [27].

1. Class instructor: The instructor imparting engineering knowledge in three treatments was the same person.
2. Class time: Each treatment received the same class time.
3. Learning contents: The instructional design on materials and strategies were the same in the three treatments.
4. Class setting: All treatments used wikis to support their professional development in the same computer lab.
5. Test implementation: The pre-test and post-test were administered in the same school day.
6. Starting behavior: Before the implementation of the experiment, the pre-test was adopted to ensure that the starting behavior for all participants was equal.
7. Control group: The control group was created to compare the varied group compositions. In order to ensure comparison consistency among three treatments, students in the control group also received wiki instruction.

2.3 Research instrument

2.3.1 Wiki system

Wikia is an online system that allows users to create free wiki platforms. In the study, the instructor asked each student group to use Wikia to register their own wikis. The rationale of using Wikia is that it has easy-to-edit features and a friendly interface. One week before the experiment, the instructor taught the student participants about Wikia's operating steps in details. Once students logged into their created wiki websites, the online system automatically recorded two of the online behaviors' frequencies: added contents directly related to the course and modified contents from other groups, which were also defined in the study as wiki performances. Figure 1 is a snapshot from a student's wiki web page. Students in one group found a teaching video clip and a static image related to carbonization on the Internet and then edited the video and image in the wiki page. Basically, students might find additional learning resources through the Google database.

2.3.2 Criterion test

A criterion test was developed to measure the students' understanding about chemical engineering knowledge. The test contains 39 multi-choice question items. The test contents related to six knowledge domains in chemical engineering: introduction to organic compounds, characteristics and applications of organic compounds, the nature of polymers, production of soap and detergents, applications of food technology, and theory and application of forces. Higher scores in the measurement represent students' higher learning achievements. The score range of the test was between 1 and 39.

The test was undergone in a three-stage process to ensure the reliability and validity. First, three teacher experts in chemical engineering examined the

Fig. 1. Snapshot from student's wiki web page.

Table 2. Profile of research participants

Class	Experiment	Number of student	Number of group	Group size (people)
Class A	Homogeneous	30	6	5
Class B	Heterogeneous	27	6	4 or 5
Class C	Natural selection	30	6	5

contents of the original 40 test items. Unclear descriptions in the question were removed at this stage. Second, the original test was administered to 32 ninth graders who have learned test knowledge before. Subsequently, the result of item analysis showed that the discrimination index of one item was below 0.19. The number of test items was decreased to 39. Finally, the Kuder-Richardson 21 (K-R 21) reliability test was performed to identify the reliability of the test. Overall, the reliability coefficient was 0.94.

2.3.3 Research participant

In the study, research participants were 116 eighth graders from three classes (Class A: 30; Class B: 27; Class C: 30) at a public junior high school in Taiwan. Overall, students were familiar with computer use in the classroom since they had already gained basic proficiency in computer applications and word processing at computer courses. Table 2 summaries the profiles of the research participants.

Since four or five students formed a group in the study, individual differences regarding skills and knowledge might exist in the study. For example, members in some groups might have excellent writing skills and better information literacy, which influenced the students' wiki performances. However, in terms of research scope, the study focused on group composition under wiki use rather than individual behavior. The selection process about research participants was one research limitation that occurred in the study.

2.3.4 Research procedure

This study focused on one course entitled 'Physics and Chemistry'. In the class, students might learn a great deal of scientific knowledge and engineering concepts in the fields of physics and chemistry. The targeted class lesson was a knowledge base in chemical engineering. The educational experiment embedded in the class lesson lasted for six weeks. In each week, the student groups should take part in three types of class instruction: traditional oral lesson (one hour), lab manipulation lesson (one hour), and wiki use lesson (two hours). In the traditional oral lesson, the instructor imparted textbook knowledge to students; in the lab manipulation lesson, students applied what they had learned into practice by experimenting with chemical instruments; in the wiki use lesson, the students summarized their received knowledge and findings in wiki pages. In each lesson, student groups sat together to facilitate collaborative learning. Table 3 lists the learning schedule in the six-week experiment.

Table 3. Learning schedule in the six-week experiment

Time*	Unit lesson
Week 1	Introduction to organic compounds
Week 2	Characteristics and applications of organic compounds
Week 3	The nature of polymers
Week 4	Production of soap and detergents
Week 5	Applications of food technology
Week 6	Theory and application of forces

* One week before and after the experiment, students received the pre-test and post-test within one hour.

During the wiki use lessons, the instructor's role shifted from knowledge transmitter to activity facilitator. The instructor walked around the computer lab to monitor the learning process. At this time, a wiki served as a learning tool used for assisting students to comprehend what they learned in the previous two class instructions. In the wiki platforms, students freely edited course-related contents and modified peers' works. After class, students were also allowed to continually edit their wiki pages at any settings. In the upcoming oral lesson, the instructor used a computer projector to exhibit student groups' wiki pages in an effort to review course knowledge.

2.3.5 Data analysis

The T-test and One-Way ANOVA were two primary statistical techniques for analyzing the collected data. While the T-test was used to compare two variables (e.g. the pre-test and post-test differences), the One-Way ANOVA was performed to observe three variables (e.g. three experiment treatment differences). The significant level was set at 0.05.

3. Research result and discussion

3.1 Starting behavior

Table 4 summaries the pre-test results of three treatments. Table 5 reports the ANOVA results of the pre-test for three treatments.

From the results listed in Table 4 and Table 5, students from three classes did not perform significantly on the pre-test (F = 2.30, p > 0.05). The findings showed that the starting behaviors for research participants were about the same before the implementation of the experiment, which in turn reflected a solid experiment control for the study.

3.2 Group composition on students' learning achievements

Table 6 lists the post-test results of three treatments. Table 7 reports the ANOVA results of the post-test for three treatments. Table 8 summarizes the t-test results of the pre-test and post-test.

The findings listed in Tables 6 and 7 indicated that no significant difference existed for students in three classes (F = 2.30, p > 0.05) in terms of their post-test scores. When considering three treatments altogether, the effect of group composition was not a strong factor influencing students' learning achievements. However, comparing the mean score between the pre-test and post-test identifies a learning improvement. The results in Table 8 showed that there was a significant difference between the pre-test and post-test for students in three treatments (t = 4.49, p < 0.05 in Class A; t = 6.71, p < 0.05 in Class B; t = 6.31, p < 0.05 in Class C). Furthermore, by using the formula of effect size, Class B yielded the highest number in Cohen's d (Class A= 0.94; Class B = 1.44; Class C = 1.34). Therefore, under

Table 4. Pre-test results of three treatments

Treatment	Number of students	Mean	S.D.	Min*	Max
Class A	30	12.93	3.13	4	17
Class B	27	12.48	3.47	5	19
Class C	30	11.30	3.78	4	18

* 1 < Pre-test < 39.

Table 5. ANOVA results of pre-test for three treatments

Test	SS	DF	MS	F	Significance
Pre-test	76.64	3	25.55	2.30	0.08

Table 6. Post-test results of three treatments

Treatment	Number of students	Mean	S.D.	Min*	Max
Class A	30	19.43	9.22	5	35
Class B	27	20.93	7.53	7	33
Class C	30	19.20	7.43	10	35

* 1 < Post-test < 39.

Table 7. ANOVA results of post-test for three treatments

Test	SS	DF	MS	F	Significance
Post-test	76.64	3	25.55	2.30	0.08

Table 8. T-test results of pre-test and post-test

Treatment	Mean difference	t	Significance
Class A	6.50	4.49	0.00**
Class B	8.44	6.71	0.00**
Class C	7.90	6.31	0.00**

** $p < 0.01$.

Table 9. Results of descriptive statistics for students' wiki performances

Type	Treatment	Group	Mean	S.D.	Min.	Max.
1. Added contents directly related to the course	Class A	6	12.50	4.59	4	17
	Class B	6	14.33	11.50	3	32
	Class C	6	10.00	6.93	3	23
2. Modified contents from other groups	Class A	6	6.67	3.44	1	10
	Class B	6	7.50	4.59	2	14
	Class C	6	7.50	3.99	2	11

Table 10. ANOVA results for students' wiki performances

Type	Group	SS	DF	MS	F	Significance
1. Added contents directly related to the course	Between	56.78	2	28.39	0.42	0.66
	Within	1006.83	15	67.12		
	Total	1063.61	17			
2. Modified contents from other groups	Between	2.78	2	1.39	0.09	0.92
	Within	244.33	15	16.29		
	Total	247.11	17			

wiki usage in classrooms, among the three treatments, students in Class B exhibited a better learning improvement between the pre-test and post-test (Class B > Class C > Class A) and showed a practical difference in the instructional settings (big Cohen's *d*).

3.3 Group composition on students' wiki performances

Table 9 lists the results of descriptive statistics for the students' wiki performances. Table 10 reports the ANOVA results for the students' wiki performances.

The findings in Table 9 showed that student groups tended to edit their wiki pages and seldom modified the contents from other groups. However, the results in Table 10 indicated that there was no significant difference in wiki performances for student groups in three treatments ($F = 0.42$, $p > 0.05$ in Type 1; $F = 0.09$, $p > 0.05$ in Type 2). The effect of group composition did not affect wiki performances for student groups.

3.4 Discussion

Before the implementation of the experiment, the starting behavior on chemical engineering knowledge for research participants in the three treatments was almost equal. After receiving the six-weeks' educational experiment, students' learning achievements in the three classes presented a significant improvement between the pre-test and post-test. Among the three treatments, students in the heterogeneous group achieved a better learning improvement (more differences between the pre-test and post-test).

When considering three experimental treatments together, the finding showed that the effects of three types of group compositions on the learning achievements were about the same. In other words, homogenous, heterogeneous, and natural selection group design shared almost the same weight on learning achievements. Three types of group compositions all might benefit students' learning outcomes using wikis in a similar way. This finding resulted in a similar outcome produced by a previous study that no significant difference was found in learning achievements when students engaged in a computer-based activity [16].

When analyzing two online behaviors on wiki platforms, no significant difference was identified on wiki performances for students in three classes. In other words, students in homogenous, heterogeneous, and natural selection groups contributed similar efforts in editing wiki contents. Types of group compositions did not seem to influence student groups' wiki performances. One additional finding was that students were more willing to edit their wiki contents rather than modifying their peers' wiki pages. This phenomenon might be attributed to the peers' relationship, since students would like to create a harmonious learning environment.

In our study, students in Treatment 3 served as a control group to compare with the other two groups. Regardless of the type of learning outcomes, the students in the natural selection group did not seem to lose their advantage points on learning achievements and wiki performances. In a wiki-supported learning environment, students in the natural selection group also seemed to obtain their chemical engineering knowledge well. The effect of natural selection on students' learning achievements and wiki performances shared almost equal effectiveness with homogeneous and heterogeneous design.

Due to the nature of a quantitative-based research design, this study did not examine real situations in the students' collaborative learning in detail. How students in different group structures collaborate with their team members in a computer-supported learning environment and this was not discussed in the current study. Future studies may employ a qualitative-based design to investigate team members' learning behaviors in groups. Furthermore, different levels of students (high- and low-ability) indeed exist in groups, especially for heterogeneous and natural selection groups. Whether high-ability students may piggyback low-ability peers remains unknown. Future studies may examine the phenomenon of social loafing in students' collaborative learning.

4. Conclusion

This study explored the effect of group composition on the students' engineering learning achievements and wiki performances by using wikis. Based on the findings described earlier, the research hypothesis was retained. Even though students, when engaging in wiki environments, in all homogeneous, heterogeneous, and natural selection groups achieved similar learning achievements of engineering knowledge, there were significant differences between their pre-tests and post-tests in all three groups. In particular, students in the heterogeneous group exhibited a better learning improvement than the other two groups. Using wikis in a team-based setting seemed to be an effective tool for facilitating student learning.

The findings yielded in the study may provide an educational implication for higher engineering education. In engineering colleges, several courses, such as capstone design or machine manipulation in labs, were usually offered in a team-based setting. Under these circumstances, engineering students were expected to collaborate with peers in different group structures. From an instructor's perspective, the group composition may not play a significant role in students' learning achievements. With computer applications in learning environments, engineering students in homogeneous and heterogeneous groups might perform equally on their learning outcomes.

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