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COLLABORATIVE ONLINE LEARNING DESIGN THROUGH LESSON STUDY ACTIVITIES FOR MATHEMATICS PROSPECTIVE TEACHER

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ABSTRACT

The aim of the research was to develop a collaborative online learning design for integral calculus courses through lesson study activities. The study employed didactical design research as the research design. Participants in the research consisted of 19 students (aged 19–22 years, 18 women) from two private universities in Indonesia. The researcher served as the main instrument in the study, utilizing several additional instruments, such as collaborative online learning design, presentation slides, and documentation studies. The data were analyzed using qualitative data analysis. The research revealed that collaborative online learning design through lesson study activities helped prospective mathematics teachers understand concepts related to integral calculus, especially definite integrals and the substitution method. This was because the collaborative online learning design used learning videos as a means for students to understand the concept of integral calculus. Apart from that, the collaborative online learning design also facilitated students' understanding of this concept more deeply.

Keywords: Collaborative Online Learning Design, Integral Calculus, Lesson Study, Didactical Design Research

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PRELIMINARY

Integral calculus is one of the courses that prospective mathematics teacher must study (Usman et al., 2020). As a mandatory subject, students' understanding of the material in integral calculus must be in-depth. However, several previous research results (Aziza, 2020; Bedada & Machaba, 2022; Yuliana et al., 2017) reveal that prospective mathematics teacher' understanding of integral concepts is still relatively low. The integral concept is important because it allows us to find the area of an arbitrary shape (Bhattacharyya & Satya, 2021; Siahaan et al., 2023). We divide any shape into several parts that form a simple shape (rectangle or triangle) and then calculate the area of the

simple shape. After finding the area of a simple shape, we find the approximate value of the area of the arbitrary shape by adding up the area of the previous random shapes.

Liu (2023) has studied calculus lectures by building a website-based digital platform at one of the universities in China. The research has concluded that this platform has not only been able to increase learning effectiveness but has also optimally facilitated student learning independence. Madrazo and Dio (2020) used descriptive development research to develop contextual learning for a calculus course at a university in the Philippines. The research has concluded that experts considered this learning design to be positive, and students have found it relatively easy to accept lectures using this learning design. Huda (2017) has conducted research with the aim of designing calculus learning using Maple software through lesson study activities at one of the universities in Indonesia. The results of this research have revealed that students' self-confidence, responsibility, and discipline are at least quite good.

Many studies have examined integral calculus learning, including some that have been previously described (Huda, 2017; Liu, 2023; Madrazo & Dio, 2020). However, not many are studying integral calculus using a collaborative online learning *(penelitian daring kolaboratif/PDK)* design involving students from two universities. Apart from that, not all previous research has used lesson study activities in preparing lecture designs. Therefore, the aim of this research is to develop a collaborative online learning design through lesson study activities to help prospective mathematics teachers understand concepts in integral calculus.

METHODS

The design in this research was DDR DDR was used because it was quite relevant when researchers wanted to develop a learning design based on student characteristics or needs. DDR in this research used didactic transposition flow as a basis for compiling a learning design (Bosch et al., 2021; Marfuah et al., 2022; Suryadi, 2019b). This research then used lesson study activities to produce a better learning design than before. Previous studies only relied on one lecturer in preparing the design, while this research asked for the opinions of several lecturers in preparing the design. This was because in lesson study activities, researchers collaborated in preparing plans, implementing designs (do), and reflecting on learning (see) (Fitriati et al., 2023; Joubert et al., 2020).

The first stage in this research was prospective analysis. At this stage, researchers analyzed various reference sources to obtain scholarly knowledge regarding the basic

theorem of 2nd calculus and integral substitution. Still on prospective analysis, this research tried to analyze the curriculum in universities to obtain the appropriate *capaian pembelajaran lulusan/*CPL and CPK-MK. The researcher prepared a collaborative online learning design for integral calculus lectures at this stage. After prospective analysis, the next stage was metapedadidactic analysis in the form of implementing collaborative online learning designs in real online meetings. The final stage was a retrospective analysis. At this stage, the researcher reflected on the learning process to revise the previously used collaborative online learning design. All stages in this research involved lecturers carrying out lesson study activities (Suryadi, 2019b, 2019a).

This research was conducted online, involving two groups of students from two private universities in West Java Province and West Nusa Tenggara Province, Indonesia. These two universities were chosen because they were two of my favorite private universities and were able to carry out online learning. Participants in this research consisted of 19 students (18 women and one man). The age range of participants was around 19 to 22 years.

The researchers were the main instrument in this research. Meanwhile, additional instruments used by researchers included: collaborative online learning design in the form of an LMS (https://phytagoras.unwir.ac.id/), presentation slides, practice questions, and documentation studies (video recordings during the implementation of collaborative online learning). The data was then analyzed using qualitative data analysis with several stages, namely reducing the data (not all raw data was analyzed; only representative raw data was used), presenting the data (displaying the data in the form of tables, pictures, or descriptions), and drawing conclusions related to the research objectives or questions (Creswel, 2017; Gall et al., 2010; Miles et al., 2014).

RESULT AND DISCUSSION

Prospective Analysis/Plan

In accordance with the DDR steps, through lesson study activities, especially during prospective analysis (DDR) or planning (lesson study), several discussion activities were carried out to develop a collaborative online learning design for the integral calculus course. Researchers equated perceptions in determining the semester learning plan *(rencana pembelajaran semester/RPS)* and reference books to be used. In general, PDK contained several things, such as the lecturer team determining the form of learning (individual offline, online exchanges, and joint online), reading the material provided,

holding discussions in discussion forums, online exchanges, and joint online activities carried out using the Zoom Meeting platform, and filling in the attendance list.

Next, the lecturer team divided the learning into 16 meetings. Table 1 provides a description of the material discussed during the 16 meetings. At each meeting, students engaged in at least three main activities: learning material presented by lecturer through learning videos and presentation slides, participating in discussion forums, and attending the session. The presentation slides aimed to strengthen the material students got from the learning videos they watched when learning through the LMS. The discussion forum aimed to ensure that learning interactions occurred in a multi-directional manner, both between students and between students and teachers. Attendance was aimed at ensuring students were administratively present during learning. Students could access the complete LMS for PDK activities on the following page: https://phytagoras.unwir.ac.id/.

Table 1. Description of Lecture Material

Order of Meetings	Learning Materials
1	Anti-derivative/indefinite integral.
2	Sum and sigma notation.
3	Area of inner and outer polygons/Riemann sum.
4	Definite integral.
5	The first five fundamental theorems of calculus.
6	The second fundamental theorem of calculus and the substitution method.
7	Partial integrals.
8	Respond to meetings 1–7.
9	Mid-semester assessment.
10	Flat area (flat).
11	Volume of a rotating object (disk plate).
12	Volume of rotating objects (rings).
13	Volume of a rotating solid body (cylindrical shell).
14	Length of a plane curve.
15	Area and volume.
16	Final semester assessment.

The researcher ensured that all learning needs, especially RPS and reference books, could be accessed before lecture activities began, based on the previous description. The intention was for students to know the objectives of the lecture, the distribution of material, the books that would be used as the main reference, and the competencies they would have in the lecture (Rahmad, 2021). The results of this research were then in line with several previous studies (Sitepu & Lestari, 2018; Sukirman et al., 2023) that revealed that educators should prepare all students' needs before carrying out learning, especially RPS,

which contains learning targets and reference books that will be used as one of the sources of learning.

The learning flow in this research was based on the distribution of material from several references for integral calculus courses (Edelstein-Keshet, 2010; Strang, 1991). Furthermore, the learning flow was adjusted to the structural learning flow to align with the rationale of the material. For example, students studied the number and sigma notation material before delving into the area of inner and outer polygons. This was because the quantity and sigma notation materials were prerequisite materials for the area of inner and outer polygons. The results of this research were then in line with several previous studies, which revealed that prerequisite material (Deeken et al., 2020; Salsabila, 2019) must be mastered by students before studying certain material.

Metapedadidactic Analysis/Do

After all the teaching materials could be accessed on the LMS, the research continued by conducting learning according to the form of learning described previously. Before learning activities took place, researchers ensured that all students could access the LMS and made sure that there were observers for each learning meeting. Before learning activities, it was certain that students had tried to access the LMS and studied the video material contained in the LMS. This was intended so that students would be better prepared to carry out online learning.

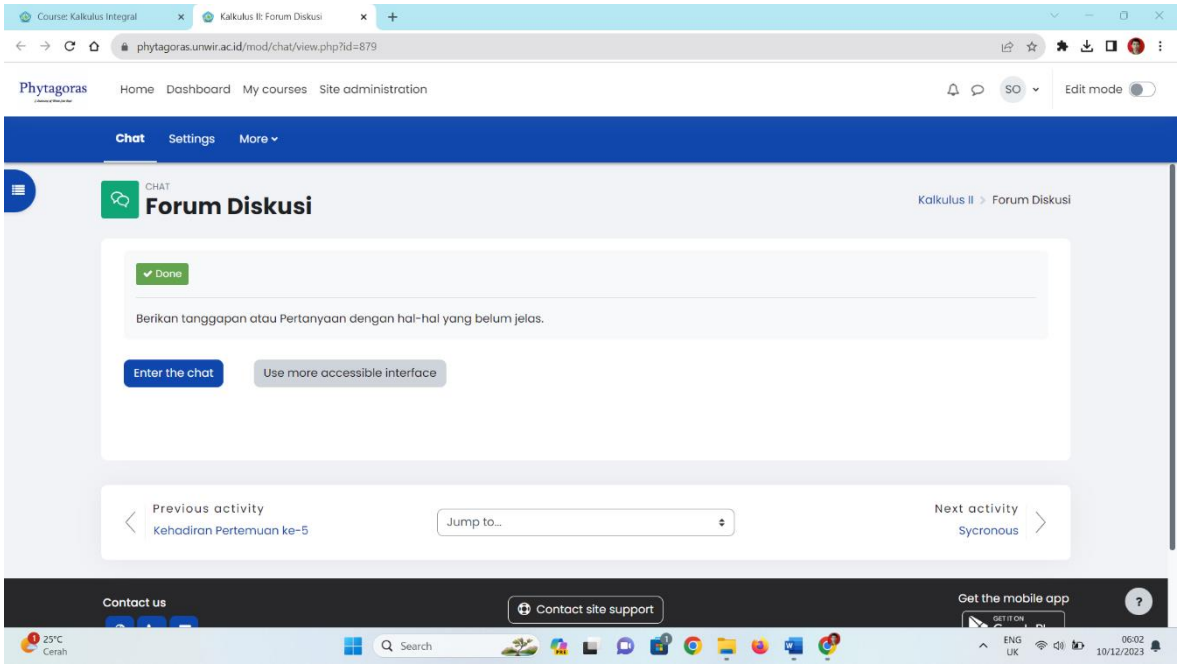
The following is a description of one of the learning meetings held online. The initial activity began by entering the Zoom meeting at the specified time. The model lecturer then opened the class by saying greetings and an opening prayer. While waiting for other students who had not yet joined, the model lecturer asked all students who were present to fill in their attendance on the LMS. After completing attendance, the model lecturer asked students to open the LMS and watch the existing learning videos.

The learning video contained material about the 2nd basic theorem of calculus and the substitution method. At the beginning of the video, the model lecturer conveyed the second basic theorem of calculus and then gave an example of using this basic theorem in proof problems. Likewise for the substitution method. The model lecturer presented theorems related to substitution methods, both indefinite and definite integrals, and then gave several examples of questions related to the substitution method. You could also access learning videos on YouTube at the following page: https://youtu.be/r3z5zB1uZ0c.

After finishing the video, the instructor asked the students to provide responses or ask questions about any material they did not understand. Some students asked the model

lecturer to explain the material again directly. According to the request and because not all students were able to understand the explanation in the learning video, the model lecturer explained again the material about *the basic theorem of calculus 2* and the substitution method using the presentation slides contained in the LMS.

Students did not use the discussion forum on the LMS optimally for this meeting. This was because students asked questions directly to the model teacher verbally. Figure 1 provides an example of a snapshot of an empty discussion forum.



English Version

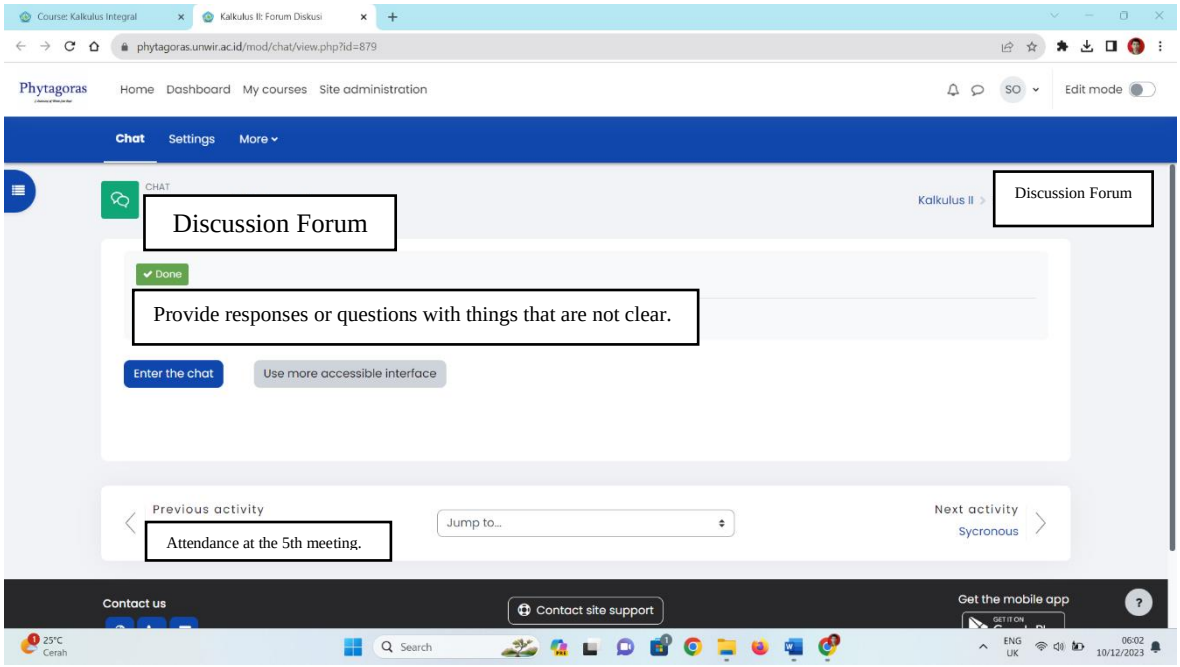
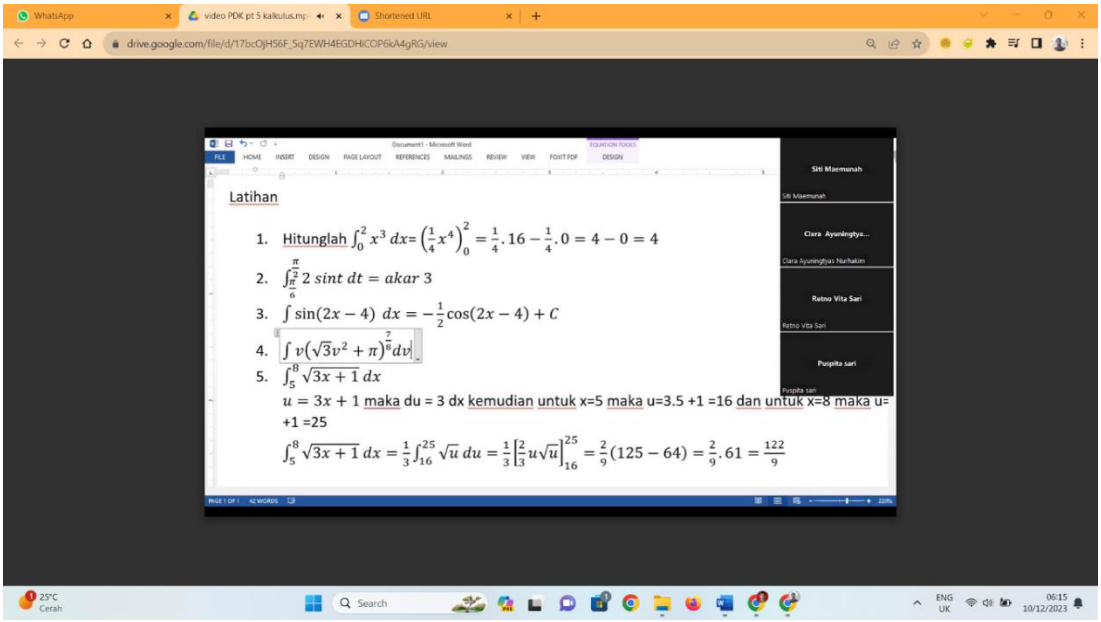


Figure 1. Empty Discussion Forum Display

The lecturer asked the students to answer several practice questions in the next activity. In this activity, students seemed to be able to solve several questions given by the model lecturer. Students could access this activity on the following page: https://shorturl.at/fqyMP. Excerpts of student answers for this activity can be seen in Figure 2. The model lecturer again asked students to fill in their attendance and summarize the material learned at the meeting. The model lecturer then closed the learning activity by asking students to study the LMS again, especially the material for the next meeting. Finally, the model lecturer closed the learning meeting with a prayer and closing greetings.



English Version

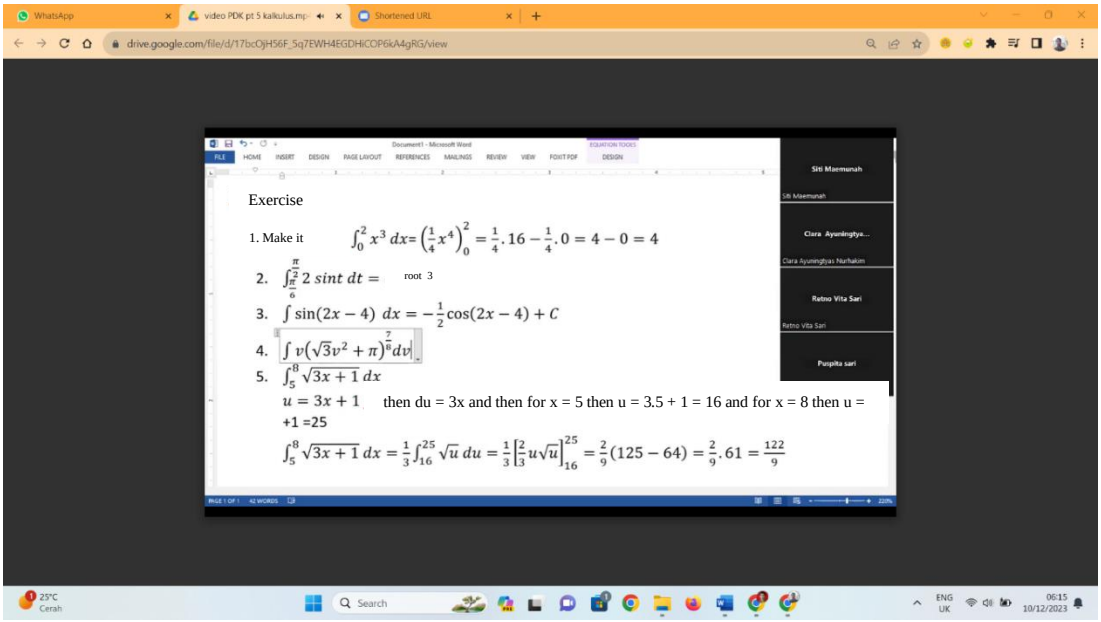


Figure 2. Excerpts of Student Answers to Practice Activities

In general, learning activities ran smoothly. The discussion activities that took place between students and lecturers went well. Students appeared to actively ask questions when there was material they did not understand. The most interesting activity was that students were able to give correct answers regarding the practice questions given by the model teacher. The results of this research were then in line with several previous studies (Shukla & Mcinnis, 2021; Sopamena et al., 2023), which revealed that learning carried out online by first giving students the opportunity to access the LMS had a positive impact on the actual implementation of learning. Likewise for learning that utilized ICT (Faisyal et al., 2023; Pradana & Noer, 2023). This was because students had more readiness before starting learning activities. These results were in line with the theory, which stated that students' readiness before learning had an impact on student activities during learning (Deeken et al., 2020; Salsabila, 2019).

Retrospective Analysis/See

The researchers analyzed student responses to the LMS and learning video recordings after completing the learning activities. During reflection, two interesting things were discussed: the empty discussion forum and the tendency of students to answer practice questions correctly. Regarding the discussion forum, the researcher attempted to analyze: why did no students respond to the discussion forum? Model lecturers and other researchers observed that students did not respond due to the lack of instructions provided by the model teacher. Students were not required to watch learning videos and discuss in discussion forums before online learning took place. The researchers proposed that the model lecturer should require all students to watch the learning video before the lesson takes place, and also require them to provide comments or questions in the discussion forum. This revision recommendation is also based on a theory that reveals that a person's response depends on the stimulus provided (Gaol, 2016; Peters & Higbea, 2014). Stimuli tend to optimize a person's response. The stimulus can also come from other people or from yourself. This revision is also in line with several previous studies that required students to study and provide comments or discussions before starting online learning.

During the reflection session, the researcher identified two possible reasons why students were able to answer the practice questions. Students were able to answer practice questions because learning activities utilized two methods of confirming understanding. The confirmation method in question is that the researcher presented material in the form of a combination of learning and reinforcement videos by a model lecturer. The results of this research are also in line with the theory, which states that learning videos tend to be

effective as a means of presenting material because they can be played repeatedly by students (Coles, 2014; Febliza et al., 2023). The results of this research are also in line with several previous studies (Naidoo & Hajaree, 2021; Santagata et al., 2021), which revealed that learning that combines learning videos and repetition of explanations by teachers tends to be able to optimize students' understanding of material. The second assumption is that students were able to answer all the practice questions because perhaps the practice questions given were ordinary questions and the material that was the focus of the meeting was simple material that students had studied and understood at the high school level. Sukmadewi (2020) noted that students at previous levels had studied material related to definite integrals and substitution methods.

Furthermore, researchers reflected on the results and identified several limitations in this research. First, the flow of learning activities for each meeting has not been clearly described, so learning does not appear to be systematic. Second, the material in the LMS does not follow a systematic learning flow, such as initial, core, and final activities. Furthermore, students are not required to complete any problems or case studies as part of the learning materials. This then has an impact on the PDK in this research, which tends to still be conventional when viewed from the perspective of the existence of problems or cases. Therefore, it is hoped that future research will be able to integrate a more systematic learning flow into the LMS and design problems as initial situations for students to construct the theorems being studied.

CONCLUSION

Collaborative online learning design through lesson study activities helps prospective mathematics teacher understand concepts related to integral calculus, especially definite integrals and the substitution method. This is because the collaborative online learning design uses learning videos as a means for students to understand the concept of integral calculus. Apart from that, the collaborative online learning design also facilitates students understanding of this concept more deeply. The deepening of the material is carried out by combining online learning via *Zoom Meetings* with the use of an LMS (https://phytagoras.unwir.ac.id/).

Based on this conclusion, the researcher recommends that mathematics lecturers collaborate, especially when preparing, implementing, and reflecting on lecture activities. This is intended to produce better-quality lectures. Researchers think that this lecture activity is still not structured well enough because the initial, core, and closing activities of

the lecture are still unclear. Therefore, this researcher provides an opportunity for future research to examine the arrangement of activities in collaborative online lectures more systematically. One activity that can be used is an epistemic learning pattern that helps students construct concepts or formulas by utilizing didactic situations.

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