



Effectiveness of Computer Assisted Instruction on Secondary School Students' Achievement in Biology: A Case Study in Samtse Dzongkhag

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This study investigated the effectiveness of the use of Computer Assisted Instruction as an innovative instructional approach in enhancing students' achievement in Biology. Study was conducted at two Bhutanese secondary level schools under Samtse district in southwest Bhutan. Sample size consisted of a total of 120 students and four Biology teachers. The study employed mixed methods since this method is particularly useful in understanding any contradictions between quantitative and qualitative findings. Quantitative data was collected based on test-retest approach (quasi-experiment) to establish a cause-and-effect of the interventions while qualitative data was collected based on semi-structured interview for both biology teachers and students. The simulation and animation were used as a mean of intervention for biological concepts teaching for the experimental group while the traditional method was applied for teaching the control group. Findings were analyzed descriptively and inferentially.

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Study revealed that Computer Assisted Instruction has positive impacts on students' performance, evidenced by the findings that the students who were exposed to Computer Assisted Instruction (Experimental Group) have significantly outperformed the students who were taught using the Traditional teaching method (Control Group). The findings on gender difference revealed no significant difference in terms of academic performance in CAI. Further, both the teachers and students showed positive perceptions towards the use of CAI in teaching Biology. Therefore, the findings of this study would encourage Biology teachers to use CAI to enhance students' achievement.

Keywords: Effectiveness; computer assisted instruction; samtse; Bhutan.

1. INTRODUCTION

Science and technology have been considered as the main backbone of the country's advancement in various life's aspects. Science has a great impression on today's knowledge-based society and science has brought incredible changes in the life of an individual. All those advancements would change society and influence the education system in the country. In the education system, technology has been integrated widely in various forms, such as storing the data, e-content development, and e-learning. The speed at which technology has developed plays a major role in this change [1]. The introduction of technology in education in different forms would immensely play a vital role in enhancing the quality of the teaching-learning process, making children more creative and providing them with an individualized environment in learning [2]. Similarly, Das [3] found out the positive attitudes of students towards the use of computers in education and some students even suggested completely stop using the traditional teaching methods in the classroom.

Science enables the learners to explore the world by inquiring, testing, experimenting, and observing. Science subject is divided into three branches (Biology, physics, and chemistry). Among the three science subjects, Biology is one of the central subjects which deals with the study of living things, their characteristics, and their environment. The study of Biology comprises of making observations, formulating a hypothesis, and performing scientific experiments to make meaning of investigation [4]. In addition, Biology subject has played a vital role in science education in Bhutan [5].

According to Dimbisso [6], academic performance is defined as how students deal with their academic studies and how students

cope up with different tasks assigned within a fixed time or academic year. The certain scores and grades obtained by the students in the exam would directly actualize the effectiveness of schools and the quality of education at large [7]. The effective teaching-learning and academic performance of students depend upon the types of instructional strategies used in the teaching-learning process. For instance, in an attempt to equip and promote teachers' use of various teaching pedagogical strategies, the Ministry of Education (MoE) of Bhutan has provided rigorous professional development programs on the topic of 21st-century transformation pedagogies to all the teachers in the country [8].

In line with this, Computer Assisted Instruction (CAI) is one proven and widely used approach in other parts of the world to meet the needs of 21st-century learners. CAI is an important and innovative method for teachers as it facilitates the students by providing individualized instruction, effective interaction with prompt feedback [9]. More prominently, CAI has various embedded characteristics, such as text, graphics, audio, visuals, pictures, animation, and simulation in the same media to students [10]. Computer-Assisted Instruction also helps in fostering learners' conceptual understanding of the particular topics, building their confidence, and promoting communication within the learners during the teaching-learning process [11].

Several other studies have reported the use of CAI being very effective in order to improve the students' academic performance in Biology as well as in other disciplines [12-14].

Therefore, this research intends to study the effectiveness of the use of CAI in improving the students' academic performance in Biology at the secondary level of schools under Samtse Dzongkhag, using simulation and animation as the CAI.

1.1 Problem Statement

The students' low academic achievements in the science subjects at the Bhutan Certificate of Secondary Education (BCSE) level examinations has always been a concern at all levels of educational communities. Although various initiatives and efforts have been geared towards improving the pedagogical approach and in shaping of the science curriculum by the Ministry of Education (MoE) and other educational bodies, the trend of students' academic achievement in Science subjects still draws an urgency of attention. For example, the academic performance of students in Biology subject based on BCSE result, published by the Bhutan Council for School Examination and Assessment (BCSEA) for the past 4 consecutive years, i.e. (2016-2019) showed the overall mean mark of 50.98% (Source: Pupil Performance Report, 2016, 2017, 2018 and 2019), which is not very encouraging.

Various factors might have contributed to this trend of poor students' performance in Biology. One such factor could be lack of teachers' incorporation of pedagogical skills into their daily instruction. Another factor can be inadequate use of CAI in delivering Biology lesson in the classroom.

Several studies have confirmed the successful use of CAI as instructional tool in improving the academic performance of students in Biology [13,15]. Therefore, this study was intended to examine the effective use of CAI in improving the students' academic performance in Biology subject.

1.2 Research Question

How effective is CAI in teaching Biology at secondary level schools?

To explore deeply into the above main research question, the research question is subdivided into three sub-questions.

1. Is there any significant difference between the test scores of the Control Group and the Experimental Group?
2. Is there any significant difference between the genders-wise performance in the Experimental group?
3. What are Biology teachers' and students' perceptions towards the use of CAI in teaching Biology?

1.3 Significance of the Study

The findings of this study are to inform the educators, curriculum developers, learners, pre-service Biology teachers, in-service Biology teachers, and policymakers about the effectiveness of incorporating CAI in improving students' academic performance in Biology. This study would also encourage all the secondary level schools of Bhutan to use CAI in teaching, not only Biology but also other science subjects. The findings of this study will provide baseline information on the effectiveness of CAI and serve as a stepping stone for future researchers who might take up a bigger research projects with more funding.

2. LITERATURE REVIEW

The study investigated the effect of CAI as a teaching strategy to teach Biology subjects. Therefore, this section provides a brief review of the various kinds of literature that are associated with the present study.

2.1 Computer Assisted Instruction in Education

Computer-Assisted Instruction has been introduced many decades ago for educational purposes and CAI started appearing in school education as early as in the 1960s. The considerable works in school education regarding CAI started between the 1950s and 1960s, by the researchers from Stanford University in California and International Business Machines Corporation (IBMC), who developed the idea of CAI into elementary schools. In the beginning, the CAI programs were found in the form of linear presentation of information with drill and practice sessions. The earlier form of CAI systems was limited due to several reasons, such as expenses and also user incompetency to obtain, maintain, and use the computers which were available during that time [12,16].

The quality of education fully depends on the quality of teaching strategies used by the teachers to deliver instruction in the teaching-learning process. Computers are not only used in schools as a means of analyzing various data but computers have become universal instructional tools to enhance students' learning. Today, the majority of the schools in different parts of the world started using varied CAI tutorials to

enhance the learning outcome to meet the educational objectives [17].

According to Julius [12], CAI is one useful and innovative instructional approach that includes the use of a computer program to present the instructional materials and monitor the learning that takes place in education. Similarly, Patel [18] states that various modes of CAI tutorials, such as simulation, video, drill and practice, and animation contain combined effects such as text, graphics, sounds, video to present the instruction to the students. Likewise, Nazimuddin [16] found that CAI is a varied and fast-growing field of technology that assists in the area of the teaching-learning process in education. CAI is one multimedia instruction, that is proven to be most effective in improving students' academic performance in education and that engages, motivates, and arouses interest in teaching-learning process [19].

2.2 Concepts of Computer Assisted Instruction

CAI refers to the use of computers and software applications to present the instruction to the students to teach concepts or skills [20]. Computer-based education (CBE) and computer-based instruction (CBI) are the broadest terms that refer to virtual environments. Computer-Assisted Instruction (CAI) and Computer-Aided Instruction (CAI) are the narrower terms that are interchangeably used. Computer-managed instruction (CMI) are strategies whereby computers are used to deliver learning objectives, teaching-learning resources, assessment, and record keeping [21]. Some of the examples of CAI are simulation, animation, tutorials, drill and practice, and multimedia instruction. CAI comprises the combination of texts, graphics, sound, and video in the learning process. It is the modified teaching method that every educator can use depending on the abilities of the computer to find relevant information with different contents. CAI packages enhance the students' learning if the lesson program is prepared well-using computers [22].

2.3 Computer Assisted Instruction and Traditional Teaching Methods

Teaching is defined as the set of events that are designed to support the internal process of students' learning [23]. Andalal and Ng'umbi [24], defined teaching as orderly procedures that a teacher employs in teaching and learning.

According to Hake [25], the daily practice of teaching has been predominantly lectured methods from a long time back. Similarly, in Bhutan Sherab and Dorji [26] have recommended the need for a major paradigm shift in terms of teaching pedagogy. Their finding indicated that there is an existence of teacher-dominated lessons in Bhutanese classrooms. Studies have shown that when the teacher uses the traditional method of teaching, students are deprived of developing critical thinking and students lose interest leading to difficulty in developing knowledge [27].

Unexceptionally, in Bhutan, the way the teacher delivers lesson are dominated by lecture method. According to Royal Education Council [28], the teacher-centered lesson becomes the knowledge transmitter; whereby students remain as passive listeners. Similarly, in the study carried out by [29] the Bhutanese classrooms are fully initiated by the teacher-centered approach. He mentioned that in a traditional teaching environment students rarely get opportunities to exchange ideas, ask questions. It was understood that such type of teacher-centered practice usually makes superficial learning of concept and that contributed to low performance making the low quality of education [30]. Such type of method has led to failure in innovations, and scientific thinking. This method has enabled learners to memorize the concepts taught.

Various studies have proven that CAI has benefits over traditional teaching methods. For example, [31] pointed out the advantages of CAI in classroom practice. First, it provides opportunities to teachers and learners to be quicker in instruction. It also promotes engaging the students in learning and provides learners with available sources of information. Second, CAI can change the responsibilities of teachers from knowledge transmitters to facilitators. Lastly, CAI can also change the roles of the students from passive learners to active learners.

Study by Tareef [32], unveiled that CAI is effective over traditional methods of teaching, this is because CAI presents the instructions in the form of text, images, audio, video, and animation. Dalal and Rani [2], report that CAI allows individual learners to evaluate, test, and provide feedback for themselves. CAI provides the learners own self-paced learning, develops creativity, and improves problem-solving skills which are not possible through the conventional methods of teaching.

According to Bhagwan [33], some of the significant advantages of CAI over traditional teaching methods are: CAI promotes positive effect on students' attitudes, provides better teaching instruction, shift the teaching-learning process from teacher-centered to a student-centered, inspires collective learning, enhances the teacher-student communication and provides active participation in the teaching-learning process. Therefore, this study intended to examine the effectiveness of CAI to teach Biological concepts over the Traditional teaching methods.

2.4 Effectiveness of CAI and Students' Achievement

Serin [34], reported that there was a statistically significant increase in the achievements of the experimental groups who were given treatment using CAI against a control group.

Similarly, Kausar and Gujjar [15] conducted a comparative study based on the use of CAI to the traditional teaching approach in terms of achievement of knowledge, analysis, and synthesis levels of Bloom's taxonomy. The findings showed significant differences between the groups on the post-achievement test in favor of the experimental group. Likewise, Bhatti [35] conducted a study to compare the effectiveness of CAI and Conventional Method (CM) for retention of Mathematics in Higher Education. The findings from his research indicated a significant difference between the mean scores of experimental group (EG) and control group (CG).

Achor and Ukwuru [36] have investigated the effect of CAI on raising the retentive ability of senior secondary school students in chemical reaction equilibrium in Nigeria. Their findings indicated that there is a significant difference in terms of the mean retention of students taught chemical reaction and equilibrium that were taught with CAI and those taught through traditional teaching methods.

Research carried out by Ardac and Sezen [37] found that when CAI is supported by teacher-directed guidance, it is very effective to increase students' academic achievement. Their study indicated a highly significant gain in content knowledge of students who were taught using CAI supported by teacher-directed guidance than learning left without guidance by the teachers.

Chaudhari [38] pointed out that CAI is effective in the different subject areas and it is useful even for the student's achievement in Biology subject. He mentioned that CAI can be used as a supplementary tool by the teachers to overcome the problems like lack of visualization of teaching-learning materials. He also concluded that, although CAI cannot replace good teachers, it enables the educator to complement them and enable easier and faster learning of content.

The CAI is important to approach particularly for the teachers, as it enables the learners to have individualized instruction, effective interaction along immediate feedback [39]. Kareem [13] also found that teaching facilitated with technology can enhance the quality of instruction, and thus it increases the understanding of contents of the subject and therefore, it can improve the students' academic performance. Hence CAI is indispensable for teaching the concepts in Biology to enhance teaching and learning.

In addition, the quantitative study by Krishnan et al. [39] in India showed that there is a significant increase in the mean post-test scores in favor of EG, indicating better learning of EG who were taught through CAI. In Negeria, Gambari et al. [40] found that the chemistry students of Nigerian Secondary schools who were treated with CAI had higher extrinsic and intrinsic motivation.

Study conducted in Japan by the researcher Chartrand [41], found that students from the experimental group who were treated with CAI have better performance in terms of academic achievement. Similarly, Kareem [13] supported that there is a significant improvement in students' academic performance in Biology after the application of CAI.

The study conducted by Akra et al. [42] in Pakistan, reported that CAI is effective in teaching chemistry than traditional instruction. For instance, students' academic achievement improved significantly in both government and private schools through CAI intervention.

In contrast, there are certain cases of CAI studies indicating that CAI is not being effective in the teaching-learning process. Ross and Bailey [43] reported that CAI is not appropriate for all types of teaching-learning content.

In addition, the study carried out by Owusu et al. [44] reported that control group students performed better than experimental group

students that taught through the CAI. Their study also reported that, though students from EG did not perform better than CG, the students' interviewees from the experiment group provided a positive response and opined that they have understood the lesson very well that was taught using CAI. It is understood that the better performance of the students in CG may be due to some other factors such as the lesson or the concepts taught might have been very easy or simple. Such findings, however, are futile and limited compared to the outperformance of the EG in the majority of the cases.

In summary, CAI is an effective teaching strategy to teach Biology which has the potential to increase academic achievement, curiosity, classroom participation, and motivation. However, no research studies have been conducted on the effectiveness of CAI on Biology in Bhutan.

2.5 Gender and Achievement

Gender is a psychological term, which refers to the characteristics of women, men, girls, and boys. These are socially constructed. Gender includes norms, behaviors, and roles associated with being a man or woman and girl or boy as well as relationships among one another [45].

Studies on gender-wise academic performance differences in Biology have indicated inconsistent findings. Some of the research findings have revealed that male students perform well than female students in Biology [46,47]. While other studies discovered no significant difference irrespective of gender. For example, [48,12] conducted a study in Nassarawa Educational Zone, Kano state. Their findings revealed that there is no significant difference between male and female students taught chemistry through CAI.

Similarly, Achuonye [1] found out no significant differences between the genders. However, there is a marginal difference in favor of male students. While the studies above have observed gender-wise achievement differences as well as no differences in various subjects including achievement in Biology. Therefore, this is a curious aspects to be investigated and see the gender differences through using the CAI approach in this study.

2.6 Students' Perceptions on the use of CAI

Aşkar [49] conducted research to explore the students' perception towards the use of CAI and attitudes towards computer-assisted learning. Their study revealed that students were more interested, better understood the materials presented through CAI. Students have also expressed that their attention and success were increased in the CAI environment. However, an interesting finding drawn from this study was the interaction between the teacher and learners was very minimal.

Another research conducted on the effectiveness of CAI on Students' Attitudes towards Science Courses in Turkey by [50] revealed that 74% of the students provided positive feedbacks whilst 26% of the students reacted negatively. Olanrewaju et al. [51] explicated that CAI engages learners, promotes students' participation, motivates or increases their interest. So, CAI possibly improves their academic achievement.

The study conducted by Owusu et al. [44] reported that students rated CAI material as exciting and interesting. Their study also revealed that students have provided the response, like, exciting, I like illustration and students showed overall positive interest toward CAI. The positive indication towards the use of CAI maybe because CAI help them understand the concept better and enjoyed the lesson.

2.7 Teachers' Perceptions on the use of CAI

Perception refers to believe or opinions of the participants in the study. According to the study carried out in Nigeria, by Nwaubani et al. [52] showed that Social Studies Head-teachers and teachers, males and females as well as rural and urban participants have agreed on the effectiveness in teaching-learning of Social studies. Their study has also revealed that CAI enables teachers to effectively teach difficult content as CAI boosts their interest, and reflection on the particular topic.

2.8 Challenges in Integration of CAI

Although CAI has been used in the classroom setting for a long time back, there is a number of factors, which hinder its effectiveness. For example, in a CAI environment, if students are kept all alone on their own, they may be

overwhelmed by the material contained in CAI which leads to the loss of the main focus of the learning. Further, malfunctioning of devices results in the loss of time making learners frustrated [53]

According to Roschelle et al. [54], there are some issues regarding the implementation of CAI, as CAI materials are not readily available and are costly. This may be an immense problem for the teachers to implement CAI in developed and underdeveloped countries. It is not necessarily teachers to use programmed CAI package all the time, instead of integrating technology in their instruction makes considerable improvement in students' achievement

Further, Harrison [55] identified that teachers' capabilities and knowledge in incorporating technology tools, and their negative attitude, personal belief towards CAI are factors that deterred the use of CAI in classroom instruction.

According to Jesse [11], the general inadequacy of various learning resources, such as curriculum, other learning material that demands the use of ICT use, and numerous ICT devices impedes the application of CAI in lesson delivery. Pelgrum [56] reported that lack of CAI-related training and knowledge of teachers was one main factor that deterred the integration of CAI lessons in the schools.

3. METHODS

3.1 Research Design

This study is designed through a mixed-method approach. Quasi-experimental design was aimed at establishing the relationship between an independent and dependent variables because this approach allows researcher to identify a comparison group that is as similar as possible to the treatment group. Accordingly, the quantitative assessment was subjected to using a survey questionnaire based on a five-point Likert scale during pre-test, and post-test events. Face-to-face semi-structured interview was designed to collect qualitative data.

3.2 Sampling and Procedure for Data Collection

A total of 120 students and four Biology teachers from two secondary schools (School 1 & School

2) with computer laboratories under Samtse District were selected using convenience sampling procedures based on the availability of ICT infrastructure. The students' grade (Class X) for the empirical data collection was purposively sampled. This is because the study on CAI (Animation and Simulation) lesson was based on the topic 'Digestion' from the tenth-grade Biology syllabus. Prior to the allocation of CG and EG, a pre-test was conducted for all sets of students. The test score of pre-tests was evaluated and based on their test scores, students were then grouped into EG and CG using a cluster sampling procedure, so that both the groups would constitute equal levels of students in terms of academic achievement. This procedure was followed to ensure minimum bias. Accordingly, the intervention was carried out for two weeks in each of the schools. The traditional method was applied to the CG and CAI was employed to EG teaching. At the end of the interventions, a post-test was conducted for both groups. Additionally, the students' survey questionnaire was administered to all the EG students. Furthermore, six students and four Biology teachers were chosen for face-to-face semi-structured interviews using simple random sampling and purposive sampling procedures respectively to collect qualitative data. Data were compiled and analyzed.

3.3 Data Analysis

The data were analyzed using SPSS version 22 and Microsoft office excel 2016. Quantitative data were subjected to statistical analysis, specifically the independent sample t-test was performed between pre-test and post-test for EG and CG. Similarly, Paired Sample t-test was performed to determine the gender-wise difference and in descriptive analysis, mean, mean difference, p-value, and range of scores for the variables were executed. Qualitative data were subjected to thematic analysis based on the biology teachers' and students' perceptions to examine how they perceived towards the use of CAI.

3.4 Results Interpretation

The data from the students' survey questionnaire were categorized and interpreted using a mean based on the Brown model. According to Brown (2010), 1-1.50 (very poor), 1.51- 2.50 (poor), 2.51- 3.50 (moderate), 3.51-4.50 (good), and 4.51- 5 (very good) (Table 1).

4. RESULTS AND DISCUSSION

4.1 Pre-test Data Analysis (CG&EG)

Prior to the intervention, the students in both EG and CG were administered through Biology Achievement Test (BAT) to test their preceding knowledge of Biology subject based on the topic "Digestion" where this topic was chosen to be used as a key area of teaching for this study. The test was conducted out of 40 marks. An Independent Sample t-test was performed to examine the statistical difference between CG and EG. No significant difference ($p=0.443$) was noted with the mean difference of 0.54 between the groups in terms of students' prior knowledge on the topic "Digestion" (Table 2). This data confirms the equal distribution of students' abilities between the groups in terms of their academic performance in Biology subjects.

4.2 Post-test Data Analysis (CG&EG)

The independent sample t-test was performed at a 95% confidence interval to validate research question 1 of the study. Data indicated that there was a significant difference between the post-test scores of CG and EG with the p -value of <0.001 and mean difference of 6.95 (Table 3). This result indicates the use of CAI as the instructional approach was useful and effective strategy to apply in biology teaching to improve the academic performance of students in Biology learning.

Similarly, the students' qualitative data also revealed enhanced knowledge particularly in the digestion chapter, and provided the most satisfactory responses with high confidence level and precision to questions that were asked. The above finding is in an agreement with that of the study conducted by [48,15].

4.3 Findings of Pre-test and Posttest Scores between CG and EG

In order to find out the significant difference between the groups of CG and EG, the paired sample t-test was performed at a 95% confidence interval. Data indicated a statistical significant difference with p -value of <0.001 between the pre-test and post-test scores of EG and the mean difference of 8.17. Further, to see the effect size of two groups (EG & CG), Cohen's d was calculated. According to Cohen [57], d is the difference between the means, $M1-M2$, which is divided by the standard deviation (s) either in the group or between the groups. Cohen considered that $d=0.2$ as "small" effect size, $d=0.5$ as "medium" effect size, and $d=0.8$ as the "large" effect size. Osteen and Bright [58] reports that in statistical inference, the effect size is an estimated measure of the strength of two or more variables. Hence, the magnitude of an effect enables us to determine the practical significance.

The Cohen's d value of pre-test and post-test of EG in this study was 2.43, this indicated that there was a large practical significant effect on students' achievement due to CAI intervention.

Table 1. Interpretation of students' perception mean scores with reference to brown model

| Mean values | Agreement | Level of perception |
|-------------|----------------|---------------------|
| 4.51-5.00 | Strongly agree | Very good |
| 3.51-4.50 | Agree | Good |
| 2.51-3.50 | Neutral | Moderate |
| 1.51-2.50 | Poor | Disagree |
| 1.00-1.50 | Very poor | Strongly Disagree |

Adapted from [59]

Table 2. Independent sample t-test of pre-test between groups of CG &EG

| Test | Group | N | Mean | Mean Differences | Sig (2 Tailed) |
|----------|-------|----|-------|------------------|----------------|
| Pre-test | CG | 60 | 11.92 | 0.54 | 0.443 |
| | EG | 60 | 11.38 | | |

* Significant ($p<0.05$)

Table 3. Independent sample t-test of post-test between groups of CG &EG

| Test | Group | N | Mean | Mean Differences | Sig (2 Tailed) |
|-----------|-------|----|-------|------------------|----------------|
| Post-test | EG | 60 | 19.55 | 6.95 | 0.001 |
| | CG | 60 | 12.60 | | |

* Significant ($p < 0.05$)

Similarly, there was a significant difference of p-value of 0.02 was observed between the pre-test and post-test scores of CG with a mean difference of 0.69. The Cohen's d value of pre-test and post-test of CG was 0.44, which indicated that there was a small practical significant effect of traditional teaching methods within the group (Table 4).

It could mean that the use of CAI intervention was more effective than the traditional teaching method. This is because the use of CAI intervention showed a large practical significant effect size with the Cohen's d value of (2.43) than the traditional teaching method with the Cohen's d value of (0.44).

This claim was also supported by qualitative data collected through face-to-face semi-structured interviews where the majority of the student's interviewees shared that the CAI approach was interesting, engaging, motivating, and made them actively participate in activities related to the concept of digestion in Biology.

Several characteristics of the CAI have been accredited to better performance of students in the EG during the intervention of this study. For example, the features embedded within CAI foster the meaningful engagement of students in learning taking place through active participation in discussion, group activities that promote student-centered learning, and such learning was mostly supplemented or simplified through digital simulations and animations. A study conducted

by Bhagwan [33] reported that CAI enables the students with active participation and facilitates student-centered learning.

It concludes that the CAI approach was found to be more effective than the traditional teaching method in teaching Biology concepts.

4.4 Gender-wise Performance between Pre-test and Post-test in EG

The other aspect of CAI in teaching Biology among differences in sex was also explored in this study because through the researcher's observation as a teacher teaching Biology and ICT subjects in the school observed that girls tended to perform low in ICT literacy. The gender-wise performance in this study was indicated ($p < 0.103$) during post-test scores analysis. This result indicates that the CAI approach applied in teaching Biology did not influence the gender-wise performance despite variation in gender performance was noted in the ICT subject. The non-significant difference in terms of academic performance of the students regardless of the gender during post-test scores was could be that it was attributed to the various embedded features of CAI. For example, CAI afforded the opportunity to learn at their own pace and engaged the learners meaningfully and actively involved in the teaching-learning Biology subject. This findings is in consistent with that of other studies by [48,15] that indicated non-significant difference regarding gender.

Table 4. Paired Sample T-test between Pre-test and Posttest scores of CG &EG

| | Control Group | | Experimental Group | | Pre-test |
|------------------|---------------|----------|--------------------|----------|----------|
| | Post-test | Pre-test | Post-test | Pre-test | |
| Mean | 12.6 | 11.9 | 19.5 | 11.3 | |
| SD | 3.63 | 3.84 | 5.28 | 3.74 | |
| Mean Differences | | 0.69 | | 8.17 | |
| Sig (t-test) | | 0.02 | | 0.01 | |
| Cohen's d | | 0.44 | | 2.43 | |

* Significant ($p < 0.05$)

Cohen's d value: $d = 0.2$ -small effect, $d = 0.5$ -medium effect, $d = 0.8$ -large effect (adapted from Cohen, 1988)

Table 5. Paired Sample T-test of Academic Performance based on Gender

| | Gender | Mean | N | Mean differences | Sig (Tailed) |
|------------------|--------|-------|----|------------------|--------------|
| Pre-test | Male | 11.53 | 30 | 0.3 | 0.761 |
| | Female | 11.23 | 30 | | |
| Post-test | Male | 20.70 | 30 | 2.3 | 0.103 |
| | Female | 18.40 | 30 | | |

* Significant ($p < 0.05$)

4.5 Students' and Biology Teachers' Perception towards CAI

Findings from the students' survey questionnaire above (Table 6) revealed that use of CAI was effective and useful in learning the topic "digestion" both by the students and teachers. For instance, the mean value for students' perception of the use of CAI was (M=4.41), and standard deviation of (SD=0.21), which indicates that the use of CAI was a good strategy to understand the concept of Digestion.

In addition, Spearman rho correlation coefficient was performed to examine the existence of any association between students' perceptions and their performance based on the post-test scores of EG. This indicated strong positive correlation ($r=0.994$, $p < 0.001$). The analysis could mean that healthier was the perception of students on the use of CAI and they were able to perform better in the academic test (Table 7)

Furthermore, face-to-face semi-structured interviews with the students revealed that the

CAI approach was effective and engaging in understanding the abstract concept of digestion by using animation, simulation, and video presentation, which we could not comprehend.

These findings are in an agreement with the findings of [51,44] who reported that the CAI lessons are exciting and interesting and improve academic achievement. Furthermore, [49,50] claimed that students taught using the CAI approach build a strong interest in learning and understanding abstract concepts. They further stated that CAI lessons are interactive, engaging and monitor the learning by providing feedback. Owing to the importance and effectiveness of CAI, T3, opined that it is of utmost importance to integrate CAI in the 21st century to teach abstract biological concepts and improve students' academic performance. This was furthermore supported by [2], who reported that CAI is interesting, effective, easy learning, and lifelong learning and has great potential for improving the teaching-learning process [60,61].

Table 6. Students' Perception towards the use of CAI in teaching learning of Biology

| SN | Items | N | Mean | SD | Degree of Perception |
|--|--|-----------|-------------|-------------|----------------------|
| 1 | I am more involved in CAI than traditional teaching | 60 | 4.05 | 0.77 | Good |
| 2 | I worked in my own pace | 60 | 3.98 | 1.14 | Good |
| 3 | I found CAI is arranged in logical sequences | 60 | 3.42 | 1.29 | Moderate |
| 4 | I felt CAI is very effective for learning Biology | 60 | 4.47 | 0.65 | Good |
| 5 | I am more motivated in learning Biology with CAI than Traditional teaching | 60 | 4.3 | 0.79 | Good |
| 6 | CAI makes subject more interesting | 60 | 4.6 | 0.81 | Very Good |
| 7 | I liked the CAI material after the lesson | 60 | 3.92 | 1.06 | Good |
| 8 | I want more CAI units for learning Biology | 60 | 4.37 | 0.74 | Good |
| 9 | I was comfortable with CAI in learning Biology | 60 | 4.47 | 0.75 | Good |
| 10 | I prefer CAI than Traditional teaching | 60 | 3.83 | 0.99 | Good |
| Overall Students' perception on CAI | | 60 | 4.14 | 0.21 | Good |

Table 7. Correlations between the Students’ Perception and their Posttest scores

| | | Students_perception_towards_CAI Scores | | |
|----------------|---------------------------------|--|--------|--------|
| Spearman's rho | Students_perception_towards_CAI | Correlation Coefficient | 1.000 | .994** |
| | | Sig. (2-tailed) | | 00.00 |
| | | N | 60 | 60 |
| Scores | | Correlation Coefficient | .994** | 1.000 |
| | | Sig. (2-tailed) | 0.00 | |
| | | N | 60 | 60 |

*Correlation is significant at the 0.05 level (2-tailed)

5. CONCLUSION

The study concluded that the use of CAI is one effective and innovative approach to improve students’ academic performance in Biology. This is mainly attributed to the enhanced motivation, curiosity, interest, and interactive involvement of students in learning while taught using CAI. Similarly, students’ academic performance in biology irrespective of gender showed non-significant differences when taught with CAI. In addition, both the teachers and students exhibited positive perceptions towards the use of CAI in teaching and learning Biology. This is mainly because of the significant benefits of CAI in actively engaging students in learning, a better understanding of Biology, and improved performance of students.

6. RECOMMENDATIONS

The findings from this study revealed that CAI is one effective approach to enhance students’ academic performance in Biology. Hence, the study would like to recommend Biology teachers, science teachers, and other subject teachers to incorporate CAI as an alternative strategy to the conventional classroom

instructional approach. In this note, it is recommended that various educational institutes in Bhutan and policymakers, such as the Teacher professional Support Division, Dzongkhag Education Officers, and Principals to articulate various guidelines on the modalities of professional development programs for in-service teachers on the use of CAI so as to help learners. Similarly, the present study also recommends the teachers in the schools to conduct similar kinds of studies in different subject areas, irrespective of grade level to confirm the effectiveness of the CAI in the

Bhutanese context and to have more evidence, so as to maximize the reliability of this present study.

7. LIMITATION OF THE STUDY

The findings of this study are unflinching and defensible with adequate evidences, such as comprehensive data collected and enough claims to support findings. However, there are some limitations as mentioned below;

- ✓ Study was conducted in only two schools under one Dzongkhag which cannot be generalize across all the schools.
- ✓ The present study was limited to teaching one chapter that was ‘Digestion’ in Biology subject.
- ✓ Study was restricted to tenth-grade students of, 120 (CG=60 &EG=60) from two schools of Samtse Dzongkhag.
- ✓ This study could not include Bhutanese literature specifically on CAI due to the lack of previous studies conducted in Bhutan.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

CONSENT

Consent was taken from all the individual participants.

ETHICAL APPROVAL

The ethical consideration was stringently followed by the researchers. Prior to the

empirical data collection, researchers have completed all types of research ethics, for instance, sought written permission to conduct the study from the concerned authorities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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