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Mathematics Teaching in the Digital Age: Teachers' Perspectives on the Use of MATLAB in BCA Program of T.U.

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Abstract

The incorporation of digital tools in the teaching-learning process is transforming the methods of teaching mathematics, which is grounded in logic and computation. MATLAB is a powerful, high-performance language for technical computing, mathematical modelling, data analysis, simulation, etc. The study examines the perspectives on the use of MATLAB in mathematics instruction, highlighting knowledge and use, which has the potential to increase student engagement and improve problem-solving skills. The findings suggest that information and communication technology (ICT)/MATLAB can significantly enrich mathematics teaching. Although 64.8% of the teachers were familiar with MATLAB, only 22.2% actively used it in their classrooms. The study highlights key challenges, including a lack of practical courses, limited resources, and insufficient training. Despite these challenges, most teachers (60.2%) expressed satisfaction with their teaching roles. The analysis revealed a significant association between access to computer labs and familiarity with MATLAB, whereas no significant associations were found between knowledge of MATLAB and age or gender. Teachers believe that enhanced engagement, visual representation of mathematical concepts, and support for self-directed collaborative learning are some of the benefits of incorporating ICT/MATLAB for effective teaching and learning.

Keywords: Teaching, Pedagogy, MATLAB, Mathematics Education

Introduction

In mathematics education, various technological resources can be integrated with teaching strategies, techniques, models, and methodologies to enhance the teaching-learning process. The sharing of information and content through online platforms, participation, collaboration in projects centered around digital technologies and educational software for teaching mathematics has played a pivotal role in promoting the Flipped Learning Model and active methodologies (G´omez et al., 2020). The integration of ICT enhances students' mathematical reasoning skills. The ultimate aim of education is to shape intudent into individuals capable of making sound decisions, solving problems creatively and processing strong reasoning abilities (Al-Hiili, 2019).

Preservice elementary school teachers face a growing demand to provide high-quality mathematics instruction to their students. Two key factors that often affect these teachers are mathematics anxiety and mathematics teacher efficacy (Bosica, 2022). Digital self-efficacy, attitudes, perceptions, gender, experience, and the level of perceived support from the school can enhance teachers' motivation to integrate ICT more effectively into their classroom (Trujillo-Torres et al., 2020).

People consider mathematics difficult, dull, and pointless. Even at the school level, teaching and learning of mathematics are greatly aided by the use of computers as teaching tools, teachers' methods, and students' progress (Bosco, 2004). For the teaching and study of mathematics from early high school to the research level, ICTs such as MATLAB are indispensable (Kilicman et al. 2010). ICT should be connected to mathematics, and mathematics should be shown, demonstrated, and seen as a computer-based process. When ICTs are used to teach and learn mathematics, a teacher's or student's gender has no bearing on the subject, and both need training. In a study by Amevor et al. (2021), rural-based preservice teachers demonstrated that MATLAB-supported learning significantly enhanced students' spatial visualization skills. The findings highlight the role of dynamic visual tools in bridging cognitive skill gaps influenced by socioeconomic factors in rural education.

Primary mathematics teachers in mainland China have demonstrated positive impacts on their technological, pedagogical, and content knowledge (TPACK) and attitudes toward ICT during the postpandemic period. While most teachers had adequate nontechnology-related knowledge, they showed a gap in technology-related expertise. Given the extensive online teaching experience during the pandemic, there is a growing need for them to incorporate digital technologies into their instructional practices (Li, 2023). Integrating ICT into mathematics teaching has posed challenges for educators, as it requires enhancing their proficiency with new technologies. The use of ICT in teaching is closely linked to the utilization of digital resources in the classroom, indicating that teachers can make diverse selections of software over varying hardware devices (G´omez-Garc´ıa et al., 2020). Motivational and emotional orientations can play a crucial role in the implementation of digital tools in mathematics education and can be used to group teachers into clusters. Such orientations can be effectively nurtured, although individual differences may influence the outcomes and success of such interventions (Reinhold et al., 2021). Future teachers should focus on incorporating standard-based strategies to create active learning experiences and address the challenges and concerns surrounding mathematics teaching and learning (Chamberlin, 2013). An emerging issue in mathematics education is the professional development of teachers and the promotion of effective training programs. It is necessary to strengthen teachers' practices in relation to the development of mathematical skills (Ramos-Rodr´ıguez et al., 2021). ICT enhances students' interest in learning

mathematics, increases their motivation and performance, fosters lifelong learning, and promotes positive interactions and relationships. However, challenges include limited knowledge of ICT, insufficient training and learning opportunities, and inadequate technical support. The authentic communication frameworks that focus on problem-solving activities improve all aspects of mathematical processes (Lavidas et al., 2022). The majority of mathematics teachers do not incorporate ICT in teaching. However, in marginal areas, mathematics teachers view ICT as a relatively important tool for mathematics teaching (Pradipta et al., 2021).

In our context, some of the programs of Tribhuvan University (TU), such as BCA, BSc-CSIT, BIT, and BICTE, use MATLAB/ICT for practical mathematics, whereas others do not. There are differences in graduate-level mathematics instruction. It is crucial for mathematics teachers to have a foundational understanding of MATLAB or other ICT tools. Many young and dynamic individuals pursuing further education, research, or advanced degrees have the potential to become proficient computer programmers in the future (Mohammed et al., 2013). In general, bachelor's-level coursework includes concepts such as limits, continuity, matrix and determinants, conic sections, vectors, derivatives, antiderivatives and their applications, computational methods, and numerical methods. An improved curriculum, trained teachers, teaching resources in the classroom, information technology, and computers can enhance teaching mathematics to teach numerical simulation, modelling, and programming languages. Mapple, Geogebra, and MATLAB are some of the tools being used by teachers in different parts of the globe, with MATLAB being the most commonly used tool.

Literature Review

Different studies have been conducted on the use of computers in mathematics education in schools and tertiary-level students (Navarra et al., 2010). Mathematical skills can be developed doactically, using different ICT tools such as animation, image processing, worksheets, software, and online resources to demonstrate, interestingly, the geometrical application of linear algebraic issues as well as the intellectual and meaningful knowledge of mathematics (Kilicman et al. , 2010). Games are also useful in tertiary-level mathematics classes (Afari et al., 2012). The use of MATLAB for teaching integral calculus affects students' views and motivations for the use of technology in engineering mathematics, which can improve students' performance, poor mathematics abilities, conceptual comprehension, and positive attitude growth (Mohammed et al., 2013). To deliver high-quality mathematics instruction, teachers need to maintain the knowledge and mental habits necessary for effective instruction (Goldsmith et al., 2014). Their learning is recursive, they grow in one area of their knowledge and practice, and they may lead to further growth in other areas.

There is a reciprocal transfer between the topics, and teaching ICT alongside certain

mathematics subjects, especially algebra, would be advantageous for our children. There are certain advantages to the existing method of using ICT alongside mathematics. Some studies have shown that gender has no effect on how mathematics is taught and learned when ICTs are used (Ameen et al., 2019). Teaching Integral Calculus courses with the help of MATLAB has improved students' conceptual grasp and mathematical performance, promoted favourable attitudes toward computer technology and mathematics (Majid et al., 2012) and fostered a positive outlook on learning mathematics. Integrating technology into mathematics at the higher level introduces new technological and pedagogical challenges, with significant variation in teaching methods, technological proficiency and the level of institutional support available (Nantschev et al., 2020). MATLAB can be used to simulate tasks that include solving differential equations; modelling projects, including simulating heat conduction and the industrial film casting process; and many more processes in scientific and engineering applications (Mutohir et al., 2017). ICT use in teaching mathematics can increase the value of mathematics, interest, and presentations of teachers. ICT-based learning environments are required for practical learning to develop a more successful approach to students' learning (Muhtadi et al., 2017). In a secondary school in Nepal with digital resources integrated into teaching-learning and assessment activities, there was a significant increase in the use of digital tools for mathematics instruction in online classes, which had a substantial impact on student assessment (Joshi et al., 2023).. The use of MATLAB or ICT tools improved students' knowledge and skills in mathematical concepts through computational methods, with significant differences in the effectiveness of teaching mathematics compared with not using them (Trinh et al., 2022). The assessment can be conducted via an achievement exam in mathematics, a motivation questionnaire, and a humor in mathematics education questionnaire. Students with learning disabilities perform better mathematically and are more motivated when humor is used in the classroom.

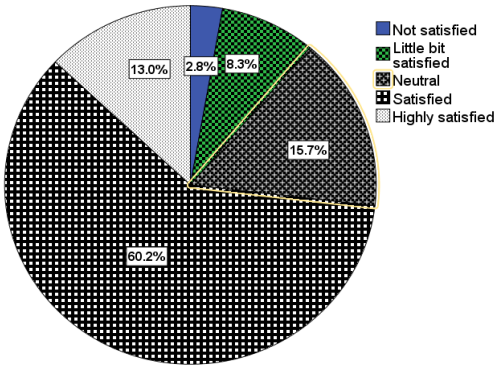
The objectives of this study are to explore the perspectives of teachers of mathematics at the graduate level and popularize mathematics.

Methodology

Here, we use a mixed-method explanatory inquiry that examines both the quantitative and the estimation and improvement of the pedagogical aspects of mathematics classroom activities. The study is theoretically grounded in Constructivist Learning Theory, where students build knowledge through experiences, often facilitated by tools and technologies. We study the integration of ICT tools and this theory examines that how teachers incorporate technology to enhance students' conceptual understanding in alignment with a constructivist approach. The study is also based on Technology Acceptance Model (TAM) developed by Davis (1989) with discussions on teachers' familiarity with MATLAB and their decision to use it. Other related theories for the study are : teacher

motivation and satisfaction theories particularly, Herzberg's Two-Factor Theory which suggests that motivators encourage job satisfaction, while hygiene (environment) factors prevent job dissatisfaction and Self-Determination Theory (Deci & Ryan, 1985) which highlights autonomy, competence, and relatedness as drivers of intrinsic motivation. The study identifies how management support, professional development, and other factors influence teacher satisfaction and openness to using ICT tools like MATLAB. The study also uses gender and demographic theories which focus on gender representation and demographic diversity that influence perspectives, access, and opportunities in professional domains.

Figure 1: Satisfaction of teachers



The descriptive conclusions drawn from the quantitative data are enhanced by the use of qualitative data, offering a more thorough justification for the conclusions. The respondents were teachers of different ages, sexes, occupations, ethnicities, education levels, and residences from different colleges. We have chosen this design to ensure the collection of detailed and precise information regarding teachers' perceptions and experiences in the BCA program. The sample was selected through a systematic sampling method to ensure representation from various campuses running the BCA within the TU. The sample size is determined via the Yamane formula (1967:886), which was cited in Glenn 1992 at the 95% confidence level. The population size of the mathematics teachers in the area under study was 275, with an adjusted sample size of 108. Structured questionnaires were designed for teachers to collect data on multiple facets of teaching and learning processes, such as curriculum content, instructional methodologies, teaching resources, assessment practices, and challenges encountered in teaching mathematics. The questionnaire included demographic details, perspectives on the mathematics curriculum, learning experiences and strategies, access to and utilization resources, difficulties encountered in teaching mathematics, and recommendations for enhancing mathematics education. The collected data were analyzed via descriptive and inferential statistical techniques, including frequency, percentage,

Figure-2: Teaching Experience of the Teachers

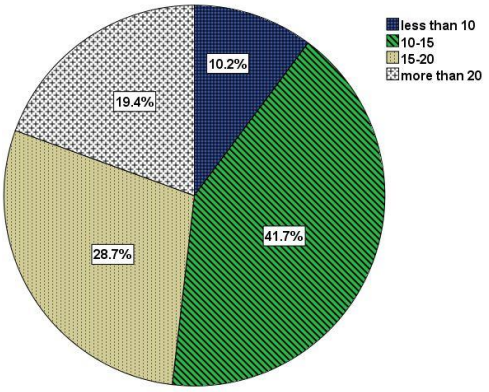


Table-1: Crosstab: Availability of Computer Lab and knowledge of MATLAB

Knowledge of MATLAB	lab at campus		Total
	Yes	No	
Yes	57.4	7.4	64.8
No	25.9	9.3	35.2
Total	83.3	16.7	100

and chi-square tests, via IBM SPSS-22 software, and the results were then interpreted to provide insights into the current state of mathematics teaching.

Results

This section presents the findings of the study, demographic information of the respondents and information gathered from their responses to the survey. The respondents represented a wide range of age groups: 24.1% were aged 40-50, 24.1% were aged 30-40, and 22.2% were aged 50-60 percentage of teachers younger than 30 years of age indicate that either they are less interested in teaching or have not received an opportunity for teaching. Most of the respondents (54.6%) were *Bhramin,* followed by 13.8% *Kshetrti* and *Madhesi*, 7.4% *Janajati*, 1.9% *Dalit*, and 8.3% other. The gender representation was significantly skewed, with 93.5% male and only 6.5% female teachers. The teaching experience of the respondents varied significantly, with only 10.2% having less than 10 years of experience, 41.7% having 10-15 years, 20.8% having 15-20 years, and 19.4% possessing more than 20 years of teaching experience in mathematics.

In terms of familiarity with MATLAB, 64.8% of the respondents reported having knowledge of the software, whereas 35.19% indicated no knowledge of MATLAB (Table-1). However, among those familiar with MATLAB, only a limited number (22%) actively incorporated the skill into their teaching and shared it with their students (Table-2).

Table-2: Use of ICT/MATLAB skill in the classroom by the teachers

Use of MATLAB in the classroom	Percent
Not using in the classroom	45.4
There is no practical course	10.2
Using it and making them familiar with the mathematics concepts	22.2
Will use whenever necessary	19.4
Other	2.8
Total	100.0

This shows that many teachers are not familiar with the ICT and that even familiar teachers are not using it to improve the teaching learning process, which could enhance the quality of mathematics education among students.

The majority of teachers (52.8%) had a

master's degree in mathematics, followed by 23% who held a master's degree and M.Phil., and 19.4% had a PhD in mathematics. Additionally, 2% of the teachers had an academic background in IT, whereas 2.8% had other disciplinary backgrounds.

There is no genderwise difference in the knowledge of MATLAB due to the observed qualitative approaches. A more complete understanding of the phenomenon under study and more precise research results are needed.

We are interested in their self-perceptions of mathematics and the use of ICT for effective classrooms as mathematics teachers. With respect to the participating teachers, most of the teachers (60.2%) were satisfied with the teaching, 13% were highly satisfied, 8.3% were slightly satisfied, 2.8% were not satisfied, and a significant percentage (15.7%) of the teachers were neutral. The percentage of high satisfaction is significantly low for teachers teaching ICT. The high satisfaction levels of teachers are attributed to their strong foundational knowledge of mathematics, ease of applying these concepts, the joy they derive from teaching, and their passion for disseminating knowledge to students. Many teachers view teaching as a passion and hobby, combined with social prestige and recognition associated with the profession. Conversely, the reasons for dissatisfaction are the need for in-depth preparation and extensive interaction with students and the preserved lack of respect, low salary and challenge involved in making complex mathematical concepts understandable.

This is an indication that not only students, guardians, and the public but also teachers lack interest in mathematics teaching. This challenge results in an interasymptotic significance of 0.002 at the 95% confidence level. Teachers of mathematics are from different backgrounds and have different skills in ICT or MATLAB. According to the survey, 64.8% of the teachers knew about MATLAB, and only 35.6% did not know about it. This finding indicates that there are factors other than the knowledge of MATLAB, which makes mathematics teaching less interesting.

The sample size of the study consists of 108 mathematics teachers determined via the Yamane formula (1967:886), which was cited in Glenn 1992 at the 95% confidence level. The population size of the study was 275, and the sample size was 108. Purposive sampling techniques are used to select the respondents for focus group discussions (FGDs) and key informant interviews. A structured questionnaire and interviews were conducted with mathematics teachers to collect information on use, applications, lab status, teacher responses, and management support for lab work. FGDs were conducted with teachers and students. The published and unpublished journals, research, reports, dissertations, publications of related authorities, internet surfing for national and international records, etc., are assessed as secondary data collection. We interviewed the college management of the BCA programs. For data analysis, we used IBM SPSS Statistics 2022.

The chi-square test was employed to examine the association between management support and job satisfaction.

The analysis yielded a *p* value of 0.014, which is below the conventional significance level of 0.05. This result indicates a statistically significant relationship between job satisfaction and management support.
On the other hand, the chi-square test did not reveal a statistically significant association between the age of the teachers and their knowledge of MATLAB, with a *p* value of 0.191. Similarly, there is no significant association between gender and knowledge of MATLAB, in which case the two-sided asymptotic significance is 0.66, which is much greater than 0.05.
A significant association was observed between the availability of computer labs at the campus and the teacher's knowledge of MATLAB, which suggests that access to such resources positively impacts familiarity with the software as well as knowledge and skill. A total of 64.1% male and 3.4% female respondents said that they have knowledge of MATLAB, whereas 32.4% male and 2.7% & female respondents do not have knowledge of MATLAB.

Table-3: Cross tabulation: knowledge in MATLAB versus gender (in percentages)

Knowledge of MATLAB	How old are you? < 30	30-40	40-50	50-60	> 60	Total
Yes	3.7	15.7	27.7	16.7	1	64.8
No	1	8.3	16.7	5.5	3.7	35.2
Total	4.7	24	44.4	22.2	4.7	108

Table-4: Cross tabulation: knowledge of MATLAB versus age of teachers

Knowledge of MATLAB	Gender Male	Female	Total
Yes	61.4	3.4	64.8
No	32.5	2.7	35.2
Total	93.9	6.1	100

Most of the teachers were 40-50 years of age, followed by 30-40 years of age. Very few young mathematics teachers aged less than 30 years and senior teachers more than 60 years were included in the study.
Encouraging young people in teaching is an issue, as the number of students has declined at the bachelor's, master's and MPhil levels.
The barriers to teaching mathematics are mentioned in the dichotomous format (Table 5), where a value of 1 indicates the presence of a specific barrier and *N* refers to the total number of responses recorded in the multiple response table.

Table-5: Barriers to teaching mathematics

Barriers of teaching mathematics	Responses *N*	%	% of cases
Lack of trained Math teachers	68	20.6	63.0
Lack of motivation	53	16.1	49.1
Lack of proper curriculum	39	11.8	36.1
Lack of proper evaluation system	35	10.6	32.4
Lack of proper foundation of maths concepts at +2 level	48	14.5	44.4
Political interference	49	14.8	45.4
Lack of horizontal and vertical linkage in curriculum	34	10.3	31.5
Other	4	1.2	3.7
Total	**330**	**100**	**305.6**

Responses regarding the evaluation system of the university are perceived in different ways by the teachers. The respondents believe that there are significant issues with a lack of practical aspects and lab work (27.3% of the respondents and 60.2% of the cases), a lack of providing assignments and feedback (19.3% of the responses, 42.6% of the cases), weak internal exams (18.9% of the responses and 41.7% of the cases), weak external exams (15.5% of the responses and 34.3% of the cases), a lack of managing student attendance (13.4% of the responses and 29.6% of the cases) and no issues (5.5% of the responses, 12% of the cases), indicating that universities must improve practical, external and internal exams, feedback and assignment, and student attendance systems. The teaching method plays a crucial role in the teaching-learning process. In the opinion of teachers, following the dichotomy group tabulated for the value of 1 (Table-6) gives the teaching method used by teachers. A large number of teachers (33.3%) use the lecture method in technical subjects such as BCA. Only 19.6% use participatory methods and ICT. Only 34% of the teachers provide basic concepts first, and then they move to excers. Very few (13.1%) use critical thinking strategies in teaching, which is considered one of the best methods. This indicates that we need to improve the teaching methods used by teachers.

Table-6: Teaching methods used by the teachers

Teaching methods used	Responses		Percent of cases
	N	%	
Lecture method	51	33.3	47.2
Participatory/ practical/ IT/ICT	30	19.6	27.8
Critical thinking and participatory learning	20	13.1	18.5
Basic concepts, examples and then exercise	52	34.0	48.1
Total	**153**	**100**	**141.7**

The government should conduct national or provincial training focused on mathematics education to increase teacher quality and ensure that the curriculum is coherent, practical, and aligned with modern educational standards. Additionally, financial and professional incentives should be provided to motivate teachers, implement continuous and formative assessments to better support student learning, strengthen the teaching of foundational mathematics at the secondary level to prepare students for advanced studies, and ensure institutional governance and transparency.

Discussion and recommendations

The findings highlight several key insights, including the limited utilization of MATLAB in BCA. Some of them are resource constraints, demographic trends, job satisfaction and management support. Although 64.8% of the teachers were familiar with MATLAB, only 22.2% used it in their

teaching. This indicates a gap between awareness and practical application, which is consistent with similar findings by Pradipta et al. (2021). Teachers cited the lack of practical courses and insufficient access to computer labs as significant barriers to incorporating MATLAB into their classrooms. Most teachers are aged 40-50 years, with few young professionals entering the field. This suggests a need to attract and retain younger talent in mathematics education. While 60.2% of the teachers expressed satisfaction with their teaching roles, only 13% were highly satisfied, reflecting underlying challenges such as resource limitations and insufficient training opportunities. A significant association was found between management support and job satisfaction, underscoring the importance of institutional support in enhancing teaching effectiveness.

On the basis of the results of the study, there are some of the recommendations to universities, government entities and related stakeholders. There is a need to improve teaching methods, class observation, evaluation, enhanced physical infrastructure, professional development, curriculum revision, encouraging youth talent in teaching, and promoting ICT usage and management support are some of the major factors to be improved. Similarly, computer labs, workshops, competitive incentives and mentorship opportunities, teacher support from college management, access to resources, recognition of innovative teachers, improvement of job satisfaction are to be improved. Broader awareness campaigns on the use of ICT tools in classrooms should focus on their potential to enhance student engagement and learning outcomes, recruitment and retention, and managing gender equity. Governments and institutions should prioritize funding for the establishment of well-equipped computer labs and access to necessary software, ensuring equal opportunities for teachers and students to engage with technology-enhanced learning. Policies should address the decline in young professionals entering mathematics teaching by offering incentives, professional growth opportunities, and a supportive teaching environment. Efforts should be made to promote gender balance among mathematics educators through targeted recruitment and support programs, addressing the current underrepresentation of women and addressing job satisfaction concerns. The curriculum is coherent, practical, standards, financial and professional incentives to teachers, continuous and formative assessments, teaching of foundational mathematics at the secondary level, and ensure institutional governance and transparency are some of the way forwards for better mathematics teaching and learning.

Conclusions

The use of ICT, particularly MATLAB, enhances the educational quality among students and increases interest in teaching compared with not using ICT. The study concludes that the integration of MATLAB into classroom instruction remains limited although the majority of mathematics teachers at the BCA level are familiar with MATLAB. The primary causes of this gap are the lack of practical courses, insufficient

management support, and inadequate access to resources. Teachers with access to computer labs demonstrated significantly greater familiarity with MATLAB, emphasizing the importance of institutional infrastructure. Teachers' satisfaction levels were also found to be influenced by management support. There is a need for training, demonstrations and evaluations of the teaching methods used by teachers; for practical, laboratory, and critical thinking approaches; and for conceptual clarity with the use of ICTs. These findings focus on the critical need for targeted interventions to foster the use of MATLAB in mathematics education.

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