JURNAL PENDIDIKAN KIMIA (JPKIM)
ISSN: 2085-3653| e-ISSN: 2549-3116

J. Pendidik. Kim 2023, 15(2), 119 - 129
DOI 10.24114/jpkim.v15i2.45523

Research Article

The effectiveness of flipped classroom on scientific literacy and critical thinking improvement

Nur Wijayanto[1], Abdul Gani[2], M. Hasan[2] and Asri Widowati[3]

[1]*Department of Science Education, Graduate Program, Universitas Syiah Kuala, Tgk Chik Pante Kulu, Banda Aceh, 2311, Indonesia*
[2]*Departement of Chemistry Education, Faculty of Teacher Training and Education, Universitas of Syiah Kuala, Banda Aceh, 23111, Indonesia*
[3]*Natural Sciences Department, Faculty of Math and Science, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia*

Received 12 May 2023 ♦ **Revised** 27 August 2023 ♦ **Accepted** 28 August 2023

Citation: Wijayanto, N., Gani, A., Hasan, M., & Widowati, A. (2023). The effectiveness of flipped classroom on scientific literacy and critical thinking improvement. Jurnal Pendidikan Kimia (JPKIM), 15(2), 119–129. https://doi.org/10.24114/jpkim.v15i2.45523

Keywords

Critical thinking
Flipped classroom model
Literacy science
21st century skill

Corresponding author:
E-mail: abdulgani051266@gmail.com
(Abdul Gani)

OpenAcces

Abstract

Scientific literacy has a vital role in supporting 21st-century skills. Good literacy skills can directly affect students' thinking abilities, which makes them more creative in solving problems. The low ability of students' scientific literacy and critical thinking is still a problem in the world of education. The application of appropriate learning models and methods can improve student learning outcomes. The goal of this study was to see how the flipped classroom learning model affected the literacy and critical thinking skills of SMAN 3 Yogyakarta grade XI students. The pretest-posttest control design experimental method was carried out on a total of 35 samples from a population of 213 students. The results of the Mann Whitney and Wilcoxon tests obtained a significance of less than 0.05 in both the control and experimental groups for pretest and posttest values. The use of the flipped classroom method effectively improved scientific literacy and critical thinking skill. There is a strong relationship between critical thinking skills and scientific literacy.

Introduction

The 21st-century learning must always be contextual and able to train students' skills in critical, creative, collaborative, and communicative thinking (Asrizal et al. 2018). Scientific literacy skills are indispensable as the basis for these skills (Mutaqin and Rizkiyah, 2022). It is essential to students' critical thinking skills to formulate solutions to problems (Primasari et al. 2020). Based on the results of the Programme for International Student Assessment (PISA), the scientific literacy of Indonesian students in 2018 was ranked 70th out of 78 participating countries with a score of 396, below the average PISA standard (OECD, 2019). This result illustrates how low the scientific literacy skills of Indonesian students are. The low score in scientific literacy also indicates students' lower critical thinking skills (Rahayuni, 2016). Scientific literacy plays a pivotal role for students to generate critical thinking and solutions from any information (Primasari et al. 2020).

Scientific literacy skills can be trained in various ways, such as by practicing decision-making and processing abilities when obtaining a new concept from learning activities through critical thinking (Hakim et al. 2016). Critical thinking skill is the ability to analyze circumstances based on evidence to bring results based on reasoning. In line with Agnafia (2020) critical thinking skill is also classified as the ability to improve and instruct arguments from information structured into a provision or varied concept. Students' critical thinking is needed to develop ideas of thinking about the problems contained in learning process (Diharjo et al. 2017). Sulistiani and Masrukan (2016) added that critical thinking skills really need to be developed in learning because it allows students to analyze their own thinking to decide a choice and draw conclusions. The learning process that sharpens students' critical thinking skills covered: providing simple explanations, building basic skills, concluding, providing further explanations, and arranging strategies and tactics (Purwaningsih and Wangid, 2021). Every educator is driven to help pupils develop their critical thinking abilities. The first step in

solving problems is for kids to be able to think critically. From there, they may solve problems by being creative, coming up with ideas, working together, and sharing their solutions with the community. Teachers are supposed to develop these skills to help students learn. the 21st century learning model that is applied according to syntax is the key to improving this ability. Study conducted by Nuryanti (2018) showed that students' critical thinking skills were low due to teacher-dominated learning. Students' critical thinking skills are one of the higher-level skills (Thamrin and Agustin, 2019) taught in the classroom by the teacher. Meaningful learning will positively influence students' thinking skills (Boleng et al. 2017). Students' critical-thinking skills are also influenced by learning models and demonstrated by their academic outcomes (Mahanal et al. 2019).

The COVID-19 pandemic has accelerated the use of technology in learning. Distance learning brings new experiences for teachers and students actively and responsibly (Arulogun et al. 2020). Digital technology utilization in the learning process provides an excellent opportunity to enhance students' 21st-century skills (Oktasari et al. 2019). New technologies can easily be used during the learning process as a source of learning, interaction, and communication from students to students and from students to teachers (Asrizal et al. 2018). Hence, it is important to consider how to maximize the opportunity, one of which is through the flipped classroom learning model. One of the example in blending method conducted by Fakhriyah (2014), she used problem-based learning to develop students' critical thinking skills. Ahmatika (2016), also said that the importance of the learning method approach in improving students' critical thinking skills

Martinez-Jiménez and Ruiz-Jiménez (2020) says that flipped classrooms can make learning more active, improve performance, motivate, and engage students. The teacher did several preparations and teaching procedures which differentiated the classroom activity and home activity (Dewi et al. 2021). Flipped classrooms allow teachers to provide guidance on mastering scientific literacy and critical thinking thoroughly. A study conducted by Long et al. (2016) explained that students generally have a positive attitude toward videos because it can aid students' understanding and assist them in completing quizzes. Mulyani et al. (2018) added that the flipped classroom model allows students to adjust their ability to understand the material because videos can be replayed. The flipped classroom model also allows the teacher to answer all questions from the students related to the material and provide evaluations in the form of questions to students during the classroom. Murillo-Zamorano et al. (2019) proved that the flipped classroom model had a positive effect on the knowledge, skills, and engagement of generation Z students through play, transformation, and creativity. Undoubtedly, this depicts what a teacher hopes for if the flipped classroom model creates a positive effect on students, especially in the current Covid-19 situation. It is in line with Tang et al. (2020), who showed that the integration of online teaching with the flipped classroom model had a positive impact on student learning. Therefore, this model is applicable to all subjects, and chemistry is no exception.

Chemistry is a subject that studies structure, composition, changes, properties, and energy. In chemistry subjects, students also learn natural events, so they are expected to compile concepts, theories, or laws that are explained by connecting symbolic, microscopic, and macroscopic levels. Such characteristics are excellent for the development of 21st-century skills. Support for literacy and critical thinking skills will provide significant learning outcomes. Dewi et al. (2022) states that optimizing aspects of chemical literacy through learning based on socio-scientific issues is very important. This is used as trigger information to increase curiosity and train students' critical abilities. The achievement of students scientific literacy increased by using this socio-cientific issue (Yani and Afrianis, 2022). Students' critical thinking skills in chemistry learning can be seen, among others, from making a conclusion or generalization of the problems that have been solved, to the ability to reason and reconstruct valid arguments (Fernanda et al. 2019).

One of the topics in chemistry is about buffer solutions, which contains complex chemical concepts and trains students to develop literacy habits and critical thinking. Students are required to understand the underlying prior concepts, namely the concepts of acid-base and equilibrium. Purnama et al. (2016), through his study, said that 68.3% of students had learning difficulties about the buffer solution material related to the calculation of pH and pOH. Sanjiwani et al. (2018) added that students had problems understanding buffer solutions due to internal and external factors. The internal factors include a lack of understanding of the concept of buffer solution, lack of motivation and interest, and low mathematical ability. Meanwhile, the external factors were the methods used by teachers in teaching, less conducive learning conditions and time, and peer influence.

Prior research on flipped classrooms has focused on either improving critical thinking skills or scientific literacy. According to the researcher's analysis, scientific literacy and critical thinking are closely related. In line with Rahayuni (2016), there is a significant relationship between scientific literacy and critical thinking abilities. Systematic asynchronous learning in the flipped classroom model will certainly be able to encourage increased student literacy, students will be motivated by the various material presented throughout the class. With existing knowledge students will systematically formulate problems and then reinforce them with discussions in synchronous learning in class. This means students in sharpening their critical thinking skill. This is supported by the research of Munzil et al. (2019) that think implementation of flipped classroom increased students' critical thinking significantly. Earlier research on buffer solutions is focusing on examining critical thinking abilities and strategies for developing them. Based on this information writer want to strengthen it by applying the flipped classroom model especially in the buffer solution topics as part of chemistry lesson in 11 grade. Flipped classrooms have taken a step forward into a new era by using innovative strategies and technologies to facilitate learning outcomes (Hwang et al. 2019). Hence, the flipped classroom method was chosen to determine its effect on improving critical thinking and scientific literacy skills.

Method

This research used an experimental method with a pretest-posttest control design. The population of this research included the entire of SMAN 3 Yogyakarta students of the class of XI science who took chemistry subjects with a total of 213 students. The sample of this research was students of class XI science 4.

The sample consisted of 19 female students (54%) and 16 male students (46%) in the control group, while the number of female respondents was 17 students (49%) and 18 male students (51%) in the experimental group. Erlinda (2018) more specifically carries out a flipped classroom approach through 5 (five) main steps; a) video lessons, b) in-class short oral quizzes, c) active learning sessions, d) follow-up tasks, 5) mastery and competency. The cycle of flipped classroom implementation can be drawn in the Fig.-1.

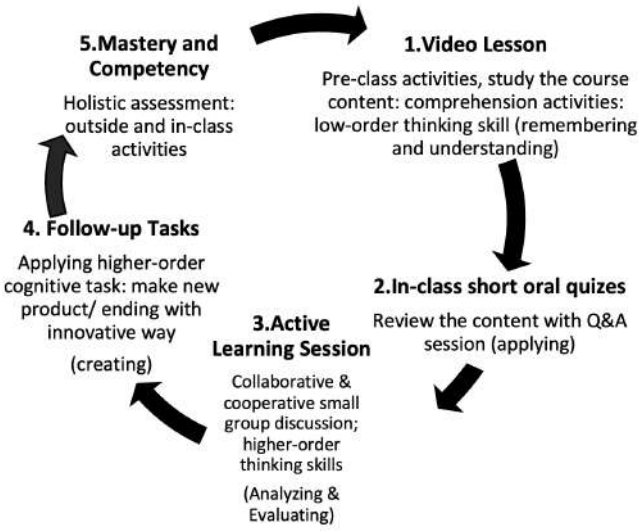

Fig.-1. Cycle of Flipped Classroom Approach Implementation (Erlinda, 2018).

The researcher collected the data through observation, written tests, and questionnaire collection. The observation sheet was used to review the implementation of the flipped classroom stages of the learning process according to the learning implementation plan. To determine the learning outcomes, the researchers administered pre-test and post-test in the form of written tests. The instrument used in this study was a multiple-choice test of scientific literacy and critical thinking skill that had been validated by experts previously. These question distributed in three scientific literacy (Rahmatulloh, 2015; Diana et al. 2015) and four critical thinking aspects (Supriyati et al. 2018) which are listed in Table 1 and Table 2.

Before collecting the data, the validity and reliability of the instrument were tested using Anatesv4 software tools or the product-moment correlation coefficient formula. Instrument reliability refers to whether it provides

a consistent result to measure the same object multiple times (Sugiyono, 2018). The use of questionnaires in this study aimed to observe students' responses regarding flipped classrooms in learning buffer solution material. The t-test was used to determine the mean difference between two related or paired samples (paired sample t-test). The significance level of the mean difference between two interconnected sample groups can be determined using this test. If the significance value exceeds 0.05 then Ho is accepted, and if the significance value is less than 0.05 then Ha is accepted. Data analysis techniques can be calculated using formulas (Sugiyono, 2018).

Table 1. Science Literacy Grid

Aspects of Science Literacy	Indicator
1. Explaining the phenomenon scientifically	1.1. Making and justifying the right predictions 1.2. Identifying, using and creating explanatory models and presenting them
2. Evaluating and designing scientific investigations	2.1. Identifying interviews investigated in scientific research 2.2. Stating methods for scientifically researching shared questions
3. Interpret data and facts scientifically	3.1. Analyze and interpret data and make appropriate conclusions 3.2. Identifying hypotheses, clues, and logic in texts related to science

Table 2. Critical Thinking Grid

Competence	Indicator
1. Provide easy and simple explanations	1.1. Analyze opinions 1.2. Ask and answer questions about an explanation or a challenge
2. Building basic skills	2.1. Consider the credibility of a source 2.2. Observe and consider the results of observations
3. Make further explanations	3.1. Identify assumptions
4. Developing tricks and strategies	4.1 Deciding an action

To carry out the t-test, the two groups must be homogeneous and have a normal distribution. If the significance value is above 0.05, the group is homogeneous. If the significance value is less than 0.05 then the group is not homogeneous. The homogeneity test was performed using SPSS 16.0. The nonparametric test was carried out because it did not pass normality and homogeneity (Sugiyono, 2018). The Mann Whitney test was performed to compare the control and experimental groups and the Wilcoxon test to compare the pre-post of the control group and the pre-post of the experimental group. A descriptive analysis of the effectiveness of the flipped classroom was also carried out by filling out a questionnaire which aims to measure the level of students' critical thinking skills. This is done based on Bloom's Critical Thinking Cue Questions using 20 questions about measuring students' critical thinking abilities.

Results and Discussion

Application of Flipped Classroom

This research implemented flipped classroom model on the buffer solution topic. The design of implementing the flipped classroom model is constructivist which requires students to be actively involved in their learning rather than passively receiving information (Kinteki, 2020). The flipped classroom application in the experimental class begins with uploading teaching materials to the learning management system (LMS) so that students can study them before learning in class synchronously (Fig.-2). The teaching materials provided include video material about buffer solutions, explanations of questions, practice questions (LKPD), and teaching modules (Zainuddin, 2019). Teaching materials uploaded on the LMS allow students to understand, evaluate and reflect on themselves (Haque et al. 2021).

The flipped classroom learning model in the classroom tells students to increase discussions, presentations, and collaboration between students to get subject reinforcement (Fig.-3). The flipped classroom can promote more scientific communication by utilizing the teaching resources that were previously offered (Oktasari et al. 2019).

Flipped classroom learning that conducting into three activities; pre-class, in-class, and after-class allows students to achieve high-order thinking skills (HOTS). Wulandari (2020) explains that before classes the students will focus on remembering and understanding abilities, inside class students can apply and analyze, then continue with activities outside the classroom by evaluating and creating. Supported by Lestari et al. (2020) that the creative thinking abilities independently of students increasing by implementing the flipped classroom model. This is because students learning by their own pace, repeat to watch the videos prepared on the learning platform, and review it by them self.

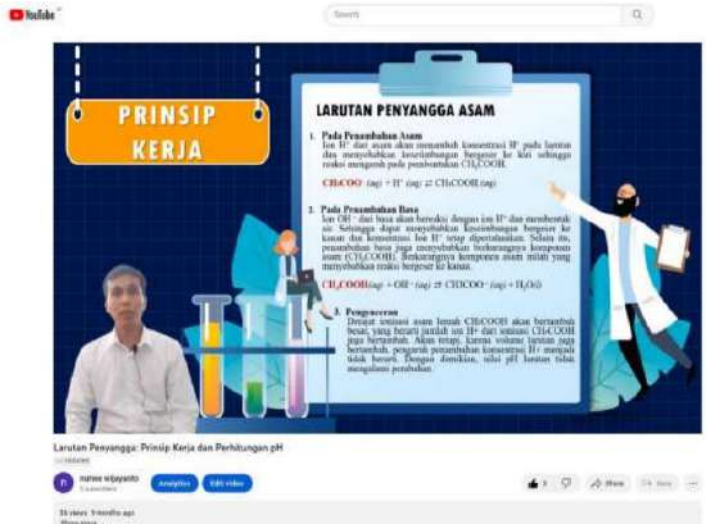

Fig.-2. Uploaded video on Flipped Classroom (Wijayanto, 2022).

Analysis of Science Literacy Ability Test

Science learning must be sustainable and oriented towards the development of scientific literacy; this is carried out as a way to improve student learning outcomes. One of the activities for developing scientific literacy is the observation of scientific phenomena and the use of the environment as a source of learning (Jufrida et al. 2019). Scientific literacy was analyzed by conducting pre-tests and post-tests to determine students' learning outcomes. The researchers used the Shapiro-Wilk test because the data per group was less than 50. The results of the normality test showed that the data were not both normally distributed and homogeneous because the significance value is less than 0.055. The nonparametric test was carried out because it did not pass normality and homogeneity (Sugiyono, 2018). The nonparametric test, Mann Whitney test was performed to compare the control and experimental groups and the Wilcoxon test to compare the pre-post of the control group and the pre-post of the experimental group.

Fig.-3. Student Collaboration During Class Session.

Students' science literacy skills were measured using test questions. Based on the results of data analysis, the average pretest, posttest, and N-gain of students' science literacy skills can be seen in Table 3. Table 3 shows that there was no difference in initial ability between the control and experimental groups. There was no significant difference between the control pre-test mean of 3.436 and the experimental group mean of 3.477. It means that initially, students in XI science 2 and 4 had relatively similar abilities, is in the low category (Jufrida et al. 2019). The effect of using the flipped classroom was indicated by a significance value of 0.008 in the final literacy skills measurement (post-test). There was a significant difference where the post-test mean of the control group was 5.786, and that of the experimental group was 7.488.

Table 3. Mann Whitney Test

Value	Group	*Mean*	Sig	Description
Pre-test	Control	3.426	0.866	No difference
	Experiment	3.477		
Post-test	Control	5.786	0.008	There is difference
	Experiment	7.448		
Gain	Control	0.352	0.001	There is difference
	Experiment	0.605		

Scientific literacy in science learning is reflected in the development of scientific attitudes and abilities, reasoning, conducting scientific investigations, scientific process skills, and self-confidence. Teachers can accommodate scientific learning in increasing scientific literacy through the flipped classroom model. It's relevant with study from Tegeh et al. (2020) that a flipped classroom strategy can support scientific approaches in chemical learning.

The Wilcoxon Test was used to compare the pre-post of the control and experimental group. The output result of Table 4 show that the significance value of the two groups is less than 0.001. There are differences in literacy skills in the pre-test and post-test scores in both the control and experimental groups. According the table 6, the science literacy ability showed a significant difference, the mean of the control N-gain was 0.352, and experimental group was 0.605. It demonstrates how the flipped classroom implementation provided higher effectiveness than traditional learning. Flipped classroom is an attractive alternative approach for teachers in improving students' productive, receptive, and literacy skills (Anwar, 2020).

This study establishes that students can begin developing scientific literacy, particularly in chemistry classes, by providing relevant materials and using a flipped classroom model. Bergman and Sams (2012) provides the basic concept of flipped classroom "reversed" between activities at home and at school as is conventional learning. Through the use of blended learning technology, asynchronous classes enable students to independently study worksheets and other teaching resources that have been uploaded to the learning management system. It is indisputable that educators must use educational tools that encourage independent student evaluation and reflection. Haque et al. (2021) states that to increase scientific literacy through the flipped classroom model, the use of technology in learning media is very necessary.

Table 4. Wilcoxon Test

Value	Group	*Mean*	Sig	Description
Control	*pretest*	3.426	0.000	No difference
	posttest	5.786		
Experiment	*pretest*	3.477	0.000	There is difference
	posttest	7.448		

Activities including scientific literacy are used to enhance students' skill capabilities in class XI chemistry while also supporting their experimental experience. Students can review lessons individually with the help of video clips, instructional materials, and LKPD to better grasp the topic, conduct self-evaluations, and engage in self-reflection, all of which can help students' reading abilities in a disciplined way. This is consistent with research from Fajar and Putri, (2020), which found that the flipped classroom model used in conjunction with video technology, slides, digital story activities, or game-based activities could enhance student performance in the area of scientific literacy. It is envisaged that students can develop the habit of independent learning as part of scientific literacy with the help of this engaging teaching material and rising motivation.

Analysis of Critical Thinking Ability

The comparing between control and experimental group given us the significant different as the result of instrument test. The result showing us slightest difference was in the very high category (81.25 < X ≤ 100), with only one student difference out of 35 children. In the high category (71.25 < X ≤ 81.25), there were ten more students in the experimental group, and in the moderate category (62.5 < X ≤ 71.25), there were six more students in the experimental group. Whereas in the low category (43.75 < X ≤ 62.5), there were ten more students in the control group than were those in the experimental group. Lastly, in the very low category (0 < X ≤ 43.75), there were seven more students in the control group. Based on Fig.-4, it can be concluded that the implementation of the flipped classroom has an effective impact on improving students' critical thinking skills.

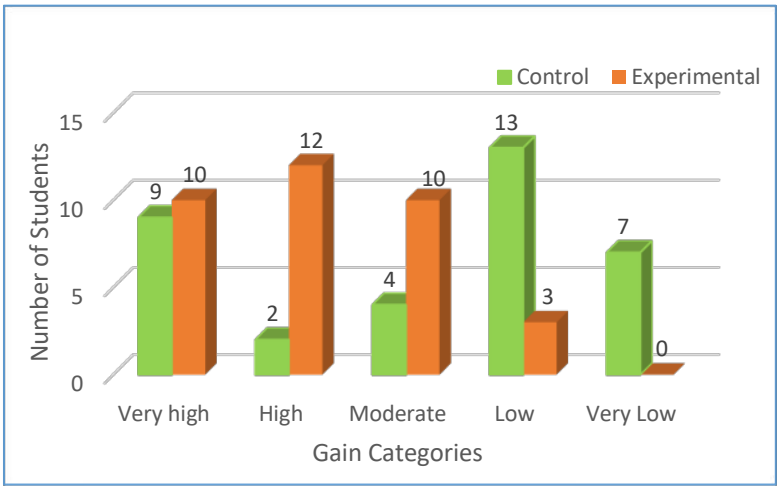

Fig.-4. Student score categories both experimental and control class

The number of students in the high category increased by 10 people compared to the control group. The application of the flipped classroom method provides opportunities for students to actively collaborate, discuss in groups, and elaborate on their knowledge in pre-class sessions with the teacher. This is supported by Rahmawati et al. (2016) research which states that providing an opportunity to provide simple explanations, build basic skills, state conclusions, explain further, and predict what has been learned. It is undeniable that the scientific learning model can be implemented in the implementation of the flipped classroom model. Wenno et al. (2022) also said that learning tools developed with a scientific approach delivered by the teacher increased students' critical thinking skill. The decrease in the number of students in the low category also shows the effectiveness of the flipped classroom. The tendency of students who experience learning difficulties due to a lack of motivation and involvement in learning (Sanjiwani et al. 2018), will certainly affect students' low critical thinking skills.

Students' critical thinking abilities will increase with the use of the proper learning paradigm. Aligned with Muzaimah et al. (2022) using the creative problem-solving methodology in the classroom has been shown to improve students' ability to think critically. Desiana et al. (2022) supports this claim by showing that using the problem-based learning paradigm considerably enhances students' critical thinking abilities. In the learning process, cognitive levels C1–C6 can be accommodated in pre-class, in-class, and after-class activities, which are supported by the flipped classroom model. To adopt flipped classrooms and improve higher education attainment and high-order thinking abilities for teachers, LMS, and other social software have been empirically demonstrated to be effective (Liu and Zhang, 2022).

Descriptive analysis of student questionnaires on students' thinking abilities based on Bloom's Critical Thinking Cue Questions shows that out of the 20 questions, 1 is in the high category and 19 are in the medium category. That the 20th indicator, students have courage to give ideas to friends in every discussion of synchronous learning in class, had the highest achievement with 84.3%. Learning materials provided through platforms in flipped classrooms include (1) teaching materials; (2) learning media; (3) LKPD; and (4) practice questions, support students to learn actively and independently. Erna et al. (2021) explains concerning the buffer solution that the KAPRA (associate, experience, think, negotiate, and apply) model has proven to be effective in improving critical thinking skills. The flipped classroom model allows each student to relate,

practice, and evaluate directly then do reinforcement through discussion and expressing ideas in class, and creating after-class activities as a follow-up.

The lowest indicator is the 19th indicator, which was related to sufficient courage to give ideas to friends in every discussion of synchronous learning in class, with 65.7%. This demonstrated the importance of paying more attention to student-teacher interaction so that students become more interactive and dare to ask teachers questions. Flipped classroom is oriented towards student activity and uses technology in the learning process (Desmarani et al. 2022). Stimulant from teacher that posted in the synchronous part have to support synchronous system during face to face learning. The teacher does not only give practice questions that are routine in nature, does not train critical power, and finally gives an assessment (Ahmatika, 2018). Inadequate preparation for learning outside the classroom in the flipped classroom model (Akcayir and Akcayir, 2018) must be minimized by the teacher by preparing activities that can increase students' self-learning and increase curiosity so that it will support activities in and after class.

This research shows a significant increase in student learning outcomes using flipped classrooms. A number of literature reviews have provided qualitative summaries of flipped classrooms. Some people find that studies on flipped classrooms report increased satisfaction and improvements in test results or subject scores (Akcayir and Akcayir, 2018; Kinteki 2018; Linling and Abdullah, 2023). This increase is seen to be more significant in students with low achievement. Those with low achievers reported significantly more positive results compared to those with high achievers in terms of attitudes toward using video as a learning tool, perceptions of increased learning, and perceptions of more effective learning (Nouri, 2016). The other side that must be considered in using flipped classrooms is the challenge for teachers in preparing learning materials and students who are required to independently carry out activities before class and after class through the LMS used. The availability and accessibility of technology is also very important for students to access online material, as well as for teachers to deliver and manage it (Hwang et al. 2015).

Based on the result above, several suggestions are proposed for effectiveness the flipped classroom model: (1) teachers should prepare appropriate teaching materials to be uploaded on the flipped classroom platform; (2) it is necessary to pay attention to the interaction of students and teachers in class as evaluation and reflection on asynchronous learning carried out to aid scientific literacy and critical thinking skills; (3) students should continue to home their science literacy and critical thinking skills to dig up information through learning resources.

Conclusion

Based on the findings of the research and data analysis, it is possible to conclude that a properly designed flipped classroom learning model can effectively improve SMAN 3 Yogyakarta students' scientific literacy and critical thinking skills. The flipped classroom model gives opportunities for teachers to provide: (1) learning materials, (2) learning media, (3) LKPD, and (4) practice questions to support students to be more active in independent learning. Active asynchronous learning can increase student literacy with teaching materials provided by the teacher through the flipped classroom platform. The ability to think critically can be improved by discussing the materials, which have previously been studied using the asynchronous method, using the synchronous method in the class.

Conflict of Interests

The author (s) declares that there is no conflict of interest in this research and manuscript.

References

Agnafia, D. N. (2019). Analisis kemampuan berpikir kritis siswa dalam pembelajaran biologi. *Florea : Jurnal Biologi dan Pembelajarannya*, 6(1), 45. https://doi.org/10.25273/florea.v6i1.4369

Ahmatika, D. (2017). Peningkatan kemampuan berpikir kritis siswa dengan pendekatan inquiry/discovery. *Euclid*, 3(1). https://doi.org/10.33603/e.v3i1.324

Akçayır, G., & Akçayır, M. (2018). The flipped classroom: A review of its advantages and challenges. *Computers & Education*, 126, 334–345. https://doi.org/10.1016/j.compedu.2018.07.021

Anwar, S. (2020). *Flipped classroom and digital literacy in EFL learning*. Bulir-Bulir Kajian Linguistik Terapan, 11-23 Program Studi S-2 Linguistik Terapan. Universitas Negeri Yogyakarta.

Asrizal, Amran, A. Ananda, A. Festiyed, F. & Sumarmin, R. (2018). The development of integrated science instructional materials to improve students' digital literacy in scientific approach. (2018). *Jurnal Pendidikan IPA Indonesia*, 7(4). https://doi.org/10.15294/jpii.v7i4.13613

Arulogun, O. T., Akande, O. N., Akindele, A. T., & Badmus, T. A. (2020). Survey dataset on open and distance learning students' intention to use social media and emerging technologies for online facilitation. *Data in brief*, 31, 105929. https://doi.org/10.1016/j.dib.2020.105929

Bergman, J., & Sams, A. (2012). *Flipped your classroom: reach every student in every class every day*. USA: International Society for Technology in Education.

Boleng, D. T., Lumowa, S. V., & Palenewen, E. (2018). Assessing Studentsâ€™ Ethnicities and Critical Thinking Skill to Develop PBL Based-Biology Learning Tools. *Biosaintifika: Journal of Biology & Biology Education*, 10(1), 79-86. https://doi.org/10.15294/biosaintifika.v10i1.10554

Desiana, G. A., Sulastri, S., & Syahrial, S. (2022). Application of project-based learning (PjBL) to improve critical thinking skills and students' learning independence on the making of colloids in dispersion. *JTK (Jurnal Tadris Kimiya)*, 7(1), 37-52. https://doi.org/10.15575/jtk.v7i1.13395

Desmarani, S., Rusdi, M., Haryanto, H., & Triwahyudi, S. (2022). Analysis of the needs of teachers and students on the inquiry-flipped classroom model in chemistry lessons. *Jurnal Pendidikan Kimia*, 14 (1), 9-18. https://doi.org/10.24114/jpkim.v14i1.33306

Dewi, C. A., Rahayu, S. Muntolib & Parlan. (2022). Pentingnya mengoptimalkan literasi kimia melalui pembelajaran berbasis isu-isu sosiosaintifik di abad ke-21. *Seminar Nasional IPA XII*,348-359.

Dewi, N. S. S., Padmadewi, N. N., & Santosa, M. H. (2021). The implementation of flipped classroom model in teaching English to Sapta Andika junior high school students in academic year 2019/2020. *Journal of Education Research and Evaluation*, 5(1), 125-135. https://doi.org/10.23887/jere.v5i1.30334

Diana, S., Rachmatulloh, A., Rahmawati, E.S. (2015). Profil Kemampuan Literasi Sains Siswa SMA berdasarkan instrumen scientific literacy assesments (SLA). *Seminar Nasional XII*, 285-291.

Diharjo, R. F., Budijanto, & Utomo, D. H. (2017). Pentingnya kemampuan berpikir kritis siswa dalam paradigma pembelajaran konstruktivistik. *Seminar Nasional Teknologi Pembelajaran dan Pendidikan Dasar*, 445-449.

Erlinda, R. (2018). Flipped classroom: an inventive learning approach in engaging 21st century learners in digital age. *The 3rd International Conference on Education: Teachers in the Digital Age*. IAIN Batusangkar, West Sumatera.

Erna, M. Anwar, L. & Durriah. (2021). The effectiveness of KAPRA learning model on buffer solution to improve students' critical thinking skills. *JTK: Jurnal Tadris Kimiya*, 6(1), 92-103. https://doi.org/10.15575/jtk.v6i1.8378

Fajar, N. & Putri, S. K. (2020). Pengaruh penerapan service learning berbasis fliiped classroom terhadap kesadaran metakognitif dan literasi sains siswa. *BIOEDUSAINS: Jurnal Pendidikan Biologi dan Sains*, 3(2), 75-84. https://doi.org/10.31539/bioedusains.v3i2.1584

Fakhriyah, F. (2014). Penerapan problem based learning dalam upaya mengembangkan kemampuan berpikir kritis mahasiswa. *Jurnal Pendidikan IPA Indonesia*, 3(1). https://doi.org/10.15294/jpii.v3i1.2906

Fernanda, A., Haryani, S., Prasetya, A. T. & Hilmi, M. (2019). Analisis Kemampuan Berpikir Kritis Siswa Kelas XI pada materi larutan penyangga dengan model pembelajaran prodict pbserve explain. *Jurnal Inovasi Pendidikan Kimia*, 13(1), 2326-2336. https://doi.org/10.15294/jipk.v13i1.16183

Hakim, A., Liliasari, Kadarohman, A. & Syah, Y. M. (2016). Improvement of student critical thinking skills with the natural product mini project laboratory learning. *Indonesian Journal of Chemistry*, 16 (3), 322–28. https://doi.org/10.22146/ijc.21149

Haque, R. A., Karim, S. & Mustika, I. (2021). Penerapan model flipped classroom berbantuan E-Book interaktif untuk meningkatkan kompetensi literasi sains momentum dan impuls peserta didik. *JRPF (Jurnal Riset Pendidikan Fisika)*, 6(2): 108-117. http://dx.doi.org/10.17977/um058v6i2p108-117

Hwang, G.-J., Lai, C.-L., & Wang, S.-Y. (2015). Seamless flipped learning: a mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education*, 2(4), 449–473. https://doi.org/10.1007/s40692-015-0043-0

Hwang, G. J., Yin C., & Chu, H. C. (2019). The era of flipped learning: promoting active learning and higher order thinking with innovative flipped learning strategies and supporting systems. *Interactive Learning Environment*, 27 (8), 991–994. https://doi.org/10.1080/10494820.2019.1667150

Jufrida, J., Basuki, F. R., Kurniawan, W., Pangestu, M. D. & Fitaloka, O. (2019). Scientific literacy and science learning achievement at junior high school. *International Journal of Evaluation and Research in Education (IJERE)*, 8(4), 630-636. https://doi.org/10.11591/ijere.v8i4.20312

Kinteki, R. (2020) *Flipped classroom: pembelajaran generasi milenial (materi seminar Kolegial)*. In: Seminar Kolegial, 16 Maret 2020, PPPPTK PKn dan IPS. (Unpublished)

Lestari, D. I., Effendi-Hasibuan, M, H. & Muhammad, D. (2020). The effect of the flipped classroom approach and self-efficacy on a guided inquiry on students' creative thinking skills. *Jurnal Pendidikan Kimia*, 12 (2), 95-105. https://doi.org/10.24114/jpkim.v12i2.19435

Linling, Z., & Abdullah, R. (2023). The Impact of COVID-19 pandemic on flipped classroom for EFL courses: A Systematic literature review. *SAGE Open*, 13(1). https://doi.org/10.1177/21582440221148149

Liu, D. & Zhang, H. (2022) Improving students' higher order thinking skills and achievement using wechat based flipped classroom in higher education. *Educ Inf Technol*, 27, 7281–7302. https://doi.org/10.1007/s10639-022-10922-y

Long, T., Logan, J. & Waugh, M. (2016). Students' perceptions of the value of using videos as a pre-class learning experience in the flipped classroom. *TechTrends*, 60, 245–252. https://doi.org/10.1007/s11528-016-0045-4

Mahanal, S., Zubaidah, S., Sumiati, I.D., Sari, T.M., & Ismirawati, N. (2019). RICOSRE: A learning model to develop critical thinking skills for students with different academic abilities. *International Journal of Instruction*, 12 (2), 417-434. https://doi.org/10.29333/iji.2019.12227a

Martínez-Jiménez, R. & Ruiz-Jiménez, M.C. (2020). Improving Students' satisfaction and learning performance using flipped classroom. *International Journal of Management Education*, 18 (3), 1-8. https://doi.org/10.1016/j.ijme.2020.100422

Mulyani, R., Saminan, S. & Sulastri, S. (2018). Peningkatan kemampuan berpikir kritis peserta didik melalui implementasi lembar kerja peserta didik berbasis predict observe explain. *Jurnal Pendidikan Sains Indonesia*, 5 (2), 19–24. https://doi.org/10.24815/jpsi.v5i2.9810

Munzil, M., Pandaleke, M., & Sumari, S. (2019). Flipped classroom : A novel model to increase critical thinking skill in chemistry courses. *The 3rd International Conference on Mathematics and Sciences Education (ICoMSE) 2019 AIP Conference*. Proceeding 2215, 020014 (2020).

Murillo-Zamorano, L. R., López Sánchez, J. Á., & Godoy-Caballero, A. L. (2019). How the flipped classroom affects knowledge, skills, and engagement in higher education: Effects on students' satisfaction. *Computers and Education*, 141, 1-18. https://doi.org/10.1016/j.compedu.2019.103608

Mutaqin, M.F. & Rizkiyah, H. (2022). Efektifitas budaya literasi dalam meningkatkan keterampilan 4C siswa sekolah dasar. *Dawuh Guru Jurnal Pendidikan MI/ SD*, 2(1), 43-54. https://doi.org/10.35878/guru.v2i1.342

Mazaimah, Gani, A., Pada, A. U. T., Rahmayani R. F. I., Syukri, M. & Yusrizal. (2022). Implementation of creative problem solving model to improve students' critical thinking skills in chemistry lessons. *JTK: Jurnal Tadris Kimiya*, 7(2), 227-244. https://doi.org/10.15575/jtk.v7i2.21262

Nouri, J. (2016). The flipped classroom: for active, effective and increased learning – especially for low achievers. *International Journal Education Technoly in Higher Education*, 13(33), 1-10. https://doi.org/10.1186/s41239-016-0032-z

Nuryanti, L., Zubaidah, S., & Diantoro, M. (2018). Analisis kemampuan berpikir kritis siswa SMP. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 3(2)1: 155–158. http://dx.doi.org/10.17977/jptpp.v3i2.10490

OECD. (2019). *PISA 2018 Result (Volume I): What Students Know and Can Do, PISA*. OECD Publishing, Paris. https://doi.org/10.1787/5f07c754-en

Oktasari, D., Jumadi, Warsono, Hariadi, M., & Syari, E. (2019). 3D Page-flipped worksheet on impulse momentum to develop students' scientific communication skills. *Jurnal Pendidikan IPA Indonesia*, 8(2), 211–219. https://doi.org/10.15294/jpii.v8i2.15737

Primasari, R., Miarsyah, M. & Rusdi, R. (2020). Science literacy, critical thinking skill, and motivation: A correlational study. *Jurnal Pendidikan Biologi Indonesia*, 6 (2), 273-280. https://doi.org/10.22219/jpbi.v6i2.11124

Purnama, R. D., Mawardi & Fadhilah, R. (2016). Analisis kesulitan belajar kimia pada materi larutan penyangga siswa kelas XI IPA 1 Man 2 Pontianak. *Ar-Razi Jurnal Ilmiah*, 4(2): 127-138. https://doi.org/10.29406/arz.v4i2.683

Purwaningsih, W. & Wangid, M. N. (2021). Improving students' critical thinking skills using time bar media in mathemathics learning in the third-grade primary school. *Jurnal Prima Edukasia*, 9(2): 248-260. https://doi.org/10.21831/jpe.v9i2.39429

Rachmatulloh, A. (2015). Profil Capaian Literasi Sains Siswa SMP di Kabupaten Sumedang dengan menggunakan scientific literacy assessments (SLA). Unpublished disertasi, Program Studi Pendidikan Biologi Departemen Pendidikan Biologi UPI. Bandung

Rahayuni, G. (2016). Hubungan keterampilan berpikir kritis dan literasi sains pada pembelajaran IPA terpadu dengan model PBM dan STM. *Jurnal Penelitian dan Pembelajaran IPA*, 2(2): 131–140. https://doi.org/10.30870/jppi.v2i2.926

Rahmawati, I., Hidayat, A. & Rahayu, S. (2016). Analisis Keterampilan Berpikir Kritis Siswa SMP pada materi gaya dan penerapannya. *Pros. Semnas Pend. IPA Pascasarjana UM*, pp. 1112–1119.

Sugiyono., S. (2018). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Bandung: Alfabeta.

Sulistiani, E. & Masrukan, M. (2016). Pentingnya berpikir kritis dalam pembelajaran matematika untuk menghadapi tantangan MEA. *Seminar Nasional Matematika X*, 605-612.

Supriyati, E., Setyawati, O. I., Purwanti, D. Y., Salsabila, L. S. & Prayitno, B. A. (2018). Profil Keterampilan Berpikir Kritis Siswa SMA Swasta di Sragen pada Materi Sistem Reproduksi. *BIOEDUKASI: Jurnal Pendidikan Biologi*, 11 (2), 74-80.

Sanjiwani, N.L.I., Muderawan, I.W. & Sudiana, I.K. (2018). Analisis kesulitan belajar kimia pada materi larutan penyangga di SMA Negeri 2 Banjar. *Jurnal Pendidikan Kimia Undiksha*, 2(2), 75-84. https://doi.org/10.23887/jjpk.v2i2.21170

Tang, T., Abuhmaid, A. M., Olaimat, M., Oudat, D. M., Aldhaeebi, M., & Bamanger, E. (2020). Efficiency of flipped classroom with online-based teaching under COVID-19. *Interactive Learning Environments*, 31(2), 1077–1088. https://doi.org/10.1080/10494820.2020.1817761

Tegeh, I. M., Sundria I. B. N., Sudarma, I. K. & Sudatha, I. G. W. (2020). Mobile-learning development for supporting scientific approaches in chemical learning using flipped classroom strategy. *Journal of Educational Research and Evaluation*, 4 (2),143-151. https://doi.org/10.23887/jere.v4i2.24684

Thamrin, N. R., & Agustin, S. (2019). Conceptual variations on reading comprehension through higher order thinking skills (HOTS) strategy. *English Review: Journal of English Education*, 7(2), 93–100. https://doi.org/10.25134/erjee.v7i2.1777

Wenno, I. H., Limba, A. & Silahoy Y. G. M. (2022). The development of physics learning tools to improve critical thinking skills. *International Journal of Evaluation and Research in Education (IJERE)*, 11(2), 826-869. https://doi.org/10.11591/ijere.v11i2.21621

Wulandari, M. (2020). Konsep dasar metode flipped classroom, Universitas Sanata Dharma, https://www.usd.ac.id/pusat/ppip/2020/05/04/konsep-dasar-metode-flipped-classroom/

Wijayanto, N. (2022, March 16). Larutan penyangga: Prinsip kerja dan perhitungan PH. [Video]. Youtube. https://youtu.be/MyElA6vRj5Y?si=zD21bOSEl23Psrfk

Yani, J. & Afrianis, N. (2022). Analysis of student scientific literacy using the socio scientific issues (SSI) approach on reaction rate. *Jurnal Pendidikan Kimia*, 14 (1), 19-27. https://doi.org/10.24114/jpkim.v14i1.32665

Zainuddin, Z. (2019). Pengembangan model pembelajaran flipped classroom dengan taksonomi bloom pada mata kuliah sistem politik Indonesia. Jurnal Dimensi Pendidikan dan Pembelajaran, 7(2), 109. https://doi.org/10.24269/dpp.v7i2.1809