Information and Communication Technology in Mathematics Education – Integration Readiness in Tanzania Higher Education Institutions

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Abstract. The use of ICT tools in mathematics instructions has been proved to have a positive impact on students' success. However, little is known about the ICT readiness of both teachers and students to incorporate these tools in mathematics teaching-learning process. This study investigates the readiness of teachers and students to integrate ICT in mathematics teaching and learning at a higher education institution in Tanzania. Specifically the study assesses the device, skills and psychological readiness of teachers and students to integrate ICT tools in mathematics instructions. The study employs both qualitative and quantitative methods whereby data are collected through interviews and questionnaires respectively. Seven teachers and 129 bachelor degree students pursuing business studies, form the study population. Descriptive statistics are used to analyze the quantitative data while qualitative data are analyzed through content analysis. Results show that teachers and students have device, skills and psychological readiness to integrate ICT in teaching and learning of mathematics. This is significant as it provides information that will be useful in planning the use of ICT tools to benefit teaching and learning. This study contributes to transfer and diffusion of technology discourses.

Keywords: ICT · Readiness · Mathematics · Higher education

1 Introduction

The use of Information and Communication Technology (ICT) in teaching and learning has brought a new experience for both teachers and students in different countries. According to Baya'a and Daher [1], incorporation of ICT tools in mathematics instructions provides teachers with integrative methods that stimulate students' active

and independent learning. These tools include computers, mobile devices, internet facilities, online tools and mathematical software packages. In Tanzania, the College of Business Education (CBE) has made several efforts to achieve the integration of ICT, in terms of provision of desktop computers, installation of projectors in classrooms and internet facilities. The reason for providing ICT facilities lies within the promises of ICT in improving teachers' productivity and student learning achievement.

Previous research shows that the use of ICT tools in mathematics classroom has an impact on student outcome [2]. These tools provide students with a learning platform for multiple representation of mathematical concepts and procedures that help them gain a deeper understanding of the subject [1]. According to Agyei and Voogt [3] the use of ICT tools encourage students to explore and understand mathematical concepts, hence promote higher order thinking and problem solving skills. These potentials make the use of ICT tools in mathematics teaching and learning a promising practice. However, in Tanzania teachers rarely use these tools for teaching purposes [4]. Besides, the success of ICT integration in the classroom depends on the teacher's readiness to incorporate these tools into the curriculum and use them to improve student learning [5].

Researchers Miglani and Awadhiya [6] pointed out that successful implementation of technology requires coordinated efforts by both, teachers, students and the school management. This allows the incorporation of their voices into the planning and implementation of ICT to maximize the acceptance of technology [7].

Technology is changing and new tools are evolving every day so new research is necessary to incorporate the changing needs of the user's in the ICT implementation. Besides, few researchers have examined ICT readiness in education in Tanzania [4, 8, 9]. These studies have shown that, teachers use ICT in various ways, but revealed low uptake in teaching and learning. Furthermore, these studies were limited to teachers and overall school infrastructure. In this study, we investigate teachers' and students' readiness to integrate ICT in teaching and learning of mathematics at a higher education institution in Tanzania, the CBE. Specifically, the study investigates the usage patterns (device and skill) and psychological readiness (perception on suitability and readiness) of teachers and students at CBE.

The relevance of this study is highlighted by providing an understanding of the perspective of teachers and students in a higher education institution in Tanzania regarding their readiness to integrate ICT in mathematics lessons. The college management and other stakeholders would be able to use the findings to more effectively target teachers and students needs and prioritize their technology investments to benefit the teaching-learning process. This contributes towards technology transfer and diffusion discourses in the context of higher education in a developing country. To achieve the objective of the study, the following research questions are addressed:

  i. What are the usage patterns of ICT tools for the CBE teachers and students?
 ii. What are the teachers and students perceptions on the suitability of integrating ICT in mathematics teaching and learning at CBE?
iii. What are the views of teachers and students on the readiness to integrate ICT in mathematics teaching and learning at CBE?

2 Related Literature

2.1 ICT in Teaching and Learning of Mathematics

Many studies have been carried out worldwide in the area of integration of ICT tools in mathematics education. Some of these studies have pointed out many useful ICT tools that improve the teaching and learning of mathematics. Examples include; tools like Personal Computers (PCs), laptops, Palmtops, mobile phones, and scientific calculators. Other tools are projectors, interactive whiteboard, data handling software, graphing applications, online demonstration tools such as Java Applets [10], and simulation programs. The study by Chinwoeke [11] advocates that effective use of interactive whiteboard can transform the students-teacher classroom interactions, allowing for discussion and analysis that enhances students' inquiry and reasoning skills. Bature [2] also states that effective use of ICT improves the process of teaching and learning, problem solving skills and motivates students to learn. Conversely, the results presented in Safdar et al. [12] show that ICT was not an effective teaching strategy in public secondary schools due to scarcity of ICT tools.

Studies conducted in Tanzania revealed several challenges hindering effective teaching of mathematics. These challenges include scarcity of reference and textbooks; teaching aids such as graphical visualization tools, and models; teaching mathematics as an abstract subject; and inadequate students support due to overcrowded classrooms [13]. ICT if effectively used can help teachers and students overcome some of these challenges thus enhancing the teaching-learning process, and consequently students' performance. However, for this to occur teachers and students should have access to ICT tools and possess the necessary skills for incorporating these tools in the teaching and learning of mathematics.

2.2 ICT Readiness in Mathematics Education

Readiness can be defined as the availability of capabilities and resources to perform a particular task requiring specialized skills and infrastructure [6]. Previous studies on ICT readiness covered various aspects of readiness that include; school infrastructure, skills, device, budget, psychological [4, 14, 15], and technological readiness [16]. In this study, we focus on device, skills, and psychological readiness. In line with Miglani and Awadhiya [6] we assess device readiness based on the availability of ICT devices such as a smartphone, computers, internet capability, and various software. Skill readiness is assessed based on the activities performed by the use of ICT tools. Psychological readiness focuses on the perceived readiness and suitability of using ICT tools in the teaching and learning of mathematics.

The study conducted by Ngeze [8] surveyed secondary school teachers regarding the schools ICT readiness in Tanzania and found that schools had inadequate infrastructure. Their findings also show that 77% of the surveyed teachers possessed either a laptop, a smart phone or both and they were ready to use such tools in the teaching - learning process but they lacked skills. Another study carried out in Tanzania secondary schools by Mwalongo [4] revealed that teachers used ICT tools for teaching purposes but such use did not transform their pedagogical practices. A study conducted

in Kenya by Joseph [17] found the inadequate infrastructure and poor internet connection in colleges. Teachers and students lacked skills to use technology in teaching and learning.

In summary, studies on ICT readiness show that, teachers possess ICT tools and are using them to benefit teaching, personal use and administrative tasks. However, most of these studies focus on elementary, primary and secondary school teachers. Few higher education studies conducted outside Tanzania indicate a low level of ICT readiness among students and teachers due to lack of skills and infrastructure. Nevertheless, the readiness of students and teachers towards ICT integration in mathematics instructions in higher education, in Tanzania, is not clear. The current study is proposed to investigate teachers and students' readiness to integrate ICT in mathematics instructions in higher education institutions, the case of CBE.

3   Methodology

A parallel convergent mixed research approach was adopted. We have combined qualitative and quantitative methods to achieve a comprehensive view of the problem. These methods complement each other's weaknesses and strengths [18] and yield a thorough analysis.

The study was conducted at the CBE Dar es Salaam campus, Tanzania. The participants in this study were seven mathematics teachers and 129 first year bachelor degree students enrolled in business mathematics course in 2017/2018. Two hundred and fifty questionnaires were administered to students, 179 were returned. However, 50 were excluded from analysis because they were not dully completed. Therefore, 129 questionnaires (51.6% of the total administered) from students and seven questionnaires from teachers were subjected to analysis. The students were pursuing business studies, notably, business administration, marketing, accounting, procurement and supplies in both full time (82) and evening classes (47).

Data were collected by means of the questionnaire and interviews. The questionnaire contained 32 items, consisting of closed-ended and five point Likert type items based on a scale from "1 = strongly disagree" to "5 = strongly agree". Two readiness constructs related to psychological readiness [6], were considered: perceived suitability sample statement: It is suitable that I can use ICT tools to learn anywhere, anytime, and perceived readiness sample item: I am ready to integrate ICT in teaching and learning of business mathematics. The Cronbach's Alpha reliability scores for perceived suitability and readiness was adequate as the values ranges between 0.82 and 0.83. Other questions asked for information such as types of ICT tools (Device readiness) and usage pattern of the tools (Skill readiness). Student class representatives facilitated the delivery and collection of questionnaires from other students. Qualitative data were collected through individual interviews using open ended questions such as what kind of ICT tools do you own? What kind of activities do you do? Followed by probes. Five face-to-face interviews with mathematics teachers and seven telephone interviews with student class representatives were conducted. The interviews were audio recorded and transcribed verbatim. The trustworthiness of the study was ensured through the use of member checking and multiple data collection techniques. Respondents were assured of voluntary participation, confidentiality and anonymity.

Descriptive statistics including percentages, mean and standard deviation were used to analyze quantitative data using SPSS version 23. Content analysis was used to analyze the qualitative data. At first, each data transcript was read from the beginning to the end. Then, the transcripts were re-read this time highlighting text that appeared to be related to, for example an ICT tool or how it was used, and writing a keyword or phrase that seemed to capture aspects of ICT readiness. After coding of five transcripts, preliminary codes were identified which were then used to code all the transcripts. The codes were then reviewed to ascertain the relationship with the original data while allowing new ones to emerge. Finally, the final codes were used to describe major issues pertaining to ICT readiness in relation to each research question.

4 Results

4.1 ICT Usage Patterns

Regarding the study, research question - what are the usage patterns of ICT tools for the CBE teachers and students? We gathered information about the type of devices used by both teachers and students (Device readiness) and the usage patterns (Skill readiness).

Device Readiness. Device readiness was assessed based on the possession of different ICT tools with internet capability and various software by both teachers and students. The results are shown in Table 1:

Quantitative Results. As indicated in Table 1 the majority of respondents own laptops (100% teachers and 86% students) and/or smartphones (86% teachers and 82% students). Furthermore, 71% of teachers and 33% of students own desktop computers with internet connectivity and 100% of teachers and about 1% of students own iPads. Although about 52% of the student own normal mobile phones, these are used along with either smartphone, laptop or desktop computers.

Qualitative Results. To explore the respondents' views further, the analysis focused on their comments about the types of ICT tools and software. Concerning ICT devices, their narratives fell into four categories: (1) smartphones (2) laptops (3) desktop

Table 1. Device readiness

Types of ICT tools	Teachers (N = 7)		Students (N = 129)	
	N	%	N	%
Laptop	7	100	86	66.7
Smartphone	6	85.7	106	82.2
Desktop PC (Internet)	5	71.4	49	38.0
Tablet	1	14.3	43	33.3
IPad	7	100	1	0.8
Mobile phone (Internet)	3	42.9	70	54.3
Normal mobile phone			67	51.9
Software (Presentation, word and data processing)	3	42.9	64	49.6

computers and (4) mobile phones with or without internet connectivity. The themes are evidenced by the following quotes: "I use a laptop and smartphone" (Student), "I have a desktop computer, laptop and smartphone" (Teacher).

Skill Readiness. Skill readiness was measured based on the activities performed through the ICT tools. Table 2 shows the different activities performed by respondents through ICT tools.

Quantitative Results. As per Table 2, apart from conventional use (making phone calls) teachers and students use ICT tools in ways that can benefit online teaching and learning. For example, widely reported activities included uploading and downloading teaching and learning materials (100% of teachers and about 83% of students), Internet search (about 86% of teachers and 77% of students), checking and sending emails (about 86% of teachers and 77% of students), social networking (57% of teachers and 78% of students) and sharing educational resources (71% of teachers and 70% of students). Furthermore, teachers have also reported to use their ICT tools for the preparation of notes and student results (100%).

Qualitative Results. Findings from the interviews are in agreement with themes stated in the questionnaire concerning respondent's usage patterns of the ICT tools. Respondents' answers, revolve around (1) internet searching, (2) downloading materials, (3) viewing and listening to music and videos, (4) sharing of learning resources, (5) social networking, (6) chatting (7) typing notes, (8) drawing graphs (9) solving mathematical problems (10) email and (11) making phone calls. In addition, issues related to the use of specialized mathematics software such as MATLAB, R, and MAPPLE also emerged. Quotes from two interviewees support the findings:*"(I use my phone)…to chat, share learning materials and information with my fellow students… search for learning materials… YouTube, Google… social media…listening to music and watching movies"* (Student); *"I usually download notes…I type notes, prepare results… share materials…I use MAPPLE, MATLAB and R for graphing and solving equations."* (Teacher).

Table 2. Usage Patterns of ICT tools

Activities performed using ICT tools	Teachers (N = 7)		Students (N = 129)	
	N	(%)	N	(%)
Watching online educational videos	7	100	87	67.4
Sharing educational resources	5	71.1	91	70.5
Chatting	4	57.1	100	77.5
Checking and sending email	6	85.7	96	74.4
Internet search	6	85.7	100	77.5
Uploading/downloading-teaching, learning materials	7	100	107	82.9
Social networking	4	57.1	101	78.3
Prepare notes and results	7	100		
Making calls	5	71.4	101	78.3
Blogging	0	0.0	1	0.7

4.2 ICT Integration Readiness

Regarding the study, research questions what are the teacher's and student's perception on the suitability of integrating ICT tools in mathematics teaching and learning at CBE?, and what are the views of teachers and students on the readiness to integrate ICT in mathematics teaching and learning at CBE?. We gathered information about the psychological readiness of the participants through their perceived suitability and their perceived readiness for integrating ICT into their mathematics teaching and learning process.

Psychological Readiness – Perception of Suitability. *Psychological* readiness was categorized into two (a) perceived suitability and (b) perceived readiness to integrate ICT in the mathematics classroom. Respondents' perception was measured on a Likert scale ranging from strongly disagree to strongly agree. The mean score (M > 3) indicates positive perception, the mean score (M = 3) neutral perception and (M < 3) indicates negative perception. The results regarding perception on suitability and readiness to integrate ICT are presented in Tables 3 and 4

Perception of Suitability - Quantitative Results. As shown in Table 3, the majority of teachers and students perceived that incorporating ICT tools in the mathematics classroom provides opportunities for teaching and learning irrespective of time and place (M = 4.08); supports teaching and learning activities (M = 4.20); provides a platform where teachers can distribute and students can access teaching-learning materials and resources (M = 3.88); provides a communication platform (M = 3.67) as well as a discussion platform for both teachers and students (M = 3.87).

Table 3. Perception on the suitability of using ICT tools in the mathematics classroom. SD: Strongly disagree; D: Disagree; U: Undecided; A: Agree; SA: Strongly agree; M: Mean; S.D: Standard deviation. Mean = 3.94, Cronbach's Alpha = 8.2

Constructs of ICT suitability	SD	D	U	A	SA	M	S.D
1. It is suitable that I can use ICT tools to learn anywhere anytime	6.8	3.0	9.0	37.6	43.6	4.08	1.12
2. Using ICT tools would support my teaching/learning	3.8	3.0	6.1	43.2	43.9	4.20	0.93
3. I can distribute/get learning materials, assignments, grades and watch instructional videos via ICT tools	5.9	10.4	6.7	43.7	33.3	3.88	1.16
5. I can chat, call, and use social media features using ICT tools to give/obtain support to students/from my lectures	7.6	15.9	7.6	40.2	28.8	3.67	1.26
6. I can discuss course related matters via online platforms	5.2	9.7	9.7	44.2	31.3	3.87	1.12

Overall, the quantitative data show that teachers and students have positive perception (Mean average of all suitability statements = 3.94) about the suitability of integrating ICT in mathematics teaching and learning at the CBE, Dar es Salaam.

Perception of Suitability - Qualitative Results. About the suitability of using ICT tools in mathematics, qualitative data show that teachers and students find it suitable to integrate ICT in teaching-learning of mathematics. During the interview, their responses pointed to themes related to (1) easy access of notes and books (2) outright support, (3) anytime-anywhere learning, and (4) online submission of assignments. This is evidenced by the following quotes: *"…you can get materials like books, notes, even help and support…at any time whenever you ask, there is an answer right then…","I can listen to lectures… anywhere, even when I am travelling…"* (Student).

Psychological Readiness – Perception of Readiness. Perceived readiness was studied in terms of appropriateness, internet infrastructure and budget. The results are presented in Table 4:

Perception of Readiness - Quantitative Results. Data presented in Table 4 indicate that both teachers and students are ready to integrate ICT in mathematics teaching and learning (M = 3.*71*). Furthermore, teachers and students both agreed that: it is appropriate to use ICT tools for teaching and learning of mathematics (M = 3.60); their ICT tools have features that can support online learning (M = 3.84); Internet connectivity is adequate to support online learning (M = 3.62) and that the cost of data bundles is within their budget (M = 3.78).

Perception of Readiness – Qualitative Results. With respect to affordability and internet reliability students had mixed feelings, some indicated that they can afford to purchase data bundles*, "The cost of internet is manageable…only 2000 shillings (0.*87 USD) per week…"* (Students). While others felt that the costs are high, especially for students living in a hostel as one student narrated "… for those living in hostels the cost is high, 2000 shilling per week you get 1 GB and 1 GB for the night…during this time

Table 4. Readiness to integrate ICT in mathematics teaching and learning. Mean = 3.71, Cronbach's Alpha = 0.83

Constructs of ICT readiness	SD	D	U	A	SA	M	S.D
1. I am ready to integrate ICT in teaching/learning of business mathematics	7.6	10.7	11.5	43.5	26.7	3.71	1.19
2. ICT is appropriate for teaching/learning mathematics	5.3	15.3	14.5	44.3	20.6	3.60	1.14
3. My ICT tool has several features to support online learning	3.9	11.7	12.5	40.6	40.6	3.84	1.11
4. Internet connectivity in my College is adequate to support online learning	6.8	15.8	9.8	44.4	23.3	3.62	1.19
5. I can afford to buy data bundles to online learning	6.8	9.8	8.3	48.9	26.3	3.78	1.14

I am doing independent studies so I feel it is costly…". With regards to internet connectivity some students felt that the mobile internet is adequate, but they were skeptical about the college internet facility in terms of limited access and speed "internet through mobile phone is adequate…I am using Vodacom internet which is very good…for those using college internet it is about time it should be accessible in the classrooms although I feel it is somehow slow…" (Students). Generally, students and teachers have agreed that they are ready to integrate ICT in mathematics teaching-learning processes (M = 3.71).

5 Discussion

The purpose of this study was to investigate the readiness based on the usage pattern, suitability, and readiness of teachers and students to integrate ICT tools in mathematics at a higher education institution in Tanzania, CBE. To fulfill the objectives of this study, we assessed ICT readiness based on the Device readiness, Skills readiness and Psychological readiness of the participants. The discussion is organized according to the research questions.

5.1 Usage Patterns - Device and Skill Readiness

In regards to *what are the usage patterns of ICT tools for the CBE teachers and students?* (Device readiness). The study found that most of the respondents own either a smartphone or a laptop and some have more than one device. The results are consistent with Ngeze [8] who found that secondary school teachers possessed either a laptop, a smartphone or both. The results also confirm high penetration of mobile devices among students of higher education [7]. This finding implies that teachers and students at the CBE Dar es Salaam have a device readiness to use ICT tools in teaching and learning of mathematics.

With regards to usage patterns (Skill readiness), the findings indicate that teachers and students use ICT tools mostly for uploading and downloading learning materials, internet search, sending and checking emails, sharing educational resources and social networking. This result corroborates that of Miglani and Awadhiya [6] who termed these activities as basic skills needed for sending information, uploading-downloading and sharing information with a study group. Their study further revealed that fewer students (30%) performed advanced skills activities such as watching online videos, blogging and the like. In this study results show that the majority of teachers and students (more that 50%) watch online educational videos which is similar to Abidin et al. [16]. Another significant finding is that more than 50% of students use word processing, data processing and presentation software. Teachers on the other hand use specialized software to solve mathematical problems showing that teachers use ICT tools for teaching purposes. This indicates that teachers and students at the CBE Dar es Salaam have the required skills and that they can make effective use of the ICT tools in teaching and learning of mathematics. ICT tools usage could help them overcome challenges such as shortage of reference and textbooks, teaching aids, and overcrowded classrooms. Teachers can complement the face-to face interactions with online learning

space, and use of digital materials including videos, books, and online notes to enhance students' learning experiences. Teachers also need to use graphing applications and simulation programs because these tools have great value in the teaching and learning of mathematics [10]. The use of these tools can help teachers to reduce the abstractness of mathematics as it is currently perceived by students.

5.2 Psychological Readiness

In relation to *what are the teacher's and student's perception on the suitability of integrating ICT tools in mathematics teaching and learning at CBE*? The findings showed that teachers and students have positive perceptions regarding the suitability of using ICT tools in mathematics teaching and learning. Both teachers and students agreed that integration of ICT in mathematics can support teaching and learning activities. They also agreed that ICT tools foster anywhere, anytime learning; provide a platform for sharing educational resources such as learning materials, quizzes, as-assignments, student results and instructional videos; provide a platform for communication and discussion. Another interesting result is that students relate the use of ICT tools with immediacy when it comes to receiving support from their teachers, they would want a prompt reply from their teachers or colleagues when they encounter some difficulties. ICT tools like smartphones, laptops and others comes with inbuilt features that allow sharing of content such as text, videos, and audio files [6]. These features allow the production and a quick transfer of content to student populations. Therefore, teachers can use text messages, social media platforms and emails to offer support to their students [16]. The finding implies that using ICT tools in a mathematics classroom can enhance communication and didactic interactions between teachers and students, therefore minimizing the limitations that are created with geographical boundaries experienced in conventional means of teaching and learning.

In regards to *what are the views of teachers and students on the readiness to integrate ICT in mathematics teaching and learning at CBE?* Results showed that teachers and students are ready to integrate ICT in mathematics teaching and learning. They agreed that their ICT tools have the needed features to support online learning. This result is in compliance with research carried out by Ngeze [8]. Their findings indicate that respondents had positive attitude towards integrating ICT in teaching and learning. The findings also show that students are confident and feel that they would be motivated to study and enjoy more their mathematics lessons through the use of ICT tool. Another significant finding is that the majority of teachers and students agreed that the internet is adequate and they were positive about purchasing data bundles. These are the features that support online learning as both e-learning and m-learning feasibility requires reliable internet access and the cost of data bundles should be within user's budget. This implies that respondents have positive perceptions towards integrating ICT in mathematics teaching and learning except for a few students who were skeptical about the cost of mobile internet, speed and availability of the college internet as they indicated that it is slow. This result is similar to Abidin et al. [16] who found that respondents were positive about m-learning, although they were uncertain when it

comes to the costs related to m-learning. Lack of adequate internet can hinder effective implementation of ICT in teaching and learning of mathematics. The findings reported in our study shed light on the areas that higher education institutions need to pay attention in order to help teachers and students use ICT in teaching and learning. In particular, making internet facilities accessible to all student populations would create an encouraging environment for teachers and students to incorporate ICT tools in mathematics lessons.

6   Conclusions and Recommendations

Conclusively, respondents were positive about the idea of integrating ICT tools in mathematics teaching and learning as they were already familiar with possible features and communication activities required when using ICT tools for teaching and learning. However, using ICT tools for teaching and learning is still very new to teachers and students and remains at its initial stage. This may be caused by the lack of emphasis from the educational administrators regarding the implementation of ICT in mathematics instructions. Effective implementation of ICT tools requires the collective efforts of both teachers, students and administrators [6]. The findings showed also that, some students were uncertain about the cost and adequacy of the internet due to low speed and inaccessibility of the college internet within classrooms. Teachers were silent about the cost of the internet; this could be a result of the availability of internet in their offices, access to information resource center and computer laboratories. It was noted that confining ICT tools to some offices, laboratories and the course will not alleviate the problem, instead ICT tools should be accessed throughout the college environment, particularly within classrooms.

Although the findings from this study cannot be generalized to all students and teachers at all CBE campuses and other higher education institutions in Tanzania, they are indicative of the phenomenon that is observed on mathematics teacher and student populations in other higher education institutions. Further research with samples from all CBE campuses, possibly including other higher education institutions would provide a clear insight into the issues of ICT readiness in the teaching and learning of mathematics in higher education institutions in Tanzania.

Based on the findings, the study recommends that: Due to the readiness observed, plans for integration of ICT in mathematics instructions at the CBE should be prepared and implemented, the purchase of specialized software required for mathematics teaching and learning. Furthermore, Customization of a Learning Management System that runs on both web and mobile environments to support mathematics courses, Computer laboratory availability to students pursuing different courses at the CBE and the provision of wireless internet access to students. In addition, Teachers should allocate time to offer online support and guidance to their students regarding various mathematical concepts and problems.

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