Sustainability of the 4.0 Revolution in University-Level Mathematics Classrooms: Disruptions, Adaptability

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Abstract: This article addresses the sustainability of using digital technologies in mathematics education. The paper emphasizes the need to understand how we can improve mathematics learning processes and the role of technology in these processes. Technology encompasses various fields such as science, manufacturing, services, and transportation, covering a wide range from machines to methods. The use of technology in mathematics education should also be evaluated within this scope. The article examines how digital technologies are used in mathematics classes and how this usage affects students' mathematics learning processes. Technological advancements, ranging from graphic calculators to web-based applications, have transformed mathematics instruction. However, it is an important question whether technology is used only to access answers more quickly or to improve how mathematics is learned. Especially when there are numerous equations and programming languages in mathematics classes, the limitations of material presentation must be considered. Additionally, this research highlights the importance of using platforms for implementing online learning policies.

Keywords: CAS, Covid-19, Education, ICT, IR, Mathematics, Sustainability, Technology, VLE, VVM.

1. Introduction

In the Microsoft Encarta Reference Library (2004), the term technology consists of "techne," the Greek word for art, and "logia," which corresponds to the field of knowledge. This technology's definition is precisely recognized as mastery or proficiency in study or science. The application of technology, tools, and methods is defined as applying technical knowledge in Encarta Dictionary Tools. Technology is "science, production, service, transportation, and so on." This notion can also be defined as a discipline that combines various aspects in a specific sequence, such as machines, processes, methods, procedures, systems, management, and control mechanisms. It serves as a bridge between science and practice (Deniz et al., 2006). According to NCTM, technology includes " all electronic devices, including computers, calculators, other handheld devices, telecommunications equipment, and the variety of multimedia hardware, and the software applications associated with their use" (NCTM, 2000).

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What is critical in the use of digital technologies in university-level mathematics? Is the technology there to assist students in achieving 'the answer' faster and more precisely, or is it to improve how they learn mathematics? Digital technology has been used in mathematics classes since the 1970s when basic four-function calculators first appeared. Since then, technological advances such as computers running increasingly complex software, graphics calculators that have evolved into "all-purpose" handheld devices integrating graphical, symbolic manipulation, statistical, and dynamic geometry packages, and web-based applications that provide virtual learning environments have changed the way mathematics is taught and learned (Goos, 2015). Technology is increasingly being used in creative ways to teach.

Furthermore, society makes extensive use of technology in a variety of daily activities. It may be helpful to summarize the technological revolution process. The 1.0 IR was defined by transitioning from hand production methods to machines through steam and waterpower between 1760 and 1820, or 1840. The 2.0IR, also known as the Technological Revolution, occurred between 1871 and 1914 due to the development of massive railroad and telegraph networks, which allowed for the speedier transfer of people and ideas and the introduction of electricity. The 3.0IR, also known as the digital revolution, occurred in the late twentieth century, following the end of the two world wars, and was caused by a slowdown in the industry and technological growth relative to previous periods. The industrial Internet of things, cloud computing, artificial intelligence, cyber-physical systems, IoT, and the industrial Internet of things are some examples of the technologies and processes that are part of the fourth industrial revolution (4.0IR), which is a trend toward automation and data exchange.

Question: What do you think about 5.0 IR?

Answer: When we asked this question to university students, we got very different and interesting answers, and we also witnessed how open their imaginations are. Some of these answers were as follows—smell transfer, taste transfer, teleportation, and more.

During the Covid-19 pandemic, several online-based learning policies have been introduced. However, this policy continues to present several challenges involving lecturers and students. According to this study, the limitations in presenting material, mainly when courses have many mathematical equations and programming languages, are among the challenges teachers face when introducing online learning. This research shows that implementing online learning policies is accompanied by using platforms that support online learning. With the motto "learning opportunities for all," no barriers can be overcome. We believe trouble and misfortunate are not desired, but we should be patient when they arrive. A tribulation is better than a hundred warnings (Kurudirek & Kurudirek, 2021).

Online and remote learning are promoted by institutions all around the world, and technology-based pedagogy is important to this effort. In the face of the COVID-19 pandemic, 21st-century higher education institutions (HEI) are adopting technology-based tools, gadgets, and online platforms to support and encourage technology-based teaching. Today, thanks to the technological opportunities we have are now easily used at university levels, even students can participate in online master's and doctoral programs and carry out both economically and in more than one job, even if there are some difficulties, by planning their family lives comfortably.

1.1 Technology in Education

The advent of technology in education has various rhythms inside and outside the classroom. This progress is sometimes impacted by traditional customs and the limited availability of mathematical professors. The growing demand for flexible instruction suited to the student's needs drives technological innovation. The association between educational technology use and academic performance is unclear.

In general, technology in education minimizes gender inequalities, motivates youngsters, and fosters a positive attitude toward studying mathematics. Furthermore, technology is linked to resilience, adaptability, technological problem-solving abilities, and improved self-efficacy in coping with future problems and progress (Hossein-Mohand et al., 2021). Furthermore, social inequalities can be reduced by inclusive technology training. Teaching in the twenty-first century's Fourth Industrial Revolution (4IR) encompasses increasing ways technology is interwoven throughout people and society. Despite living in a technologically advanced society, many university students cannot handle technologically based tools and equipment competently. To successfully implement technology-based pedagogy, teachers must be competent and actively involved in ensuring that technological tools, platforms, and devices are used to support learning.

The successful integration of technology into educational environments has enabled effective and efficient teaching practice, resulting in more favorable outcomes. The widespread use of technical tools in educational institutions provides the opportunity for students to further enhance their talents. The use of technology in education aids in the accomplishment of learning objectives (Serin, 2015).

Furthermore, in the 4.0IR age, mathematics teacher education must appropriately train instructors to use and integrate technology-based devices and apps in classroom settings. In contrast, the COVID-19 epidemic drove HEIs to reorganize and deploy technology-based education without adequately preparing their professors or students for this significant shift. Technology influences math instructional activities and interactions (Naidoo, 2022).

However, sometimes we can experience very different extremes. Even when so much technology takes place in our lives and education, some institutions do not allow even the letter T of technology to enter through and touch the student. There is only one property that makes the institution exciting and attracts the rich, which is "old-school education"; there are no technological devices such as computers, laptops, or tablets in this school, and old materials are used to reveal all their skills.

1.2 Students' Digital Qualification

In education, digital competence comprises the capacity to generate and manage content and information, handle communication technologies, and address technology challenges, among other things. Those in primary school utilize ICT for online social interactions but cannot manage academic knowledge. Intermediate-level users can handle and update essential papers, tables, and presentations. Advanced students can execute apps and grasp the importance of computer security. Despite not engaging in specific ICT training programs, the fourth group can perform the aforementioned activities, as well as programming and self-education (Hossein-Mohand et al., 2021).

The students' competence with tools places a greater emphasis on the roles and actions of teachers through the following questions (Trgalova et al., 2018):

- How can we understand how mathematics teachers integrate technology into their teaching?
- How might we encourage more mathematics lecturers to use technology?
- How does technology change how mathematics lecturers think about teaching and learning?

Most students, however, lack a high level of digital proficiency, making learning mathematics with instructional software problematic. As a result, academic training activities that improve these competencies must be promoted. University students today are referred to as digital natives because they were born in the digital age and have a natural propensity to use technology. Even though several programs and tools are available, students rarely use them in their mathematical practice and study.

1.3 Justification

Classroom education presents a limited view of industrialized cultures' teaching/learning process. Because they are not subject to spatial-temporal constraints, remote education models enabled the United Nations Organization (UNO) to accomplish Rio+20 target 4 (education for sustainable development) in 2019. On the other hand, students see distance education as a stimulating approach due to its involvement and convenience, promoting student-centered learning and work. Again, mobile understanding has advanced quickly. The cloud's capabilities, scalability, and demand-based pricing enable unlimited training of the world's population. Academically, the COVID-19 epidemic has indicated that the current controlled educational approach has to be rethought, with on-site and online learning possibilities being investigated (Hossein-Mohand et al., 2021). The flipped classroom is an active methodology that is flexible with various programs, relevant to both primary and secondary cycles and provides more outstanding results than traditional approaches.

2. Background

Scientific calculators were used in tertiary entrance exams and mathematics courses in the 1970s, and microcomputers were then used. Since then, advanced technology has had an impact on educational mathematics. Although microcomputers first appeared in classrooms in the early 1980s, primarily as teaching labs, their impact on the math curriculum in schools was minimal. On the other hand, the acceptance of scientific calculators as tools for individual students to use in the classroom and on important exams had some effects on the curriculum and teaching strategies, most notably by reducing the emphasis on manual calculation and allowing the use of more accurate data in Math applications.

When deciding whether to use technology in mathematics education, four guiding principles are often given, according to a pioneer in the field (computer algebra systems-CAS). These four principles were placed in a significant study outlining the relationships between the development of technologies and reform in university-level mathematics (Kissane et al., 2015).

- A student-centered approach to education is beneficial, and technology can help make education more student-centered.

- It is critical to provide students with opportunities to experience what it is like to be a mathematician, and technology is thought to provide these opportunities.
- Reflection will improve learning, and technology can play a role in promoting thinking.
- There is a redefining of epistemic authority in technology-intensive instruction or training that involves constant student access to technological resources, and this realignment is desirable.

The use of digital technology, particularly mobile technologies, in mathematics teaching and learning is increasing in popularity. Technology design, learning activities, assignments; the role of the instructor; and the educational context are all critical variables in integrating technology into mathematical education (Viberg et al., 2020).

In the literature, research findings show differences between gender and attitudes toward technology. Women's perceptions of their efficacy in using computers and online experiences are found to be more disadvantageous than men's. Men are more optimistic about computers and the internet than women, while women are more anxious about computers.

The authors highlighted teachers' initial views, beliefs, attitudes, and knowledge on technology integration, concluding that "using technology makes teaching easier because students can picture the mathematics concepts and draw out their meaning" (Benning et al., 2018).

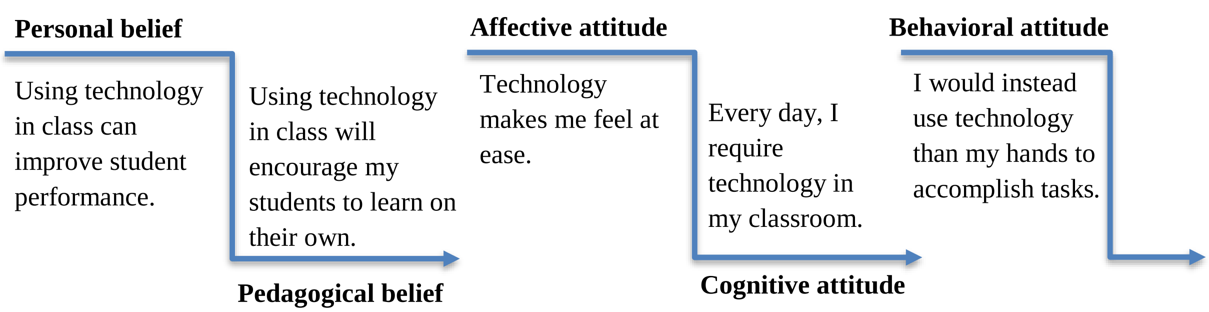

Table 1: Perceived beliefs and attitudes of lecturers regarding technology integration

Researchers have a consensus that lecturers' beliefs "designate individual, subjectively true, value-laden mental constructs." There are numerous definitions of lecture beliefs, though, and various points of view on how to tell beliefs apart from attitudes, values, or worldviews. The term "beliefs about the function of technology in learning" describes lecturer beliefs regarding teaching with technology. These notions include, for instance, the advantages or disadvantages of using technology in education (Thurm & Barzel, 2021).

Regarding lecturers' knowledge of technology integration, Table 2 indicates that lecturers have a relatively limited understanding of technology integration (Benning et al., 2018).

Technology knowledge	Technology content knowledge	Technology pedagogy knowledge	Technology pedagogy content knowledge
I know how to solve my technological issues.	I can locate and assess the resources I require for my mathematical studies.	I can pick technology to improve a class's teaching approaches.	I can teach lessons that effectively mix mathematics topics, technologies, and instructional methods.

Table 2: Lecturers' perceived knowledge of technology integration in mathematics teaching

In conclusion, the findings of this study provide significant evidence that lecturers may have high values and attitudes regarding the importance of technology. They do, however, necessitate technical expertise and skills for efficient application. Preparing preservice lecturers to utilize instructional tools such as graphing calculators and computers for future practice is one strategy to join the gap and bring mathematics teaching into the twenty-first century (Powers & Blubaugh, 2005).

3. Learning Environment

We can attribute the newly modified responsibilities in the ICT learning environment to the following reasons: More cooperative, learner-centered activities are needed, and teachers need to support students' active engagement in the classroom. Learners need to be able to improve their information literacy, develop collaborative work habits, and hone their critical thinking abilities to be ready for an increasingly competitive information world (Moila, 2006). ICT learning environments may be tailored to the specific needs of individual students. Many learners prefer to learn through speech, graphics, and simulations. However, to realize these evolving obligations, educators and learners must invest in skill development. ICT can give quick and up-to-date resources for educational resource distribution. Facilitating communication- ICT can assist learners and instructors in using various communication strategies. Adolescents can use ICT technology as a bridge from tangible to abstract thinking to build and explore multiple representations (Atteh et al., 2020). Responding to the many learning styles of students, educators can create rich environments that include visual, auditory, and a combination of visual and aural senses, resulting in long-term memory.

3.1 Virtual Learning Environments

The internet has grown into a big multimedia communication tool, which is increasingly being used in large math lectures. On the other hand, using the internet as a medium of instruction for a course necessitates adjustments in presentation and delivery. Despite the difficulties of communicating mathematical symbols and processes on the internet owing to programming constraints, mathematics is becoming more popular for online instruction. This is because the internet now provides "visual facilities and exploratory opportunities" that were previously unavailable, such as graphing calculators and programming tools. A Virtual Learning Environment (VLE), often known as a Learning Management System (LMS), uses the Internet to successfully teach undergraduate mathematics. With content pages, facilities for surveys and quizzes, student monitoring, file management, and assessment software, these systems serve as online learning environments. VLE can be classified based on their use in math lessons, such as sites for mathematical resources, practice exercises, discussion with peers and instructors, and system diffusion. We have seen the advantages of using VLEs: students can interact with the material independently. For instance, courses can be set up such that learners complete assignments or tests online at their speed.

Additionally, students may monitor their development online and contrast it with their peers' average growth. They found a mix of online peer interaction, visualization tools, quizzes, and continuous online access to course material and progress, even if not many sites are used with the intention of total participation and information usage (Engelbrecht & Harding, 2005). Thus, despite their youth, VLEs offer the advantage of enhancing student involvement and learning with mathematics.

4. Virtual Volunteer Mentors

Mentorship is the influence, counsel, or direction a mentor provides. A mentor educates or provides assistance and guidance to a less experienced, often younger, individual. They impact a mentee's personal and professional development in an organizational setting. Most traditional mentorships involve senior employees advising more junior colleagues, though mentors are not required to be more senior than those they advise. What matters is that mentors have experience that others can learn from.

We have a hypothesis called VVM that I've been thinking about and developing in our little domain with great success. The Virtual Mentors (VM) hypothesis is a social learning theory that uses the community as a main unit of study. The Virtual Mentors (VM) hypothesis is a social theory of knowledge that examines the community as the basic unit of study. Virtual mentors concentrate on individual experiences. According to this hypothesis, VM is formed when individuals collaborate on the learning process with other community members. Virtual Volunteer Mentors (VVM) differ from typical communities of practice in that they include a technology component and online platforms. Upper-class students advise and guide those who follow them in their mathematical and technological pursuits. These mentors, who voluntarily work until they graduate, help students at every level that comes after them. And this system continues as a tradition. Also, it has been observed that not only solving technological problems and achieving success but also affecting the quality of mathematics education at a high level.

5. Disruptions, Adaptability

Technology opens new possibilities for math and classroom learning. We can improve education and bring concepts to life through engaging and interactive media. Making math visual through interactive visualizations and explorations goes beyond student engagement; brain research reveals that it is essential to understanding math. Stanford University Neuroscientists are investigating how the brain thinks mathematically, and evidence suggests that visual pathways are imperative even while performing symbolic number computations.

The benefits of using educational technology in mathematics teaching and learning should inform the ICT tools in education that will be provided to the school system (Moila, 2006). Through easy practice exercises such as Kahoot!, we watched and witnessed the pupils' motivation. As impediments or problems in the broad adoption of ICT technologies in Mathematics teaching and learning, the following reasons were stated (Atteh et al., 2020).

- Educators are lacking in ICT tools and abilities.
- Inadequate time for adequate skill preparation and learning.
- Exam-oriented learning, which causes anxiety in students.
- Inadequate resources.
- Inadequate planning.
- Lack of adaptability (Resistance to change).
- Inability to connect ICT tools to the curriculum.
- Educators' lack of expertise; and
- Allowing ICT technologies to dictate what needs to be done without being led by goals, teaching, and learning.

However, it has already been proven that the use of ICT technologies in mathematics teaching and learning is limited for the following reasons:

- Insufficient help, encouragement, and training.
- Insufficient funding.
- Uncertainty or doubts regarding the value of using ICT tools in teaching and learning; and
- A lack of awareness about appropriate available resources.

Briefly, the following five concepts outline how technology can be used to improve teaching and learning:

- Exploration: New concepts and applications can be investigated using technology.
- Computation: Students can use technology to work with rich examples, practical applications, and large data sets.
- Communication: Technology can improve communication between students and teachers both within and outside of the classroom.
- Assessment: Technology can give students more chances to demonstrate their knowledge and understanding and improve the effectiveness of formative and summative tests. This issue will be discussed more below.
- Motivation: Using technology can help students become more engaged and motivated.

Students are more likely to persevere and achieve when they take charge of their learning. This ownership can be promoted through pedagogical practices, engaging students in studying and discovering ideas, solving problems, communicating their ideas to others, and reflecting on their thinking. Seeing the mathematics, they are learning applied to real-world situations is a tremendous motivator for many students. Students can use technology to deal with more practical maths applications and more precise data. The scale could range from a modest classroom activity to a substantial student effort. Indeed, there is a growing interest in using apps and technology to introduce and motivate kids to study mathematics.

Furthermore, when students work with large data sets or perform complex computations in mathematics classes, they can apply what they learn to projects in other departments. Pupils look more inclined to attempt things again, more playful, and less frightened of making mistakes while utilizing technology. By-hand solutions may be perceived as difficult and error-prone by students, causing them to be more cautious when working by hand. Because the electronic world is more private, it is less threatening.

6. Departmental Issues

Math departments are responsible for investigating how their curricula might or should be altered due to technological advancements. They can work on technology and curriculum in various ways, including department committee research, external reviews, asking and receiving grant funds, and institutional requirements. We believe that, for the best results, this programmatic activity should include input from all department stakeholders as well as education of everyone on what technology is available and what possibilities exist in the department's environment. Individuals should not feel excluded because they lack experience or interest in using technology, nor should we assume that these categories are invariably related to age.

The potential of technology instruments to improve mathematical learning and instruction has lately received widespread recognition. The paper (Serin & Oz, 2017) shows that when teachers include technology in their teaching approaches, pupils' mathematical learning improves dramatically. It was discovered that the utilization of excellent presentations via technology gadgets significantly inspired pupils and enhanced their mathematical proficiency. This demonstrates that the availability of technology equipment, instructor attitudes, simple access to information, and, most significantly, teacher abilities in properly employing technological devices are critical aspects that can help learners grasp mathematical ideas.

We encourage collaborative practices, shared learning, and demonstrations by lecturers who have effectively employed technology instead of coercion. It is crucial to select simple entry points for new users: essential areas where technology saves time, additions to what they currently do (such as illustrating rudimentary Riemann sums and integral computations), and simple ways to engage students more actively during class.

Suppose technology is used in an exam (such as an open-ended question). In that case, students should be forced to define the process and goal of each computation, analyze the outcome, and explain its significance. An exam question can show the result of a calculation and ask students to explain and interpret it. Higher-order, philosophical concerns that technology cannot address should also be provided for students. With this technology, we should all be able to up our "game" and our students' expectations. Simultaneously, we must carefully raise our students to the level we aspire to. Not everything must take place at the departmental level. Departments should also support individual lecturers' efforts to discover or invent novel and helpful technology uses in the classroom. This can be accomplished by encouraging individuals, particularly younger faculty, to explore and take reasonable risks when using technology. Several methods are in place to provide incentives and rewards to those working on curriculum and teaching in new ways. This type of activity should undoubtedly be recognized in annual teacher evaluations. Some universities provide internal course development subsidies to their lecturers.

There is a focus on innovation and a campus-wide group of judges judges' applications. The popularity of online courses has recently increased. In some colleges, teaching accolades are awarded to teachers by institution-wide committees to recognize their achievements in the classroom, including technical advancements. Reasoned technological experimentation should be encouraged and supported. Identifying the risks of any invention in its early stages is vital, and institutional motivation to learn from mistakes and improve should be in place. They are causing technological issues in departments where part-time adjuncts teach most of the time. These educators might need help using the technology. More importantly, they may require technological assistance to supplement rather than replace their mathematical ideas.

Internal factors such as available resources, organizational culture, faculty training, the expected level of opposition, and deviation from the norm can all influence higher education technology adoption rates and levels. Training, time commitments, and academic freedom are examples of technological support resources in addition to money. The authoritative personalities and regulations of the institution are linked to the organizational culture, which may influence technology utilization. Universities must provide recommendations to faculty members to boost their openness to use technology while minimizing resistance. Higher education administrators should consider introducing more technology but should also be aware of faculty reluctance and design strategies to help them transition. The final factor to consider when adopting technology is how it will allow instructional approaches to diverge from the norm. The researchers discovered that increasing faculty awareness of technology's potential, demonstrating the relevance of implementation, fostering confidence through mentoring, and rewarding excellent technology use increased the amount of technology used in higher education mathematics classrooms. Like any other new initiative, technology integration must be well planned by university administration and staff to ensure that technology is supplied and used as efficiently as possible.

Cohesive training programs must be created "with an emphasis on learning and provide enough technical assistance to aid faculty in integrating technology into instruction" for technology integration to be successful for higher education faculty. Teachers must be willing to move their classrooms from teacher-centered to student-centered to fully employ technology—teachers' skill requirements "transition from instructional delivery to instructional design" due to technology integration. Lecturers must be able to tie technology to the topic they teach to focus on instructional design. Students will benefit from integrating technology into subject understanding when they enter the industry and interact with technology related to their field (Walker, 2014).

Finally, we will discuss how technology affects institutional infrastructure. While specific technological applications impose new expenses, there may also be some savings. We believe advancing technology in mathematics education is critical for our field. Ignoring technology is ignoring the future.

7. Discussion from a Sustainability Perspective

To safeguard the future of our planet, humanity faces enormous global problems. Suppose the goal is to lead students and offer them opportunities for personal satisfaction in the twenty-first century. In such a situation, education should attempt to represent a country's social expectations as well as the requirements of its learners. However, the current educational system, which was formed in the intellectual culture of the Enlightenment and actively pushed as a result of the improved economic circumstances brought about by the Industrial Revolution, fails to satisfy the demands of many modern cultures, some of which are extremely technological.

The incorporation of technology into university-level mathematics education and learning raises the bar for lecturers, lecturer educators, and curriculum developers. Additionally, because it brings new representations, new means for students to demonstrate their knowledge and further mathematics, it places new expectations on researchers. Designing technology-intensive curricula or technical mathematics tools has several challenges, including the need to capitalize on new representations, manifestations of student comprehension, and distinctive mathematics while keeping an eye on research lessons. The development of software and curriculum in the past has resulted in tools and programs whose characteristics have been fashioned by theory and research and whose effects on the teaching and learning of mathematics have been verified by formative and summative research (Blume & Heid, 2008).

To integrate technology sustainability into university curricula, students must first develop critical knowledge contextualization skills. Thus, it implies instruction in which knowledge generation and idea transmission are critical, reflective, and democratic (Moreno-Pino et al., 2022). On the other side, including sustainability in university courses allows students to achieve competency in implementing ethical concepts connected to sustainability ideals. As a result, it views social cooperation education as one in which connections with others are marked by respect, accountability, and solidarity—values that are consistent with the global perception principle. Furthermore, data analysis and comparison revealed the identification of components necessary to drive mathematics education training when focused on sustainability (Atasoy et al., 2015).

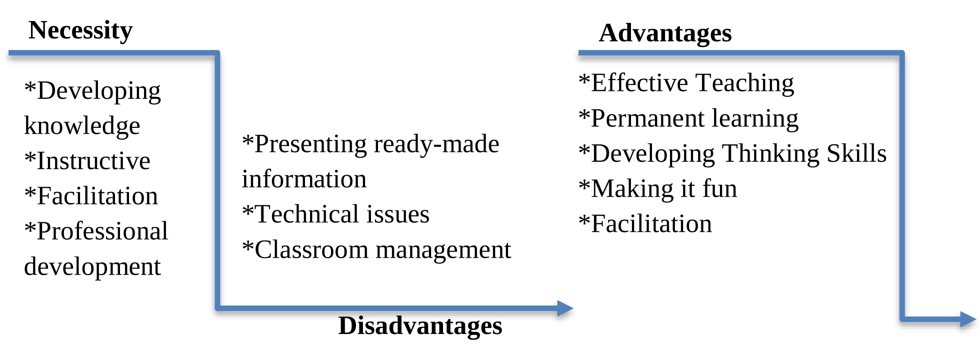

Table 3: Lecturers' perception views on technology use

8. Digital Assessment

Assessment is important in many areas of education, not just mathematics. Student evaluation can take several forms, including summative and formative assessments. Since summative evaluations are designed to evaluate students' learning, skill growth, and accomplishment after the conclusion of training, they are commonly used as a tool for higher levels. Formative assessment is "the process by which teachers and students observe and respond to student learning to improve learning while learning." Traditionally, mathematical evaluation, particularly summative assessment, has been limited to pen-and-paper assignments. At the same time, all pupils accomplish similar activities (Drijvers et al., 2016). A human assessor, generally the student's math teacher, grades student work. Partial credit is widely used in grading: if a student commits an error in a series of actions or manipulations, the assessor may allocate a percentage of the total credit available for the assignment.

The digital assessment paradigm challenges the traditional assessment by giving new opportunities for formative and summative mathematics evaluation. The transition from print to digital media may affect the form of assignments, grading, and even the sorts of talents and skills tested. A common concern is how frequently online digital testing is supplied and completed, which impacts the skill set, assessment goals, tasks, assessment validity, and dependability.

A regular written test can be used to assess technology, and students may use technology such as graphing calculators. A similar paradigm is used in final national examinations in several countries. When technical means are utilized to provide and administer the exam, a technological evaluation is performed. The latter is typically evaluated via an online test. This section mostly focuses on technology-assisted evaluation, but it is not wholly so. Because technology may provide precise information about people's strengths and shortcomings in the form of an overview or an individual diagnostic, it impacts how teachers respond to student responses and how they apply penalties.

9. Recommendations for Further Studies

We should focus on the following points.

- The presence of a link between the use of ICT tools and ICT policy.
- An effective approach to ICT tool training for teaching and learning.

To foster mathematical thinking, teachers must incorporate hard and thought-provoking tasks and assignments in their lessons, and they must pay particular attention to classroom management. Predicting technology's influence on mathematics education is impossible ten years in advance (Drijvers et al., 2016). We can only speculate on future technologies and how to present ones that may grow to provide even more opportunities for learning and teaching. Because anticipating future technologies is difficult, predicting what might be achievable in mathematical education is impossible. Nonetheless, there is a potential to develop principles that will lead to future technological advancements. Think tanks and educators can be brought together on the abovementioned topics, and workshops can be organized.

10. Conclusion

The topics discussed here are not meant to be the end of the discussion for the reader. To make mathematics instruction in higher education more sustainable, it is necessary to carefully examine the ideas that impact instructional practice in the first training of math teachers using sustainability principles. Education for sustainable development is essential in higher education degrees because it allows professionals to act as change agents and social transformation agents.

Although it is known that the subject is not academically clear, we want to underline some important points as follows.

- Especially every environment that shows resistance to change should be dealt with closely, and training courses should be organized to pave the way for using these opportunities in a balanced and beneficial way.
- If necessary, some updates should be made to the curriculum, and the work of both students and lecturers should be facilitated by adjusting in parallel with technology.
- Absolutely at all levels, orientation programs and technological opportunities should be introduced, ways of making use of it at the most uncomplicated and basic level should be explained, and it should be shown in practice that it is easy to use. And in this context, as mentioned in the article, volunteer virtual mentors should be at work.
- Universities should cooperate with reliable and well-established companies that can offer them support, convenience, and new developments to use technology sustainably in math education. Continuous feedback should be obtained from students and lecturers on this subject; accordingly, updated studies and other studies should be directed.
- *Supply and Demand:* There is no doubt that this issue is also considered an economic model. The acceptance of this case, the rate of increase in its use, and new needs will reveal the latest technologies and try to meet them. Of course, everyone will be tested to be happy by increasing the development level with the feedback taken. While it is seen that the future is the age of technology, there is no escape from this issue; on the contrary, it is helpful to dive into the subject and get used to it as soon as possible. If the problem is mainly considered from an economic point of view, it will be a mistake and out of sustainability. In this regard, belief, and the feeling of being able to cope with the difficulties should outweigh. Government support should be provided to all private and public universities if necessary. After all, the main issue is to raise people who know and love mathematics, which is our future and will contribute to developing a country.
- It should be considered that some problems may arise from using technology sustainably, and psychological support services should be provided to students accordingly. Subjects such as traumas, laziness, ... that excessive use may cause in the brain should not be underestimated.

We anticipate that entering a complex computation into technology will be as simple as writing it down. We envision currently either unreachable or prohibitively expensive models becoming more widely available. Exploration will become more accessible thanks to integrated technologies. Aside from disruptions and adaptability, advancing technology in university-level mathematics classrooms is crucial for the sustainability of the 4.0 revolution. Ignoring technology is ignoring the future.

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Author's Contribution:

We confirm that the manuscript has been read and approved by all named authors. We also confirm that each author has the same contribution to the paper.

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