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Use of Technology to Improve Students' Attitude in Learning Mathematics of Non-Mathematics Undergraduate Students

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***Abstract*—**This paper will investigate a form of learning mathematics by integrating technology in mathematics specifically for the university first-year calculus class to support students' engagement in learning which influences students' conceptual and procedural understanding of the calculus content in a better way. The students with good grades in high school calculus generally struggle in first-year university calculus classes in learning mathematical analysis concepts. This problem has to be addressed. If this problem is not resolved, then most likely students with less ability to do mathematics might not able to complete their degrees. In this work, MATLAB is used to help students in learning and in improving calculus concepts.

***Keywords*—**Calculus, first-year university students, teaching strategies, MATLAB.

I. Introduction

IN the field of mathematics education, the use of technology has become increasingly important in enhancing student learning. In particular, incorporating MATLAB as a supplement to traditional teaching methods can provide instructors and students with new opportunities to learn and practice calculus. By utilizing MATLAB's powerful interactive and dynamic working environment, the effectiveness of conventional teaching methods can be greatly improved.

The use of MATLAB in calculus instruction provides numerous benefits for both instructors and students. Incorporating this tool into teaching practices allows for a more hands-on, interactive approach to learning, allowing students to explore mathematical concepts visually and intuitively. This deepens their understanding and retention of the material and helps them develop problem-solving skills through the use of powerful tools and functions that solve complex mathematical problems. MATLAB also provides a more personalized learning experience as instructors can create customized exercises and assignments that are tailored to the needs and abilities of individual students [6]. This helps to ensure that students' progress at their own pace and receive the support and guidance they need to succeed. Furthermore, MATLAB can be used as a tool for visualizing mathematical functions and graphs, helping students to better understand complex concepts and relationships and improving their ability to solve problems and perform computations. As a result, the use of MATLAB increases students' motivation and self-confidence, as they gain experience using this powerful tool to explore and master calculus concepts.

Incorporating educational technology such as MATLAB into instruction can also have positive effects on student engagement and learning outcomes. However, the effectiveness of such technology depends on several factors, including the goals of instruction, the characteristics of the learners, and the design of the software itself. To be successful, educators must receive proper training in the use of technology and must make informed decisions about when and how to incorporate it into their teaching practices.

The successful integration of MATLAB into calculus instruction requires a thoughtful and strategic approach. Educators must consider the unique needs and abilities of their students, and must carefully select and design software and instructional materials that support their learning goals. With careful planning and implementation, the use of MATLAB can help to improve students' understanding and mastery of calculus and can foster a more engaged and effective learning environment. [9]. At the university level in mathematics classes the most popular CAS program, MATLAB is widely used.

As technology becomes increasingly integrated into higher education, it is essential to examine how software can be used to enhance the teaching and learning of mathematics. This requires careful analysis of the benefits and limitations of different software tools, as well as consideration of how they can be effectively integrated into instruction. By leveraging the power of software to provide interactive and dynamic learning experiences, educators can help students to better understand and retain mathematical concepts. However, this requires careful planning and training to ensure that software is used in a way that is both effective and supportive of student learning goals. According to Heid the Computer algebra system is one of the modern cognitive tools [5].

Cognitive technology refers to a set of tools and techniques that aid in problem-solving activities by enhancing the limitations of the human mind in learning and thinking. These technologies are designed to mimic human cognitive abilities, such as perception, reasoning, and learning, and can be used to augment human intelligence and decision-making processes. One of the key benefits of cognitive technology is its ability to process vast amounts of data and identify patterns and insights that might be difficult or impossible for humans to detect on their own. This can be particularly useful in fields such as

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finance, healthcare, and marketing, where large amounts of complex data must be analyzed to make informed decisions. In addition, cognitive technology can help to improve learning outcomes by providing personalized and adaptive learning experiences that are tailored to the needs and abilities of individual learners. This can help overcome the limitations of traditional classroom instruction, which may not be able to accommodate the diverse learning styles and preferences of all students. However, the effective use of cognitive technology requires careful consideration of its limitations, as well as its potential benefits. Educators and practitioners must ensure that cognitive technologies are used ethically and responsibly and that they are properly integrated into existing teaching and learning practices to maximize their effectiveness. With careful planning and implementation, cognitive technology has the potential to significantly improve problem-solving activities and support more effective learning and decision-making processes [10]. Both mental and computational devices are considered to be cognitive tools that support and enhance thinking processes by providing a means for individuals to externalize their thoughts and manipulate information, ultimately leading to improved problem-solving and decision-making skills [3]. Students' mathematical learning and essential career-related skills can be excelled with didactical tools like technology. Integration of technology influences mathematics teaching and enhances students learning. Schneiderman highlighted that the degree of effectiveness of education technology depends upon the congruence of instruction, characteristics of the learners, design of the software, educator training, and decision-making [9].

By engaging in learning and teaching with MATLAB in calculus classes, educators can provide students with practical ideas and processes that they can use to actively engage in the learning and research process. This approach can help to increase students' interest and engagement in mathematics, as well as their overall understanding of the subject. In addition, the use of MATLAB in mathematics education can help prepare students for careers in fields such as engineering, science, and finance, where proficiency in MATLAB is often required. By introducing students to MATLAB early in their education, educators can help ensure that they have the skills and knowledge necessary to succeed in these fields.

II. Teaching Calculus

Calculus is often considered one of the most challenging subjects in higher education due to its difficult concepts and real-world applications that can be confusing for students. This can be attributed to a variety of factors, including prior experiences with calculus in lower grades and a lack of time and effort dedicated to studying the subject. To address these challenges, teachers can use special methods to improve students' performance and dedication to studying calculus.

Another advantage of using MATLAB is that it can be used to solve complex problems that would be difficult to solve by hand. Moreover, MATLAB is a programming language that is widely used in the field of engineering and science, so teaching students how to program in MATLAB can help them to develop important skills that are relevant to their future careers.

Assessing students' understanding of calculus can also be enhanced through the use of MATLAB. Teachers can create quizzes and tests that are based on MATLAB simulations and problem sets, which can provide more detailed information about students' understanding of the material. This can help teachers to identify areas where students may need additional support, and adjust instruction accordingly.

In summary, incorporating technology such as MATLAB into calculus instruction can be an effective way to improve students' understanding and performance. By using visualizations, simulations, programming, and assessments, teachers can make the material more engaging and relevant to students, and help them to develop important skills that are applicable in their future careers. We propose a question: How does the use of technology (software like MATLAB) affect the students' engagement and learning outcomes in the first-year calculus class at the university?

Reference [4] investigated the correlation between gender differences, students' attitudes, and the software program experiences. According to [4], it is vital to assess students' attitudes enthusiasm, and curiosity while using MATLAB-like programs. The effectiveness of computer technologies in solving mathematical problems by pre-service teachers was investigated. Also, the assessments of teachers' skills in using these computer tools; their attitudes toward them; and their willingness to use these tools in their careers as teachers were considered [12].

A study found that students taking Algebra and calculus courses in their first semester developed an interest in using technology, specifically MATLAB [2]. The students reported a positive experience in learning areas under curves, and the concept of definite integral by taking Riemann sums through computing and visualization with the use of MATLAB. Students appreciated graphical capacity, speed in performing computation, clarity in understanding through explorations, and for the confirmation of their answers. Students showed a preference for using MATLAB's 3-D graphing capacity over the graphing calculator. Several authors have indicated in their research work that MATLAB-like software benefits in increasing motivation and fostering a positive attitude in learning mathematics [1], [7], [8], [11].

III. Research Design and Methodology

The qualitative method is used in this study as qualitative research is best to allow the participant to express their views [18]. In this study, the sources of the problem and the difficulties in learning and understanding calculus by first-year university students are identified. The qualitative method allowed flexibility throughout the process. It is such a refined way of researching that for this method, the researcher does not follow the standardized rules but decides what to do next as the problems arise.

Instructors or Professors of calculus from the department of mathematics at the university in Islamabad, Pakistan, and first-year undergraduate students from the mathematics department

of the University participated in this research. Students belong to various cultures and different backgrounds. Students receiving services for English as a second language, speech or language services, special education services for reading or math, and students without signed students are excluded from the study. The three sites in this study were considered. Through interviews conducted with 10 students and three instructors of calculus classes, valuable insights were gained into the experiences and perspectives of both learners and educators in this subject area. These 10 students will likely provide different views on the integration of technology (MATLAB) in learning and understanding calculus.

In Calculus I, the coursework covered various topics each week, including Functions, Limits, Differentiation, Applications of the Derivative, and Integration. To assess students' abilities, a test based on high school math content was given at the start of the semester. Any student who scored lower than the expected level was invited to participate in a project focused on using MATLAB to improve their skills. The project was designed to address areas where the students needed help, and aimed to increase their understanding of the fundamental concepts in calculus.

In total 400 students enrolled and participated. They were divided into three classes. This project was designed for 10 weeks. A broad range of instruments like interviews, observation, and document analysis was used to gather information and monitor the effects of this trial on students' skills, views, and approaches to calculus and learning. A breadth of information was sought via tests and a broad range of assignment tasks.

In this study, we acted as a *non-participant observer* during data collection. We investigated calculus classes and informal one-to-one observation with individual instructors and took field notes to describe the classroom activities by using an observation guide (Appendix: A). The approaches used by the instructor during teaching calculus with MATLAB were observed: How instructors use MATLAB during calculus class.

1. How do instructors utilize MATLAB in the classroom to illustrate and explain ideas and various concepts in calculus?
2. What strategies do instructors use to check the answer after work is done by students by hand? (Will they use MATLAB to check results?)
3. How often are students allowed to use MATLAB in class?

Informal observation data are supported by open-ended questions in interviews. The interviews followed an open-ended questions protocol, with a standard set of questions asked of each interviewee in addition to specific questions for individuals regarding their learning calculus with MATLAB experiences. The interview questions were designed to uncover instructors' and students' views and perceptions on the process of learning calculus content with MATLAB. The interview questions are constructed from the literature on action research, the research questions, and the observation.

In the third phase, the documents and slides used during the mathematics teaching were collected to confirm what has been seen during the observation and heard during the interviews. This included students' notes, the instructor's work schedule, and mathematics teaching material (instructional notes) with MATLAB from the three instructors over ten weeks.

IV. Results

Students expressed positive feelings about learning calculus with the use of MATLAB. Most students believe that calculus is abstract mathematics and difficult to understand conceptually. The use of technology improved the way students learn calculus as with MATLAB they get the answer more quickly, and accurately. This promoted a climate of enjoyment and interest in learning calculus. Also, students positively responded to the opportunity for visualization, ease of graphing and computation, and exploration. However, this sudden change in the learning experience for many students did not allow them to address potential errors generated by the use of technology. With the application of MATLAB, students in the class can share their experiences and can help each other in learning a new concept.

Close to 20% of students had difficulty using MATLAB even with all the information and resources available. Therefore, we suggest that before its use, training (in-person) is offered for familiarization with MATLAB. On the other hand, only, a few students wanted the same traditional teaching system and wished to copy material from the blackboard.

In the testimonies presented, we found that students believe that the use of MATLAB supports the learning of calculus concepts positively. The respective professor of the regular discipline of calculus we informed that those students who participated in the project improved their results in the final evaluation with their performance in the initial class test.

V. Conclusion

In recent years, technology has increasingly played a role in enhancing the learning experience for students in higher education. One area where technology can be particularly useful is in the teaching of calculus, a subject that many students find challenging. In this research, we proposed a project to explore the use of MATLAB as a tool to help first-year university students better understand calculus concepts.

The instructors showed great interest in this project and were eager to try this new teaching style. They found that the use of MATLAB helped engage students more actively in the learning process, and facilitated discussions between educators and learners. This in turn led to the development of stronger relationships between educators and learners.

The students who participated in this project reported that they found the use of MATLAB to be very helpful in understanding calculus concepts. They were able to visualize difficult concepts more clearly and discuss their problems with their instructors more confidently. The use of technology also allowed students to work at their own pace, which was particularly helpful for students who may have struggled with the traditional teaching style.

One of the key benefits of using MATLAB in calculus education is that it allows students to see how different concepts are related to one another. This can help to build a more coherent and intuitive understanding of calculus, which is critical for success in the subject. It also allows students to explore real-world applications of calculus, which can make the subject more relevant and interesting.

Despite the benefits of using technology in calculus education, it is important to acknowledge that students have different abilities and experiences. Instructors need to be mindful of this when designing their teaching strategies and should aim to provide a learning environment that is inclusive and accessible to all students. This may involve using a variety of teaching methods, including technology, and providing additional support to students who may be struggling.

In conclusion, the use of MATLAB in calculus education has the potential to be a very effective teaching tool. It can help students to better understand difficult concepts and to engage more actively in the learning process. By reflecting on the difficulties that students encounter, instructors can design teaching strategies that are tailored to the needs of their students, and that foster a more inclusive and supportive learning environment.

VI. Limitation

In any research, it is important to acknowledge the limitations of the study. In this research, there were a few limitations that need to be addressed. Firstly, the research sample was relatively small, consisting of only 3 sections/ classes of a university and three instructors. This limits the generalizability of the study. While the findings of the study are promising, it is important to replicate the study on a larger scale to see if the same results are obtained. Additionally, the study was conducted at a single university, which further limits the generalizability of the findings.

Secondly, the fieldwork was undertaken at a time when instructors were busy teaching other classes and involved in various departmental activities. This may have impacted the instructors' ability to prepare for their classes using MATLAB and may have influenced their practices. It is possible that if the instructors had more time to prepare and integrate the use of MATLAB into their teaching, the results may have been even more positive.

Despite these limitations, the study is still valuable in that it provides insight into the potential benefits of using MATLAB in teaching calculus. It suggests that MATLAB can be an effective tool for helping students visualize difficult concepts and develop a more intuitive understanding of calculus. However, more research is needed to confirm these findings on a larger scale and in different settings.

Moving forward, future studies could explore the use of MATLAB in teaching calculus in different types of universities and with larger sample sizes. They could also examine the impact of different types of interventions, such as providing instructors with more preparation time or offering additional support to students who may be struggling. By addressing these limitations and building on the findings of this study, we can continue to improve and refine the use of technology in teaching calculus and provide students with the best possible learning experience.

References

[1] Canfield, R. A. (2012). *Teaching Computational Methods to 140+ Second-Year Engineering Students at Virginia Tech* https://www.gedcouncil.org/sites/default/files/02.27.15%20Teaching%20Computational%20Methods%20to%20140%2B%20Second-Year%20Engineering%20Students%20at%20Virginia%20Tech.pdf

[2] Colgan, L. (2000). MATLAB in first year engineering math, *International Journal of Mathematical Education in Science and Technology*,31(1) 15-25.

[3] Deny, S J. (1990). *Flexible cognitive tools for problem solving instruction*. Paper presented at the annual meeting of the American Educational Research Association, Boston, MA, April 16–20.

[4] Dweck, C. (2006). *Mindset*. New York: Random House

[5] Heid, M.K. (2001). Theories that inform the use of CAS in the Teaching and Learning of Mathematics. In P. Kent (Ed.), *Proceedings of the 2nd Biennial Symposium of the Computer Algebra in Mathematics Education Group*: <http://ltsn.mathstore.ac.uk/came/events/freudenthal/3-

[6] K. A. Qing, *Principles and standards for school mathematics,* National Council of Teachers of Mathematics, Edmonds, University of Calgary, 2000.

[7] Kazimovich, M. Z. & Guvercin, S. (2012). Applications of Symbolic computation in MATLAB, *International Journal of Computer Applications* 41(8).

[8] Kemmis, S. 2009. Action Research as a Practice-Based Practice. *Educational Action Research* 17 (3): 463–474.

[9] M. Schneiderman, (2004), What does SBR mean for educational technology? *T.H.E. Journal*, 31(11), 30-36,

[10] Papert, S. (1993*). Mindstorms: children, computers and powerful ideas,* Basic Books, New York.

[11] Selden, A. (2005). New developments and trends in tertiary mathematics education: or, more of the same? *International Journal of Mathematical Education in Science and Technology,* 36(2-3), 131-147

[12] Wilkins, J.L.M., 2000. Preparing for the 21st century: The status of quantitative literacy in the United States. *School Science and Mathematics*, 100(8), 405-418.