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Enhancing Students' Understanding of Abstract Concepts in Physics by Integrating ICT in Teaching-Learning Process

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Authors' contributions

This work was carried out in collaboration among three authors. Author ST designed the study, performed the statistical analysis and wrote the protocol of the manuscript. Author PT performed the literature searches and author NZ conducted survey and collected data. All authors read and approved the final manuscript.

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ABSTRACT

Conceptualizing abstract concepts in physics has been a challenge that has impeded the learning and performance of the students in the schools in Bhutan. The advent of science and technology has led to development of numerous Information and Communication Technologies (ICT) that are apt to use in physics education but are hardly explored and used in the Bhutanese education system. Thus, there is a compelling need to revamp the conventional instructional approach to accommodate the modern physics education system. A quantitative quasi-experimental pretest-posttest control group design study was used to enhance students' performance in physics by integrating ICT in the teaching-learning process at Chundu Armed Force Public School, Haa. Two rounds of data (baseline and post-intervention) were collected from both experimental classes (IX C and IX D) and control class (IX E) having 30 students in each section. The data were gathered through valid survey questionnaires, physics achievement tests, and classroom observation techniques between July and August 2021. The collected data sets were analyzed and triangulated using SPSS-22 and Microsoft excel 2011.

The study revealed 100% of participants' preferences over ICT based approach to the conventional "chalk and talk" method in learning physics. The use of ICT facilities in the teaching and learning process has put the abstractness of physics concepts out of question and has

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enabled more entertaining, engaging, effective, and meaningful learning. It was evident with the significant increase in the mean score of students' performance in the physics achievement test from 38.26 to 56.19, which account for 46.9 % for the experimental class. The opposite trend was also found for the controlled class with a mean-score difference of -0.12. Thus, the study suggests integrating ICT in teaching learning of physics to encourage two-way interactive delivery methods and enhance students' performance in physics.

Keywords: Information and communication technology; integration; performance; physics; abstract; perception; traditional; interactive.

1. INTRODUCTION

In the era of rapid advancement in science and technology, everything undergoes changes and evolves every now and then. For the nation to thrive economically, education system in the country requires closer look and necessary reformation to cope with the changes. The educational psychologist John Dewey pointed out that we could not teach the way we were taught yesterday to today's children because everything undergoes change, and we need to cope with the change [1]. Additionally, in 2009, His Majesty the King at Paro College of Education during the 3rd convocation shared the concerns regarding the need to update the education system in Bhutan. His Majesty further reiterated that we could not face the same challenges with the same tools in this given era [2]. Moreover, in 2021 during the 113th national day, to the much anxious Bhutanese, His Majesty the King symbolically handed over the Royal edict to the people on the reforms decreed for the education on December 17. The Royal edict stated that there is an irony in our context with the absence of technology in classrooms for a generation of students who are exposed to, and live in the digital age [3]. To this end, the government of Bhutan declared that ICT become the third language besides English and Dzongkha (national language of Bhutan) for all classes in Bhutan beginning 2021 academic session [4]. The government probably saw the knowledge of ICT as the only possible way out in such high tech and competitive society [5] to abridge the gap between ICT native students and ICT immigrant teachers.

ICT is defined as any communication devices such as radio, television, cellular phone, computer, CD-ROM, digital camera, network hardware, software, satellite systems as well as various services and applications associated with them, such as video conference and distance learning [6]. According to World Bank, ICT consists of hardware, software, networks, and media for collection, storage, processing, transmission and presentation of information. Similarly, United Nations Educational, Scientific and Cultural Organization (UNESCO) viewed ICT as technology of creating, displaying, storing, manipulating, and exchanging information [7]. With such profound services and application, effective use of such ICT in teaching and learning process has found great advantages in demystifying complex and abstract concepts in physics that enhances learning [8].

The use of ICT has revolutionized education globally and opened up the diversity of learning avenues like online learning, virtual learning, distance learning, e-journal, and e-education [9]. Teacher and student can communicate without having to be in a face-to-face classroom using social network and online chat. Having good Internet connectivity is the best tool for learning physics. The teacher could be away from school yet keeping in contact with the student by sending resources through email. Many of the projects and assignments can be submitted in soft copy for the assessment through email but the trend in the Bhutan is just on the rise. The trend is expected to be fully functional in the academic community with the government of Bhutan pledging to distribute personal computers to teachers and tablets to students across the country [10]. Ekanayake argued that due to a wide range of aspect such as spontaneous, personal, informal, contextual, portable, pervasive application such as talk, text, still camera, video, radio, mobile phone and the internet could add a complete new dimension to the teaching and learning process [11]. As Bhutan being on the verge of digital transformation, ICT facilities such as the Encarta educational software, Matlab, computer-based testing system, data acquisition and computer-assisted instruction are not popular. However, email system, computer simulation, computer-assisted instruction, Skype, Zoom and video conferencing are picking up in the education system and became main tools during the ongoing COVID-19 pandemic situation. Teachers and students also picked up web-based learning through Google, Wikipedia, blogs and vblogs including other ICT services such as social network, online chat, and Internet connectivity during the pandemic.

Education being the backbone of the nation, the use of ICT facilities in education facilitates the economic development in the country. In addition, the sound academic performance in science subjects by students is considered as one of the measures in economy. His Majesty the King of Bhutan emphasized that in all the countries where progress has been strong in the areas, which strive to develop, the strength of the education system has been in math and science [2]. However, students in Bhutan have underperformed in science [12] and moreover physics in particular still struggles on winning the mindset of students. It is because, physics being abstract in nature [13], it is quite challenging and demands enormous effort and energy, which is beyond the capacity of both students and teachers. Tamang suggest that physics remains as one of the knotty subject for the majority of our students with its many derivations, definitions, formulae, laws and most importantly its unending calculations [14]. The subject also lacks captivating learning activities to engage students mentally and physically and instead demands aggressive memorization [14]. According to Aina, physics is a fundamental science concerned with the basic principles of universe [15]. In fact, everything we see around us is related to physics and it is indispensable to learn physics. Through physics we understand and make sense of the working of the universe and the natural world around us. However, teaching and learning physics has been a daunting task for both teachers and learners. Partly, are to be blamed for teachers limiting their teaching strategy to the traditional lecture method and partly for using the drills and practice for solving numerical problems in the past [15,16].

The appropriate teaching method is central to successful learning in physics [17]. The traditional lecture method of instruction in physics does not cater for the present classroom environment and has not considered the learners' skills required in their place of work [18]. Furthermore, Joyce argues that there still exists a huge gap between theoretical knowledge and actual teaching practice [19]. Therefore, teachers need to design suitable teaching strategies, which enable students to grow socially, emotionally, physically, and intellectually. It is achieved by integrating ICT in teaching-learning process [20]. Shedd also supports teachers to incorporate technology into their classroom teachings [21]. Thus, the use of ICT in the present digital age has become imperative for teachers [6] to satiate insatiable desires of the students. Ntorukiri et al. also confirmed the integration of ICT in teaching learning process, which enhances accessibility, improves efficiency and promotes quality teaching and learning [9]. Physics education on the other hand, comprises numerical solving techniques and includes abstract topics [13] such as analytical geometry, trigonometry, calculus, mechanics, electromagnetism, properties of matter, digital electronics, thermodynamics, heat, optics, classical physics, and modern and quantum physics. Also, learners find it difficult to conceptualize and actualize when taught theoretically with the traditional lecture method. As a result, it has led to development of negative attitude toward the subject and decreases proficiency of the subject. Therefore, objectives of this study were to:

a. Dislodge negative views such as 'physics is difficult' and aid students having positive views towards the subject embedded in their minds,
b. Help students with conceptualizing abstract physics concepts and enhance academic performance,
c. Literate students on the use of ICT facilities to garner its merits,
d. Ensure effective and efficient teaching-learning process, and finally
e. Revamp the conventional physics instruction and introduce contemporary physics instructional approach in a classroom setting by infusing ICT in Teaching-Learning process.

2. METHODOLOGY

The quasi-experimental pre-test post-test control group design study was conducted in Chundu Armed Forces Public School (CAFPS), Haa, Bhutan to collect the data. The pre-test and post-test for controlled group and experimental group were done to measure the impact of ICT intervention program. This design helps to compare groups and measure changes resulting from experimental treatments [15, 22]. Class IX E was taken as the control group and classes IX C and IX D as the experimental group.

2.1 Data Acquisition

Both base-line data and post-intervention data were collected quantitatively administering the following tools:

2.1.1 Questionnaire

This tool was used to study the student's perception and willingness on the use of ICT in teaching learning of physics. This tool provides no opportunity for interviewers' bias [23]. The same questionnaire was used twice: one before the intervention and one after the intervention. Questionnaires were framed on five-point Likert scale (Appendix A.) with the following ratings: Strongly Agree = 1; Agree=2; Not Sure = 3; Disagree = 4; and Strongly Disagree = 5 [24].

2.1.2 Physics Achievement Test

For two consecutive months, experimental group was treated with various intervening ICT programs for teaching-learning the same topics, while the control group was deprived of the ICT intervening programs. At the end of the two months, physics achievement test was conducted on the same day for both control and experimental groups to get the post-intervention data. The test questions were framed based on the Bloom's Taxonomy from topics covered during the two months and verified by the co-authors. The midterm examination physics scores were used as the base-line data since the students were taught without the aids of ICT in any form before midterm exam.

2.1.3 Observation Technique

Johnson and Christensen [25] postulate that data gathering through observation entails observing people's behavior so as to get information about phenomena of interest. Therefore, student's conduct and behavior in the class such as the number of questions raised, the frequency of clarification sought, volunteered for presentation, initiative in the group work, any sort of misbehavior, interaction with peers and teachers were recorded within the two rounds of observation by the two co-authors.

2.2 Intervention Programs

The existing literature review suggested myriad of strategies for integration of ICT in teaching of physics lessons. But most of them are not locally available and some are beyond our competency. Therefore, intervention used in this study is limited to following few feasible programs:

2.2.1 Menti-meter presentation

Menti-meter provides real-time interaction with the audience and adds dynamics to the presentation. It is an easy-to-use online tool that allows the presenter to create digital questions, get answers, show result that are more engaging, interactive and inclusive [26,27]. Mobile phone or any other device connected to the Internet is enough to use this technology in the classroom. Besides adding variety to teaching, it breaks the inefficient one-way communication of traditional lecture method of teaching [27]. Therefore, this tool was used at the end of the unit to revise the lesson learnt and at the beginning of a new topic to check their prior knowledge on the topic in the IT laboratory.

2.2.2 3D interactive simulation

Computer simulation is a powerful tool to teach abstract concepts in physics. Some physics experiments are hazardous and require well set-up laboratory, which is impossible to perform in the school laboratory such as X-rays, radioactivity, projectile motion, an electric motor and generator. For such lessons, we could make use of computer simulation [8]. The physics textbook has the virtual simulation links under every complex topic that can be downloaded and played in the class through projector.

2.2.3 YouTube videos

The use of YouTube videos, especially 'Khan Academy' is a great educational tool for both teacher and student to learn physics [20]. Khan Academy teaches various concepts in an eloquent manner with the use of graphics, which is easy to grasp and retain the lesson. For class IX, chapter 4 'Electricity and magnetism' was mostly abstract. The relevant videos were downloaded and used as teaching material for several times in the classroom.

2.2.4 PowerPoint presentation

The lesson was prepared in the form of power point presentation (ppt) and was presented to the class with the help of LCD projector. With the animation, photos, illustrations, drawings, table, graphs used in the ppt lesson, it was easier for us to gain attention and keep student focused. However, it requires many hours in preparing a good ppt lesson.

2.2.5 Google classroom

Online classroom is convenient and can happen anytime as long as they have access to the

Internet [28]. Students were invited to join Google Classroom through emails. Students were given easy access to learning materials (offline videos, past questions papers, sample papers, and notes), by uploading onto the Google Classroom. It was noticed, during the off-hours that students exchanges ideas, clarifies doubt and makes comment through Google Classroom and learns independently at his/her own pace.

2.2.6 Web-Quest

Web-Quest is an independent inquiry-oriented learning platform where learners retrieve most or all information from the relevant website. This method of learning is appropriate for middle and higher-grade students. The experimental classes were made to do assignment worth 10 points through Web-Quest in the IT lab during the physics periods after covering every topic. In the following day, the students were asked to submit in hard copy for the assessment.

2.2.7 Education software (Hot potatoes)

Hot Potatoes is the freeware application which has six applications that can create interactive exercises for the World Wide Web. The application includes JCloze, JCross, JMatch, JMix, JQuiz, and Masher. The Masher compiles all the Hot Potatoes exercises into one unit. The software is even handy for the real-time assessment and feedback. The software was used twice during the revision of the syllabus.

2.3 Statistical Analysis

The descriptive analysis including percentage, mean, standard deviation, and paired sample t-test were performed using Statistical Package for Social Sciences (SPSS) version 22.0 and data triangulation from multiple sources using Microsoft excel 2011. The analyzed data were described under three subheadings: a) students' perception on the use of ICT in teaching-learning of physics, b) ICT and the abstract concepts in physics, and c) ICT and students' performance in physics.

2.3.1 Student's perception on the use of ICT in Teaching-Learning of physics

The information on student's perception on the use of ICT in teaching and learning of physics was obtained from survey questionnaires Part C item 1 through 10 (Appendix A). The items included both positive and negative statements to validate their understanding of statements. The mean score for both positive and negative statements were calculated and were interpreted in line with previous studies [29].

2.3.2 ICT and the abstract concepts in physics

The information regarding the relation between ICT and abstractness of subject is obtained from survey questionnaire Part C item 1 (Appendix A) and from physics achievement test. The mean score was calculated and interpreted in accordance with the previous study [29].

2.3.3 ICT and student's performance in Physics

The mean for pre-test and post-test were compared by the paired sample t-test using SPSS-22. The individual physics achievement test scores were also compared using Microsoft excel 2011 (Figure 2). To authenticate the finding, paired sample t-test and individual physics achievement test scores for control class were also run and compared.

3. RESULTS AND DISCUSSION

3.1 Student's Perception on the Use of ICT in Teaching-Learning of Physics

The overall means for positive statements regarding the students' perception toward the use of ICT in teaching-learning process before and after intervention are 3.75 and 4.41 respectively as shown in the Table 1. According to the interpretation guide, the mean score for both before and after intervention falls under the 'agree' category. It indicates that students have a positive attitude towards the use of ICT in teaching-learning process of physics even prior to this study. It may also mean that ICT integrated teaching-learning process makes the learning more enjoyable, interactive, effective, and develop positive outlook toward the subject [8,9]. While implementing the intervention programs, it was also noticed that students were exhibiting unusual curiosity, became proactive, responsive, gain attention easily, retain the attention for longer duration, create conducive learning environment, and eventually initiate true learning. Except for few introverts, many students became open to the classroom discussion. Some students even started to clarify their doubts in the class as well in off-hours. It may be how the ICT competent teacher dislodges the preconceived notion and plants the positive views in students towards the subject using ICT facilities.

Table 1. Mean score for the positive statement before and after intervention for experimental class

Sl. No	Positive statements	Baseline data			Post intervention data		
		Mean	S.D	Opinion level	Mean	S.D	Opinion Level
1	Use of ICT makes learning more enjoyable	3.93	.95	Agree	4.43	.56	Agree
2	I think technology-supported teaching makes learning more effective	3.90	.66	Agree	4.33	.60	Agree
3	Internet makes easy for us to source information in physics	2.52	1.23	Agree	4.33	1.08	Agree
4	Mobile phone is necessary for me to source information in physics	4.27	.92	Agree	4.53	.79	Agree
5	I believe tools like email, Facebook, We-Chat, Google+, Twitter, WhatsApp, and Snap-chat make communication with teacher easier	4.15	.90	Agree	4.45	1.06	Agree
Overall		**3.75**	0.932	**Agree**	**4.41**	0.818	**Agree**

Table 2. Mean score for the negative statements before and after intervention

Sl. No	Negative statements	Baseline data			Post intervention data		
		Mean	S.D	Opinion Level	Mean	S.D	Opinion Level
1	Use of ICT slow down syllabus coverage in physics	2.85	.82	Not Sure	2.87	1.07	Not Sure
2	I do not want physics teacher to use ICT in teaching	2.33	1.13	Disagree	2.07	1.10	Disagree
3	I can still learn physics better without computer and LCD projector	3.17	1.06	Not Sure	2.07	1.10	Disagree
4	Television, computer, phone, and radio are suitable for use in entertainment and not for learning physics	3.03	1.04	Not Sure	2.10	1.15	Disagree
Overall		**2.28**	0.81	**Disagree**	**1.82**	0.88	**Disagree**

The overall means for negative statements on students' perception towards the use of ICT in teaching-learning process before and after intervention are 2.28 and 1.82, which falls under the 'disagree' category (Table 2). It indicates that students are convinced of the positive impact of ICT use and it does not necessarily slow down the syllabus. The result also reveals that students are well aware of ICT facilities like television, computer, radio, mobile phone, and LCD projector as not just the source of entertainment but they also recognized them as instrumental tools for learning physics (Table 2). It is the direct indication of students' awareness on ICT literacy and the implication of ICT use in the teaching-learning process. Thus, it may suggest the maximum use of ICT services and application by teachers.

3.2 ICT and the Abstract Concepts in Physics

The mean rating before intervention and after intervention on experimental class stands at 3.15 and 4.55 score, respectively (Fig. 1). This result indicates that students already knew ICT demystify the abstract physics concepts and the study has ascertained their prior view. Thus, it signifies that teacher should use ICT in the teaching-learning process as students could learn more clearly and deeply despite the abstract and complex nature of physics. In addition, students find physics as one of the most difficult subjects due to the abstract nature of the physics concepts [30]. But the use of ICT facilities simplifies the abstract and complex concepts in physics [8]. Furthermore, ICT facility enables learners to investigate systems that are too fast, too slow, too remote, too dangerous or too expensive within the classroom in short duration and enhances the learning to a great extent [8]. Indeed, students might now say physics is not a difficult subject if physics teachers infuse ICT in the teaching-learning process.

3.3 ICT and Student's Performance in Physics

The mean rating for the pre-test and post-test of experimental class were recorded at 41.64 and 52.35, respectively (Table 3), which constitutes the mean difference of 3.93 with the significant value (p) of 0.001. It infers statistically significant improvement in the students' scores when compared to their score in the pre-test. The individual physics achievement test scores were also compared and these provide us with the visual understanding of the impact of ICT for the physics performance (Fig. 2).

This result (Fig. 2) may suggest and encourage teachers to employ a variety of ICT-based intervening programs during the teaching-learning process. It is because ICT caters to most of the senses and improves retention power that ensures better academic performance [31]. Similarly, ICT includes even the special need students and caters for the diversity of learners in the classroom [9], which was not achieved by the traditional lecture method. Thus performance of every individual student is improved.

Integration of ICT infrastructure in the teaching-learning process also makes learning learner-centred, enhances accessibility to education, provides flexibility to learning, and ultimately facilitates the improvement of the quality of education [32].

It is evident that without integrating ICT in the teaching-learning process, the mean score difference remains shallow at -0.12 with p-value of 0.972 (Table 4). There is no statistically significant difference in the mean score. The individual student's performance without employing ICT can also be seen (Fig. 3). The results (Fig. 3 and Table 4) may imply that the use of ICT enhances the performance or vice-versa.

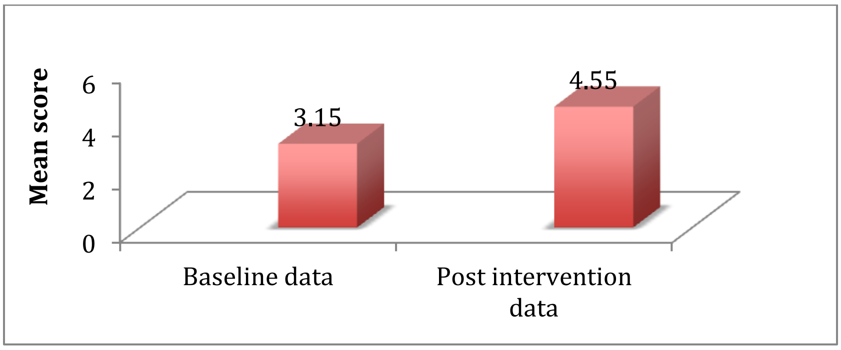

Fig. 1. Mean score for the statement "Use of ICT makes me understand physics abstract better" before and after intervention for experimental class

Table 3. Comparison of Pre-test and Post-test by Paired samples t-test [Significant (p<0.05)] for experimental class

Group	Test	Mean	Mean difference	Standard deviation	Sig. (2 tailed)
IX D & IX E	Pre-test	52.26	3.93	35.99	0.001*
	Post-test	56.19		19.39	

Table 4. Comparison of the Pre-test and Post-test by Paired samples t-test [Significant (p<0.05)] for the control class

Group	Test	Mean	Mean difference	Standard deviation	Sig. (2 tailed)
IXC	Pre-test	47.17		19.62	
	Post-test	47.05	- 0.12	20.70	0.972*

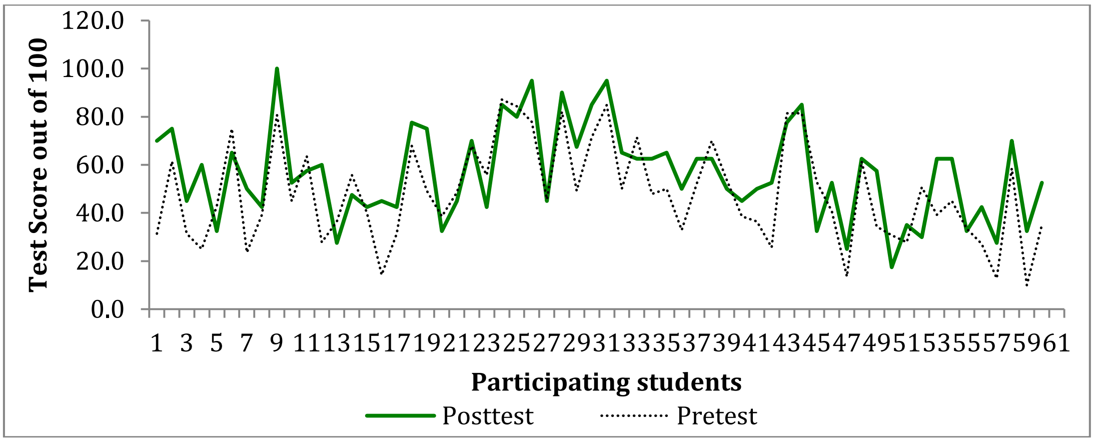

Fig. 2. Comparison of individual scores in the pre-test and post-test for the experimental class

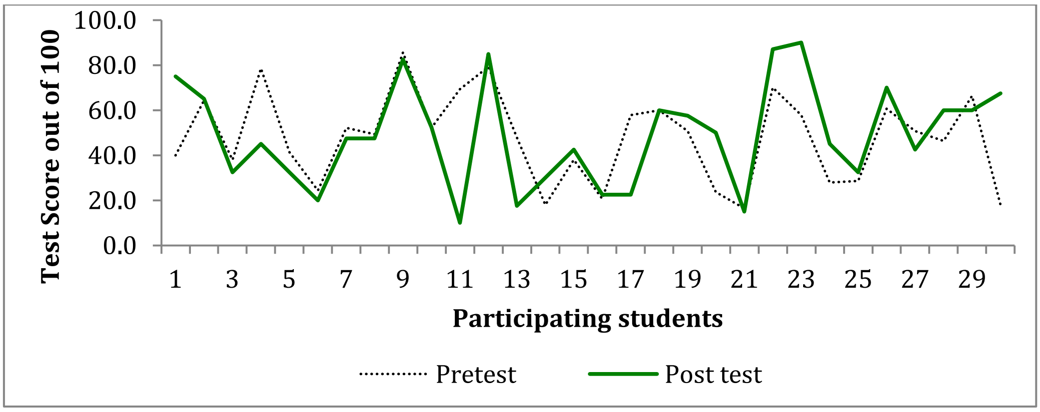

Fig. 3. Comparison of individual scores in the pre-test and post-test for the control class

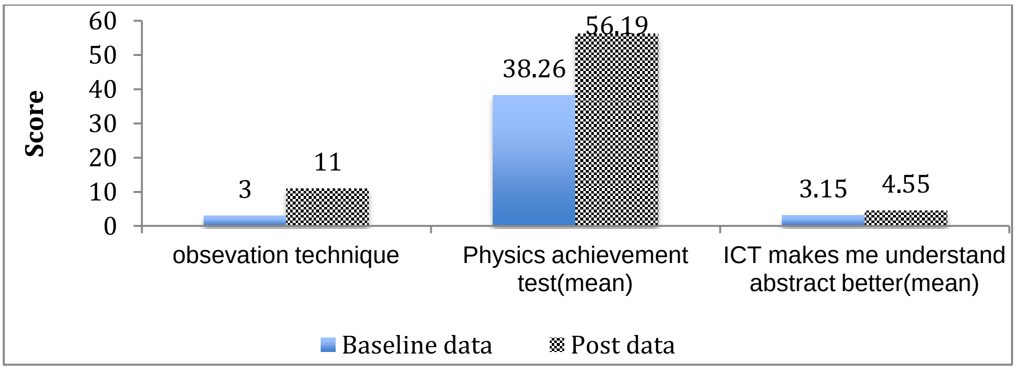

Fig. 4. Triangulation of data from class observation, physics achievement test and questionnaires (Use of ICT makes me understand abstract physics better) for both baseline data and post intervention data

3.4 Data Triangulation

Data triangulation for multiple data sources was performed to authenticate and ascertain the finding. There is an impressive rise in the student participation from regular 3 in the beginning to 11 at the end for the experimental class (Fig. 4). The physics achievement score and the questionnaire score with the mean difference of 3.93 and -0.12, and significant p-values of 0.001 and 0.972, respectively also illustrate the clear indication of the success of the intervention program.

Prior to implementing the intervention program, students were not certain if ICT would really play a part in their learning of physics. But after intervention program, they agreed that ICT facilities are inevitable tools for meaningful learning of physics and thereby enhances their academic performance [22]. The similar study conducted in Ghana also showed the same result [8,22]. However, having ICT competent teacher and adequate ICT infrastructure in school is indispensable attributes for increasing physics achievement by students. The study hardly focuses on the availability of ICT facilities and ICT competent teacher, but seen as probable future study to complete the ICT impact puzzle.

The students are also aware that the ICT can transform the culture and practice of traditional memory-base learning into education that stimulates critical and creative thinking skills to meet the challenges of the current century. It is because ICT provides student-centred teaching-learning process that is conducive to learning environment [32]. Moreover, ICT service reduces teachers using traditional 'chalk and talk' method but encourages the use of electronic technology to keep pace with the latest trend [5]. However, teachers feel the use of ICT in the teaching-learning process slows down the lesson delivery and hampers the syllabus coverage. But students are still not sure whether the use of ICT in the teaching-learning process slows down the syllabus completion. It may be due to short duration, limited ICT-based intervention programs and limited teacher's knowledge on ICT use. Aina argued that there is no limit to the ICT application and services [20] but it is the matter of ICT knowledge and the availability of ICT facilities in the school. Therefore, teachers across the country may be drilled on the use of ICT in education and encourage them to use it as a supplementary tools for the teaching-learning process.

4. CONCLUSION

The study reveals students' strong embracement of the use of ICT by physics teachers in the teaching-learning process. ICT services and application such as television, multimedia, videos, computer software, simulation, combine text, and colorful motion pictures provide challenging and rich content material in much simpler way. ICT also breaks the one-way traditional lecture method and provides a two-way interactive delivery mode with timely transmission of information and knowledge that provoke curiosity, gain and retain attention, and provide inclusive education, which has initiated true learning for every individual in the classroom. The ICT infused lesson also dislodges the preconceived notion and plants positive views toward the subject. The result also indicates that physics with abstract and complex ideas may not be considered as a difficult subject if ICT is used.

The study shows about 46.9% improvement in the physics achievement test between pre-test and post-test and there may be more improvements if the duration of intervention was increased. There are many ICT applications and services that can be used in education but depend on the teacher's knowledge in ICT. The advocacy or creating awareness on the appropriate use of ICT, providing technical and administrative support to teachers, ensuring fast Internet connection and training teachers on use of ICT in lesson delivery may recommend to consider by the concerned stakeholders. The Ministry of Education may also consider conducting in-depth research and look into 'No phone policy' for High Scholars and reconsider after weighing the negative and positive impact of using smartphone. Infusion of ICT in the teaching-learning process has become a necessity more than anything else in the classroom. True learning is possible when the ICT is used as a supplementary tool along with the traditional method of classroom teaching. Thus teacher may use ICT as a flavor that adds taste to the teaching-learning process, not as substitute teacher.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge.

ETHICAL APPROVAL

As per international standard or university standard, written ethical approval has been collected and preserved by the author(s).

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Turkmen H. What technology plays supporting role in learning cycle approach for science education. The Turkish online Journal of Educational Technology. 2006; 5(2):71-76.
2. Royal Education Council. The national education framework (NFE): shaping Bhutan's future. Royal Government of Bhutan. 2012;13-142.
3. Royal Kashos on civil servant and education. Kuensel; 2021. Accessed 27 January 2022. Available:https://kuenselonline.com/royal-kashos-on-civil-service-and-education/
4. Dorji P. ICT to be the third language for all classes starting next year, PM. Bhutan Broadcasting Service limited. 2020. Accessed 24 January 2022. Available:http://www.bbs.bt/news/?p=140612
5. Sharma A, Gandhar K, Seema, Sharma S. Role of ICT in the process of teaching and learning. Journal of Education and Practice. 2011;5(2):1-5.
6. Livingstone MJ. Use of ICT in teaching physics: A case of secondary schools in Kimillili district, Bungona county, Kenya (2015). MSc. Thesis, Kenyatta University, Kenya.
7. The world bank group. ICT and MDGs: A world bank group perspective. 2003. Accessed 20 November 2021. Available:https://asksource.info/resources/ict-and-mdgs-a-world-bank-group-perspective
8. Aina JK. Integration of ICT into physics learning to improve students' academic achievement: problems and solutions. Open Journal of Education. 2013;1(4):117-121. DOI: 10.12966/oje.07.01.2013
9. Ntorukiri TB, Mukami E, Kirimi F, Riungu CM. Impact of integrating ICT infrastructure in teaching and learning in Kenyan secondary schools in Meru county. European Academic Research. 202;8(12):7229-7241
10. Drukpa U. MoE to put up proposal to the government to provide tablets for all students. The Bhutanese. 2020. Accessed 1 February 2020. Available: https://thebhutanese.bt/moe-to-put-up-proposal-to-the-government-to-provide-tablets-for-all-students/
11. Ekanayake SY, Wishart J. Integrating mobile phones into teaching and learning: A case study of teacher training through professional development workshops. British Journal of Educational Technology. 2015;46(1):173-189. DOI:10.1111/bjet.12131
12. Palden T. Mathematics and science – the usual suspects. Kuensel. 2015. Accessed 29 December 2021. Available: http://www.kuenselonline.com/mathematics-and-science-the-usual-suspects/
13. Adeyemo SA. Teaching-learning physics in Nigerian secondary school: The curriculum transformation, issues, problems, and prospects. International Journal of Educational Research and Technology. 2010;1(1):99-111.
14. Tamang M. Strategies for teaching physics. Rabsel-Center for Educational Research and Development. 2004;4(1):34-45.
15. Aina JK. Investigating the conceptual understanding of physics through an interactive lecture engagement. Cumhuriyet International Journal of Education. 2017;6(1):82-96.
16. Tao P, Gunstone. The process of conceptual change in force and motion during computer-supported physics instruction. Journal of Research in Science Teaching. 1999;36(7):859-882. DOI:10.1002/(SICI)1098-2736(199909)36:7
17. Wambugu PW, Changeiywo JM. Effects of mastery learning approach on secondary school students' physics achievement. Eurasia Journal of Mathematics, Science and Technology Education. 2008;4(3):293-302. DOI:10.12973/ejmste/75352

18. Yelland N. Teaching and learning with ICT for numeracy in the early childhood and primary years of schooling. Australia: Department of education, training and youth affairs; 2001.
19. Joyce B. Changing school culture through staff development: Yearbook of the association for supervision and curriculum development. Virginia: Alexandria Va; 1990.
20. Aina JK. Effective teaching and learning in science education through information and communication (ICT). Journal of Research and Method in Education. 2013;5(2):43-47.
21. Shedd J. Incorporating technology in the classroom: A publication of the school of education. USA: Syracuse University; 2004.
22. Jarosievitz B. ICT in physics teaching for secondary schools and colleges. New Perspectives in Science Education. 2012;1-6.
23. Saunders M, Lewis P, Hornhill A. Research methods for business students. 4th ed. England: Prentice Hall; 2007.
24. Jatsho S. Rinchen S. Strategies for teaching physics: An action research. Educational innovative and practice. A Biannual Journal of Samtse College of Education. 2016;1(1):53-66
25. Johnson B, Christensen LB. Educational research: quantitative, qualitative and mixed approaches. 2nd ed. USA: University of Virginia; 2004.
26. Kay RH, Lesage A. Examining the benefits and challenges of using audience response system: A review of literature. Computer and Education. 2009;53(3):819-827.
27. Mohin M, Kunzwa L, Patel S. Using mentimeter to enhance learning and teaching in a large class. UK: School of Engineering and Technology, University of Hertfordshire, Hatfield; 2020.
28. Brekke M, Hogstad. New teaching methods-using computer technology in physics, mathematics and computer science; 2010. DOI: 10.20533/ijds.2040.2570.2010.0004
29. Tshering, Phu-Ampai S. Effects of using rubrics on the learning achievement of students in educational assessment and evaluation. Educational Innovation and Practice. 2018;8(1):75-88.
30. Zangmo S. Attitudes of grade ten and twelve students towards science in Bhutan (2016). MSc. Thesis, Prince of Songkla University, Thailand.
31. Begum AJ. ICT in Teaching-Learning. Delhi: Navin Shahdara; 2011.
32. Dei DJ. Assessing the use of information and communication technology in teaching and learning in secondary schools. Library Philosophy and Practice (e-journal); 2018. DOI:10.6025/jet/2018/9/3/97-102

APENDIX A

Questionnaires

PART A: Demographic Information

Instruction: Please TICK [✓] the most appropriate choice

a) Gender: Male ☐ Female ☐

b) Class: VII ☐ VIII ☐ IX ☐ X ☐

c) Age: 12-15 ☐ 16 -20 ☐ 21 -25 ☐ 26 -30 ☐

d) Home town: Urban ☐ Semi-Urban ☐ Rural ☐

e) For how long have you been using computer?

None ☐ Below one year ☐ 1-2 years ☐ 3-4 years ☐ More than 5 years ☐

f) For how long have you been using Internet?

None ☐ Below one year ☐ 1-2 years ☐ 3-4 years ☐ More than 5 years ☐

g) Have you been trained in using computer? Yes ☐ No ☐

h) Have you receive any training in using Internet? Yes ☐ No ☐

i) I use smart phone after school at home for doing homework, assignment, and project work. Yes ☐ No ☐

PART B: Student's general perception on physics

Instruction:
Please rate the following statement with the tick [✓] that best describes your opinion

Key: 5 – Strongly agree, 4-Agree, 3-Not Sure, 2-Disagree, 1-Strongly Disagree

Sl. No	Physics Interest Indicators	5	4	3	2	1
1	Physics is a very interesting subject					
2	Teacher's way of teaching determines my understanding of physics					
3	I am feeling bored when I listened to teacher's lecture throughout the period					
4	Physics is not difficult but need competent teacher					
5	I will do degree in physics					

PART C: Perception on use of ICT in Teaching/Learning of Physics

Instruction: Please consider each of the following statements and indicate the response that reflects your opinion by ticking (✓) in the appropriate column.

Key: 5 – Strongly agree, 4-Agree, 3-Not Sure, 2-Disagree, 1-Strongly Disagree

Sl. no	Statement	5	4	3	2	1
1	Use of ICT makes me understand physics abstract better					
2	Use of ICT makes learning more enjoyable					
3	I think technology supported teaching makes learning more effective					
4	Use of ICT slow down syllabus coverage in physics					
5	I do not want physics teacher to use ICT in teaching					
6	Internet make easy for us to source information in physics					
7	Mobile Phone is necessary for me to source information from Internet					
8	I can still learn physics better without computer and LCD projector					
9	Television, computer, phone, and radio are suitable for use in entertainment and not for learning physics					
10	I believe tools like e-mail, Facebook, WeChat, Google+, twitter, WhatsApp, and SnapChat make communication with teacher easier					

Thank you for sparing your valuable time to respond to this questionnaire

APENDIX B

Principal's consent form

Date:

Respected Principal,

This year, I am in the process of working on an Action Research. The topic of my research is …………………… Over a period of ……………………., I will observe the class………… to collect data and I assure that no harm in any form will be done to the students. Any information that can be identified with students will remain confidential.

In order to successfully conduct my research, I am requesting your permission to use the students' data for my research. If you agree to let the students of class………to participate in my research, I would like you to kindly fill up the form given below with your signature.

If you have any questions or concerns, please feel free to talk to me.
Thank you in advance for your support.
Sincerely

Tick the relevant:

I have read the consent form. I give my consent for class…………students to take part in the research study.

I have read the consent form. I do not give my consent for class……….students to take part in the research study.

Principal's signature:……………………………   Date: /   /

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