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PROBLEM SOLVING ON INTEGRAL CALCULUS WITH THE ASSISTANCE OF LECTURERS TUTORS, GOOGLE SEARCH, AND ARTIFICIAL INTELLEGANCE TUTORS: PHENOMENOLOGY STUDY ON PROSPECTIVE MATHEMATICS TEACHER

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ABSTRACT

This study reveals how prospective teacher students solve Integral Calculus problems with three different assistances, namely the Assistance of Lecturer Tutors, Google Search Tutors, and Artificial Intelligent (AI) Tutors through Socratic Application. This study used a qualitative approach with phenomenological methods to reveal participants' learning experiences. Research participants consisted of nine people who were divided into three groups with different assistance. The data obtained were in the form of recorded discussions, interviews, recorded cellphone screens, and artifacts of student answers. All data is analyzed based on the activity of the respondents in seeking and finding answers. The research findings show that students who study with the help of lecturer tutors are more careful in proposing assistance from the search and sorting of answers stage. While students who use AI and Google Search have almost the same characteristics in starting a search, but at the stage of sorting answers, AI is thought as able to provide more efficient and accurate recommendations answers.

Penelitian ini mengungkap bagaimana mahasiswa calon guru menyelesaikan masalah Kalkulus Integral dengan tiga bantuan berbeda yaitu berbantuan tutor dosen, pencarian google search, dan tutor cerdas melalui aplikasi Artificial Intellegance (AI) Socratic. Penelitian ini menggunakan pendekatan kualitatif dengan metode fenomenologi untuk mengungkap pengalaman belajar partisipan. Partisipan penelitian terdiri dari 9 orang yang dibagi menjadi 3 kelompok dengan bantuan berbeda. Data yang diperoleh berupa rekaman diskusi, wawancara, rekam layar handphone, dan artefak jawaban mahasiswa. Semua data dianalisis berdasarkan aktivitas responden dalam mencari dan menemukan jawaban. Temuan penelitian menunjukan bahwa mahasiswa yang belajar dengan bantuan tutor dosen lebih hati-hati dalam mengajukan suatu bantuan sejak tahap pencarian dan pemilahan jawaban. Sedangkan mahasiswa yang menggunakan AI dan Google Search memiliki karakter yang hampir sama dalam memulai pencarian, perbedaannya pada tahap melakukan pemilahan jawaban yakni AI dipandang dapat memberikan rekomendasi jawaban yang lebih efisian dan akurat.

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1. INTRODUCTION

Calculus is a compulsory subject in mathematics as a prerequisite for the next course (Shodikin & Novianti, 2017; Susilo, Mashuri, Winarti, & Soedjoko, 2022). Specifically, Integral calculus studies a function by discussing the antiderivatives of Indefinite Integrals, Riemann Additions, the Basic Theorems of Definite Integral Calculus, and The Application of Integrals (Susilo, Darhim, & Prabawanto, 2019). In the lectures of integral calculus, students often experience difficulties caused by a lack of practice (drill) and a shallow understanding of calculus theorems (Monariska, 2019). In other cases, sometimes students are not able to apply existing formulas and are not careful in writing questions causing misperceptions (Hidayah, Danial, & Takdir, 2021).

The findings of some difficulties on the lectures of Calculus need to be found for solutions so that integral calculus lectures can be more successful. Some of the solutions that have been done were using the Maple (Panjaitan, 2019; Sallah, Sogli, Owusu, & Edekor, 2021; Salleh & Zakaria, 2013), blended learning (Soesanto, Bermuli, & Mumu, 2022), lesson study (Hutagalung, Purwanto, & Prasetya, 2020; Saparwadi, 2015), peer tutors (Yaman, 2019). Several studies have shown that peer tutors are effective models for learning calculus (Yaman, 2019). Based on these studies, the problems in teaching Integral Calculus can be assisted with several alternatives, including tutor-based learning. Tutor-based learning is a learning method that involves a tutor or individual instructor who provides guidance and teaching to a student or group of students (Yaman, 2019).

The main goal of tutor-based learning is to help students gain a deeper and more sustainable understanding of a particular material or specific skill (Moliner & Alegre, 2022; Roscoe & Chi, 2007). In tutor-based learning, tutors must have academic qualifications or expertise relevant to the material being taught. Tutors can provide guidance and instruction through a variety of methods, including live conversations, presentations and practical demonstrations. Tutor-based learning is usually more personalized and flexible than traditional learning methods. Tutors can adapt learning methods to the needs and individual learning styles of students. In addition, tutors can provide quick and direct feedback to students, enabling them to more effectively evaluate progress and correct their deficiencies.

In today's rapidly technology era, learning with the help of tutors is not only for humans but also for technologies such as Artificial Intelligence (AI) and Google Search can be considered as tutors. Both of these technologies (AI and Google Search) can be positioned as tutors because they can help understand what is being studied by providing the solutions of problem (Khosrawi-Rad, Rinn, Schlimbach, & Gebbing, 2022; Wellnhammer, Dolata, Steigler, & Schwabe, 2020).

AI has the same characteristics as humans because AI can use Natural Language Processing which helps humans understand what is communicated by AI. In addition to Artificial Intelligence-assisted tutors, there are also those who search with Google Search. The characteristics of Google Search are almost the same as AI, but Google usually provides answers in the form of a list in order from the most appropriate to several other alternatives. Both of these technologies can be included in tutors because they can help prospective teacher students to learn more personally.

With a variety of alternative tutors, an in-depth investigation of the cognitive development that occurs when prospective teacher students use the tutor's assistance is required. This interaction behavior with different tutors can provide a broad picture for educators to better prepare learning materials more maturely. In this study, cognitive characteristics will be revealed. They need to be looked at in more depth to be able to provide a cognitive picture. Looking for answers to integral calculus problems needs to be explored in order to provide a broad picture for teachers to be able to see what cognitive is happening. This cognitive development is related to the preparation of teachers in preparing teaching materials and effective teaching techniques.

This study reveals how prospective teacher students solve Integral Calculus problems with three different assistances, namely the Assistance of Lecturer Tutors, Google Search Tutors, and Artificial Intelligent (AI) Tutors through Socratic Application. This study investigates how the participants used the assistance cognitively as seen from the keywords in asking questions and looking for answers, choosing the answers they want, and reflecting on the answers that have been made to ensure their correctness.

2. METHOD

This qualitative research used phenomenological approach. Phenomenology is research that focuses on lived experience of the the respondent (Bowden & Green, 2005; Langdridge, 2007; Routledge Falmer, 2003), in the context of this research is the student learning experience. The learning experience seen is the experience in solving integral calculus problems. In this research setting, prospective teacher students are given 3 alternative assistance, namely assistance from teaching lecturers, assistance with Google search engines, and assistance from intelligent Artificial Intelligence (AI) tutors in the Socratic application. The research focuses on 3 things, namely: (1) how to ask or search for answers with keywords; (2) deciding which answer choices will be given; (3) re-understand what has been answered.

Participants in this research consisted of 9 mathematics education students in integral calculus classes. The students were grouped into 3 groups to work on the questions given with different assistance.

Table 1. Participants Code

Grup of Learning Class	Participants Code
Lecture Assistance	TD1, TD2, TD3
Google Search	TG1, TG2, TG3
Socratic AI Application	TA1, TA2, TA3

In this study, participants were given 3 questions to work on with different assistance. The following questions are given:

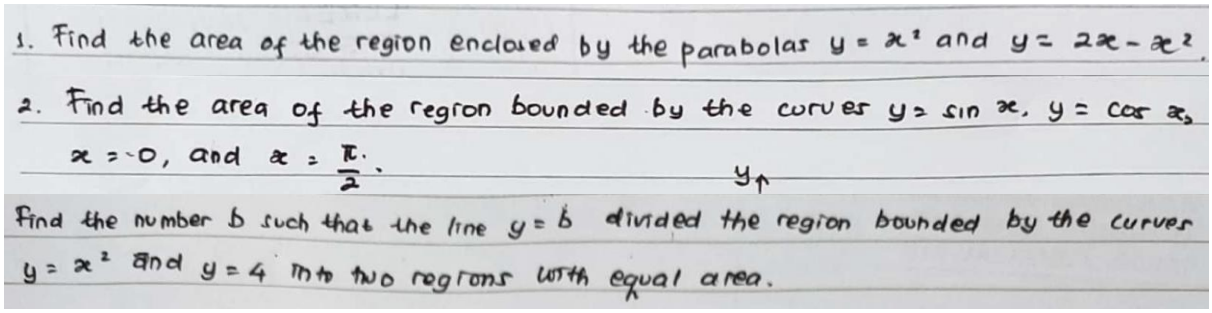

Figure 1. Calculus Problem

2.1. Research Subject

The subjects of this research were prospective mathematics teacher in the Integral Calculus class. Sample selection was carried out using a convenience sampling method based on student interest. From one class there were 9 students who were openly willing to become respondents and be observed further. The research was conducted in the mathematics education student class at Swadaya Gunung Jati University, Cirebon in 2022.

2.2. Data Collection

The questions are given in English with the aim of making it easier to search in a wider database. The data obtained was in the form of video recordings containing the activities of each group, cellphone screen recordings, and classical class videos. Following are all the data obtained:

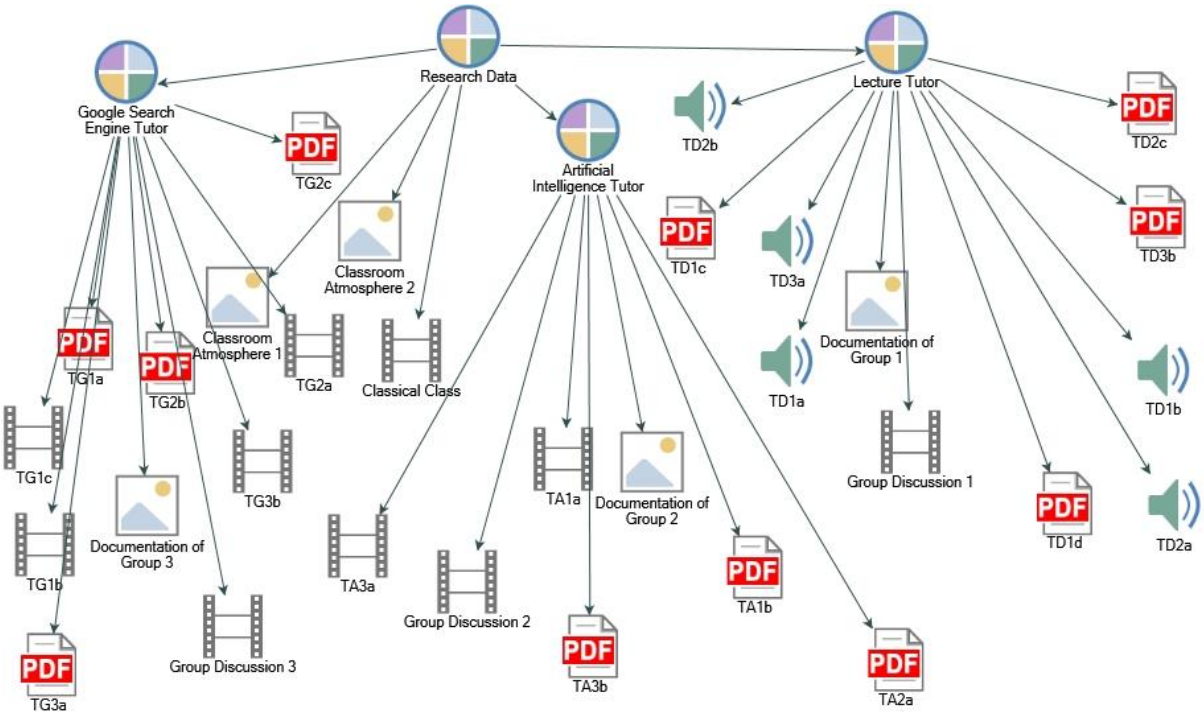

Figure 2. Research Data

Figure 2 shows the variety of research data that appears in each class studied. In the AI-assisted class there are 3 video recordings which are cellphone screen recordings and 3 pdf files which are notes of the answers to the problems given. In the lecturer-assisted class, there are 4 PDF files which are answer notes, 4 audio discussions among themselves and with the lecturer, and there is a video of activities when working on questions. In classes assisted with Google Search, there is data in the form of 4 screen recording videos, 1 interview video recording, 4 pdf files of question answers, and 1 image file in the form of activities.

2.3. Data Analysis

Research data is reduced based on research needs related to the central phenomenon. After that, the open coding and axial coding processes were carried out which were managed by Nvivo. A hermeneutic approach was applied in this analysis by examining participants' notes both from sources they found and notes containing their own mathematical thinking processes.

3. FINDING AND DISCUSSION

3.1. FINDING

This research focuses on the learning experience when facing problems in integral calculus courses. This research will reveal what students do when solving problems with three different types of learning assistance. The research findings obtained are adjusted to the research question group. The following findings were obtained:

- How students ask questions and find answers to integral calculus problems

This section explains how students ask questions and search for keywords in finding answers related to Integral Calculus which will be explored in depth. Prospective teacher students who are in classes assisted by lecturer tutors try to discuss with their colleagues more than consulting with the lecturer. Student teachers ask questions or ask the lecturer for help when they feel they can no longer find the answer.

Figure 3. Activities of prospective teacher in lecturer tutor class

The following are the data findings obtained during the research:

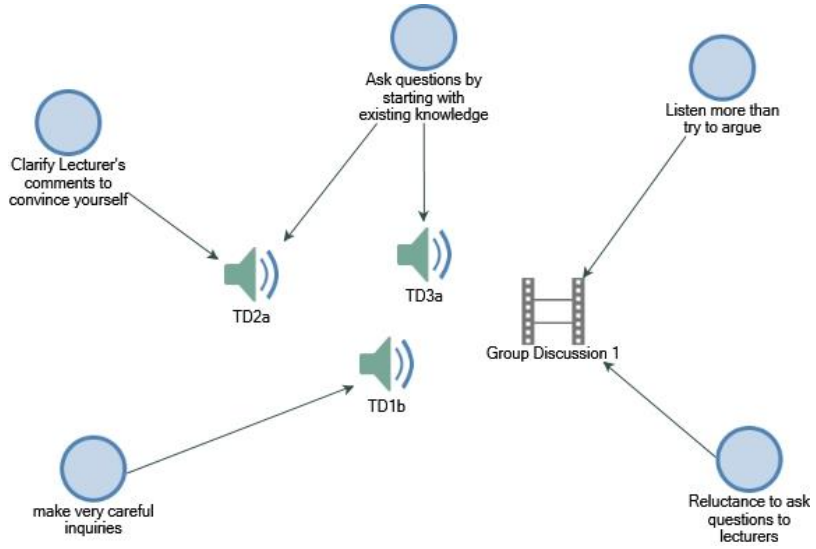

Figure 4. Data of prospective teacher in lecturer tutor class

Based on the picture above, participants in classes assisted by lecturers' tutors are less brave in asking questions or asking the lecturer for direct assistance. They focus more on trying to solve the problem independently. Even when asking for help, student teachers are very careful in asking questions. They tend to listen to what the lecturer says. This is likely caused by the psychological limitations felt by the participants.

Student teacher candidates in classes assisted by AI Socratic try to find answers to the questions given by taking photos directly. This Socratic application is installed on cellphones, both Android and iOS. The following are the activities carried out by prospective teacher students at the beginning of using Socratic:

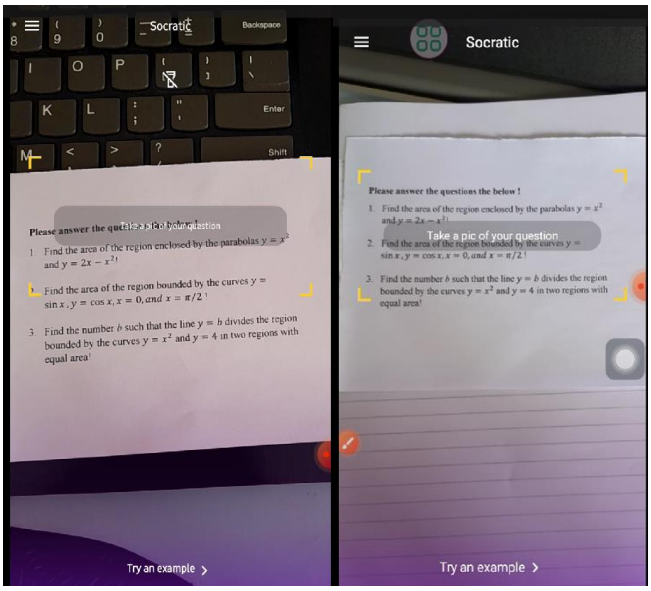

Figure 5. Activities of prospective teacher students in AI Socratic class

In searching for answers using AI, prospective teacher students start by taking photos of the questions given with the application. Next, the application directs the answer to a list on Google search. This AI can detect the text of the question provided so that users no longer retype it to find the answer. After being photographed, this AI will provide recommendations for answers for the user to choose from. This selection list is connected to Google search so that there is a lot of data sorted from relevant to potentially appropriate. In this case, basic knowledge about the answers given is needed so that prospective teachers can determine which answers are considered correct. Based on the data obtained, unique characteristics emerged. The following are the results of the analysis of this data:

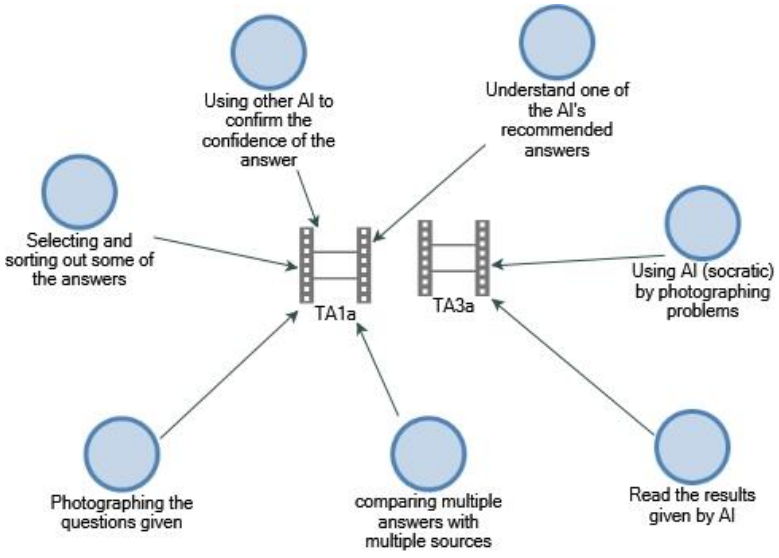

Figure 6. Data of prospective teacher in AI Socratic Class

Authors found interesting cognitive activities among prospective teacher students in Socratic AI-assisted classes. When Socratic AI offers several answers to Integral Calculus questions, they do not immediately take them as answers, but they confirm and compare the answers with other AI. This shows that the prospective teacher students are very selective in taking steps to solve problems. From the screen recording data on the learning process, they work by observing the questions given through the Socratic AI application.

Student teacher candidates in classes assisted by Google Search also try to find answers by taking photos of the questions they are given which are connected directly to Google. Apart from taking photos of the questions, there are also those who translate them first into Indonesian. Some of them immediately wrote down the questions given on Google.

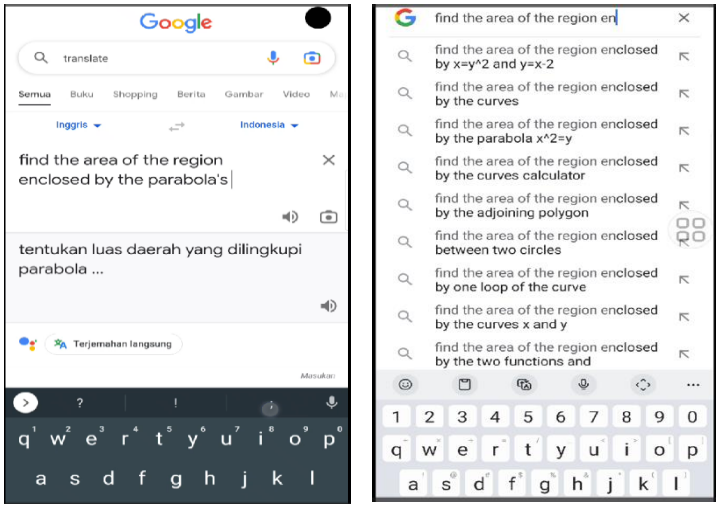

Figure 7. Activities of prospective teacher students in Google Search class

Based on the existing data findings, the activities of these prospective student teachers were to search by rewriting the questions given. The following are the data findings obtained:

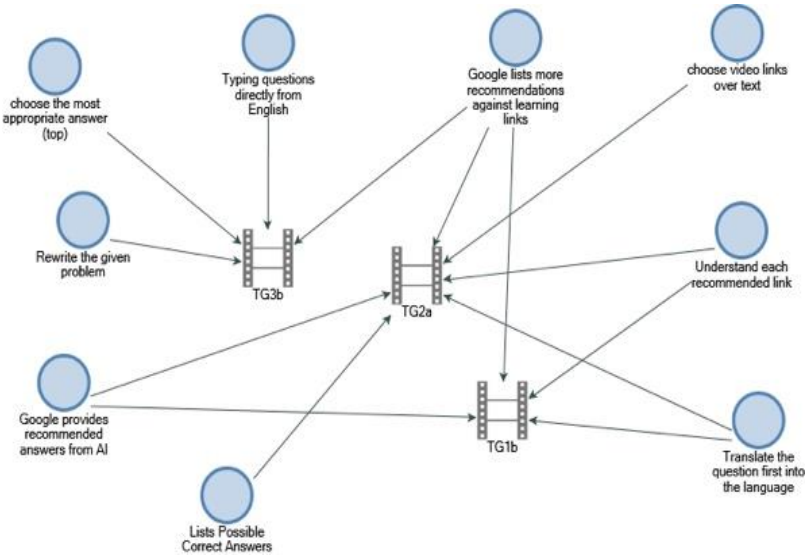

Figure 8. Data of prospective teacher in Google Search class

Coding research data shows that the activities of prospective teachers in Google Search classes are almost the same as the activities of prospective teachers in classes assisted by Artificial Intelligence. The difference is, in classes using Google Search, some students retype the questions given. The recommended answers in the Google list are also different, perhaps because they were retyped in Indonesian. Meanwhile, when you retype the questions in English, the recommended answers that appear are relatively the same.

3.2. Discussion

Student interaction activities with 3 types of tutors have different and unique characteristics. Student teacher candidates who are assisted by lecturers are very careful in asking questions. They try hard to try to find the answer independently first. When asking questions to the lecturer, they have first mastered the introductory material which can help their minds make more logical questions. The meaning of tutoring in this activity is more inclined towards learning together where the lecturer guides the direction of solving a problem.

In Integral Calculus learning guided by lecturers, it can be seen from three aspects, namely Management of Learning, Student Sensitivity, and Mathematical Challenge (Jaworski, 2002). Based on this aspect of theory, students in classes assisted by tutors have good sensitivity and challenges in trying to solve these problems.

Students who are given assistance with Google Search focus on the recommended answers given. They must understand one by one the list provided by Google Search. This thinking condition requires good critical thinking skills. Students must be sensitive to the answers given to complete the understanding obtained previously.

The behavior of prospective teacher students in using Google search and Artificial Intelligence (AI) is almost the same when starting a search. They started by taking photos of the questions given but the aim was different. When using AI, the photography activity immediately leads to a list of answers, while Google Search translates the questions given. The cognitive activities of these two types of assistance must be accompanied by prior knowledge and the prerequisites for a course must be good. This is to avoid copy-paste activities.

Critical thinking and abstraction skills are also very important in learning with the help of these two things. Critical thinking skills are needed to remain sensitive to the focus of the problem given so that one can sharply see the flow of the answers given. Abstraction thinking is also important to use when prospective teacher students have to select and sort all the lists provided by Google search and AI.

Based on research findings with the help of Google search and AI, they have similarities in the steps to start solving problems, such as taking photos, listing data, and sorting data answer choices. When the research took place, AI based on Natural Language Processing (NPL) such as ChatGPT was not yet popular, so the existing AI only recommended answers from a list of data. The author acknowledges this as one of the limitations of this research, including the researcher's sharpness in seeing student behavior in their interactions with AI. However, it is reasonable to believe that in the future AI will develop very rapidly so that the interaction between lecturers and students will have to change. The changes that are initiated include joint adaptation to AI in classroom learning. AI can be positioned as a guide, inspiration, or alternative solution that students and lecturers themselves must analyze more deeply about the truth provided by AI. Lecturers must always be open with students when students find different ways of solving a problem because students' learning resources are now very diverse and complete. The next challenge from the emergence of AI is the mathematical process which may be more pragmatic for students. Pragmatic thinking processes tend to support mathematics as

"*wiskunde*", while natural thinking processes through students' natural imagination support mathematics as "*wiskunst*" (Yulianto, Santika, Arumsari & Turmudi, 2019).

4. CONCLUSION

Based on the findings and discussion, the author proposes several important points, including: (1) The role of the lecturer as a tutor can be carried out well if the participant's dialogue with the tutor has the same basic knowledge. Such as the basic knowledge of previous calculus material which must be strong and participants are able to do in-depth analysis of the connections to the problems they face; (2) The use of Google search can be sharper if participants are able to think critically and sharply in using keywords when searching; (3) Socratic AI can be used when participants have strong basic knowledge. This is necessary to understand the answers given so that they have deep meaning.

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REFERENCES

Bowden, J. a, & Green, P. (2005). Doing developmental phenomenography. *Qualitative research methods*, vii 183.

Hidayah, N., Danial, D., & Takdir, T. (2021). Diagnostik Kesulitan Belajar Mahasiswa Pada Mata Kuliah Kalkulus Program Studi Tadris Matematika IAIM Sinjai. *JTMT: Journal Tadris Matematika*, *2*(2), 31–39.

Jaworski, B. (2002). Sensitivity and Challenge in University Mathematics Tutorial Teaching. *Educational Studies in Mathematics*, *51*(1/2), 71–94.

Khosrawi-Rad, B., Rinn, H., Schlimbach, R., & Gebbing, P. (2022). Conversational Agents in Education – A Systematic Literature Review. *Conference: European Conference on Information Systems*, (May).

Langdridge, D. (2007). Phenomenological psychology: Theory, Research and Method. In *Pearson Education Limited*.

Moliner, L., & Alegre, F. (2022). Attitudes, beliefs and knowledge of mathematics teachers regarding peer tutoring. *European Journal of Teacher Education*, *45*(1), 93–112.

Monariska, E.-. (2019). Analisis kesulitan belajar mahasiswa pada materi integral. *Jurnal Analisa*, *5*(1), 9–19.

Panjaitan, A. C. (2019). Peranan Representasi Berbantuan Software Maple Pada Pembelajaran Mata Kuliah Kalkulus. *MES: Journal of Mathematics Education and Science*, *4*(2), 132–138.

Roscoe, R. D., & Chi, M. T. H. (2007). Understanding tutor learning: Knowledge-building and knowledge-telling in peer tutors' explanations and questions. *Review of Educational Research*, *77*(4), 534–574.

Routledge Falmer. (2003). Qualitative educational research in action: Doing and reflecting. In *Qualitative Educational Research in Action: Doing and Reflecting*.

Sallah, E. K., Sogli, J. K., Owusu, A., & Edekor, L. K. (2021). Effective Application of Maple Software to Reduce Student Teachers' Errors In Integral Calculus. *African Journal of Mathematics and Statistics Studies*, *4*(3), 64–78.

Salleh, T. S. A. @, & Zakaria, E. (2013). Enhancing Students' Understanding in Integral Calculus through the Integration of Maple in Learning. *Procedia - Social and Behavioral Sciences*, *102*(Ifee 2012), 204–211.

Saparwadi, L. (2015). Peningkatan Kualitas Pembelajaran Kalkulus Integral Melalui

Kegiatan Lesson Sudy Di Program Studi Pendidikan Matematika. *Jurnal Pendidikan Matematika*, *9*(1), 35–48.

Shodikin, A., & Novianti, A. (2017). Design of Animated Subject Materials in Integral Calculus CourseRancang Bangun Bahan Ajar Animasi Kalkulus Integral. *Unnes Journal of Mathematics Education*, *6*(3), 294–298.

Soesanto, R., Bermuli, J., & Mumu, B. (2022). Implementation of Blended Learning Models during the Pandemic. *EDUTEC : Journal of Education And Technology*, *5*(4), 875–886.

Susilo, B. E., Darhim, D., & Prabawanto, S. (2019). Students Critical Thinking Skills Toward Concepts Differences In Finding Area Of A Plane Region And Definite Integral. *Unnes Journal of Mathematics Education*, *8*(1), 1–7.

Susilo, B. E., Mashuri, Winarti, E. R., & Soedjoko, E. (2022). Analisis Kesulitan Belajar Kalkulus, Reduksi, Dan Strateginya Sebagai Upaya Konstruksi Kemampuan Berpikir Kritis Mahasiswa Calon Guru. *Konservasi Pendidikan Jilid 2*, 163–194.

Wellnhammer, N., Dolata, M., Steigler, S., & Schwabe, G. (2020). Studying with the Help of Digital Tutors: Design Aspects of Conversational Agents that Influence the Learning Process. *Proceedings of the Annual Hawaii International Conference on System Sciences*, *2020-Janua*, 146–155.

Yaman, B. B. (2019). A multiple case study: What Happens in Peer Tutoring Of Calculus Studies? *International Journal of Education in Mathematics, Science and Technology*, *7*(1), 53–72.

Yulianto, E., Santika, S., Arumsari, C., & Turmudi. (2019). Trends for 'wiskunde' or 'wiskunst'? the case of students' problem solving on elementary math problem (a little practical review from 'revisiting mathematics education'). IOP Conf. Series: Journal of Physics: Conf. Series 1315. DOI:10.1088/1742-6596/1315/1/012038