Implementation of discovery learning in a digital class and its effect on student learning outcomes and learning independence level

by Wasis Wuyung Wisnu Brata

RESEARCH ARTICLE

Implementation of discovery learning in a digital class and its effect on student learning outcomes and learning independence level [version 1; peer review: awaiting peer review]

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v1 **First published:** 14 May 2021, **10**:386
https://doi.org/10.12688/f1000research.51763.1
Latest published: 14 May 2021, **10**:386
https://doi.org/10.12688/f1000research.51763.1

Abstract

Background: The need to use online learning is inevitable during the Covid-19 pandemic. There has been a call for action in education policy to provide a more flexible, digitally based learning strategy. It is presumed that this change in learning methods will reduce meaningful learning experiences.
Methods: This study examines the application of discovery learning in the digital classroom and its effect on learning outcomes and independent learning. The research employed a quasi-experiment method, and the sample was taken using a randomized sampling technique. Two classes with the same initial knowledge value were used as experimental and control groups. The instrument used was a cognitive test and a Self-Directed Learning (SDL) questionnaire.
Results: The results of this research show that there is a significant difference in learning outcomes and SDL in the experiment and control group. Students that apply discovery learning with a combination of face-to-face and digital classes get better results on both variables than in conventional discovery class.
Conclusions: It can be concluded that the application of discovery learning through the digital classroom has a positive effect on learning outcomes and students' level of independence. This study was only conducted in one secondary school and more samples are recommended for further study. The limitations of the application of face-to-face discovery learning can be overcome by the application of online learning, which facilitates meaningful learning experiences for students.

Keywords

Digital class, discovery learning, self-directed learning

Open Peer Review

Reviewer Status *AWAITING PEER REVIEW*

Any reports and responses or comments on the article can be found at the end of the article.

This article is included in the Research Synergy Foundation gateway.

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Author roles: Brata WWW: Conceptualization, Methodology, Project Administration, Writing – Original Draft Preparation, Writing – Review & Editing; **Wibowo FC**: Supervision, Writing – Review & Editing; **Rahmadina N**: Data Curation, Investigation, Visualization

Competing interests: No competing interests were disclosed.

Grant information: This research was funded by LPPM Universitas Negeri Medan awarded to Wasis Wuyung Wisnu Brata. [Grant contract number: 016/UN33.8/PL-PNBP/2020].
The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

How to cite this article: Brata WWW, Wibowo FC and Rahmadina N. **Implementation of discovery learning in a digital class and its effect on student learning outcomes and learning independence level [version 1; peer review: awaiting peer review]** F1000Research 2021, **10**:386 https://doi.org/10.12688/f1000research.51763.1

First published: 14 May 2021, **10**:386 https://doi.org/10.12688/f1000research.51763.1

Introduction

The fast development of Information and Communication Technologies (ICT) has had an impact on the development of learning strategies, especially the use of the internet in learning. The use of the internet, and information and communication technologies have become an everyday occurrence for learners. The presence of e-learning makes it easier for teachers to monitor, supervise, and deliver assignments without the need for them to be face-to-face.[1] The rapid advances in technology have enabled educational institutions to reach and educate students beyond the constraints of space and time.[2] In addition, the need to use online learning is inevitable during the Covid-19 pandemic.

In response to this, the Ministry of Education and Culture, an educational institution in Indonesia, has designed a portal that supports e-learning. The education policy has called for a national call to provide a more flexible learning strategy based on digital resources. It is assumed that this change in learning methods will reduce meaningful learning experiences due to the ease with which students learn the subject matter instantly. It is therefore necessary that the implementation of online learning ensures a constructive and meaningful learning experience.

Digital classrooms can allow teachers to create their own classes by designing student worksheets, adding contextual problems to solve and answer questions about specific material.[3] The learning process through digital classrooms can be done anytime and anywhere without having to engage in face-to-face learning activities.[4] In this case, the teacher can provide material enrichment to complement additional face-to-face learning in class.[5]

The features of the digital classroom are expected to enhance students' learning independence in a constructive way so that it can support students' learning outcomes. Learning independence is one of the factors that determine student success in learning, having an impact on the growth of optimal learning independence that supports good learning outcomes.[6,7]

Today, online learning has become the new norm in learning, yet specific studies on the effects of implementing discovery-based learning in online environments are not clearly understood. This study considers the use of discovery-based online learning, in particular aiming to understand how it can provide learning experiences that support independence and learning outcomes.

Methods

Ethical Approval

This research was approved by the Research and Community Service Institute, Medan State University (approval number: IC220121/IC2RSE/LPPM/2020). Written informed consent was obtained from participants and approved by the parents/guardians and the school principal.

This research is quasi-experimental with a non-equivalent control group and post-test design. The study was conducted in state secondary school 11 Medan, Indonesia, in the period January to March 2020. The population of the study was the grade 12 science class of the middle school 11 Medan, which consists of three classes. As the sample inclusion criteria, the classes must have an average initial knowledge in biotechnology that do not differ significantly. Based on these criteria, only two classes passed.[26] These two classes were randomly selected: one class as an experimental group and the other as a control group. The experimental group received a discovery learning treatment in blended mode, using digital classroom in addition to face-to-face learning. The treatment is, they can access learning materials flexibly, and can have online discussions with the teacher using the online discussion feature in the LMS. In the control group, face-to-face learning based on discovery learning takes place as usual. Both classes learn the same material and do the same thing in different ways.

The follow-up period was carried out for three weeks with five meetings. The learning took place twice a week. At the first meeting, a pre-test was given to measure students' initial knowledge. Learning of biotechnology was carried out in the second to fourth meetings, according to the scenario in the experimental and control class. The post-test was conducted at the fifth meeting to measure student learning outcomes and learning independence. The total number of students in this study was 68, with 35 students in the experimental group (10 males, 25 females) and 33 students in the control group (13 males, 20 females). The sample size in each group follows the number and list of students in each class. This consideration is made to avoid bias that can arise if the composition of students in the class changes. The number of samples in each group is also under the Frankel & Wallen method for causal-comparative, with at least 30 people per group.[27]

This study focuses on the variable cognitive learning outcomes and student learning independence. The instrument for measuring learning outcomes used a test instrument of 25 items of cognitive questions on biotechnology.[26] Learning

independence was measured using Fisher's Self-Directed Learning questionnaire[8] with 42 items related to self-management indicators, desire to learn, and self-control.[26]

The rules for scoring on the learning outcome data were for each correct answer, the value is 1 and for the wrong answer, the value is 0. The questionnaire scoring rules use a Likert scale with four choices: strongly agree (score 4), agree (score 3), disagree (score 2), and strongly disagree (score 1). All items in the questionnaire are positive statements. The data were analysed using SPSS 21 software. Data on cognitive learning outcomes and student learning independence were tested for normality and homogeneity as prerequisites for testing research hypotheses. Hypothesis testing uses the Independent T-Test to compare the average scores of the two groups that are not related to each other.[25] Sig. < ½ α (0.025) was considered to indicate a significant difference.

Steps to overcome the potential bias were made by preventing the possibility of student access to the control group into the Learning Management System (LMS). The LMS is provided for online learning support for the experimental class through their respective accounts and can only be done with the teacher's permission. Also, all instruments and learning tools were validated by experts from Universitas Negeri Medan. As for the test instrument, it was checked for validity, reliability, level of difficulty of questions, and distinguishing features.[25] The instrument was tested on other students who had studied biotechnology. During the study, no data was lost as all participants completed the necessary data.

Results

The data was taken after students in both classes had carried out the learning from January to March 2020. In both classes, students studied biotechnology with discovery learning models. The difference was that students in the experimental class did mixed learning that combines face-to-face and online learning by utilizing the digital class feature in the Learning Management System developed by the researcher. During using digital classroom, students in experimental class had accessed to Biotechnology material that include content and videos. They also could download worksheet from tasks, uploaded them back after finishing the tasks and discussed biotechnology outside learning hours. The data obtained in the study were the cognitive learning outcomes and learning independence of the students (Table 1). An independent t-test (Table 3) was performed to determine whether there is a significant difference between the two groups.[24]

Analysis of student learning outcomes and SDL based on gender was carried out to see if there were differences influenced by gender (Table 2). In the experimental class, the mean score of male students was 83. The mean score of female students was 82.09. In the control class, the average score of male students is 79.50, and the average score of female students is 76.95. Student learning independence data shows that the mean score of male and female students in the experimental class is 86.90 and 82.12, respectively. Whereas in the control class, the SDL average for male and female students was 79.56 and 80.44, respectively.

The t-test results for student learning outcomes and student learning independence with Sig. (2-tailed) was less than ½ α. Moreover, the scores obtained for students' learning outcomes and student learning independence are higher than the t-table. Consequently, it can be stated that there are significant differences in the experimental and control groups.[24]

The data on the acquisition of students' learning independence is based on the fact that the average value of students' learning independence in the experimental group was 83.86, while in the control group was 78.85. The difference in values for each indicator of students' learning independence is shown in Table 5. On all indicators, the experimental class that applies discovery learning in a combination of face-to-face and digital classes has a higher score than the control class.

The students' learning independence level (Figure 1) is very varied. The students' learning independence criteria in the experimental group were 23 students with very high criteria, 11 students with high criteria, and one student with low criteria. In contrast, the learning independence level of the students in the control group are 14 students with very high criteria, 16 students with high criteria and three students with low criteria. These categories were decided to see the distribution of students' independence levels in both classes. Knowing the difference in the distribution of the level of learning independence in the two sample groups can provide an argument for the assumption that differences in the level of independence in the experimental and control groups may affect learning outcomes.

Four criteria determine the level of independence with a range of scores that are arranged by considering the number of answer choices, the minimum, and maximum scores. The four criteria for the level are very high ($81.25 < SDL \leq 100$), high ($62.5 < SDL \leq 81.25$), low ($43.75 < SDL \leq 62.5$), and very low ($25 < SDL \leq 43.75$). The three indicators with the level of students' learning independence are shown in Figure 2. There was no additional analysis took place in this study.

Table 1. **Cognitive learning outcomes (LO) and self-directed learning (SDL).**

Statistics	Experiment		Control	
	LO[a]	SDL[b]	LO[a]	SDL[b]
Number of Participants	35	35	33	33
Mean	82.51	83.86	77.88	78.85
Std. Deviation	7.706	8.092	7.59	8.65
Max.	92	92	63	61
Min.	72	68	97	94

[a]Learning outcomes.
[b]Self-directed Learning.

Table 2. **Student learning outcomes and students SDL by gender.**

Statistics	Experiment		Control	
	Male	Female	Male	Female
Number of Participants	12	23	12	21
Mean of learning outcomes	83.33	82.09	79.50	76.95
Std. Deviation	7.97	7.71	7.63	8.38
Mean of SDL	86.90	82.12	79.56	80.44
Std. Deviation	6.89	7.55	12.34	7.53

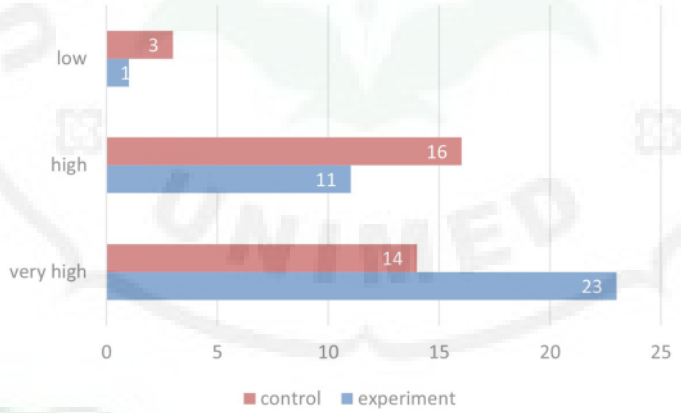

Figure 1. **Criteria for student learning independence.**

Discussion

The digital classroom (Figure 3) in the study was used as a treatment in the experimental group. Students are free to access the digital classroom at any time without being limited in time according to their wishes. Teachers can support students by providing them with learning content, offering feedback during discussions, and providing help to engage students in the learning activities.[9] The teacher's role in face-to-face classroom learning can be optimized by using digital classrooms so that students who do not understand can learn anytime, anywhere.

The content of the learning materials provided in the digital classrooms varies, including reading materials, worksheets, images, and videos related to biotechnology. Findings from previous studies indicate that e-learning influences improved learning outcomes[10] and learning independence.[6] The use of e-learning and the features available in e-learning can improve learning outcomes.[11]

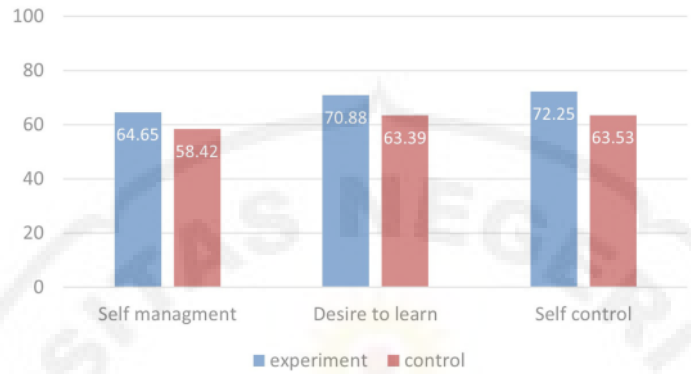

Figure 2. Differences in the level of student learning independence on each indicator.

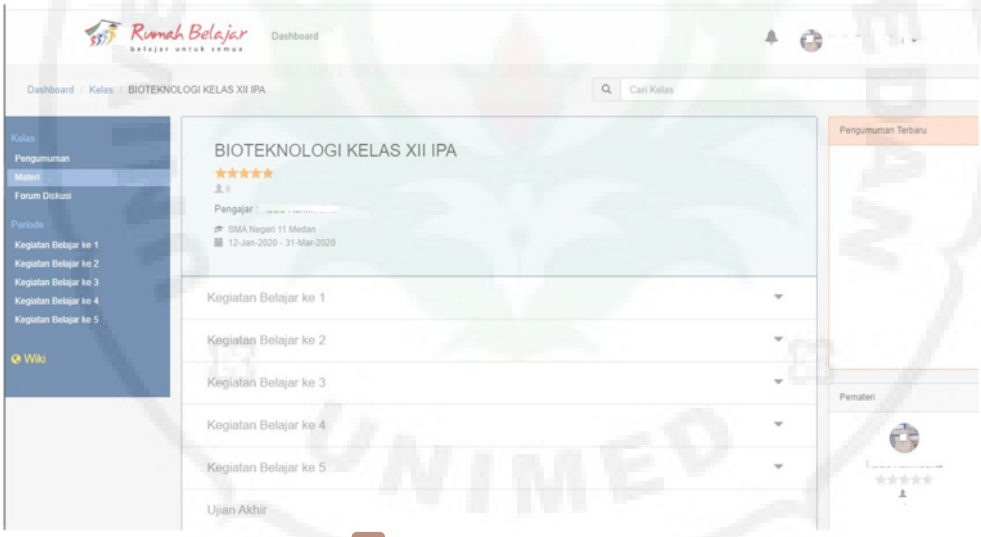

Figure 3. Home display of digital class. Copyright 2021 © Rumah Belajar. URL: https://belajar.kemdikbud.go.id. This content is available under the terms of the Attribution-NonCommercial-ShareAlike 4.0 International license (CC BY-NC SA 4.0). Modifications are made by adding biotechnology content for purposes tailored to the learning objectives. The images were deidentified and consent was received from participants for screenshots of their discussion to be taken.

According to the research design, the experimental group was treated using a digital classroom which allowed students to discuss through the LMS about the material taught outside of learning hours. The discussion can take place using the existing discussion forum functions (Figure 4).

Discussion forums are a tool that students can use to question teachers about learning.[4] In these spaces, students can discuss various issues, such as constraints and developments in the assigned discovery project. Similarly, the teacher can also provide group-directed questions.

In the control group, students did not have access to the use of digital classrooms. If students in the control group do not have the initiative to learn independently at home by repeating what they learn in class or learning material using books, the internet, or other learning resources, then this may affect students' learning outcomes.

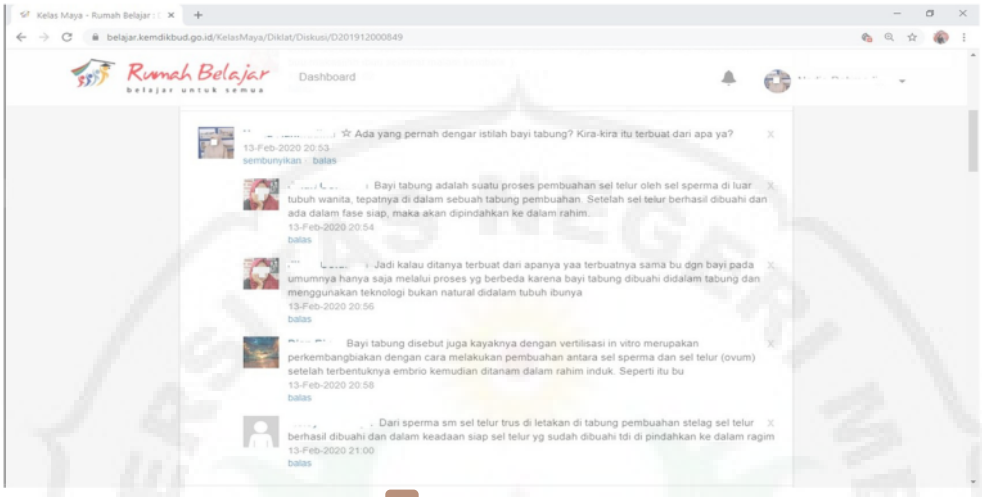

Figure 4. Utilization of discussion features. Copyright 2021 © Rumah Belajar. URL: https://belajar.kemdikbud.go.id. This content is available under the terms of the Attribution-NonCommercial-ShareAlike 4.0 International license (CC BY-NC SA 4.0). Modifications are made by adding biotechnology content for purposes tailored to the learning objectives. The images were deidentified and consent was received from participants for screenshots of their discussion to be taken.

Cognitive learning outcomes

The success of learning through e-learning depends on whether the learning has achieved the desired outcomes,[12] i.e., the cognitive learning outcomes of the learner. From the analysis of the research data, it is clear that the learning outcomes of students in the experimental group are higher than in the control group. Learning outcomes are influenced by students' experiences with the learning environment.[13] Students' access to a learning environment that is systematically designed to provide meaningful learning experiences is thought to be a factor that contributes to a positive impact.

The acquisition of higher learning outcomes in the experimental groups can be assumed due to the existence of a learning environment with the application of e-learning in the form of digital classrooms in the activities. These results are in line with previous studies in relation to e-learning based learning by indicating that six out of 10 teachers who apply e-learning based learning in class claim that the use of e-learning has a positive impact on students' learning outcomes.[14] The application of e-learning by using certain platforms can develop students' cognitive abilities and s[illegible].[15] In addition, the application of e-learning can influence students' learning outcomes, and 73% of students agree that the use of e-learning is applied in the learning process.[1]

On the use of e-learning, students can learn the material they need at any time and from anywhere.[9] With the use of digital classrooms, students in the experimental group get more time to learn independently. The ease of access to learning anywhere makes it easier for students to understand the subject matter.[16] All students (males and females) have been confirmed to have smartphones that can be used to access digital classes. Even though, in its implementation, network constraints have been experienced by some students in accessing digital classes.

Learning activities using e-learning should involve learners in an experimental way.[17] In the study, the experimental group had the opportunity to discuss in the digital classroom, which is one of the advantages that the face-to-face learning control group does not have. In addition, students in the experimental group tend to be more active during face-to-face learning activities in the classroom or online outside the classroom. Students in the control group do not show the same behavior, and the material obtained by them is only limited to that given during face-to-face classroom learning. The advantages that exist in e-learning are the reasons why the cognitive learning outcomes in the experimental group were recorded as superior to those of the control group. The use of digital classrooms in learning has also been reported to have received positive responses from students as users.[18]

Independence learning

The analysis of self-management indicators in the experimental group was 6.23 higher than the control group (Table 4). This means that students' ability to manage learning time is higher than that of the control group. Students' learning

Table 3. Data analysis using t-test.

Data	Group	Mean	Sig. (2-tailed)	t-count	t-table	α	result
Learning outcomes	Experiment	82,51	0,018	2,420	1,671	0,05	significantly different
	Control	77,88					
SDL	Experiment	83,86	0,013	2,541			
	Control	78,85					

Table 4. Differences in indicators of student learning independence in the experiment and control groups.

Indicator	Experiment group				Control group			
	Skor	$\bar{X}$	Max	Min	Skor	$\bar{X}$	Max	Min
Self-management	840	64.65	74	54	760	58.42	65	53
Desire to learn	992	70.88	55	67	888	63.39	53	64
Self-control	1099	73.25	74	65	953	63.53	64	63

independence can be seen from students' ability to take responsibility for their own learning activities.[19] In this case, students in the experimental group are more disciplined and skilled in time management. When the researchers determine the time for discussion in a digital classroom, the students in the experimental group are prepared before the discussion takes place. The same is true for face-to-face classroom learning. Students in the experimental group always learn on time. In contrast, the control group tends to lack discipline, e.g., by delaying study time with late entry during class hours.

The analysis of the learning desire indicator in the experimental group was 7.49 higher than in the control group (Table 3). This shows that the students in the experimental group are more interested in learning. As the research progresses, students in the experimental group have a strong desire to learn, especially if the researcher provides them with the latest information on biotechnology materials. In contrast, in the control group, the researchers must encourage the students' willingness to learn.

The analysis of the indicators of self-control in the experimental group was 9.72 higher than in the control group (Table 3). This can be observed during learning, where students in the experimental group use more time in the learning process. With the availability of learning materials in digital classrooms, the time spent by students is certainly more effective. In addition, students in the experimental group are more responsible in completing the given task. When given a task in the form of practice, they performed better than those in the control group.

From the analysis of the research data, benefits are assumed due to the use of digital classrooms in the learning activities in the experimental group. The results show that learning through digital classes has a positive effect on students' learning independence.[20] In this sense, in the experimental group, students are expected to study independently at home using digital lessons. So, a learning environment with the help of technology can provide opportunities and positive influence on students to achieve learning independence.[21,22]

During learning, students who have a high level of learning independence exhibit characteristics such as they are used to learning with technology and are active in learning activities. Furthermore, students who are independent learners can determine their own study time.[23] Students who have independence in their learning tend to be more actively engaged in independent learning, such as reading online learning materials, completing class assignments, and planning and assessing their own learning.[6] In addition, the involvement of technology in learning has a positive impact on students' learning independence.[24]

Limitations

It is important to be aware of some limitations of this research despite all possible efforts. During the conduct of the research, both male and female students have adequate tools to access the internet such as smartphones or laptops, still some students reported that they had experienced network connection problems when accessing the digital classroom, and this condition may have affected the results.

Conclusion

In this study, we examined the differences between conventional and blended discovery learning implementations. Our findings show that the combination of face-to-face and digital classrooms positively impacts student learning independence and achievement of learning outcomes. This research was conducted with participants who have a relatively good chance of access to technology and the internet, and it might not generally be representative of all general high school students.

Data availability

Underlying data

Figshare: Instrument validity, sampling and result of implementation discovery learning in online setting https://doi.org/10.6084/m9.figshare.14419262.v1.[25]

This project contains the following extended data:

- the validity, reliability, discrepancy and difficulty level of the questions.
- sample selection.
- data on learning outcomes and student independence, including the calculation of the t-test.

Figshare. Biotechnology test and Fisher's self-directed learning (SDL questionnaire) https://doi.org/10.6084/m9.figshare.14398943.v1.[26]

This project contains the following extended data:

- This data contains the 25 item biotechnology cognitive test instrument and Fisher's SDL questionnaire

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