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Problem-based learning in the online flipped classroom: Its impact on statistical literacy skills

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Abstract

This study aimed to improve students' literacy skills in carrying out distance learning and examine the effect of problem-based learning in reverse online classes on statistical literacy skills in distance learning. This research was conducted during the COVID-19 pandemic at Prisma University and Manado State University with 198 students taking statistical methods courses. A quantitative approach to quasi-experimental research was used. The instruments used are written tests and video-based projects with relevant entrepreneurship questions. Data was collected through pre- and post-tests, then analyzed using a two-way Analysis of Variance (ANOVA) and an independent sample t-test. The results showed that problem-based learning in reverse online classes positively affected statistical literacy skills in distance learning. In addition, positive responses from students working on statistical projects in entrepreneurship were found. This may be observed from the perceptions of students who show high satisfaction with the assignment in the field of entrepreneurship in this study. Furthermore, the results of this study confirm that student involvement is a critical element in implementing distance learning.

Keywords: Distance learning, Problem-based learning, Online flipped classroom, Statistical literacy skills, Mathematical literacy, E-learning.

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Ethical: This study followed all ethical practices during writing.

Contents

Contribution of this paper to the literature
The results of this study strengthen the theory of problem-based learning models combined with online flipped classroom learning (PBL-OFC) which positively affects students' statistical literacy abilities so that the contribution of theory from this research can be an alternative to improve students' statistical literacy skills.

1. Introduction

The implementation of distance learning is necessary during the COVID-19 pandemic (Nuraini, Qihua, Venatius, Slamet, & Cholifah, 2020; Petretto, Masala, & Masala, 2020). This is not a new concept but a new practice in many countries especially Indonesia. Distance learning is the best solution in education and it also has a significant impact on improving implementation and learning outcomes. Therefore, regardless of whether the pandemic will end soon or not, the distance learning that is currently being implemented needs to be continuously evaluated.

Distance learning has two forms, i.e., offline and online. The Ministry of Education and Culture states that offline learning uses books, modules, national or local television media and national or local radio while online learning is through virtual meetings using a learning management system (LMS) as well as social media and the web (Gelir & Duzen, 2022; Haghshenas, 2019; Jusas et al., 2021). The implementation of distance learning has several problems from the teaching, student and technical perspectives. Students' perspectives include: motivation and interaction problems, the demands of independent learning allow for a lack of knowledge and poor time management. Teachers' perspectives include: unpreparedness of digital teaching materials, the use of traditional learning models in online sessions as well as technical problems such as lack of knowledge and the availability of technological tools (Al-Ansi, Garad, & Al-Ansi, 2021; Domu & Mangelep, 2019; Sari & Nayır, 2020). Other problems are found in financial support, network support, student discipline, increased stress levels due to high learning loads, anxiety about learning outcomes and misuse of digital media by students (Pedrelli, Nyer, Yeung, Zulauf, & Wilens, 2015; Pozdnyakova & Pozdnyakov, 2017; Rashid & Rashid, 2012). In Indonesia, the same thing is being experienced even with the risk of a high dropout rate.

The Ministry of Education and Culture has suggested the flipped classroom (FC) model be applied to online learning so that students can actively interact with the learning process (Cabı, 2018; Campillo-Ferrer & Miralles-Martínez, 2021; Sosa, Guerra, & Cerezo, 2021). A flipped classroom is a form of learning that turns activities in the classroom into homework (Cabı, 2018; Danker, 2015; Kong, 2014). A flipped classroom is a form of blended learning (Abeysekera & Dawson, 2015; Warsah, 2020). There are many studies in various fields that have been carried out on the positive impact of the flipped classroom (FC) including on learning outcomes, motivation and perception, challenges, types of lectures, support for FC implementation and exploration with other forms of learning (Albalawi, 2018; Shi-Chun, Ze-Tian, & Yi, 2014; Ziegelmeier & Topaz, 2015).

Indonesia has a low literacy rate (Barus, Simanjuntak, & Resmayasari, 2021; Sakhiyya & Hapsari, 2021). Data from the Organisation for Economic Co-operation and Development (OECD) noted reading skills at 371 out of an average of 487, math skills at 379 out of an average of 489 and science skills at 396 out of an average of 489. Indonesia is ranked 74th out of 79 countries. These figures provide impetus for continuing to evaluate education in Indonesia given the importance of literacy skills for life (Fuhs, Hornburg, & McNeil, 2016; Shanley, Clarke, Doabler, Kurtz-Nelson, & Fien, 2017). Low literacy levels can cause problems in society in areas such as education, work the economy and the law (Stromquist, 2015; Wilson, 2016). On the other hand, good literacy leads a person to participate, function and contribute well to the community.

Previous studies describe how widely statistics are applied in various fields of life (Hanief & Himawanto, 2017). Statistics is a tool for problem solving and a medium for the development of science (Phungsuk, Viriyavejakul, & Ratanaolarn, 2017; Yusuf, 2017). Statistics is a guide in the decision-making process. Thus, literacy skills in statistics are necessary to solve simple and complex problems based on the facts of the information found.

Statistical literacy is the ability to read and interpret summary information on media including graphs, tables, statements and descriptions (Özmen & Baki, 2021; Sharma, 2017). Statistical capacity is divided into 3 types: statistical literacy, statistical reasoning and statistical thinking. According to them, statistical literacy is the ability to understand definitions, understand statistical symbols and be able to interpret differences in data. In the development process, these three terms are often interchangeably used and to distinguish them, the concerns about statistical literacy include activities such as identifying, describing, translating, interpreting, reading and computing.

Project-based learning (PBL) has been widely used and developed in various fields. Project-based learning (PBL) is teaching models oriented to the "real world" so that students gain a critical capability in solving problems in various fields and can assimilate the essential concepts of the problem (Gorghiu, Drăghicescu, Cristea, Petrescu, & Gorghiu, 2015; Saad & Zainudin, 2022). In the field of education, research on the effectiveness of PBL and its development in the curriculum continues to be carried out (Dolmans, Loyens, Marcq, & Gijbels, 2016; Yew & Goh, 2016). PBL implementation uses information and communication technology (ICT) generates better content for teaching materials and skills than teachers (Belagra & Draoui, 2018; Yuliansyah & Ayu, 2021). Previous studies found positive results in the ecological literacy skills of students using subject specific pedagogy and PBL (Riyadi, Prayitno, & Karyanto, 2018; Widowati, Purwanto, & Akbar, 2021). Similar studies found positive results in increasing students' digital literacy using PBL with online laboratory simulation (Perdana, Jumadi, Rosana, & Riwayani, 2020; Yustina, Mahadi, Daryanes, Alimin, & Nengsih, 2022).

FC and PBL have a positive effect on education including improving student learning outcomes. Problems with literacy levels and the implementation of distance learning need to be evaluated for improvement. This study is developmental and focuses on the online implementation of FC because distance learning (the earlier implementation of FC had offline sessions in the classroom) uses PBL at online FC (PBL-OFC) and aims to

improve students' statistical literacy while studying from home. In addition, it aims to investigate and find other consequential factors.

2. Methods

This research is quasi-experimental and carried out in two places sequentially: the Faculty of Science and Technology, Prisma University from February to June 2021 and the Mathematics Department, Manado State University from September to November 2021. The samples of R1 and R2 had a total of 198 university students who took statistical methods courses. The research samples at R1 and R2 were divided into 2 classes: the experimental class and the control class. Table 1 shows a description of the sample distribution.

Table 1. Research sample.

Sample	Class		Total
	Experiment	Control	
R1	48	48	96
R2	51	51	102
Total	99	99	198

The experimental class uses PBL-OFC while the control class uses only online FC. The PBL activities of students in the experimental class are focused on sessions outside the FC class. The e-module prepared by the lecturer is given to students in the experimental class to carry out project assignments while the control class only uses video screencasts as learning resources. Each FC meeting session in the control and experimental classes is used for question and answer, clarification and deepening interaction sessions. Students are required to study the lecture material before the meeting begins. Google Classroom is used as a virtual class and YouTube is used as a medium for sending video material.

The variables studied are students' statistical literacy skills. This is measured by a written test. The controlled variables in R1 and R2 are the same teacher such as the researcher, the same material and the same written test, the same number and duration of meetings. The research design used pre- and post-tests and a control group design with the two classes being compared to the results of the course. Interviews are also conducted to collect students' perceptions of lectures conducted remotely.

Data analysis is performed using a 2-way ANOVA test and a two-sample t-test. The experimental and control classes have the same number of samples at each level of ability to meet the balance design assumptions in the two-way ANOVA test. Normality tests on residual data and homogeneity are also carried out as a condition for performing parametric statistical tests. Furthermore, Tukey's test is used as a further ANOVA test to determine the location of the mean difference. To support data analysis, SPSS version 25 and Minitab 19 software are used. This study claims that the implementation of PBL-OFC will have a positive impact on students' statistical literacy skills during distance learning.

3. Results

Tables 2 and 3 show the results of the pre- and post-tests conducted in the experimental and control classes at R1 and R2.

Table 2. Summary of pre- and post-test results at R1.

Size	Experiment class		Control class	
	Pre-test	Post-test	Pre-test	Post-test
Average	58.96	86.02	59.71	74.27
Variance	314. 85	81.68	389.79	171.44
Max.	90.00	100.00	90.00	94.00
Min.	30.00	67.00	27.00	47.00
N	48	48	48	48

Table 3. Summary of pre- and post-test results at R2.

Size	Experiment class		Control class	
	Pre-test	Post-test	Pre-test	Post-test
Average	59.67	80.41	59.86	74.02
Variance	616.67	196.33	562.40	257.46
Max	96.00	100.00	95.00	100.00
Min	18.00	52.00	10.00	39.00
N	51	51	51	51

Tables 2 and 3 show the increase in the average score of the pre- and post-tests. The variance score is reduced by the minimum and maximum intervals. The same information is obtained for the R1 and R2 studies. Based on the results of the pre-test as an initial ability test, the experimental and control classes are divided into 3 groups, i.e., low, medium and high ability levels with the same number of samples.

Table 4. Summary of the average group gain score based on the pre-test

Average	R1			R2		
	Low	Medium	High	Low	Medium	High
Experiment	39.00	27.44	14.75	29.12	19.82	8.29
Control	24.75	16.50	2.44	23.70	12.77	6.00
N	16	16	16	17	17	17

Table 4 shows the average gain score or the difference in scores on the pre- and post-tests in each group. The pre- and post-test scores are the results of a written test of students' statistical literacy skills. The highest average increases in the low, medium and high groups are based on Table 4. This happens to R1 and R2, both the experimental and control groups. Normality and homogeneity tests are prerequisites for conducting a two-way ANOVA parametric test. The normality test using the Kolmogorov-Smirnov test is performed on the residual gain score of the literacy skills. In contrast, the homogeneity test using the Levene test is performed on the gain score data. The results are presented in Table 5.

Table 5. Normality and homogeneity tests of gain score data

Variable	R1		R2	
	Df	P-value	Df	P-value
Kolmogorov- Smirnov normality test	96	0.192	2	0.078
Levene homogeneity test	90	0.358	1	0.160

Table 5 shows that the p-value in Kolmogorov-Smirnov is greater than $\alpha = 0.05$ and the degree of freedom (df) is 96. So it can be concluded that the residual gain scores of students' literacy abilities are normally distributed. Furthermore, the p-value on the Levene test is greater than $\alpha = 0.05$, so it can be concluded that the data in the experimental and control classes are homogeneous. Conclusions about normally distributed data and homogeneous data are obtained in R1 and R2. Thus, the data was followed by a two-way ANOVA analysis.

Table 6. Summary of a two-way ANOVA.

Variable	R1		R2	
	Df	P-value	Df	P-value
Inter-level-of-ability	2	0.000	2	0.000
Inter-class	1	0.000	1	0.000
Interaction	2	0.701	2	0.658

Table 6 shows that the experimental and control classes p-value = $0.000 < \alpha = 0.05$, so H_0 is rejected which means that the average score of improving literacy skills in classes taught using PBL- OFC is higher than the online FC class only. The same conclusion is obtained for R1 and R2. Furthermore, among students' ability levels, it is shown that p-value = $0.000 < \alpha = 0.05$, so H_0 is rejected which means that there is a difference in the average score of improvement in the groups of students' ability levels.

The same conclusion is drawn in R1 and R2. The interaction score p-value is 0.701 at R1 and 0.658 at R2 based on Table 6. Both are larger than $\alpha = 0.05$. There is no interaction between the classes (experimental-control) and the level of students' ability (low, medium or high) in both R1 and R2 studies. To find out where the average difference in the student's ability level lies, a further Tukey test is carried out.

Table 7. Summary of statistical literation score based on capacity level.

Level		R1			R2		
		Mean diff.	Std. error	P-value	Mean diff.	Std. error	P-value
High	Low	-23.28	1.97	0.000	-21.76	0.89	0.000
	medium	-13.37	1.97	0.000	-9.15	0.89	0.000
Medium	Low	-9.91	1.97	0.000	-12.62	0.89	0.000
	high	13.37	1.97	0.000	9.15	0.89	0.000
Low	Medium	9.91	1.97	0.000	12.62	0.89	0.000
	high	23.28	1.97	0.000	21.76	0.89	0.000

Based on Table 7, the mean difference value and all p-values are $0.000 < \alpha = 0.05$, so it can be concluded that (1) the average increase in the low group is greater than in the medium and high groups, (2) the average increase in the medium group is greater than in the high group and smaller than in the low group and (3) the average increase in the high group is smaller than in the medium and low groups. To compare the increase in the experimental class versus the control classes in each group in pairs, analysis using a t-test of two samples, i.e., ex-high vs con-high, ex-med vs con-med, and ex-low vs con-low, is conducted. The test results are presented in Table 8.

Table 8. Summary of the t-test result based on class and level combination.

Variable	R1		R2	
	Df	T-count	Df	T-count
Ex-high vs con-high	30	5.43	32	2.13
Ex-med vs con-med	30	4.00	32	4.58
Ex-low vs con-low	30	4.36	32	2.55

Table 8 shows that all the results of $t_{(30)}$ at R1 are greater than $t_{(0.05,30)} = 1.697$ and all the results of $t_{(32)}$ at R2 are greater than $t_{(0.05,32)} = 1.694$, so it can be concluded that the average increase in literacy scores in each group in the class taught using PBL-OFC is greater than in each control group taught with OFC. Conclusions are obtained in research R1 and R2.

The problem-based assignment given to the students in this study is to collect, assess and analyze the data statistically in the field of entrepreneurship. Students are assigned to collect information from entrepreneurs, process the data, analyze it and test the hypotheses using statistical software. This assignment is recorded in audio-visual form and presented in an in-class session at the PBL-OFC class as shown in Figure 1. Students' understanding is not limited to the statistical topics on the needs of the completion of the study but to understand statistics as a science that continues to evolve in various fields. This is in accordance with the results by Negara,

Santosa, and Ibrahim (2019) where the process of optimising students' statistical literacy requires a condition where students experience the process of data collection, exploration and drawing conclusions directly from the observed statistical data.

The interview process conducted after the lecture shows student satisfaction with the lecture model and the type of project given. Students are familiar with the use of statistics in an applied and entrepreneurial way. However, students expressed a desire to re-implement the on-site lectures in the classroom.

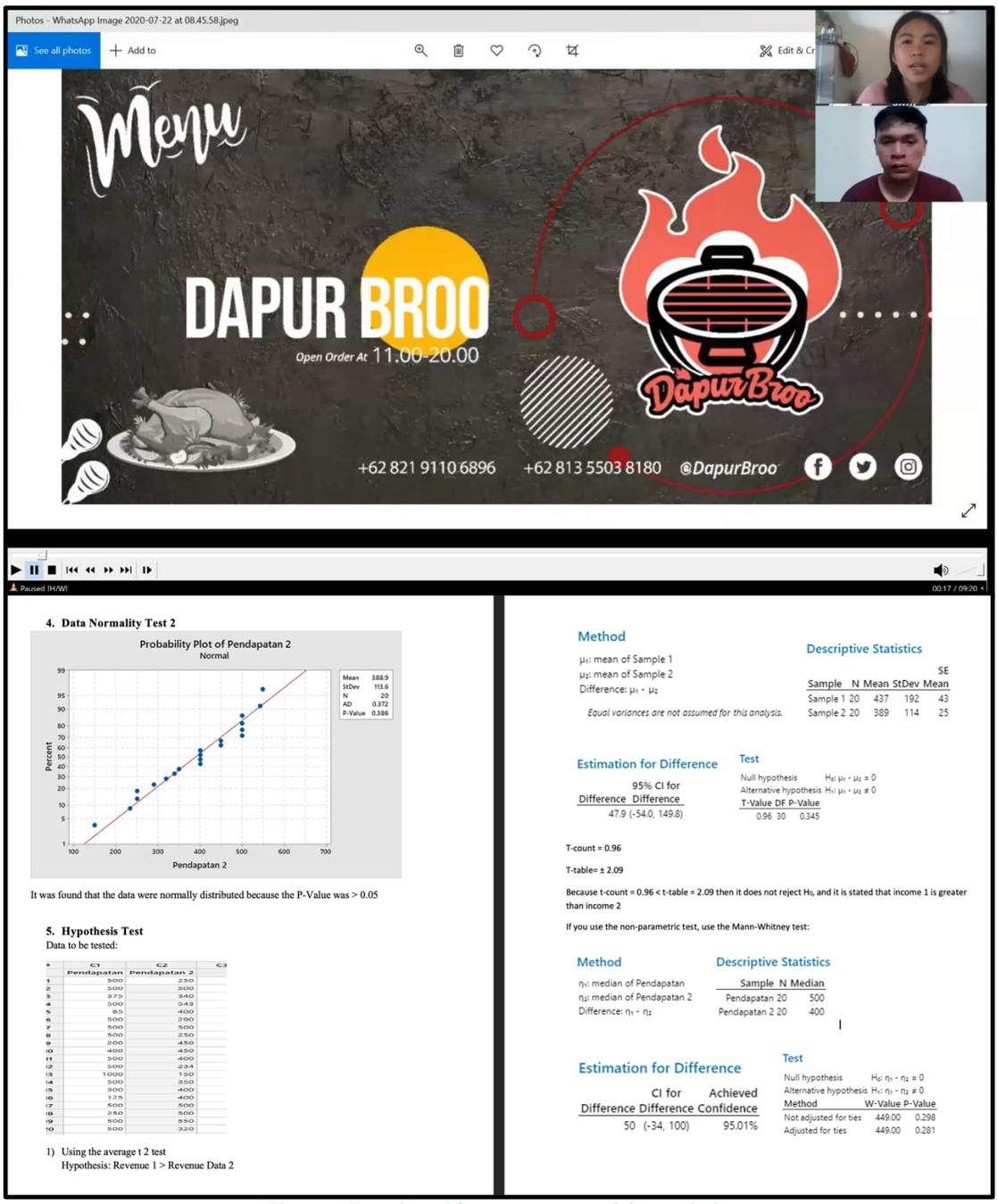

Figure 1. Interview with entrepreneurs and data analysis.

Entrepreneurial problem-based assignments are not only having an impact on the statistical literacy skills of students but some students have also started their own businesses after studying. Written examinations conducted in the research include statistics problems to measure the students' literacy which include information identification (A), data description (B), data translation (C), information interpretation (D), data reading (E) and calculation (F). Figure 2 shows the students' analysis of the statistical problems related to points (A) to (F). Most items are given to the students as shown in the following:

Problem 1: Researchers are interested in the mean age of a particular population. A random sample of 10 individuals drawn from the population of interest has a mean of 27. The population is approximately normally distributed with a variance of 20, we conclude that the mean differs by 30 years (α =5%) Daniel & Cross 2018. Problem 2: The amount of protein (in grams) for various fast-foods is reported here. Construct a frequency distribution using six classes. Using relative frequencies, draw a histogram, a frequency polygon and an ogive for the data (Bluman, 2018).

23 30 20 27 44 26 35 20 29 29 25 15
18 27 19 22 12 26 34 15 27 35 26 43
35 14 24 12 23 31 40 35 38 57 22 42
24 21 27 33

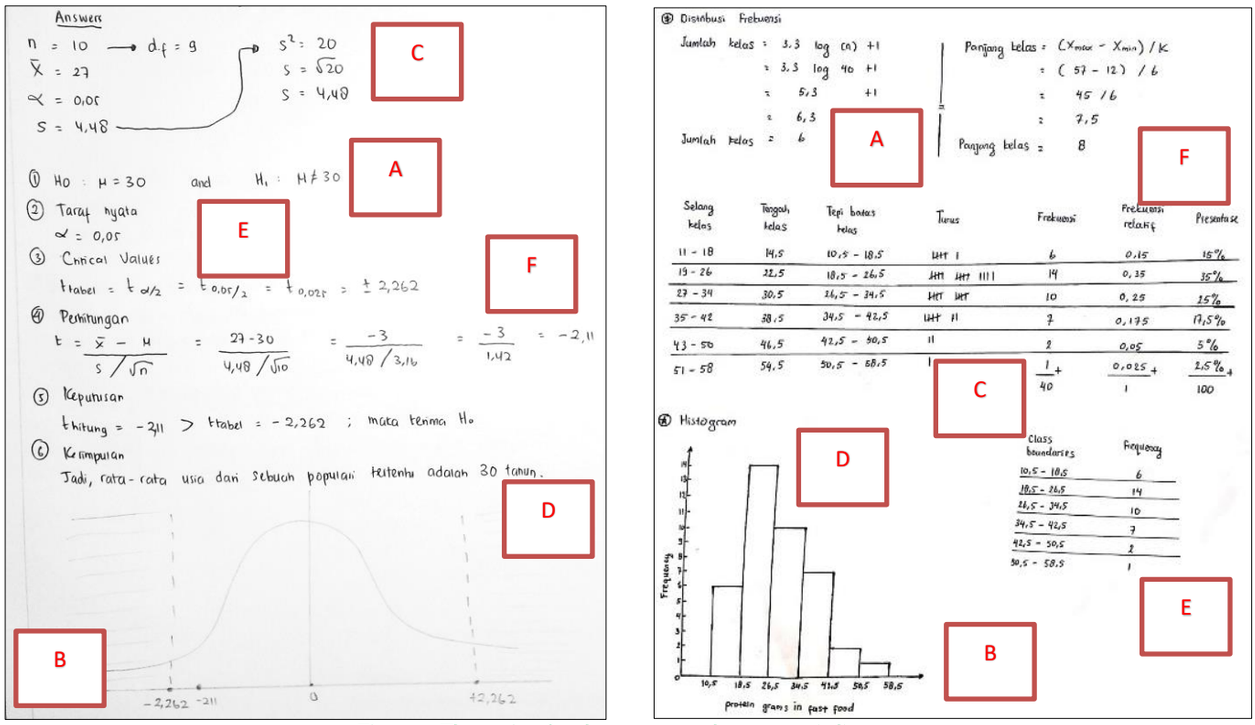

Figure 2. The results of student answers and assessment indicators.

4. Discussion

The implementation of in-class sessions on FC in the study is carried out for about 45-60 minutes at each meeting. This session is only intended for clarification, discussion or mentoring activities because the core content of lectures provided through e-modules and videos on YouTube has been previously studied independently by students in out-class sessions. In accordance with the previous study, the given video duration is 10-15 minutes (Kirkwood & Price, 2014; Woolfitt, 2015).

The results showed that students had difficulties understanding the type of data, data presentation, size, sample and population as well as hypothesis testing (Chan & Ismail, 2014; Negara et al., 2019). Statistics classes at the university level are still oriented towards understanding theory and are focused on completing studies at the final level. The characteristics of this applied course need to be explored again so that it does not only have a minimal impact. Statistics should be studied using data from everyday life problems.

Distance learning gives the impression that there is distance between lecturers and students because lectures are carried out through virtual media. Online learning requires sophisticated digital technology (Dwivedi et al., 2020; Shih & Tsai, 2017). Software such as Zoom, WizIQ, and Google Meet are used to support virtual meeting activities (Basilaia & Kvavadze, 2020; Singh et al., 2020). The use of virtual classroom applications did not have a significant impact on learning outcomes (Singh et al., 2020). Students have requested a reduction in the number of virtual meetings to cope with other courses. This is in accordance with a previous study that the presence of students in virtual lectures does not guarantee attention or the achievement of good learning outcomes (Tang et al., 2021).

The implementation of FC allows the development of media support such as e-modules to guide students in independent learning especially in out-of-class sessions. The e-module has been used since the beginning of the lecture in this study. The use of e-modules in lectures in the form of FC is appropriate for lecturers and students because it provides an increase in students' learning outcomes (Iglesias-Pradas, Hernández-García, Chaparro-Peláez, & Prieto, 2021; Kuzmina, Kochkina, & Kuzmin, 2021). Flip PDF Professional software can be used in the creation of e-modules to support effective and efficient learning (Komikesari et al., 2020; Seruni, Munawaroh, Kurniadewi, & Nurjayadi, 2020).

The FC lectures emphasizes interactions between lecturers and students (Mehmet, 2018; Schallert, Lavicza, & Vandervieren, 2022). Several studies have found that FC is beneficial for students and lecturers. For lecturers, (1) there is active interaction that is simpler to achieve between lecturer and students, (2) it improve learning attitudes in students, (3) students actively discuss in groups, (4) there are increased problem-solving abilities and (5) the teaching materials provided can be watched repeatedly. For students, (1) it is more flexible regarding the time and location of learning, (2) they can learn according to their own pace and will, (3) it is easier to understand briefly (4) they can attend class meetings more confidently because they have learned previously, (5) on-site class meetings do not add more load, (6) the opportunity to discuss in an on-site meeting is more facilitated, (7) studying videos further increases motivation than reading books (Mehmet, 2018; Sosa et al., 2021; Thai, De Wever, & Valcke, 2017).

A flipped classroom increases the independence of information literacy skills (Arnold-Garza, 2014; Kong, 2014). On the other hand, the implementation of PBL provides opportunities for students to develop problem-solving skills and improve information literacy skills (Kim, Vicentini, & Belland, 2022; Wenger, 2014).The implementation of PBL in the class improves scientific literacy as it encourages students to activate themselves and groups to think independently, meaningfully and seriously (Bellová, Melicherčíková, & Tomčík, 2018; Tanti, Kurniawan, Sukarni, Erika, & Hoyi, 2021). The results of this study support previous studies by considering the variables of distant learning implementation and online modification of FC to improve students' statistical literacy skills. Students think that e-modules, videos and assignments encourage students to read, to watch many times and even to apply what is learned so that it is easier to understand comprehensively.

5. Conclusion

In the digital era, humans depend on data information for their activities. Thus, their statistical literacy skills need to be improved to overcome problems and continue to grow. The implementation of distance learning encourages online learning to be carried out and this study finds a positive impact on the implementation of online flipped classrooms. It is also found that PBL-OFC improves the literacy skills of students who are categorized as having low initial abilities. Students' perceptions indicate satisfaction with assignments in the field of entrepreneurship in PBL learning. An extra level of preparation is needed for lecturers to provide media such as e-modules, videos and active interaction for the implementation of PBL-OFC. The activeness of lecturers to monitor students' independent learning activities such as studying e-modules and videos is needed to direct and maintain interactions. Things that are found for further study are (1) assessment methods in distance learning and (2) student learning styles.

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