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THE EFFECTIVENESS OF FLIPPED CLASSROOMS IN IMPROVING STUDENTS' CRITICAL REASONING BASED ON ONLINE SOCIOSCIENTIFIC ISSUES

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Abstract

The research aimed to investigate the effectiveness of the Flipped Classroom model to improve critical reasoning based on online socioscientific issues. Non-equivalent pretest-posttest design was utilized in quasi-experimental research. The sample comprised 125 10th-grade students chosen using cluster random sampling. The experimental group comprised 66 students taught using the flipped classroom model, while the control group comprised 59 students taught using the conventional classroom model. The instrument consists of 12 essay questions to derive scores for critical reasoning based on online socioscientific issues, which are then analysed using Mann-Whitney U analysis. The formula of Cohen d was applied to effect size. This study showed that there is a significant difference in the average score of students between the experimental class and the control class, which is confirmed in the three dimensions analysed, namely identifying the complexity of SSI ($0.000<0.05$), assessing the credibility of information sources ($0.002<0.05$), and multiperspective ($0.000<0.005$). However, there was no significant difference in the information evaluation dimension ($0.913>0.05$). Multipersfective dimensions, the flipped classroom model yields effect size values that fall into the high category. Moreover, the effect sizes of the remaining three dimensions, namely identifying the complexity of SSI, evaluating information sources, and assessing the credibility of information sources, fall within the moderate range. Thus, using the flipped classroom model effectively increases critical reasoning based on online socioscientific issues.

Keywords: Effectiveness, Flipped classroom, Critical reasoning, Socioscientific issues online.

1. Introduction

Science education is crucial for improving students' abilities to evaluate online resources critically [1, 2]. The vast quantity of incomplete, contradictory, incorrect, and biased information obtained from online sources requires training for students to reason critically by accessing, selecting, processing, and utilizing reliable information [3]. Reasoning can be enhanced through learning using dilemmatic issues that require argumentation and decision-making [4, 5]. Socioscientific issues are complex dilemmas that seek to develop knowledge content, the nature of science, and argumentation and decision-making skills [6]. Socioscientific problems (SSI) encompass contentious subjects that necessitate students' active participation in communication, deliberation, and argumentation to arrive at a resolution to the situation at hand [7]. The process of decision-making about socioscientific matters involves several stages: inquiry, evidence collection, understanding the attributes and constraints of scientific evidence, assessment of the credibility of scientists based on social factors, and identification of the value or ideological stances of both parties [8].

The flipped classroom is a pedagogical strategy that combines online learning as homework assignments with interactive learning activities during in-class sessions [9, 10]. In pre-class activities, students can gain knowledge or information individually or in groups. Classroom activities allow students to collaborate with teacher guidance. Teachers can encourage student participation to solve issues and make decisions related to socio-scientific issues. The use of flipped classrooms has been observed to exert a positive and significant impact on students' cognitive processing capabilities and their ability to generate knowledge [11]. Cognitive processing abilities support students' critical reasoning abilities when solving online socioscientific issues [12].

Previous research reported that the use of the flipped classroom (FC) had an impact on critical thinking [13], critical reading [14], digital literacy [15], learner achievement [16], scientific literacy, and decision-making skills [17]. In this study, the novelty of the research lies in the FC strategy to improve online socioscientific-based critical reasoning, which has never been done in previous studies. This research additionally investigated for the first time critical reasoning based on online socioscientific issues, particularly in the context of illicit mining. The Internet was the source of the unlawful mining information that has been examined. The research aimed to investigate the effectiveness of the FC model in improving critical reasoning based on online socioscientific issues about environmental change. This study was conducted in first-year high school biology classes, specifically on the topic of environmental change. The results of this study discuss the impact of implementing FC in online SSI critical reasoning and test its effectiveness based on (1) SSI complexity dimensions, (2) SSI information evaluation dimensions, (3) SSI information source credibility assessment dimensions, and (4) multiperspective dimensions.

2. Information Technology in Flipped Classroom

One form of blended learning is the "flipped classroom"[18]. It is a new method of education in which lectures are given in a classroom and assignments are completed outside of it. Students need to accomplish their homework or practice their abilities as instructed by their teachers either before or after class. Educators can now make

it easier for their students to access learning resources before class by storing things like course materials and readings in the cloud. The use of digital devices or information technology in education is intended as a complementary or additional method, not as a replacement for more conventional approaches. Several studies investigating FC have consistently found numerous benefits, including the development of positive attitudes, increased self-efficacy, enhanced self-regulated learning, and improved students' talents and skills [19].

The FC concept emphasizes the potential of technology-enhanced instruction that can effectively complement constructivist pedagogies. Results of a systematic review of the use of information and communication technology in FC learning in pre-class and in-class activities such as using Edmodo, Moodle, Facebook, websites, web pages, and the cloud [20]. ICT is being utilized in the educational domain [21-25]. Also, it is implemented in FC learning, which represents a contemporary approach to instruction by integrating technology and digital learning methodologies [26]. The implementation of the FC methodology, which prioritizes hands-on problem-solving learning, may offer a suitable solution for educators facing difficulties in teaching the Internet of Things (IoT).

3.2. Methods

The research was carried out experimentally with a quasi-experimental design with a non-equivalent control group pretest-posttest design. In this test, the population members were all class X high school students in Bengkayang district, West Kalimantan, Indonesia. The sampling technique uses cluster random sampling. The sample for this study consisted of 125 students (sample characteristics are presented in Table 1).

Table 1. Characteristics of experimental and control class samples.

School	Experimental class		Control class	
	Student Total	Percentage	Student Total	Percentage
A	21	31,82%	20	33,90%
B	21	31,82%	19	32,20%
C	24	36,36%	20	33,90%

This study used pre-test and post-test questions with 12 items each. The questions were in the form of descriptions that came from 4 different areas: identifying SSI complexity, evaluating SSI information, assessing the credibility of information sources, and multiperspective. All instruments have been validated by an expert judgment team and meet valid criteria (Aiken V index >0.87) as well as a Cronbach's alpha value of 0.92 in the very good category. Non-parametric statistical test was carried out using the Mann-Whitney U test. Cohen's d equation is used to calculate the effectiveness of the FC model, with the criteria; low ($0.0 \geq d > 0.2$), medium ($0.2 \geq d > 0.8$), and high ($0.8 \geq d > 2$). Detailed information for the statistical analysis is explained in the literature [27].

4. Results and Discussion

4.1. Data results

Table 2 shows descriptive statistics regarding the outcomes of critical reasoning assessments based on online socioscientific issues for the experimental and control

groups. In addition, Table 3 contains the effect size values calculated using Cohen's d formula.

Table 2. Descriptive statistics and effect size.

Dimension	Experimental group			Control group			ES	Category
	Mean	SD	SE	Mean	SD	SE		
Identifying SSI Complexities	2.57	0.76	0.09	2.24	0.76	0.09	0.43	Medium
Evaluating SSI Information	2.44	0.97	0.12	1.81	0.64	0.08	0.76	Medium
Assessing the Credibility of Information Sources	2.01	0.67	0.08	1.59	0.58	0.08	0.65	Medium
Multiperspective	1.92	0.95	0.12	1.29	0.48	0.06	0.84	High

SD=standard deviation, SE=standard error, ES=effect size

The posttest average score on the whole dimension for the experimental class is higher than the control class. Based on Table 2, it can be seen that the highest effect size value was achieved by the multiperspective dimension (d = 0.84) in the high category, and the lowest was achieved by the SSI complexity identification dimension (d = 0.43) in the medium category. The dimensions of evaluating SSI information (d = 0.76) and assessing the credibility of information sources (d = 0.65) are in the medium category. Table 3 shows that the dimensions of identifying SSI complexity, assessing the credibility of information sources, and multiperspective have a p-value of <0.05.

Table 3. Mann Whitney U test results final test data.

Dimension	Data Analysis Results						
	Group (n)	Mean rank	Sum of ranks	Mann Whitney U	z	p-value	Significance
Identifying SSI Complexities	EG = 66 CG = 59	79,26 44,81	5231 2644	874	-5,330	0.000	Significant
Evaluating SSI Information	EG = 66 CG = 59	66,33 62,63	4180 3695	1925	-0,110	0,913	Not significant
Assessing the Credibility of Information Sources	EG = 66 CG = 59	72,47 52,41	4783 3092	1322	-3,134	0,002	Significant
Multiperspective	EG = 66 CG = 59	73,96 50,74	4881,50 2993,50	1223,50	-3,648	0,000	Significant

Note: Statistically significant at the 0.05 level, EC = experimental group, CG = control group

There is a significant difference between the average score of the SSI complexity identification dimension, assessing the credibility of information sources, and the multiperspective of the experimental class and the control class. Meanwhile, in the SSI information evaluation dimension, the p-value is > 0.05. So, there is no difference in the average score of the SSI information evaluation dimension in the experimental group (students taught using FC) and the control group (students taught using conventional).

4.2. Discussion

The FC model has a positive impact on students in identifying the complexity of SSI, assessing the credibility of information sources, and multiperspective. This is also shown by the effect size value, which shows that these three dimensions have a moderate to high effect on critical reasoning based on online socioscientific issues. Nevertheless, the evaluation dimension of the SSI information source indicates that there is no discernible disparity in the mean score between students who were instructed using the FC model and those who were taught using the

conventional model. However, the effect size shows that the evaluation dimension of SSI information is in the medium category. The findings show that critical reasoning based on socioscientific issues after applying the FC model has strength in all three dimensions (identifying SSI complexity, assessing the credibility of information sources, and multiperspective).

In class activity, students are urged to surmount the multidimensional information they obtain from the issues presented or from various Internet sources. This enables students to recognize information that is contradictory or pertinent to morals, law, ethics, or science. The results of previous research report that during the decision-making process on socio-scientific issues, students refer to cultural, environmental, economic, scientific, ethical/moral, and political values, followed by their own knowledge and personal experiences [28]. Students can comprehend issues and propose solutions from multiple perspectives (multiperspective) as a result. The research findings indicate that there are no distinctions between the FC and conventional models in terms of SSI information evaluation dimensions. The study results indicate that face-to-face conventional classes face-to-face is also able to increase the outcome of learners' performances [29]. One of the influencing factors is that students who use online search strategies involve metacognition, which functions in evaluating information when solving socioscientific problems. The FC learning paradigm affords students the ability to obtain information from diverse sources, hence creating opportunities for them to engage in the critical evaluation of said knowledge. Throughout both in-class and pre-class activities, students diligently search the Internet for accurate information about the socioscientific issues that are being discussed. According to previous research, the FC increases student participation and activity [30].

Pre-class activities in the FC approach afford students the chance to engage in active learning utilizing digital materials curated by the instructor. These activities enable students to interact with course content, fulfil reading requirements, and access recorded lectures in the form of video webcasts, PowerPoint slide narratives, podcasts, and interactive videos [31]. In this pre-class activity, students can also investigate internet-based learning resources pertinent to the SSI topic and context. During collaborative in-class activities, information obtained through pre-class activities is refined. To evaluate information, it is necessary to compare it to information obtained from specialists or other credible sources [32]. When students evaluate controversial SSI information, alignments, and incongruities will emerge between the digital tools used and the logic that encourages them to engage in productive collaborative negotiations to understand a controversy. It is essential to verify online information to combat misinformation. During this phase, the teacher plays a crucial role in offering scaffolding support to students as they engage with the online world. Scaffolding is one of the effective methods [33, 34]. It is the implementation of the FC model at the beginning of students' use of Internet resources. It aims to ensure that students have digital skills and information literacy [35-38]. Information literacy is very important so that every individual can verify information [39].

The factors that influence the evaluation of information are highly dependent on the source's credibility [40]. Students evaluate the website's suitability as a source of information. According to the research findings, there is a disparity between users' knowledge, experience, intentions, and information behavior when searching for and verifying web-based information. To prepare for this, the teacher

compiled a guide for evaluating information sources that can be used as reliable sources of information. After evaluating the information and assessing the source's credibility, students can implement previously acquired knowledge and exchange ideas based on verified knowledge as a basis for decision-making regarding socioscientific issues.

5. Conclusion

This study demonstrates that learning using the FC model is more effective than face-to-face class for enhancing critical reasoning skills related to online socioscientific issues in the dimensions of identifying SSI complexity, evaluating the credibility of information sources, and multiperspective. The results of this research demonstrate that using the FC model can help students develop skills in assessing the credibility of information sources and evaluating information to obtain unbiased scientific knowledge, allowing them to acquire life skills in the age of big data. Teachers can therefore utilize the FC model to address socioscientific issues that students can readily access online.

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