ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 10, 2021

TEACHING OF BIOLOGY AT COLLEGE LEVEL USING ICT TOOLS

Dr. Preeti Dharmik
Assistant Professor, UGC Human Resource Development Centre, RTM Nagpur University, Nagpur, Maharashtra

Abstract
Biology deals with the study of living organisms, their living environment and interactions between living beings and the environment. The majority of the topics in biology education are closely linked to sustainable development, especially in the fields of ecology, biodiversity, conservation and system biology. Biology encompasses various biological processes and organisms described in the textbooks, but these cannot be seen by the naked eye. Therefore, it becomes difficult for the students to comprehend biological subjects only by reading textbooks or through traditional class lectures. Practical classes play a very important role in clarifying the theoretical portion. However, it is expensive to maintain a biology laboratory in the schools. For instance, most Colleges in Nagpur neither have a dedicated biology Lecturer nor do they have a dedicated biology laboratory. Practical biology classes start from 10+1 in the Colleges of Nagpur. In Nagpur, 63% of Colleges have a science laboratory, whereas 75% of Colleges have a multimedia classroom and 73% of Colleges have internet connection. The Government of Maharashtra is aiming to turn the huge number of its potential young intelligent populace into a resourceful one and has emphasized Information and Communication Technology (ICT) in education by introducing 'multimedia classrooms' and 'Lecturer-led content development' in Colleges throughout Nagpur.

Key Words: biology, classroom, communication, content, education, technical tools

Introduction

It is vital to assess lecturers' acceptance and readiness to include ICT in the classroom and their readiness to integrate technology into education. Hence, it is imperative to evaluate the competency of biology lecturers in ICT skills, including their capacity to proficiently employ educational software, e-resources, and diverse technical tools in instructional settings. The Technology Acceptance Model (TAM) is crucial in assessing biology instructors' acceptance and use of ICT in their instructional practices. Moreover, it is essential to examine the distinct problems that biology lecturers in developing countries encounter when using ICT into their pedagogical approaches. The Technological Pedagogical and Content Knowledge (TPACK) paradigm elucidates these issues by highlighting the convergence of technology, pedagogy, and content knowledge. The TPACK framework provides a comprehensive view on how lecturers can proficiently incorporate technology into subject-specific instruction while meeting the pedagogical requirements of learners.

Furthermore, a significant gap exists in the studies about the preparedness and obstacles related to the use of ICT in biology education in developing countries such as India. Moreover, current research on ICT in education predominantly emphasizes science, technology, engineering, and mathematics (STEM) fields or general courses, although there

is a deficiency of targeted studies on ICT integration in college biology teaching. While there exists research on ICT in education in Nagpur, they tend to be broad and fail to thoroughly investigate the specific issues encountered by lecturers. Moreover, the socio-economic and infrastructural conditions of Nagpur present distinct issues regarding resource availability, Lecturer training, and access to digital technologies. Consequently, a substantial gap exists in comprehending the particular obstacles encountered by biology lecturers in integrating ICT with conventional teaching methodologies within the educational context of Nagpur. This study seeks to elucidate the preparedness, obstacles, and possibilities associated with ICT integration in college biology teaching in Nagpur. It aims to address the current research gap and provide concrete recommendations for enhancing ICT adoption, essential for equipping students to fulfil the requirements of a technology-centric society, especially within the framework of the 4th Industrial Revolution. The purpose of this study is to explore the use of ICT in enhancing the teaching–learning process of biology in the colleges of Nagpur.

This study aims to explore the following research objectives:
i. To explore the attitude and competence of biology lecturers towards the use of ICT.
ii.To what extent ICT has been integrated in teaching and learning college biology.
iii.To specify the challenges experienced by Colleges while integrating ICT with traditional pedagogy of biology.
iv.To propose a framework for sustainable integration of ICT in college biology education.

ICT in biology education: a global perspective

Globally, the incorporation of ICT in biology education has demonstrated advantages in improving teaching and learning processes. Kalogiannakis emphasized the necessity of training lecturers in ICT tools to guarantee their efficient utilization of these technologies in educational settings. His research emphasizes the necessity for lecturers to develop both technical and pedagogical skills to proficiently integrate ICT into their instructional methods. Stasinakis and Kalogiannakis discovered that ICT tools can substantially enhance lecturers' pedagogical content knowledge, especially in instructing complex subjects like the theory of evolution and natural selection. Their research on Moodle-based training programs indicates that lecturers proficient in ICT not only augment their subject expertise but also provide more significant learning experiences for students. Additional studies suggest that ICT helps improve students' understanding of abstract biological concepts by using digital simulations and virtual labs, enhancing engagement and critical thinking. For instance, interactive tools can demystify complex processes like cellular biology, genetic mutations, and ecological systems, fostering deeper comprehension across diverse student populations. Furthermore, recent advances in artificial intelligence and virtual reality have enabled biology educators to create immersive learning environments, allowing students to interact with complex biological structures in 3D, further improving retention and understanding. Studies have also shown that the use of ICT in biology enhances collaborative learning through online platforms, where students can participate in virtual group experiments, fostering peer interaction and improving teamwork skills. As educational technologies continue to evolve, integrating gamification elements into biology lessons has been proven to motivate students, making learning more enjoyable and effective.

Lecturers' readiness for ICT in education

The readiness of lecturers to integrate ICT into the classroom is a critical factor in its effective implementation. Research demonstrates that many lecturers, particularly in developing countries like India, face challenges in adopting new technologies due to insufficient training and inadequate infrastructure. A study conducted in Nagpur revealed that while lecturers acknowledge the importance of ICT in education, they often lack the necessary skills and confidence to effectively employ these technologies. The gap between the perceived importance of ICT and its actual implementation underscores the need for focused professional development programs.

Kalogiannakis emphasized the importance of continuous ICT training for lecturers, not only to familiarize them with advanced technology but also to aid in the integration of these tools into effective teaching methods. His research on the Greek school system demonstrates that lecturers' opinions of ICT significantly improve with consistent training and access to technological resources. In Nagpur, these training initiatives are essential for enhancing lecturers' readiness for ICT-integrated biology education. Recent analyses highlight the importance of mentorship programs, where experienced ICT educators can support novice lecturers in building confidence and proficiency in technology-enhanced instruction. Studies show that lecturers are more likely to adopt ICT tools when they perceive direct benefits to student outcomes and receive consistent institutional support. Furthermore, integrating ICT into pre-service Lecturer education programs has proven successful in equipping future educators with the necessary skills and confidence.

Challenges in implementing ICT in biology education

The potential benefits of ICT in biology teaching are accompanied by numerous difficulties that impede its effective adoption. A significant obstacle is the insufficient infrastructure in educational institutions, especially in rural regions. Many educational institutions in Nagpur are deficient in reliable electricity, internet access, and ICT resources, hindering instructors' ability to integrate these tools into their instruction. Moreover, Stasinakis and Kalogiannakis observed that lecturers frequently encounter difficulties in the pedagogical integration of ICT, as they lack understanding on how to integrate technology with curricular objectives and student outcomes. The difficulty is exacerbated by the lack of a definitive framework for ICT integration in biology instruction, resulting in variations in instructors' implementation of these tools. Kalogiannakis emphasized the prevalence of technophobia among elderly lecturers, who may exhibit reluctance to utilize ICT due to their lack of experience with contemporary technologies. To further complicate matters, budget constraints in many educational systems limit access to cutting-edge technological tools and Lecturer support programs, leading to unequal access and ICT-driven disparities in student learning outcomes.

Proposed solutions for enhancing ICT integration

A comprehensive approach that encompasses both technological and pedagogical support for lecturers is essential to tackle ICT integration in education related challenges. Kalogiannakis proposed that ICT training programs can be included into Lecturer education curricula to adequately educate future lecturers for the utilization of these tools in their instruction. This approach corresponds with the conclusions of Stasinakis and Kalogiannakis, who

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 10, 2021

underscored the necessity for specialized professional development initiatives that concentrate on both the technical and pedagogical dimensions of ICT integration. Furthermore, policymakers should provide lecturers with continuous professional development opportunities to enhance their confidence and competencies in utilizing ICT for biology instruction. In addition, research advocates for integrating feedback mechanisms where lecturers can reflect on ICT effectiveness and adapt their methods based on student performance and engagement data, ensuring the continual evolution of technology-based educational strategies.

Conceptual framework

The TAM and TPACK model both frameworks have been used in this study as conceptual framework, as they served different purposes and focused on different aspects of integrating technology into teaching and learning.

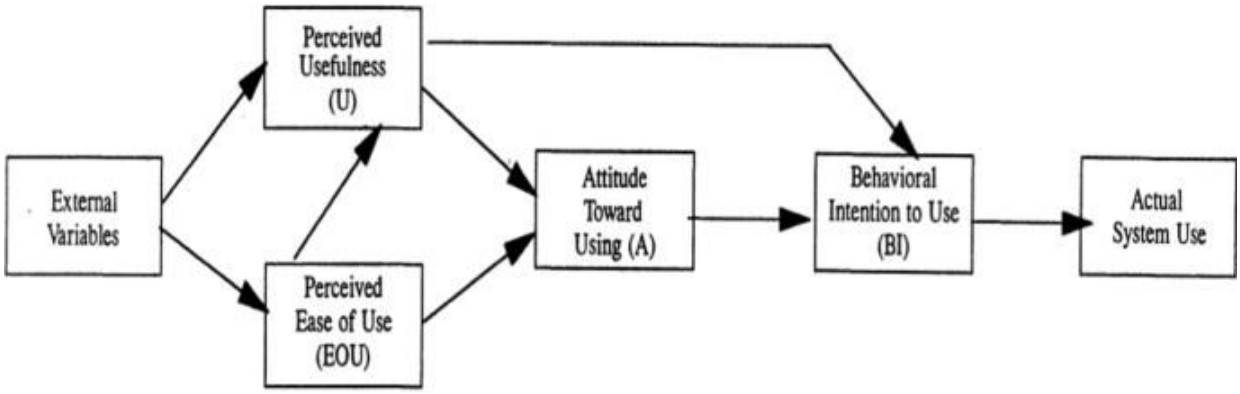
- Technology acceptance model (TAM)

Davis introduced the Technology Acceptance Model in the 1980s as a theoretical framework for predicting and explaining the uptake and acceptance of new technologies. According to the Technology Acceptance Model (TAM), the attitudes of users towards a certain technology, as well as their judgements of its usefulness and simplicity of use, have a significant impact on their intention to use it. This intention, in turn, influences their actual usage behavior. TAM generally comprises two primary constructs (Fig. 1):

Perceived usefulness: The extent to which an individual holds the belief that the utilization of a specific technology would augment their performance or facilitate the completion of their activities.

Perceived ease of use: The level of an individual's perception regarding the ease of use of a specific technology.

Fig. 1



Technology Acceptance Model:

The TAM was utilized in this study to comprehend and forecast the acceptance of technology in educational settings, and to investigate lecturers' acceptance towards educational technologies.

- Technological pedagogical content knowledge (TPACK) Model

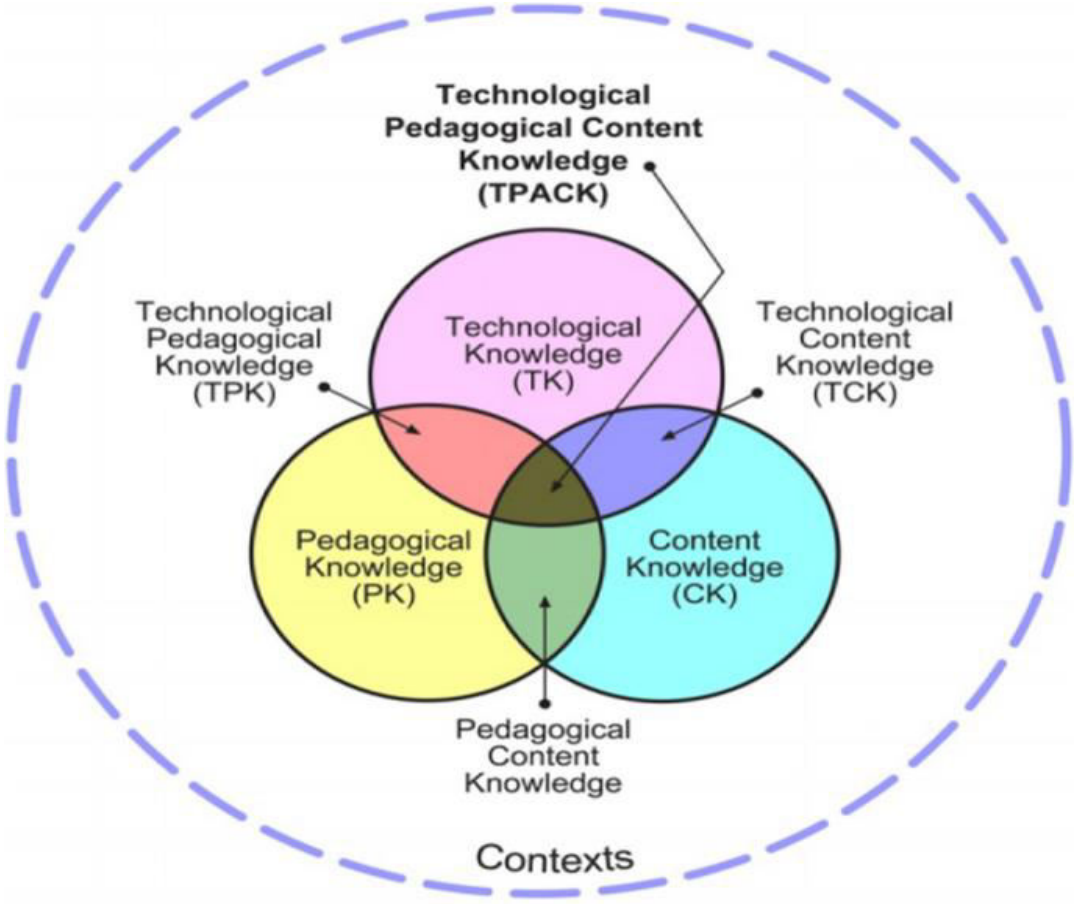
According to Koehler et al. (2014), the TPACK model, which was introduced by Mishra and Koehler, is a conceptual framework that highlights the dynamic relationship among technology, pedagogy, and content knowledge in the context of education. According to Koehler and Mishra, the TPACK framework (Fig. 2) suggests that to effectively teach with technology, lecturers must possess three distinct types of knowledge:

Technological Knowledge (TK): Proficiency in utilising diverse technologies with efficacy.

Pedagogical Knowledge (PK): Comprehension of pedagogical methodologies and strategies for instruction.

Content Knowledge (CK): A profound comprehension of the content being instructed.

Fig. 2



TPACK Framework [Source:]

TPACK highlights that successful incorporation of technology in education takes place when these three forms of knowledge cross. Lecturers with a strong TPACK may effectively choose suitable technologies, create captivating learning experiences, and promote meaningful learning that is in line with the subject matter being taught. Stasinakis and Kalogiannakis illustrated the application of the TPACK framework in biology education to augment lecturers' pedagogical content knowledge and enhance student learning outcomes.

This study leverages both TAM and TPACK, providing a dual perspective: TAM elucidates the factors influencing lecturers' acceptance and use of ICT, emphasising attitudes, perceptions, and usability and TPACK elucidates the required knowledge and abilities instructors must possess to effectively integrate ICT into their pedagogy. Collectively, these frameworks offer an extensive comprehension of lecturers' preparedness and the obstacles encountered in the integration of ICT into biology instruction. In Nagpur, where lecturers may face challenges regarding the acceptance and practical integration of ICT, the combination of these two frameworks effectively addresses both psychological and pedagogical obstacles to successful implementation.

METHODOLOGY

Research design

The study has been conducted through the lenses of interpretive paradigm. In the adoption of a particular research methodology, explanatory sequential mixed method design has been applied in this study to comprehend the process in a holistic way.

Sample design

In this study, data was sourced from 10 Colleges of Nagpur city. These educational institutions encompass every type of college, including government, private and autonomous. Within the selected institutions, 23 biology lecturers were chosen using a purposive sampling technique. The median age of the interviewees was 40. The participants had an average of 9.7 years of experience. It is to be noted that the median was 23 years of experience (Table 1). In addition, 3 Key Informants have been chosen from a higher educational institute using purposive sampling technique. This ensured that participants possessed the requisite knowledge and familiarity with ICT tools pertinent to the subject.

Data collection methods

The quantitative phase involves a cross-sectional survey among biology lecturers, assessing their ICT skills, preparedness, and attitudes towards ICT integration. The participating lecturers were required to assess quantitative items on the 5-point Likert scale: (1 [strongly disagree], 2 [disagree], 3[unsure], 4 [agree] and 5 [strongly agree]). In contrast, the qualitative phase includes semi-structured questionnaire, interview schedule, in-depth interviews with selected lecturers and observation checklist allowing for more nuanced insights into the specific challenges they face. Interview schedules have been used to collect information from 6 lecturers. Subsequently, 3 classes of each interviewed lecturers, i.e., 18 classes have been observed through observation checklist. In addition, qualitative data has

also been gathered through Key Informant Interviews with 3 faculty members from University of Nagpur.

Data analysis

A combination of quantitative and qualitative approaches has been used in the data analysis. The quantitative data has been analyzed using SPSS version 22.0. Data obtained from questionnaire and observation has been analyzed using descriptive statistics. A thematic approach has been followed to analyze qualitative data. Furthermore, the triangulation method has been followed through using multiple methods of data collection sources (questionnaire, observation checklist, and interview) to strengthen internal validity.

Ethical Considerations

Ethical approval

All procedures involving participants in this study complied with the ethical standards set forth by the 1964 Helsinki Declaration and its later modifications or comparable ethical guidelines. An ethical or institutional committee was not constituted at the researcher's institution during the conduct of the study.

Informed consent

Study participants are informed of the research's goal, and their consent is secured prior to their involvement in the data collection process. The participants' confidentiality is maintained by anonymising their responses throughout data analysis. Participants are guaranteed the right to withdraw from the study at any time without consequences.

Data protection statement

The research was conducted in compliance with any relevant regulations. The General Data Protection Regulation (GDPR) was adhered to in order to protect the data.

Findings

This study employs the TAM to analyze the factors affecting lecturers' readiness and acceptance of ICT, while the TPACK framework is utilized to investigate the intricate relationship among technology, pedagogy, and content knowledge, which directly influences their capacity to integrate technology into biology education. The following sections are going to address the attitude of biology lecturers in using ICT in their biology classes, their competency in using ICT, to what extent ICT is being used in the biology classrooms by the lecturers of college education level and the types of challenges that hinder ICT integration in teaching–learning.

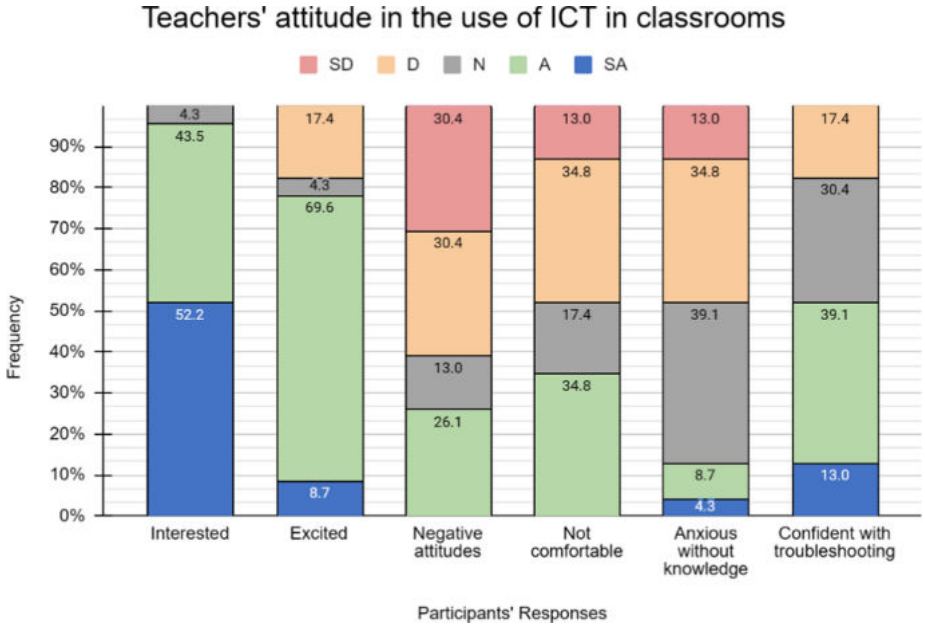
Attitude and competence of biology lecturers towards the use of ICT

Considering the TAM model, the adoption of ICT in the classroom is influenced by lecturers' perceptions of its usefulness. Additionally, lecturers' readiness to integrate ICT tools into teaching methods is also influenced by their perception of the ease of utilizing these tools. From the interview it was observed that 69.6% of the interviewees were excited using new

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 10, 2021

technology in the classroom and 52.2% were interested to do so. More than half (56.5%) of the lecturers thought that students learn easily when ICT were used in the classroom, and that the lessons were more fun. A larger proportion (60.9%) of the interviewees strongly agreed that pupils were more interested in classes presented using ICT and the overall presentation of the class was improved (Fig. 3).

Fig. 3

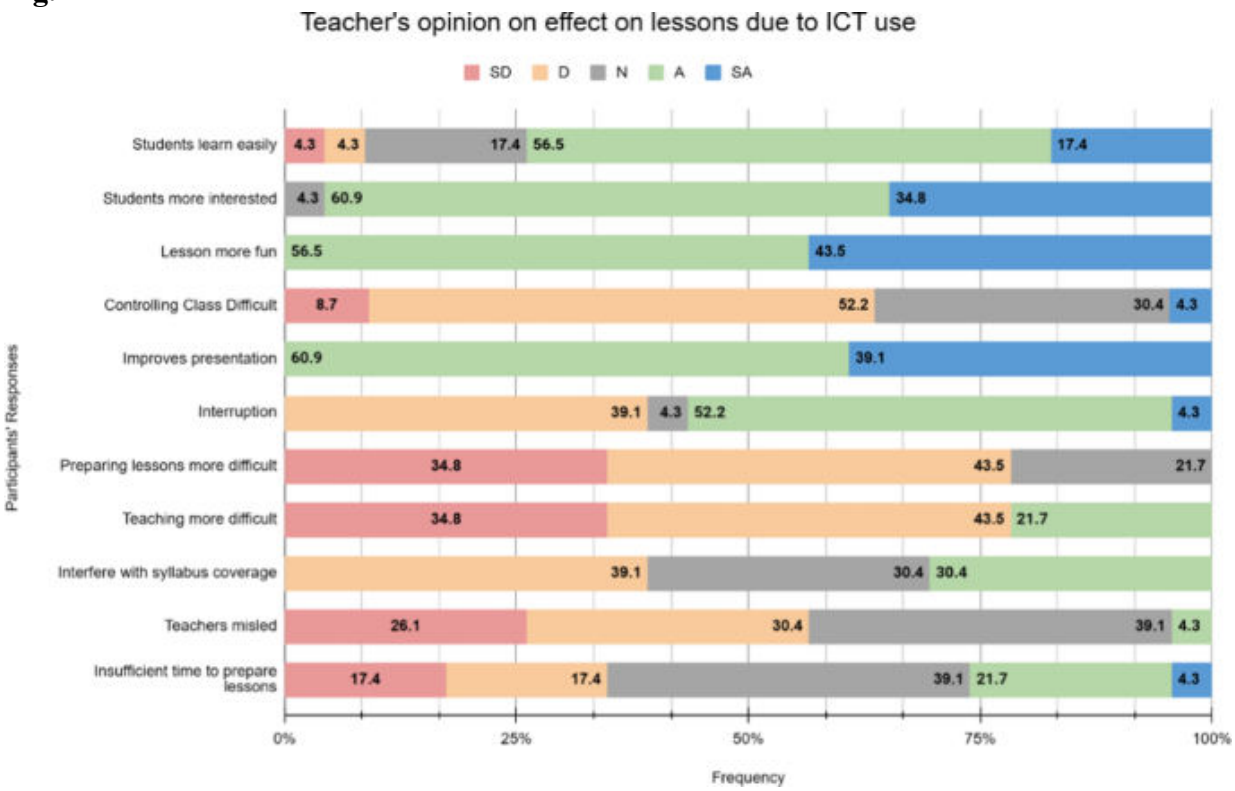


Biology lecturers' attitude towards the use of ICT in teaching and learning

In contrast to these positive attitudes, 26% expressed negative attitudes towards using ICT in the classroom. More than one-third of the participants (34.8%) found learning new technology is confusing and not comfortable in using these. 34.8% strongly agreed that they were anxious using new technology without knowledge. More than half of the lecturers (52.2%) opined that use of ICT creates difficulties in controlling class. Teaching becomes more difficult for 21.7% of the interviewees, though 43.5% opined the opposite. Although 52.2% interviewees agreed that ICT causes interruptions in teaching, 39.1% disagreed. While 30.4% said use of ICT interferes with syllabus coverage, 39.1% did not agree to this opinion. Almost half (43.5%) disagreed that using ICT poses difficulty in preparing lessons, but none agreed that it did. When asked about whether technology misleads lecturers and availability of sufficient time to prepare lessons, most respondents (39.1%) remained neutral (Fig. 4).

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 10, 2021

Fig. 4



Biology lecturers' attitude towards the use of ICT in lessons and preparations

However, preparing classes with ICT materials takes time and thus discourages some lecturers from taking such classes frequently. Many lecturers faced interruptions in conducting classes using ICT due to technological malfunctions or electricity failures. According to Lecturer-6,

"If any hardware or software related problems arise in the class where we are using ICT, we are unable to handle the situation promptly and it eats up most of the class time."

Lecturers also think that making ICT based lessons needs more time but they always have administrative pressure to complete the syllabus within stipulated time. Lecturer-4 said,
"I think using ICT kills time and I cannot complete the syllabus in time if I take several classes using ICT."

However, most of the lecturers did not share the same view and they expressed that the advent of new pedagogical ICT tools will attract the students to different complex biological contexts.

Some of the lecturers are yet to comprehend the importance of using ICT in biology. Lecturer-4 said,

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 10, 2021

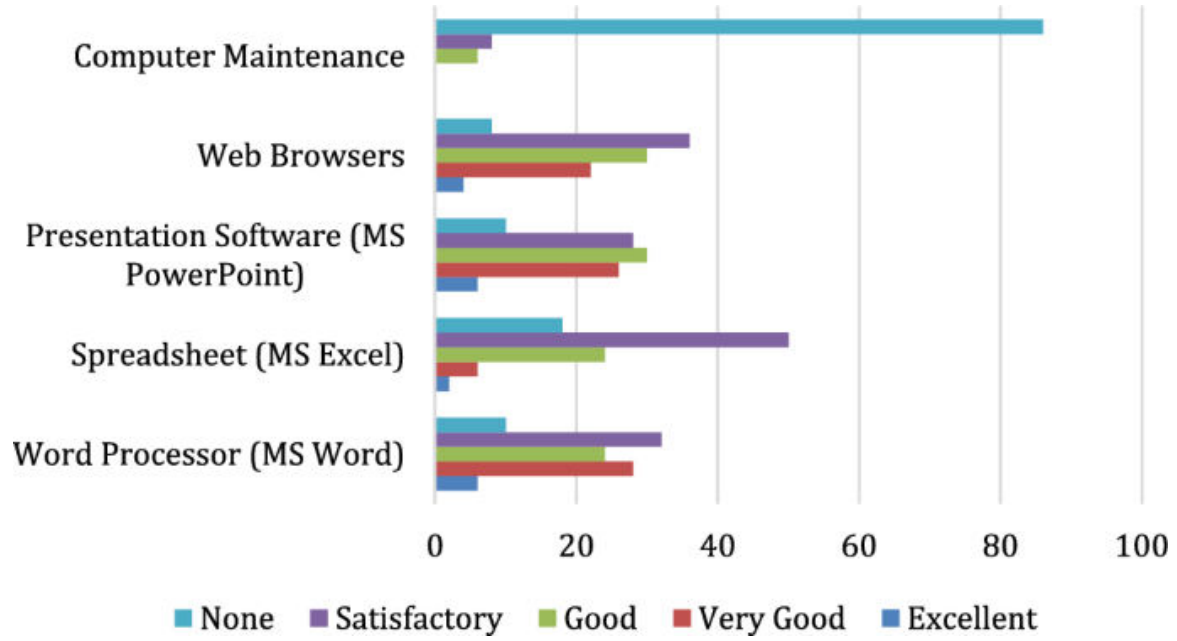
"I think the importance of using ICT in biology class is roughly about 50%. Traditional pedagogical tools like lectures, demonstration with models and charts etc. have better impact on the understanding of the students."

Status of ICT integration in teaching and learning college biology

Lecturer competency

Only a small proportion (13.0%) of the participants were confident to troubleshoot issues that accompanied the use of ICT in the classroom. The surveyed lecturers were asked to rate their knowledge on a few basic software applications such as word processing, spreadsheet, presentation software, internet browsers etc.; their responses are shown in Fig. 5.

Fig. 5



Survey Response about ICT Knowledge of Biology Lecturers

ICT Infrastructure

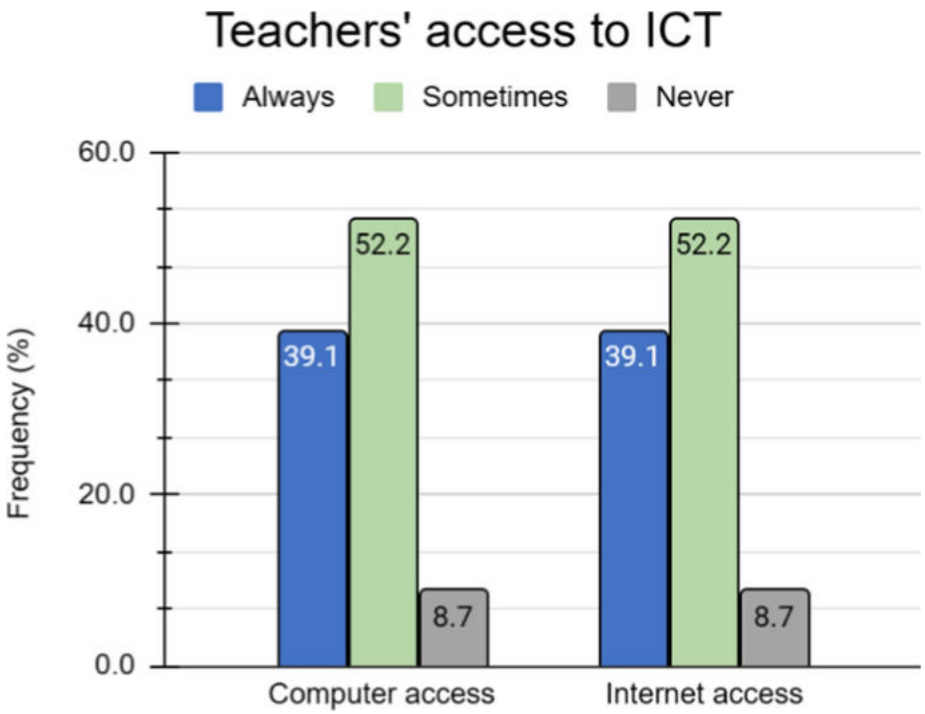
According to the observation checklist, only 22.22% of Colleges have multimedia classrooms and computer laboratories, but some of these facilities were found unusable. Some of the Colleges use computers for administrative purposes rather than for multimedia class. No computer was found in the biology laboratory at some of the schools. Some biology lecturers used the computer laboratory or multimedia classroom for taking classes using ICT. It was found that three among participating Colleges had the most computers-thirty, which was the highest in this study. One school did not possess any computers or multimedia facilities. Three other Colleges had less than ten computers. Two of the participating Colleges had the most multimedia facilities (12). Three Colleges had less than ten whereas three others had none. Only two Colleges had dedicated computer laboratories.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 10, 2021

Access to ICT

There is a disparity in access to computer and internet and/or both for a large proportion of the participants. Around one-third of the participant lecturers claimed that they can access computer and internet all the time. It is alarming that around one-tenth of the participant lecturers have no access to computers and internet as well (Fig. 6).

Fig. 6



Access of lecturers to ICT expressed in percentages

ICT usage pattern

Lecturers' competency in ICT skills is another important factor influencing their adoption of technology. The status quo in ICT usage was also observed in this study besides Lecturer's attitudes. Frequency of ICT was reported to be often among around half of the participants (47.8%), and the same number used it rarely. Among the users, the largest group (39.1%) used ICT in both practical and theory classes. However, ICT was less employed in practical classes (17.4%). Among the media used, PowerPoint presentations were the most prevalent (58.5%), followed by videos (39.1%), images using laptop or mobile (26.1%) and audio (17.4%). Lecturers used animated photos or text (13%) and online audio and video the least (13%). Around half the lecturers have access to the internet and computers (52.2%). But 18.7% never have access to either and 39.1% have access to both (Table 2).

Attitude and competence of biology lecturers towards the use of ICT

The attitude of the Lecturer toward using technologies in the classrooms is a major factor in successful technology integration. In this study, most of the surveyed and interviewed biology lecturers bear positive attitudes toward using ICT for teaching and learning in their college classes. In addition, they expressed that they are enthusiastic to learn how to use new

technology in the classroom. Most of the lecturers opined that students take more interest in classes if ICT is used in biology class and learn easily if ICT is used in biology class. This is a good sign because Voogt found that lecturers who use technology extensively in their lessons tend to have a high level of confidence in pedagogical technology skills and focus on a learner-centered approach. With such a positive attitude, these biology lecturers are capable of working for the development of the education sector by integrating ICT with traditional pedagogical tools. This optimistic outlook echoes broader trends in education, where lecturers with good attitudes toward ICT are more likely to incorporate technology into their lessons. These attitudes are important because they influence how lecturers perceive new technology and their willingness to experiment with innovative teaching approaches.

While assessing the competencies, it was found that biology lecturers have average operational knowledge of Microsoft Office Word, Excel, PowerPoint, and different web browsers. Frequencies of lecturers' competencies on instructional tools and materials usage were observed at an average level. It was noted that the Government of Maharashtra has played an important role in imparting training for the school lecturers. Lecturers are not anxious about using new technology, and they are learning different pedagogical uses of ICT day by day.

However, 41% of lecturers agreed that they are not comfortable using ICT in the classroom. It is also to be noted that a good portion of lecturers (8 to 18%) do not possess knowledge of any of these software applications. Some of the lecturers' competencies in instructional tools, as well as materials usage, were found to be below average level. This incompetency and anxiety might have arisen since biology lecturers get rare opportunities to use ICT in preparation or conduction of class. This gap between positive attitudes and practical application is significant, as highlighted by Khlaif et al., where similar discomforts were observed among lecturers using ICT.

Conclusion

The findings reveal that lecturers' positive attitudes towards ICT are crucial for integrating technology into classrooms, encouraging the use of interactive methods like virtual labs, simulations, and collaborative platforms, particularly in biology education. Enthusiastic lecturers are more likely to seek professional development and adopt learner-centered approaches, transforming traditional teaching methods. However, these attitudes must be supported with adequate training and resources to ensure effective application. Colleges can leverage positive attitudes by identifying early adopters and creating professional learning communities that promote peer mentorship. Additionally, targeted training programs aligned with lecturers' competence in ICT should be developed to enhance both basic and advanced digital skills. The generalizability of these findings may vary across educational contexts; in well-resourced settings like higher education, where ICT infrastructure is stronger, positive attitudes may lead to more comprehensive technology integration, while in under-resourced schools, additional support is required to turn these attitudes into meaningful instructional changes.

References

1. Abercrombie M, Hickman CJ, Johnson ML. A dictionary of biology. Routledge; 2017.
2. Akram H, Abdelrady AH, Al-Adwan AS, Ramzan M. Lecturers' perceptions of technology integration in teaching-learning practices: a systematic review. Front Psychol. 2022.
3. Alayyar G. Developing pre-service Lecturer competencies for ICT-integration through design teams. Enschede: University of Twente; 2011.
4. Banbeis. Bangladesh education statistics. Nagpur: Bangladesh Bureau of Educational Information and Statistics; 2015.
5. Davis FD. Technology acceptance model: TAM. In: Al-Suqri, MN Al-Aufi AS, editors. Information Seeking Behavior and Technology Adoption. 1989. p. 205, 219.
6. Davis FD, Bagozzi R, Warshaw P. Technology acceptance model. J Manag Sci, 1989; 35:982–1003.
7. Farhana Z, Chowdhury SA. Use of ICT by biology lecturers in the secondary schools: Bangladesh perspective. J Cult Soc Dev. 2019.
8. Ferri F, Grifoni P, Guzzo T. Online learning and emergency remote teaching: opportunities and challenges in emergency situations. Societies. 2020;10(4):86.
9. Fitch WT. Toward a computational framework for cognitive biology: unifying approaches from cognitive neuroscience and comparative cognition. Phys Life Rev. 2014; 11:329–64.
10. Ghavifekr S, Kunjappan T, Ramasamy L, Anthony A. Teaching and learning with ICT Tools: issues and challenges from lecturers' perceptions. Malaysian Online J Educ Technol. 2016;4(2):38–57.
11. Hsu P. Examining current beliefs, practices and barriers about technology Integration: a case study. TechTrends. 2016;60(1):30–40.
12. Inan FA, Lowther DL. Factors affecting technology integration in K-12 classrooms: a path model. Educ Tech Res Dev. 2009;58(2):137–54.
13. Islam MS, Grönlund Å. An international literature review of 1:1 computing in Colleges and their implementation in Bangladesh. J Educ Technol Soc. 2016;19(3):150–63.
14. Jeronen E, Palmberg I, Yli-Panula E. Teaching methods in biology education and sustainability education including outdoor education for promoting sustainability-a literature review. Educ Sci. 2017;7(1):1–19.
15. Kalogiannakis M. Information and communication technologies in class practice: a case study of secondary physical sciences lecturers. Welsh J Educ. 2003;12(1):64–74.
16. Kalogiannakis M. Training with ICT for ICT from the trainer's perspective. A Greek case study. Educ Inform Technol. 2010; 15(1):3–17.
17. Lawrence JE, Tar UA. Factors that influence lecturers' adoption and integration of ICT in teaching/learning process. Educ Media Int. 2018;55(1):79–105.
18. Masrom M. Technology acceptance model and e-learning. Technology. 2007;21:81.
19. Mishra P, Koehler MJ. Technological pedagogical content knowledge: a framework for Lecturer knowledge. Teach Coll Rec. 2006;108(6):1017–54.
20. Nungu L, Mukama E, Nsabayezu E. Online collaborative learning and cognitive presence in mathematics and science education. Case study of university of Rwanda, college of education. Educ Inform Technol. 2023; 28(9):10865–84.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 10, 2021

21. Raygan A, Moradkhani S. Factors influencing technology integration in an EFL context: investigating EFL lecturers' attitudes, TPACK level, and educational climate. Comput Assist Lang Learn. 2020;35(8):1789–810.
22. Smith D. Issues and trends in higher education biology fieldwork. J Biol Educ. 2004;39:6–10.
23. Tabata L, Johnsrud L. The impact of faculty attitudes toward technology, distance education, and innovation. Res High Educ. 2008;49(7):625–46.
24. Tondeur J, Van Keer H, Van Braak J, Valcke M. ICT integration in the classroom: challenging the potential of a school policy. Comput Educ. 2008;51(1):212–23.
25. Voogt J. Lecturer factors associated with innovative curriculum goals and pedagogical practices: differences between extensive and non-extensive ICT-using science lecturers. J Comput Assist Learn. 2010; 26:453–64.
26. Wang Q. Design of 3D animation special effects in animation 3D modeling teaching based on QFD theory. Int J Emerg Technol Learn. 2017; 12(07):90–100.