****STRATEGIES OF SELF-REGULATED LEARNING CALCULUS 1****

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**Abstract:** University students have adopted various strategies to learn Calculus 1, especially during the pandemic era when digital technology became integral to their learning processes. This study aims to explore how university students leverage digital technology to engage in self-regulated learning (SRL) while studying Calculus 1. A qualitative research approach was employed, focusing on university students who completed the course through online learning. Six participants were interviewed to gather insights into their use of digital tools for learning regulation. The findings reveal that communication tools such as WhatsApp, Microsoft Teams Chat, and email are commonly used by students to seek social support, share information, and keep each other informed about schedules, assignments, and assessments. Online conference platforms, such as Zoom and Microsoft Teams, are employed for group discussions, particularly to clarify concepts and address doubts about complex topics. Students also regulate their learning by organizing and compiling study materials through online storage services like Google Drive. This allows them to access their resources efficiently and maintain a structured approach to studying. Furthermore, students utilize open resource technologies such as Desmos, GeoGebra, and online scientific calculators to validate their answers and visualize mathematical concepts. These tools help students deepen their understanding of Calculus 1 by enabling interactive exploration and immediate feedback. This study underscores the significance of digital technology in facilitating SRL among university students. By effectively incorporating digital tools into their learning strategies, students can adapt to online learning environments and enhance their engagement with challenging subjects like Calculus 1.

**Keywords**: SRL strategies, learning calculus, digital technology, Calculus 1, qualitative research, online learning

# Introduction

In recent years, the use of digital technology in education has become increasingly prevalent. With the onset of the COVID-19 pandemic, online learning has become the norm for many students across the world. However, the shift to online learning has presented new challenges for students, particularly in terms of self-regulated learning strategies. Especially, in the naturalist setting where students learning in non-classroom environments, they face difficulties in developing self-regulated learning strategies.

Self-regulated learning refers to the process by which students take control of their own learning, setting goals, monitoring their progress, and adapting their strategies as needed. Research has shown that self-regulated learning strategies are crucial for success in mathematics and other STEM subjects (Zimmerman, 2002; Pintrich, 2004). This is because these subjects require students to engage in complex problem-solving tasks that often involve multiple steps and require the application of various mathematical concepts and techniques. Self-regulated learning strategies such as goal setting, self-monitoring, and self-reflection can help students stay motivated, focused, and on track with their learning objectives. A study by Zimmerman and Schunk (2011) found that self-regulated learning strategies were positively correlated with academic achievement in mathematics.

Despite the potential benefits of self-regulated learning strategies, many students struggle with developing them effectively, particularly in the context of online learning. This is where digital technology can play a crucial role. Digital tools such as online tutorials, interactive simulations, and virtual manipulatives can provide students with additional support and scaffolding to help them develop effective self-regulated learning strategies. In a study conducted by Siregar (2022) it was found that the use of digital technology, such as online tutorials, improved students' self-regulated learning strategies in mathematics. Similarly, a study by Karakirik et al. (2016) found that the use of virtual manipulatives improved students' self-regulated learning strategies in geometry.

Therefore, this study aims to investigate the use of students' self-regulated learning strategies in calculus 1 during online learning using digital technology. By examining the use of various digital tools, this study aims to provide insights into how self-regulated learning strategies can be used to support students' success in learning Calculus 1.

# Literature Review

Independent learning necessitates a variety of activities that go far beyond reading and listening, as self-regulated learning demonstrates. Setting learning objectives for a lesson, an assignment, and a study session is required. The learner must next decide how to approach the task successfully based on how each learner prefers to learn: through listening, taking notes, outlining, portraying the information visually, self-questioning, reviewing, or writing a summary. In addition, the student must control and direct their own attention and conduct in order to remain on track.

Self-regulated learning is the activity that includes complete attention and concentration, self-awareness and introspection, honest self-assessment, openness to change, genuine self-discipline, and acceptance of responsibility for one's learning (Zimmerman, 2008, 2009; Zimmerman & Schunk, 2011). Along with awareness and control of cognitive processes, self-regulation also entails awareness and control of emotions, motives, behaviors, and situations that are conducive to learning, such as Self-control, effort, and time management are all examples of behavior (Karabenick & Dembo, 2011).

The strategy for SRL developed in many different ways. Zimmerman conclude there are 14 types of strategies used by the university students in developing their SRL in learning such us self-evaluation, organization and transforming, goal-setting and planning, seeking information, keeping records and monitoring, environmental structurings, self-consequating, rehearsing and memorizing, seeking social assistance, and reviewing records (Zimmerman, 2011). There are numerous research about the SRL, about the digital technology learning, and about calculus 1, but then there is only few research discussing how SRL in learning Calculus 1 during the online learning.

# Methods

Research Design

The research design is using a qualitative approach because the research question aims to explore the strategies of self-regulated learning using digital technology in learning calculus 1 during an online setting. Qualitative research is an appropriate approach for this question because it allows for an in-depth exploration of participants' experiences, perceptions, and behaviours. Qualitative research also allows for the collection of rich and detailed data that can provide insights into the complexities of participants' experiences. Gay (2006) stated that in order to understand a specific occurrence, qualitative research entails the collection, analysis, and interpretation of considerable narrative and visual information. The results of this study will also be evaluated and related to a number of other similar investigations.

Population and Sample

This research examines the strategy of SRL of students in learning Calculus 1 during online learning. Therefore, the population of this research are students who took Calculus 1 course during the full online learning period from Fall semester Academic Year 2021/2022, Spring semester Academic Year 2021/2022, fall semester Academic Year 2022/2023, to Spring semester Academic Year 2022/2023. The total population is around 100 students. The sample is taken from population is six students with the purposive sampling. The six participants is taken from different roaster and they already enough in explaining about the SRL in learning.

Data Collection

The data of this research is taken by semi-structured interview with participants. The participants were invited to meet in the online meeting, and then given some questions. The questions is developed from the Zimmerman and Pintrich models about Self-Regulated Learning with Technology in University (SRLTU). It contains the technology used for communication tools, repositories, social network, storage tools, multimedia resources, assessment tools, management tools, and other technologies.

**Data Analysis**

Summative content analysis was used to analyze the data that were obtained from the interview. summative content analysis is used in qualitative research to allow researchers to get deeply into textual data (Rapport, 2010). Summative analysis helps readers interpret the content correctly. Comparing keywords or content with an understanding of the underlying context is the process of summative context analysis (Akintolu et al, 2023).

# Result and Discussion

Six students were interviewed to understand how they use digital technology for self-regulated learning in Calculus 1 during online classes. The interview data, presenting respondents' answers on digital tools for self-regulation, is detailed based on the types of technology supporting Zimmerman's Self-Regulated Learning (SRL) strategy, as identified by previous research by Yot Dominguez and Marcelo.

Result

1. Organizing and Transforming

The SRL method of organizing and transforming demonstrates that students have secretly or overtly shifted educational materials to improve learning. According to the interview, a variety of technologies, including Google Drive, Canvas Learning, File Explorer, Digital Scanning, Digital Online Translator, Digital Scientific Calculator, Hypetia Create, and WhatsApp, can be used to organize and transform a strategy.

Google Drive is the first digital technology to enable organizing and transforming SRL strategy. According to the findings of the interview, students use Google Drive to save and organize their files for themselves and their friends, as well as to find peers with whom to collaborate using the access provided. Additionally, the students use the Google Drive tools (such as Google Doc, Spreadsheet, and Google Slide) to support their studies and take notes on Calculus 1.

According to the interview, Sampoerna University's implementation of Canvas as a learning management system aids students in planning their academic pursuits, particularly when studying Calculus 1 online. According to the interview results, P3 states that he uses Canvas to help organize and change his learning since "we can upload our work there and can be seen back to the canvas".

Furthermore, digital scanner technologies like CamScanner and Office lens are another piece of technology indicated to enhance the organizing and transformation plan in SRL. Because Calculus 1 is taught online and involves a lot of writing by hand, all assignments and projects must be turned in online to each lecturer. Consequently, in order to submit their handwritten assignments to the lecturer online, they require a digital scanning tool.

Digital scientific calculators like Symbolab, Geogebra, Desmos Graphing Calculators, Algebra Calculators, Trigonometry Calculators, and Scientific Online Calculators are another example of digital technology highlighted. The students use a digital scientific calculator to assist them in finding solutions to specific issues, learning how to solve problems step-by-step, and visualizing graphs for each function in Calculus 1

2. Seeking Information

Seeking information is an SRL strategy that demonstrates student initiative in looking for additional assignment details from non-social sources. According to an interview, Sampoerna University's calculus I students use a variety of digital tools, including YouTube, websites, learning management systems, Instagram, and Tiktok.

Based on the interview, the students utilize Youtube as a place to search for tutorials step by step for solving the problem, and the explanation of the Calculus 1 concept. The website is used by the students to look up Calculus 1 terms, properties, and formulas as well as explanations of certain topics. The search engine is used to enter certain themes or subtopics that the user wants to locate in order to find the notion. The students’ strategy for using digital technology to search for information is searching video explanations, an article, module that was uploaded by the lecturer and short video about tips and tricks to learn and solve the Calculus 1 problem.

3. Seeking Social Assistance

Asking for social support or assistance is a strategy used by students to demonstrate initiative when asking their peers, teachers, and adults for help. According to the results of the interview, Sampoerna University's Calculus I students use a variety of communication methods, including instant messaging (WhatsApp) and online conferencing platforms (Microsoft Teams, Zoom, Google Meet), to request help.

Through conversation or brief calls, students use WhatsApp to request or provide a variety of information about Calculus 1. The students use WhatsApp using two different strategies: management class and content and problem discussion of complete assignments and work on problems.

Web conferencing applications like Zoom, Google Meet, and Microsoft Teams are another type of communication tool that students frequently use. These resources are used to support students' SRL, which entails asking for social support in lectures or group discussions. The students conduct group discussions using online conferencing facilities as a means of knowledge exchange. According to the interview, this technology includes capabilities like a share screen, video conference, phone call, and chat that can assist students in having effective discussions.

4. Rehearsing and Memorizing

Rehearsing and memorizing is a declaration that shows the learner is making an attempt to memorize knowledge through overt or hidden practice. According to the interview, Sampoerna University's Calculus I students use a variety of platforms, including YouTube, Khan Academy, Bing Video, and Google Image, to help their study and memorization method.

The students begin by watching video explanations from Bing Video, Khan Academy, and Youtube. Students can listen to explanations on Calculus 1 and instructions on how to answer Calculus 1 problems on YouTube, Khan Academy, and Bing Video.

A picture or image is also another type of multimedia resource used to help the rehearsing and memorization (SRL) technique. According to the results of the interview, Google image serves as where most people find images. The students use Google images to find more work that has been posted to Google Web, to view graphs, and to look up formulas relating to Calculus 1.

5. Keeping Records and Monitoring

A SRL strategy that demonstrates the initiative taken by students to record activities or results is keeping records and monitoring. According to the results of an interview, Sampoerna University's calculus I students use a variety of management tools, including Canvas, a platform chosen by the professor, and specialized programs like Notion and Quick Notes. The students first utilize Canvas to help their self-observation, such as looking for the assignment due date so they can prioritize what has to be done first. Additionally, the students make use of Notion, Google Calendar, and Quick Notes as management tools. Using this digital technology, the students record their academic calendar and to-do list in order to engage in self-observation.

6. Record Review

A statement that suggests the student has made an effort to reread their notes, examinations, or textbooks in order to be prepared for class or future testing. According to the interview, Sampoerna University's Calculus 1 students use a variety of devices to support their record review technique. the tools that students use, such as LMSs (Learning Management Systems), Instagram, and WhatsApp, to record reviews.

Additionally, the students use Microsoft Teams and Canvas, the LMS (Learning Management System) used by Sampoerna University. They use the lecturer's LMS to check the uploaded modules or review the work that has been collected into the system. The lecturer is assisted by the canvas. WhatsApp is the second type of repository technology that students use. Despite being a communication tool, WhatsApp can also be used for document evaluation. According to the interview, WhatsApp makes it simpler for her to review the issues she has resolved on her phone or to check on her work in general. As is well known, WhatsApp is an app that can be downloaded to all smartphone models.

7. Self-Evaluation

A SRL method known as self-evaluation presents assessments of the standard or progression of student work that they have initiated. Based on the results of the interview, Sampoerna University's Calculus I students use a variety of assessment resources, including YouTube, Khan Academy, and Paul's Notes, to support their self-evaluation of their online learning. First of all, YouTube videos are utilized as the assessment tool to promote self-assessment in studying Calculus 1. The students use Youtube videos to do self-evaluations by looking up videos that cover related Calculus 1 issues. When a problem or query arises, they attempt to solve it on their own before verifying the creator's response.

Khan Academy is the second assessment tool intended to support students' self-evaluation. Based on the interview, Khan Academy assists students in self-evaluation by providing a variety of Calculus I-related tasks and instructions for solving them.The third assessment tool for evaluating one's own use of the SRL method is Paul's Notes. According to the interview, Paul's Notes is a website for self-evaluations that offers numerous Calculus 1 problems. The answers may also provide detailed instructions for how to solve each problem.

**Discussion**

Students at Sampoerna University who are taking Calculus 1 online engage in a variety of SRL strategy. The first common strategy is organization and transform. Organization and transform information is an essential component of academic work. Students today are getting used to using specific technologies, like Google Drive, Canvas, Digital Scanning, etc., that let them locate, organize, and retrieve the data they need. Bitter and Legacy (2007) says that in order to simplify the educational system, technology must be employed to its fullest extent. Additionally, Calculus 1 contains a lot of equation-solving problems that are effectively written by hand, necessitating the use of digital technologies, specifically digital scanning. The effectiveness of a scanner was stated by Bitter and Legacy (2007) "A scanner helps the students replicate learning materials, such as documents and images, as well as capture and store images,”. In especially for students above the primary level, it is quick, convenient, and easy to use, which benefits the students (Bitter and Legacy, 2007).

The second strategy is seeking information. The strategies taken into account are those that make it easier for students to understand the data handled during academic activities like studying. In order to provide clear explanations and need less information processing, the students discuss using a webpage and a brief video from Instagram and TikTok. Students use online encyclopaedias rather than printed ones to search up the definition of a term (He et al., 2012). More specifically, people use Wikipedia to quickly investigate obscure facts or subjects or to obtain in-depth knowledge on a specific issue (Lim, 2009).

The third strategy is seeking social assistance. Concerns raised by the students around requesting, exchanging, and making public the materials they produce for class. Various presentation formats, such as books, blogs, electronic addresses, and presentations, may be used to display these works. While choosing to share digital resources, students display a great level of self-control because doing so puts them in the "risk" of others. Furthermore, when they ask for help from others and watch how other people work. Additionally, the students start group conversations via web conferencing to solve the issue. Through its tools' share screen capability, they collaborate and discuss ideas. According to Johnson et al. (2014), interactive features on online discussion boards encourage peer participation while seeking peer evaluation.

The fourth common strategy is rehearshing and memorizing. The fourth SRL strategy places more of an emphasis on students' proactive mindsets who are dissatisfied with learning only from what their lecturer have to provide. In contrast, students now engage in a more in-depth and independent learning process thanks to digital tools like videos, blogs, presentations, etc. Ganan et al. (2014), who claim that multimedia tools go above and beyond by making knowledge more interactive and personal for the student, bolster this claim. Utilizing interactive, audio, video, and other multimedia elements improves subject understanding while increasing motivation and involvement in learning.

The students most commonly make use of online search engines and databases out of all the strategies and digital technology utilised. Kennedy et al. (2008) recognized these resources as the ones that students frequently want to use for their coursework. Mirriahi & Alonzo (2015) agreed that the type of technology utilized by students for learning has virtually not changed over time, despite the passage of time since the publication of this research.

Besides the mentioned technologies and how to apply it. Students also spoke about how interesting it was to learn Calculus I online. They frequently use multiple scheduling tools at once, including Google Calendar, Notion, and Canvas, to effectively organize their learning. Additionally, they use WhatsApp for communication and storage, using it as a simple way to open instructional materials on their phones. They also manage their social media, such as Instagram, by setting up separate accounts for personal and academic use, sharing information about academic events like Calculus 1 on the latter. This findings shows how students use SRL in learning but it is limited to the learning mathematics especially Calculus 1 course.

# Conclusion

Students at Sampoerna University self-regulate their learning methods for learning Calculus 1 by using digital technologies. The students use a variety of SRL tactics and digital tools while participating in online learning. 1). Organizing and transforming: They use Google Drive, File Explorer, and WhatsApp to efficiently arrange their files, such as materials, and their work. Additionally, the students use Google Translate and a Digital Scientific Calculator to simplify equations and translate English phrases into Indonesian to better grasp concepts. Additionally, students use hypatia generate to assist them in entering the mathematical equation in their poster or media creation, enhancing their learning. 2). Seeking for Information strategy in which students make use of online resources like YouTube, websites, learning management systems (LMS), Instagram, and Tiktok. In order to study and solve the Calculus 1 problem, the students' technique for using digital technology to get material includes searching for video explanations, an article, a module that the lecturer posted, and a brief video about tips and tricks. 3). Seeking social assistance, digital technology such as WhatsApp and Web Conferencing Tools, Gdrive, and Instagram support this SRL strategy when learning Calculus 1 during online learning. Students use this approach to get and give information on Calculus 1 outside of class, such as assignment due dates, class schedules, and solutions to problems from peers and the lecturer. Additionally, the students start group discussions via web conferencing to share ideas and collaborate using the share screen function. 4). rehearsing and memorization. In this method, the students watch videos on YouTube, Khan Academy, and Bing Video to learn how to solve calculus 1 problems and understand the subjects covered in the course. Additionally, the students use the image they discover on Google Photo to see how to solve the issue from Calculus 1, as well as the graph's image and a list of associated formulas. 5) Monitoring and keeping records. Students at Sampoerna University who are learning Calculus 1 online can keep track of their progress and keep an eye on themselves by using management tools like Canvas, Notion, Google Calendar, and Quick Notes. The students make use of these management tools by keeping track of their own behavior, particularly by posting their academic work on time online. 6). Record review is a type of SRL activity where students use Canvas, Instagram, and WhatsApp as learning tools while reviewing submitted work, checking modules, and sharing information. 7) Self-evaluation: In this technique, students use assessment tools to help their self-evaluation, like Paul's Note, Khan Academy, and YouTube videos. The students make use of these tools by working out the problem on their own and then double-checking their work against the solution. This research is limited to the SRL in learning calculus 1. In the future research, this researchc can be developed in the field on mathematics not only Calculus 1.

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