REVIEW ARTICLE

SAMRIDDHI Volume 15, Issue 1, 2023 Print ISSN: 2229-7111 Online ISSN: 2454-5767

Teaching and Learning Processes in Physics: Using Information and Communication Technology: Advantages, Challenges and Remedies

Vijay Sharma[1*], N. L. Gupta[2], Atul K. Agarwal[3]

[1]Department of Humanities and Science (Physics) Govt. Mahila Engineering College, Ajmer, Rajasthan, India

[2]Department of Physics, Govt. College, Kishangarh, Ajmer, Rajasthan, India

[3]Department of Physics, Govt. College, Nasirabad, Ajmer, Rajasthan, India

Abstract

A nation with significant human capital that can govern science and technology will be competent to exist in the future. The success of applying basic science, particularly physics, to numerous technologies is primarily responsible for the advancement of technology today. Physics is a natural science that has made the greatest contribution for the development of many technologies and engineering applications that make life more convenient for humans. As numerous, Physics principles are very abstract and require very depth knowledge and experience to explain to students. The question arises, how to make physics education more engaging, lucid and relevant for students? At this point, Information and Communication Technology (ICT) becomes very beneficial because of its capacity to ease the abstract subject, stimulate interest and enhance learning outcomes in physics education. Despite the importance of ICTs and educational software, these technologies have yet to be incorporated properly into physics education.

This article focuses on the contribution of ICT in physics education along with challenges and their remedies. The online link of several ICT platforms that could be utilized in the teaching and learning of physics is also mentioned, which are open source and can be used freely. The benefits of employing instructional software and incorporating ICTs into the physics curriculum are becoming essential in the current scenario. The barriers to ICT integration in the physics classroom are also discussed. It is experienced and recommended that ICT can be used in the form of blended learning as well as potential solutions to the issues that physics teachers /instructors confront.

Keywords: Information Communication Technology, Physics, Teaching and Learning Pedagogy, Open source links.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology (2023); DOI: 10.18090/samriddhi.v15i01.31

Introduction

A very legendary quote by Benjamin Franklin, "Tell me and I forget, teach me and I may remember, involve me and I learn". The question is how to involve the learner. As it is known that Physics is a scientific discipline that is based on experimentation and explanation. Without experiments and explanations, it is impossible to comprehend physics and most of the time it becomes quite difficult to involve the learners. Resources available in physics laboratories in institutions (colleges/ schools) are unable to conduct all of the experiments in the prescribed syllabus due to various constraints and learners lost their involvement.[1] Also several times it becomes quite difficult for teacher and student to grasp some of the physics topics like optics that require colorful diagrams to explain with simple chalk and blackboard. For example, the instructor is explaining the rainbow with white chalk; this is the point where there is a chance that student may lose their involvement. Some other examples are the motion of waves, topics involving three-dimensional systems like spherical and cylindrical systems, vectors, projectile motion and many more.

New information technologies like ICT have become very crucial and come to the rescue in this situation. Recently, great attention is paid to the use of information and communication

Corresponding Author: Vijay Sharma, Department of Humanities and Science (Physics) Govt. Mahila Engineering College, Ajmer, Rajasthan, India, e-mail: phyvijay@gmail.com

How to cite this article: Sharma, V., Gupta, N. L., Agarwal, A.K. (2023). Teaching and Learning Processes in Physics: Using Information and Communication Technology: Advantages, Challenges and Remedies. *SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology,* 15(1), 166-170.

Source of support: Nil

Conflict of interest: None

Table 1: Challenge for Physics Teachers in Teaching while using ICT and their Remedies

Factors	*Challenges*	*Remedies*
Lack of ICT Skills	One of the major issues that a teacher faces; is their attitudes toward technology. Since there is an absence of pedagogical teacher training the user is not much comfortable with ICT tools.	This lack of ICT skills can be ratified by organizing and sponsoring many seminars and training for ICT skills that would help them improve their ICT competency in the teaching and learning process.
The Dearth of Teacher Confidence	Teachers are struggling with an absence of proficiency in using ICT, which has resulted in a loss of confidence in providing ICT-based lessons to students leading to a shortage of ICT knowledge and abilities.	To overcome this dearth of teacher confidence, a teacher should be allowed access to resources as per his continence. Extra time for the integration of the subject with the ICT tool should also be given.
Lack of technical assistance (deficiency of training in integrating ICT)	When instructors run into technical issues, they are unable to handle them due to a shortage of ICT professionals who can fix or correct the issues that may prevent teachers from using ICT resources such as the projector, laptop/computer, speaker, and printer.	The service of an expert technical person 24*7 should be provided so that teachers can access the service at their convenience. For this purpose, a cluster of nearby institutions can be created.
Lack of Institutional support	Institutions have limited access to ICT with a low student-to-computer ratio. There is a non-availability of appropriate educational software and internet resources.	This issue can also be resolved by making a cluster of nearby institutions and institutions can also take the help of society and other collaborators.
Lack of appropriate e-content (study material)	There is a lack of authentic, concise and appropriate e-content (study material) for all standards.	Recently, the Ministry of Education is facilitating and providing financial assistance for the development of appropriate e-Content through various missions including Virtual Lab, Swayam, NPTEL etc.
Rigid structure of traditional education systems	Restrictive curricula, rigid acadmic calnder etc are the examples of these impediments.	Flexibility in the curriculum should be given to teachers. The experiments based on ICT-enabled technology should be a part of the curriculum.

technologies in teaching Physics. ICT proposes an extensive range of tools that transform the conventional teaching process (teacher-centered learning) to a provoking and cooperative educational process (student-centered learning). ICT and educational software have been integrated into physics education because they can streamline abstract; content, produce concentration and improve learning outcomes. Computers, software and hardware, learning management systems (LMS), internet, networks, e-mail, mobile, smart television, etc are all examples of ICTs.[2-3] These ICTs platforms are becoming popular in learning and teaching physics and are the need of the hour. ICT helps the learner that in any experiment, the terms and the parameters of physical phenomena can be changed using a computer simulation. Several physical phenomena, processes and devices can be better understood with computer-enabled ICT. Nguyen[4] revealed that the widespread pedagogy underlying the use of ICTs in university physics classes was to mimic and visualize physics experiments and phenomena. This article discusses the benefits of ICT in physics education, challenges in using ICT in physics education, and their solutions.[5]

ICT's Contribution to Physics Education

ICT allows for a versatile, multipurpose and configurable computer learning environment. There is substantial research indicating that learners seem to be more inspired in Physics learning; when ICT is used to support their learning.[6] When used appropriately, ICT can significantly contribute to physics students and teachers. The following are a few of these advantages:

- Most physics concepts, principles, and theories were learned by memorization, which students may easily lose; however, using ICT allows students to learn them quickly and maintain them in their memory for a long time.
- ICT improves physics learners' classroom engagement and encourages students and teachers to work hard. Learners are more interested in activities, show increased attention, and have a longer attention span.
- ICT expands the spectrum of applications that can be

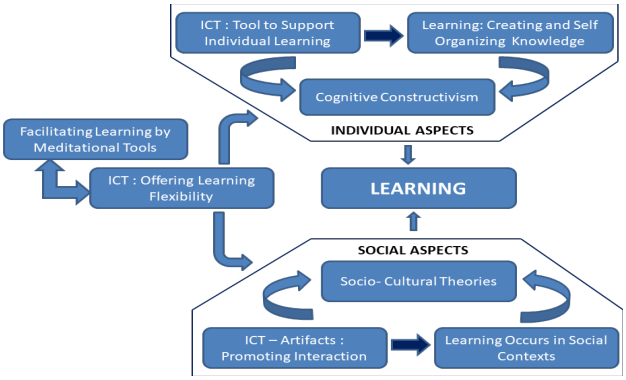

Figure 1: CSI Model

applied in learning and teaching Physics to include text, animated images and audio.

- ICT consents physics teachers and students to immediately communicate their ideas, learning resources and teaching methodologies
- ICT assists in maintaining and updating the expertise in the field of Physics education.
- ICT provides several ways, where the material for learning Physics could be used for the whole class and/or individual learning. This means that a teacher can go a long way toward meeting the needs of students with various learning styles.
- The readily accessible multi-media resources allow for the visual representation and manipulation of advanced Physics models, their 3D images and motion to enhance the understanding of scientific ideas.
- The experiment began in one classroom virtually can be kept going later during the day and then at home as per the time availability.
- ICT can provide access to a vast array of high-quality and relevant resources for scientific learning.
- ICT offers a wide collection of superior-quality and relevant scientific learning resources. It also helps in gaining access to the current physics bibliography and standards.
- ICT allows organizing conferences, seminars, and workshops on issues relating to physics education all over the world without having to travel.

Challenges for Physics Teachers in Teaching while using ICT and their Resolutions

In the last three decades, various studies have looked into the factors that influence physics teacher's acceptance and integration of information and communication technology into the classroom. Several factors at the teacher level (personal), institutional and system levels restrict teachers from using ICT, despite significant investments in ICT (infrastructure, equipment, and professional development). For their reasons and to assist students in using ICT as a teaching and learning tool, physics professors must understand how it is used.[7-8] The goal should be to use ICT as a tool in the Physics classroom to increase teaching effectiveness and improve student learning. Stakeholders should encourage an ICT-enhanced learning environment in physics teaching, learning, and associated activities. Some of these factors are tabulated in Table 1.

Discussion

ICT supports POE (Predict-Observe-Explain) learning model in Physics education. The POE method entails students' predictions based on demonstration results (predict), performing experiments (observing), addressing the causes for their predictions (demonstration results), and subsequently attempting to explain the outcomes of their predictions (explain).[9] Various ICT-enabled tools, especially mobiles are becoming a vital part of the young generation daily lives that can support the POE learning model. Because of their widespread use, Mobile can be an effective resource for teaching physics ideas. Experiments that cannot be carried out in real laboratories do not lead to a complete comprehension of science; can be carried out utilizing technology features with mobile, desktop and laptop etc. Learners interact, not only through virtual things but also with one another, exchanging ideas not only in the micro-world of a classroom but as well as with their colleagues all over the world and they can learn without being physically present. Learners have their views and perceptions of natural occurrences built on their everyday experiences and language, making it difficult for them to internalize scientific models that are needed to understand scientific concepts accurately. As per National Education Policy (NEP -2020), the findings reveal that learning can occur in cognitively, linguistically, and culturally meaningful and significant learning environments for learners.[10] Learning is a cultural process even within single class learning is a cultural process. Students' experiences in the classroom impact their attitudes and ideas about physics and learning physics.[11-12] With these ICT tools, students can convert the e-content from a different language to their mother tongue to better understand the concept. Nguyen and Williams offered a CSI Model, a pedagogic theoretical model of integrating constructivist and sociocultural learning principles with ICT, as delibrated in Figure 1.[13]

Some conceptual topics in Physics are difficult to understand, such as how motors and generators operate, transistors and transformers work, etc. Computer animation can help learners and teachers learn them more efficiently. Some physical phenomena appear abstract to students, such as optical, magnetic, and mechanical phenomena; some of these are too quick for the student to understand; computer simulation will slow down the speed, allowing students to study and learn. The motion of the medium particle (air molecule movement), their interactions, and collisions can easily be explained by computer simulation and video.

A large number of free and open-source tools are available for Physics learners the links for the same are given in Table 2. These links can easily be used with just an internet

Table 2: The links for Online Physics Demos/Lessons/ Resources

Source	Link
PhET Interactive Simulations[14]	https://phet.colorado.edu/en/simulations/category/physics
The Physics Classroom[15]	https://www.myphysicslab.com/
My Physics Lab – Physics Simulations [16]	https://www.physicsclassroom.com/
NJAAPT – Physics Teaching Resources[17]	https://blossoms.mit.edu/resources/physics_resources
American Physical Society[18]	https://www.myphysicslab.com/
National Science Foundation – Physics Classroom Resources[19]	https://www.vlab.co.in/
Virtual Lab[20]	https://njaapt.wildapricot.org/Websites-for-Physics-Teachers

connection. The learner can use most of these applications on their android mobile apps. These links include a huge number of animations, video links, chat options, and study material for understanding physics phenomena. Although, interested faculty members can create their code for any experiments and can contribute to society with the help of these organizations. An Initiative of the Ministry of Education, Government of India under the National Mission on Education through ICT is a virtual lab platform[20] with the philosophy that provides "(a) Access to online labs to those engineering colleges that lack these lab facilities, (b) Access to online labs as a complementary facility to those colleges that already have labs and (iii) Training and skill-set augmentation through workshops and on-site/ online training". In a recent study, Agyei and Agyei[21] showed that by using PhETs not only the learning of learners increases but also learners had constructive experiences with the simulations. The study reflects that interactive implementation techniques that are exploratory and demonstrative in character, as well as context-sensitive, can enable learners more about physics ideas through simulations.

Disadvantages of using ICT in Physics Education

As every coin has two sides, though ICT has numerous merits, it also involves some demerits, including:

- Misleading and misguiding information: Since a big stack of physics education-related material is available with a single click, the learner should always be aware of authentic physics.
- Risk of cyber-attacks and hacks: There is always a risk of any phishing and hacks. So the user should visit only the authenticated link.
- There is always a chance of misuse of technology. It also evolves a risk to the traditional understanding of physics.
- Sometimes it becomes difficult to manage courses online.
- One of the adverse effects of ICT is that it limits direct interaction between students and instructors.
- Students miss a sensory experience with ICT technology that they experience in a real lab, such as smells, faulty machinery, random errors and strange noises, etc.

Conclusions

The present study establishes that technology may assist physics education to make it more relevant, real-world-connected and authentic. ICT allows Physics teachers to be more innovative in their teaching and Physics learners in their learning. ICT is providing an increasing opportunity for students to do their simulations to explore numerous scientific phenomena in a short amount of time utilizing various methods of presentation such as graphics, graphs, vectors, and so on. Using visualization (PPT, videos), student's learning and understanding of physics will also be improved. Learners can also change the variables, create other cases, get instant results, see the consequences, and draw their conclusions. As a result, it adds value rather than just simply providing another method of delivering the same material. However, ICT technology is a very powerful tool it cannot be considered a replacement for a teacher in any way. Recently, some developed countries are using AI-enabled ICT technology, but it may also result in poor performance and degradation. So it is recommended that blended learning is more useful than taking alone the conventional methodology of teaching physics or using ICT technology.

References

[1] Owusu-Sekyere, K., & Darkeh, H. A. (2022). Physics Tutors' Self-Efficacy and Use of Information and Communication Technology (ICT) for Research Activities in the Colleges of Education in Ghana. Issues and Ideas in Education, 10(1), 21–30. https://doi.org/10.15415/iie.2022.101003

[2] Yusuf Ahmad Yunusa, Zainab Yusuf Lambisa, Fatima Umar Yarima, (2019). ICT in Teaching and Learning Physics: Prospects and Challenges in Nigerian Educational Sector. World Academics Journal of Management, 7(1), 9-11.

[3] Alonso-García, S., Aznar-Díaz, I., Cáceres-Reche, M.-P., Trujillo-Torres, J.-M., & Romero-Rodríguez, J.-M. (2019). Systematic Review of Good Teaching Practices with ICT in Spanish Higher Education. Trends and Challenges for Sustainability. Sustainability, 11(24), 7150. https://doi. org/10.3390/su11247150

[4] Nhung Nguyen, John Williams & Tuan Nguyen (2012). The use of ICT in teaching tertiary physics: Technology and pedagogy. Asia-Pacific Forum on Science Learning and Teaching, Volume 13, Issue 2, Article 6, p.1.

[5] Ellermeijer, T., & Tran, T. (2019). Technology in Teaching Physics: Benefits, Challenges, and Solutions. Upgrading Physics Education to Meet the Needs of Society. doi:10.1007/978-3-319-96163-7_3

[6] M Ma'ruf, A Setiawan, A Suhandi and P Siahaan (2021), Profile of early ICT capabilities of prospective physics teachers

through basic physics learning in Makassar, Journal of Physics: Conference Series, International Conference on Mathematics and Science Education (ICMScE). Volume 1806, 012044. https://doi.org/10.1088/1742-6596/1806/1/012044

[7] Samaila, K., Dauda, S., Aliyu, M., & Aliero, A.A. (2021). Application of ICTs and Educational Software in Teaching Physics: Advantages, Challenges and Proposed Solutions. International Journal of Research and Review, 8 (1), 293-304.

[8] Svetec, Milan & Repnik, Robert & Arcet, Robi & Klemenčič, Eva. (2019). Educational Technology at the Study Program of Educational Physics at the University of Maribor in Slovenia. doi: 10.5772/intechopen.85081

[9] Nasir, M., & Raya, I.P. (2018). How to Teach Physics using Information and Communication Technology Media: A Review to Propose New Idea of Learning Models. IOSR Journal of Research & Method in Education (IOSR-JRME), 8(6), 52-58. doi:10.9790/7388-0806045258

[10] https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

[11] Drigas, A., & Kontopoulou, M.-T. L. (2016). ICTs based Physics Learning. International Journal of Engineering Pedagogy (iJEP), 6(3), 53–59. https://doi.org/10.3991/ijep.v6i3.5899

[12] Kola, A.J. (2013). Integration of ICT into Physics Learning to Improve Students' Academic Achievement: Problems and Solutions. Open Journal of Education, 1, 117-121. doi:10.12966/OJE.07.01.2013

[13] Nguyen, N., Williams, P.J. (2016). An ICT Supported Socio Cultural Approach to Improve the Teaching of Physics. Asia Pac. Sci. Educ. 2, 2. https://doi.org/10.1186/s41029-016-0008-2

[14] https://phet.colorado.edu/en/simulations/category/physics accessed on May 2022-05-20.

[15] https://www.physicsclassroom.com/ accessed on May 2022-05-20.

[16] https://www.myphysicslab.com/ accessed on May 2022-05-23.

[17] https://njaapt.wildapricot.org/Websites-for-Physics-Teachers accessed on May 2022-05-24.

[18] https://blossoms.mit.edu/resources/physics_resources accessed on May 2022-05-21.

[19] https://www.nsf.gov/news/classroom/physics.jsp accessed on May 2022-05-22.

[20] https://www.vlab.co.in/ accessed on May 2022-05-19.

[21] Agyei, E. D., & Agyei, D. D. (2021). Enhancing Students' Learning of Physics Concepts with Simulation as an Instructional ICT Tool. European Journal of Interactive Multimedia and Education, 2(2), e02111. https://doi.org/10.30935/ejimed/11259