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The effects of teaching biology concepts with interactive animated video in secondary school

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ABSTRACT

The expository methods of teaching biology have become obsolete with advancements in information and communication technology (ICT) and the learning needs of digital natives. The role of a teacher has become more of a facilitator rather than a sage on the stage. The integration of interactive animated video (IAV) in biology education can be a paradigm shift from teacher-centered methods of teaching and learning biology to student-centered teaching and learning processes. IAV containing text, animation, voice-over narration and interactivities makes the abstract and dynamic biology concepts more realistic, comprehensible, interesting and motivating through both the audio and visual inputs. This study explored the effects of teaching biology concepts with IAV on students' cognitive domain of conceptual understanding and affective domains of motivation, interest and lesson satisfaction in one of the secondary schools in Samtse, Bhutan. The participants were taught the concepts of diffusions, osmosis and transpiration using IAVs. Both descriptive and inferential data analysis in SPSS revealed that the IAV increased the motivation, interest, lesson satisfaction and conceptual understanding of biology students significantly. The descriptive statistics indicated an increase in cognitive and affective learning domains of the participants from high to very high levels. The inferential statistics of paired-sample t-tests and eta squared statistics indicated positive effects of IAV on their learning domains at $p<0.00$ (2-tailed test). The IAV is the multimedia tool that elevated the conceptual understanding, motivation, interest and lesson satisfaction of secondary biology students.

Keywords: Interactive animated video, Information and communication technology, cognitive and affective learning domains

1. INTRODUCTION

Bhutanese education system is just over a century old since the launch of first school in 1914. The modern education was initiated in 1955 and science education in next five years. The initial science curriculum was started in the form of nature study and general science in 1970s [1]. The present science education spirals up from concrete everyday experiences in key stages 1 and 2 (Grades Pre-Primary-VI) to more abstract ideas as theories and models in key stages 3 to 5 (Grades VII – XII) [2]. In key stage 4 (Grades VII & VIII), the learners are expected to develop basic knowledge and understanding for further studies in three science subjects of biology, chemistry and physics in later stages. Students opting science stream for higher studies can

continue to study biology with chemistry and physics for higher studies in classes XI and XII. The secondary biology education in Bhutan consists of fundamental concepts in botany, zoology, physiology and health and hygiene. Biology is a distinct subject but it is taught like mathematics and arts subjects in the schools. The methods of teaching and learning biology have stagnated as expository and teacher-centered methods. The expository method is a teaching method in which the teacher presents a verbal discourse on a particular subject, theme or concept to the learners with little or no instructional aids [3]. The teacher-centered mode of teaching relies heavily on chalk-and-talk method and students reading the textbook to follow it. A study found that inadequate use of instructional materials, student's attitude and their poor reading habits are the most serious causes of difficulties in learning biology. The students' learning difficulties and their achievement in biology bear a negative correlation [4]. The effectiveness of teaching and learning biology concepts fundamentally depend on the teaching strategies practiced in the classrooms.

The academic performances of secondary students in the biology are never at par or above in many other subjects. In the 2018 Bhutan Certificate of Secondary Education (BCSE), biology stood at 5th rank among the six subjects in pass percentage as well as in national mean marks. The mean marks without continuous assessments (CA) remained 33.25, 33.81, 34.30 and 43 over the last three years. The national mean mark in BCSE biology remained 51.9, 45.73, 53.20, and 53.29 for the last consecutive four years [5-8]. The performances of the students in their annual examinations over the past three years have indicated that biology has been a little easier subject than chemistry but more difficult one than literature, language, computer applications, environment studies and even physics subject. The consistent subpar performances of students in biology have become a matter of concern to the educators, parents, students themselves and the ministry of education. Annually, very few take up higher studies in the science stream with biology after the completion of BCSE. They opt out biology for other subjects for their higher studies. In different higher secondary schools, only 13.20%, 11.58%, 11.75%, and 11.65% of the total students who studied biology appeared for Bhutan higher secondary education certificate (BHSEC) in the last four years respectively [5-8]. With such minimal number of Bhutanese students pursuing higher studies in biology, the shortage of professionals and specialists in biology-based fields remain a major setback of education system in Bhutan. On 9th February 2020, 19 specialists from Bangladesh joined Bhutanese health care system [9]. There is a shortage of medical doctors, nurses and paramedics in our country. Based on the number of employees by major occupation and nationality in various private and corporate sectors, 21.83% are foreigners [10]. Moreover, ministry of health (MoH) could establish only four of the eight emergency health facilities envisioned since 1980s. The Prime Minister of the ruling government cited the shortage of specialists in the field of gynecology, pediatric, medicine, surgery and anesthesiology as the impeding factor in providing adequate health facilities in the country. In the meanwhile, the rate of unemployment in Bhutan is rising every year. The current overall unemployment rate stands at 2.7% and the youth unemployment rate at 11.7% [11]. To address the shortage of health professionals and provide opportunities for employments in the country, a Bachelor of Medicine and Surgery (MBBS) will be instituted in the country by next year [12]. Considering the subpar academic performances of secondary biology students, opportunities for biology-based professionals and the unemployment rate in the country, biology education needs paradigm shift towards achieving greater proficiency and efficiency in teaching and learning biology.

In classrooms, students can make more sense and learn better with visual and verbal stimuli. The verbal and visual instructions are possible with the use of computer technologies. The use of computer technologies to enhance learning was pioneered by Atkinson and Suppes in 1960s. The presence of computer technology in schools has increased dramatically since that time, and the trend will continue accelerate [13]. Today, animated videos are increasingly used in education. The animated videos present the concept more effectively than static illustration or reading of text catering to auditory, visual, and kinetic modes of learning for the students [14]. Studies have found that teaching theory concepts through animation videos help students in understanding biological concepts effectively. The animated videos make the cognition easier for the students to learn and understand the subject matter. Mayer and Anderson (1991) suggest that effective understanding of scientific explanations requires a mapping between words and pictures [15]. Presenting verbal and visual explanations together in a coordinated way was found to be more effective than separate verbal and visual explanations. Animations facilitate effective learning through strong associations between verbal and nonverbal stimuli. These associations promote conceptual understanding and long-term memory [15]. In consistence, Mayer (2005), revels that people learn more deeply from words and pictures than from words alone as human information processing system includes dual channels for visual (pictorial) and auditory (verbal) processing. The author claims that the cognitive learning process takes place through organizing and integrating the coherent and relevant words and images [16]. Morsid *et al.* (2020) suggest that Technological Pedagogical Content Knowledge (TPCK) framework is a powerful integration of technology, pedagogy, and content knowledge and has great potential to be used in the integration of ICT in education [17]. The TPCK model was developed by P. Mishra and M. J. Koehler in 2006 from the existing idea of knowledge in teaching. Shulman (1986) argued that having knowledge of subject matter and general pedagogical strategies was not sufficient for accepting the knowledge of a good teacher [18]. A successful teacher has to confront both issues of content and pedagogy simultaneously and find different ways to represent it accessible to the learners. The TPCK model uses audio and visual presentations consisting of texts, animation, narration and interactivities which supports the Dual Coding Theory (DCT) theory. According to DCT, Cognition involves associative and referential processes among the logogens and imagens. It claims that learning can be maximized by connecting words with images or vice versa. It boosts not only memory of individual words and ideas but connects between concepts [19]. The teaching and learning process is more effective with interactive animation video as it integrates the three fundamental components of technology, pedagogy and content knowledge for effective teaching and learning processes.

2. MATERIALS AND METHODS

2.1. Research Paradigm and Design

This study used quantitative research approach and pre-experimental design, inspired by post positivist worldview. The post positivism represents the thinking after positivism, challenging the traditional notion of the absolute truth of knowledge and denounces the absolute positive claims of knowledge when studying the behaviors and actions of human. In pre-experimental design, the researcher studies a single group and implements an intervention during the experiment and does not have a control group to compare with the experimental group [20]. It involves asking people for information through questionnaires after an intervention. This study used a pre-experimental design: one-group pre-survey-post-survey design to examine the effects of using IAVs in teaching diffusion, osmosis and transpiration to students taking BCSE, applying 7E

teaching strategy and adopting the TPCK model. The numerical data were collected using survey questionnaires. The descriptive and explanatory information were analyzed statistically.

2.2. Research Method

The study was conducted in one of the secondary schools in Samtse, targeting BCSE biology students. The purposive sampling of the school was necessary for the ICT facilities like LCD projector, a working projector, source of electricity, Wi-Fi connectivity, and LCD projector. The independent variable was administered to the target group of students in the school. The class X students were taught diffusion and osmosis and grade IX students were taught transpiration with interactive animated videos during their usual class hours by their regular biology teacher. The interactive animated videos on the selected topic contained text, voice-over narration and interactive questions (TANI). The three animated videos were downloaded from youtube and were edited and curated for content, text, and narration using multimedia editing software. The editing was necessary for customization and content validation. The animated videos were embedded with interactive questions using the free offline web-based tool eXeLearning 2.5.1. To reduce Hawthorne effect, the lessons were taught by their regular biology teachers of the school. A day before the lesson of intervention, pre-survey questionnaire consisting of four themes (motivation, interest, lesson satisfaction and conceptual understanding) was administered to the participants. In the pre-survey questionnaires, the statements contained the learning process experienced by the students previously, that is, when they learned biology in the classroom as usual through expository methods of teaching and learning. The students were given instructions and demonstration on using the IAVs before they were asked to explore and learn from the interactive animation videos during the lesson in the computer laboratory. In pairs, they played the video listening to the narrations with legends and responded to the interactive questions in the video under the guidance of their teacher. They used earphones to avoid disturbing others with the video sounds. After the video session, they discussed and completed the worksheet provided to them in pairs. The students shared their worksheet answers with the whole class. The lesson was delivered through a 7E teaching strategy involving eliciting, engaging, exploring, explaining, evaluating, elaborating, and extending the lesson. After the lesson with the intervention, a post-survey questionnaire was administered to the sample population. The statements in post-survey questionnaire included the learning process experienced by using the IAVs. The respondents for the survey questionnaire were selected through non-probability convenience sampling method.

2.3. Research participants

The study focused on BCSE biology students in Samtse, about 31.73% students were from grade IX and 68.27% were from grade X. In Non-probability sampling, researcher derive sample from a particular group which frequently happens in small-scale research. Taking account of non-response, attrition, and respondent mortality, the sample size was calculated using the online Sample size calculator. Thus, the sample size was 104 with confidence level = 95%, confidence interval = ±5 & population = 175. The respondents were assigned with the respondent identity numbers. The screening questions on demography and dichotomous questions were coded with 1 (yes) and 2 (no). A total of 104 students participated in the study of which 61 were females (58.65%) and 43 boys (41.35%). All the participants were secondary biology students taking the same board examination (BCSE).

2.4. Data collection

The questionnaires of Interactive Animated Diffusion and Osmosis Lesson Assessment (IADOLA) and Interactive Animated Transpiration Lesson assessment (IATLA) contained 20 Likert scales and 5 dichotomous questions each. The questionnaires were developed using the adopted four-point Likert scales [22]. The four-point Likert scale was preferable as it is possible to report percentage responses for each statement by combining the two outer side categories: "strongly agree" and "agree," "disagree" and "strongly disagree." For favourable statements (items), the scale values are assigned from left to right as 4, 3, 2, and 1 [23].

The internal consistency reliability test of the instrument in Cronbach's alpha computed was within the acceptable range of 0.85 (N=25). The items were designed to measure the intended dimensions ensuring content validity and construct validity. The construct validity was ensured by the appropriate design of questionnaire items which measures the underlying issues.

2.5. Data Analysis

The authors further assert that having a large sample size (> 30) can attenuate the problems of violations of normality. After the normality test was carried out, descriptive and inferential statistics were analyzed using Statistical Package for the Social Sciences (IBM SPSS version 22).

To gauge the gender difference in learning achievements by IAVs, independent-samples t-test was computed in the SPSS. The confidence level of 90% and level of significance (α) of 5% were predetermined for the hypothesis testing.

3. RESULTS AND DISCUSSION

This study explored the effects of teaching biology concepts using IAVs to secondary biology students taking BCSE board examination. The students of grade nine and ten of one of the high schools in Samtse were asked to rate twenty items for four variables of interest. The survey questionnaire consisted of demographic questions, a four-point Likert scale questions, two matrix questions and two closed ended questions. The themes were predetermined based on the literature review. The four themes were ordered in sequence of motivation, interest, lesson satisfaction and conceptual understanding. The first three themes focused on their affective learning domains of interest, motivation and lesson satisfaction and the fourth theme focused on their cognitive learning domain of conceptual understanding. The students rated their perceptions on the four themes of learning domains before and after the intervention. The descriptive and inferential statics were computed using SPSS 22.0 software. Descriptive and inferential statistics were analyzed to determine the effects of the intervention on their learning domains.

3.1. Motivation Level

The increase of mean (3.03 to 3.52), median (3 to 3.6) and mode (3 to 4.6) corresponds to an increase of the opinion levels from high to very high for motivation of the students to learn biology with IAVs as indicated in Table 1 & Table 2. A paired-sample t-test shown in Table 3 also indicated a significant increase in the mean of the motivation before (Mean = 3.03, SD = .312) to after (Mean = 3.52, SD = .366), t (9.956), $p < .05$ (2-tailed). The eta squared statistics (0.976) indicated moderate effect size. The researcher rejected the null hypothesis. The increase in learning motivation is due to the use of learning media in the form of IAVs which sustain attention, participation and curiosity of students during the learning process. They feel learning biology with IAVs meaningful as they get encouraged and curious to learn biology. They find the learning biology concepts with IAVs meaningful and relevant. The result is in line with the claim by Widianingsih *et al.* (2021) which found that students' average score for learning

Table 1. Comparison of Students' Achievements before and after the Intervention

	Post-intervention			Pre-intervention		
	Mean	SD	Level of Outcome	Mean	SD	Level of Outcome
Motivation	3.52	0.366	Very High	3.03	0.312	High
Interest	3.51	0.326	Very High	3.11	0.34	High
Lesson satisfaction	3.47	0.343	Very High	3.06	0.376	High
Conceptual understanding	3.42	0.315	Very High	2.85	0.513	High
Average	3.48	0.335	Very High	3.01	1.22	High

Table 2. Comparison of Modes and Medians before and after the Intervention

	Post-Intervention		Pre-Intervention	
	Mode	Median	Mode	Median
Motivation	4	3.6	3	3
Interest	4	3.6	3	3.2
Lesson Satisfaction	4	3.5	3	3
Conceptual understanding	3	3.4	3	2.8
Average	3.75	3.53	3	3

Table 3. Motivation level Analysis of before and after the Intervention

Paired Samples Statistics			Paired Samples Test							
	Mean	Std. dev.	Mean Diff.	Std. dev.	Std. error mean	95% Confidence Interval		t	df	Sig.(2tailed)
						Lower	Upper			
Post- Survey	3.52	0.36								
Pre-Survey	3.03	0.31	0.49	0.50	0.049	0.39	0.58	9.95	103	0.00

motivation increased from 58.86 (before implementation of animation video) to 61.43 (after implementation of animated video). The study found significant difference between motivation before and after the treatment was applied using the SkelToon

animation videos. Meanwhile, a study found high motivation of the learners for both animated video (M = 3.35, df = 0.79) and interactive video (M = 3.26, df = 0.76). The study found that there was no statistical difference between the motivation of participants learning with the animated video and those learning with the interactive video (t (931) = 1.77; p > 0.05; d = 0.12). However, interactive video group scored significantly higher in cognitive load score than the animated group (t (931) = -1.15; p < 0.05; d = -0.14) [28]. The animations and interactivities visualize and simplify the concepts which help students understand the concepts better. In the same vein, Nnorom and Henrietta (2021), posited that the use of multimedia computer animation could increase students' motivation and make the learning of biology more interesting, enjoyable and understandable [24]. Therefore, students' motivation is elevated significantly when biology is taught using IAVs. The IAVs provide the innate psychological needs of competence, autonomy and relatedness to the learners and thereby conducing their high motivation level.

3.2. Interest Level

The increase of mean (3.11 to 3.51), median (3.2 to 3.6) and mode (3 to 4) corresponds to an increase of the opinion levels from high to very high for interest of the students to learn biology with IAVs as indicated in Table 1 & Table 2. A paired-sample t-test shown in table 4 also indicated a significant increase in the mean of the interest before (Mean = 3.11, SD = .340) to after (Mean = 3.51, SD = .3326), t (8.55), p < .05 (2-tailed). The mean

difference of the interest level was 0.400 with 95% confidence interval ranging from 0.307 to 0.493. The eta squared statistics (0.838) indicated moderate effect size. Along with the motivation, the IAVs also elevated the interest level of the students in learning biology. The students enjoy watching, listening and playing with the IAVs as the animation media stimulated multi-sense organs of hearing, seeing, psychomotor and amusement by animations. The interactive questions embedded in the video made the lesson engaging and captivating. The elements of color, texts, animation and simultaneous narration in the IAVs trigger and sustain the interest of the students throughout the lesson.

In the same line, study revealed that students have positive opinion to educational technology tools as they enjoyed biology class when taught using different educational technology tools [25]. The students found educational technology tools interesting, fun and user-friendly. In a study, the pre-test means interest score of students taught biology using the computer animation was 27.18 (SD = 4.12) and their post-test mean score was 67.55 (SD = 2.30) and 40.37 mean gain. The study found that students taught biology concepts using computer animation yielded greater interest mean gain score than those taught using expository method. The authors assert that computer animation is an effective method of teaching biology in enhancing students' interest and academic achievement in biology [26]. In consistence, Astuti and Nurchyo (2019) revealed that students interest score increased significantly to 83.7 from 65.1 when taught human reproduction system using interactive learning media. The authors further concluded that increase in increase level is due to multimedia which has functions to stimulate the attention of the learners as they become more focused on learning the topic [26]. The biology concepts become more interesting and enjoyable to learn through IAVs which has the elements of text, animation, narration and interactivities. The IAVs will not only improve comprehensibility but arouse and sustain interest of the learners in learning biology concepts significantly.

3.3. Lesson Satisfaction Level (LS) of the students

The increase of mean (3.06 to 3.47), median (3 to 3.5) and mode (3 to 4) corresponds to an increase of the opinion levels from high to very high for lesson satisfaction of the students to learn biology with IAVs as indicated in table 1 & table 2. A paired-sample t-test shown in table 5 also indicated a significant increase in the mean of lesion satisfaction before (Mean = 3.06, SD = .376) to after (Mean = 3.47, SD = .343) t (8.065), $p < .05$ (2-tailed). In favor of the alternate hypothesis, the results indicate positive effects of IAVs on the lesson satisfaction level of biology students.

The students get lesson satisfaction when taught using interactive animated videos as they prefer students-centered teaching methods with IAVs over teacher-centered or the expository method of teaching and learning biology. The students find the lessons with IAVs exciting and effective experiences. They are active throughout the lesson due to the interactive questions embedded in the IAVs. The IAVs allow students to control the player, watch as many times needed and interact with the video by answering quiz questions embedded in it. Their learning is further reinforced by the appropriate feedback scores, congratulatory words for correct answers and motivational words for wrong answers that follow up after completion of each interaction in the videos.

In the same vein, Cookson *et al.* (2020) found that students were more engaged and satisfied with the course with the addition of the animated instructional videos. The students were more engaged with animation video lessons where all students completed video lessons and assignments with 76% of the students reported viewing the animation videos more than once. The authors further claim that the students

overwhelmingly responded that they did prefer the animation videos over the textbook with 93% responded they enjoyed the animation videos. The students were satisfied with the length of the video and the embedded questions. Meanwhile, in a study concluded that, interactive science learning media significantly improved students' learning motivation, confidence and satisfaction. The satisfaction aspect of students' learning increased by 9.54%, to 73.05% and then 82.54%. The authors claim that lesson satisfaction is related to the feeling of satisfaction with the process of result of learning experiences [27]. The students find the biology lessons with IAVs more exciting, effective and satisfying than expository method of teaching and learning biology. The activity scores, congratulatory words and motivational words contribute instrumentally towards the satisfaction level of the students.

3.4. Conceptual Understanding (CU) of the students

The increase of mean (2.85 to 3.4), median (2.8 to 3.4) and mode (3 to 3.7) corresponds to an increase of the opinion levels from high to very high for conceptual understanding of the students to learn biology with IAVs as indicated in table 1 & table 2. A paired-sample t-test shown in table 6 also indicated a significant increase in the mean of conceptual understanding before (Mean = 2.85, SD = .513) to after (Mean = 3.42, SD = .315) t (9.148), $p < .05$ (2-tailed). Supporting the alternate hypothesis, the results indicated positive effects of IAVs on the conceptual understanding level of biology students. The students' conceptual understanding is improved significantly when biology concepts are taught with IAVs.

The increase in conceptual understanding level is due to didactic reduction of the biology concepts by the animation media which consists of text, animation voice-over narration and interactive questions. The IAVs simplify and reduce complexity of the dynamic and abstract concepts in biology which enhances the conceptual understanding of the students. The students are able to understand biology concepts taught in the classroom and relate it in their real world. The concepts are simplified for an easy understanding. The students answered the interactive questions correctly as they understood concepts better with IAVs.

Student gained confidence to apply the concepts learned meaningfully through IAVs in classroom to their real world. Mayer (2005) maintains that learning is measured by tests of retention and transfer, being able to use the information to solve new problems. According to the author, multimedia instruction makes use of two sensory channels; eyes and ears [28]. The IAVs used in this study were developed with this notion in mind, allowing the students to watch the IAVs which contained text, animation, voice-over narration and interactive questions. The efficiency and effectiveness of IAVs is increased with the addition of text, animation and voice-over narrations. It was concluded that animation instructional packages were a better strategy in improving students' achievements in biology than the conventional teaching method at the least. The animation combined with narration and on-screen text (T + A + N) package was found to be the best package for teaching and learning biology [29]. It concurred with the findings of Gambari *et al.* (2014), who reported that concurrent use of animation + narration + on-screen text in an instructional interface was more effective in teaching the biological concepts of fungi. The study found that students exposed to animation + narration (A + N = 73.33, CTM = 42.93), animation + text (A + T = 69.40, CTM = 42.93) and animation + narration + on-screen text (A + N + T = 73.73, CTM = 42.93) performed better than those taught with conventional teaching method (CTM) [30]. Similarly, another study done by Cookson *et al.* (2020), on college students' achievement using animated instructional videos in Southern United States found that the animated instructional videos did have a positive impact on exam scores which indicates

higher conceptual understanding achieved by students due to the animation media. It was found that the average score from the pre-test to post-test increased by 25.83 points, improving from an average of 49.77 to 75.60) [31]. Later, another study also found that biology increased form 22.81 (pre-test) to 52.50 (post-test) with 29.69 mean gain [24]. The positive effects of IAVs on achievement score or the conceptual understanding is consistent in various studies. In consistence to previous

findings, a study on grade 11 students' conceptual understanding found that Predict-Observe-Explain based animation videos greatly improved the conceptual understanding on acid-base models. Before the intervention, students had the knowledge of an acid and a base as hydrogen and hydroxyl ions respectively referring to Arrhenius model which they had learnt in previous grade. After the lesson with the intervention of animation videos, their conceptual understanding of acid and base improved with majority of them viewed Arrhenius model inadequate explanation to imply the features of acids and bases [32]. Moreover, Mayer (2005) argues that Cognitive Theory of Multimedia Learning (CTML) functions in five forms. The first form is the spoken words and images which are presented in animation videos. The forms of sounds are captured by ear and the image is captured by the eyes in the sensory memory. The third form is sound and images in the working memory. The fourth form is the verbal model and pictorial model contained in the working memory. The fifth form is the prior knowledge stored in the long-term memory which integrates with the forms in the working memory [34]. The elements of text, animation, narration and interactive questions in the IAVs cater to all aspects of effective learning of audio, visual and psychomotor. The students understand the biology concepts significantly better when taught with IAVs due to the didactic reduction of the biology concepts. The dual modalities of hearing and visual in the interactive multimedia improve cognitions in working memory and long-term memory which result in better conceptual

Table 4. Interest level Analysis of before and after the Intervention

Paired Samples Statistics			Paired Samples Test							
	Mean	Std.dev	Mean diff.	Std. dev.	Std. error Mean	95% Confidence Interval		t	df	Sig. (2-tailed)
						Lower	Upper			
Post-Survey	3.51	0.32								
Pre-Survey	3.11	0.34	0.4	0.47	0.04	0.30	0.49	8.55	103	.00

Table 5. Lesson Satisfaction level Analysis of before and after the Intervention.

Paired Samples Statistics			Paired Samples Test							
	Mean	Std. Dev.	Mean Diff.	Std. Dev.	Std. Error Mean	95% Confidence Interval		t	df	Sig. (2-tailed)
						Lower	Upper			
Post-Survey	3.47	0.34								
Pre-Survey	3.06	0.37	0.41	0.51	0.05	0.30	0.51	8.07	103	0.00

Table 6. Conceptual Understanding level Analysis of before and after the Intervention.

Paired Samples Statistics			Paired Samples Test							
	Mean	Std. Dev.	Mean diff.	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
						Lower	Upper			
Post-Survey	3.42	0.31								
Pre-Survey	2.85	0.51	0.565	0.63	0.06	0.44	0.66	9.14	103	0.00

understanding of the students. Therefore, IAVs have positive effects on conceptual understanding of the biology concepts which are evident in increase in their test scores after the intervention.

3.5. Effect size of Teaching Biology Concepts using IAVs on their Learning Achievements

The effect size (eta squared) calculated using the formula t^2/(t^2+(N-1)) are presented in table 7. As indicated in the table, students had the least learning effects on their conceptual understanding (Mean = 2.85), highest in interest level (Mean = 3.11) during Pre-intervention Survey. In the post-intervention survey, the students indicated the least perception level in conceptual understanding (Mean = 3.42) and highest in motivation level (3.52). The mean difference of conceptual understanding turned out to be the maximum (0.57) with the highest SD (0.63) and second-highest size effect (0.44). There is the second highest mean difference (0.49) and highest effect size (0.49) with an SD of 0.502 in motivation level. Therefore, the IAV has highest effects on motivation level (effect size = 0.49) of the biology students followed by conceptual understanding level (effect size = 0.44), interest (effect size = 0.41) and least on lesson satisfaction (effect size = 0.38).

Gender Difference in Effects of Teaching Biology Concepts Using IAVs between Male and Female Students

The result is in line with the self-determination theory. Human beings can be proactive and engaged or, alternatively passive and alienated, largely as a function of the social conditions in which they develop and function. The text, animation, voice-over narration, interactive questions, the activity-end score, congratulatory for correct answers and encouraging words and for wrong answers for every interactivity in the IAVs satisfied the three innate psychological needs of competence, autonomy and relatedness for the intrinsic motivation. The social-contextual events (feedbacks, rewards) that conduce toward feelings of competence during action can enhance intrinsic motivation for that action. The feeling of competence will not enhance intrinsic motivation unless accompanied by a sense of autonomy. They must experience their behavior as self-determined for intrinsic motivation. The third factor, relatedness equally contributes to intrinsic motivation.

The proximal relational support may not be necessary but a sense of secure relational base is fundamental for intrinsic motivation [35]. The IAVs seem to provide all the innate psychological needs of competence, autonomy and relatedness to the learners, conducing toward maximum impact on their motivation level in comparison to other learning perceptions.

An independent-samples t-test was conducted to compare the effects of teaching biology concepts using IAVs on the male and female students' affective and cognitive learning domains after the interventions. The table 8 indicated that mean score for the male respondents' post-survey motivation level (Mean = 3.53, SD = 0.41) did not differ significantly (t = 0.45, df = 102, two-tailed p = 0.651) from that of the female respondents (Mean = 3.502, SD = 0.33). The magnitude of the differences in the means (mean difference = 0.033, 95% CI: -0.112 to 0.1785) was very small. Similarly, the mean score for the male respondents' post-survey interest level (Mean = 3.52, SD = 0.32) did not differ significantly (t = 0.24, df = 102, two-tailed p = 0.807) from that of the female respondents (Mean = 3.521, SD = 0.32). The magnitude of the differences in the means (mean difference = 0.016, 95% CI: -0.113 to 0.145) was very small. The table also indicates that mean score for the male respondents' post-survey lesson satisfaction level (Mean = 3.50, SD = .360) did not differ significantly (t = .99, df = 102, two-tailed p = 0.325) from that of the female respondents (Mean = 3.43, SD = 0.33). The magnitude of the differences in the means (mean difference = 0.06, 95% CI: -0.067 to 0.203) was very

small. In the same result the mean score for the male respondents' post-survey conceptual understanding level (Mean = 3.46, SD = .3339) did not differ significantly (t = 1.17, df = 102, two-tailed p = 0.243) from that of the female respondents (Mean = 3.387, SD = 0.300). The magnitude of the differences in the means (mean difference = 0.07, 95% CI: -0.050 to 0.197) was very small. The magnitude of the differences in the means (mean difference = 0.033), 95% CI: -0.112 to 0.1785) was very small.

The mean differences of learning domains score between male and female students are very small. This indicates that male and female students derived the benefits of IAVs consistently. This result in line with a study done by Tamang *et al.* (2021) that found that mean score of male students (M = 4, SD = 0.89) was not significantly higher than female students (M = 3.47, SD = 0.96) when they were taught ecology with different educational technology tools in the college [25]. In support of the results, Thomas & Israel (2004), found that there was no significant difference in the performance of male (M = 23.92, SD = 4.73) and female (M = 23.42, SD = 3.86) students when students are taught with animation and multimedia [34].

However, some studies have revealed difference in learning outcomes between male and female students when they were taught using animated videos. A study done by Prinz *et al.* (2005), found the difference in performance between male and female students when the college students were taught ophthalmic surgery with 3D interactive multimedia. The women in 3D interactive multimedia group gained most by 19% over the control group which was not the case with the male students [35]. Similarly, Ercan (2014) found that there

Table 7. Mean difference and effect size of the students' learning achievements before and after the intervention

	Post-Intervention	Pre-Intervention	Mean Difference	SD	Effect Size
Motivation	3.52	3.03	0.49	0.502	0.49
Interest	3.51	3.11	0.40	0.477	0.41
Lesson Satisfaction	3.47	3.06	0.41	0.518	0.38
Conceptual Understanding	3.42	2.85	0.57	0.63	0.44

Table 8. Independent-samples t-test for Gender difference in learning achievements

			Levine's Test		t-test for Equality of Means						
	Mean	SD	F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% CI of the Diff.	
M										Lower	Upper
Male	3.53	.41	3.5	.06	.45	102	.651	.033	.07	-.112	.1785
Female	3.50	.33									
I											
Male	3.52	.32	.00	.99	.24	102	.80	.016	.06	-.113	.145
Female	3.50	.32									
LS											
Male	3.50	.36	.01	.89	.99	102	.325	.06	.068	-.06	.203
Female	3.43	.33									
CU											
Male	3.46	.33	1.1	.28	1.17	102	.24	.07	.06	-.05	.19
Female	3.38	.30									

*M: Motivation, I: Interest, LS: Lesson Satisfaction and CU: Conceptual Understanding

was significant difference between female (M= 22.56) and male (M= 19.57) students' performance, in favor of female students when taught food and healthy nutrition to 5th graders using multi-media of text, pictures, sounds, animation and video [36]. In another study, a significant (p = .04) difference in performances of male and female students though there was positive impact of multimedia of text, animation video, audio, sound, images and interactive content. The male students outperformed (M= 25.21) female students (M = 21.48) in post-test when taught with the multimedia [37]. Thus, the effects of using IAVs on the learning domains of male and female students remain inconsistent as revealed by various studies. Therefore, the study on the effects of using IAVs and other multimedia tools between male and female students needs further studies.

3.6. Co-relationship Between the Effects of Teaching Biology Concepts using IAVs on Their Learning Domains

A Pearson correlation was conducted to measure the closeness of relationship between the variables of the students' learning domains. Table 9 indicated that motivation level is more strongly related to interest level r (103) = .678, p < 0.01, than to other perceptions of lesson satisfaction level, r (103) = .556, p < .001 and conceptual understanding level, r (103) = .399, p < .01. The statistics indicated positive correlations among the affective and cognitive learning domains of the students when they were taught biology concepts using IAVs during their biology lessons. As the cognitive learning domains of conceptual understanding and affective learning domains of interest, motivation and lesson satisfaction are positively influenced by IAVs, they are also positively correlated. Correlation is significant at the 0.01 level (2-tailed) with r (103) values = 0.38, 0.39, 0.44, 0.52, 0.56 and 0.67, p< 0.01. The result indicated strong and positive correlation among all the cognitive and affective learning domains of biology students when taught biology concepts using IAVs. Stronger correlation is observed between motivation and interest (.678**) and least between interest and conceptual understanding (.381**).

In support of the findings, Astuti *et al.* (2020) found positive correlation between the animated videos and the learning achievements of elementary school students in science with a correlation value of 0.858. The R-square value of 0.736 indicated that increase in students' learning achievements is determined by animated videos by 73% [26]. The learning achievements in the form of learning perceptions are motivation, interest, learning satisfaction and conceptual understanding of the subject matter. Motivation is the primary learning achievement which manifests into other learning achievements of interest, lesion satisfaction and conceptual understanding. Animations videos in teaching and learning function through five applications: (i) Cosmetic function which aims to make the instruction attractive; (ii) Attention gaining function which aids in capturing student's attention especially at the beginning of the lesson; (iii) Motivation function which can be used as positive feedback mechanism during lessons; (iv) Presentation function which supplements the teacher's instructional materials and text; and (v) practice and clarity function which provides a conceptual understanding of concepts and clarifies abstract relationships through practice activities [38]. Therefore, learning perceptions of motivation, interest, lesson satisfaction and conceptual understanding are positively correlated to each other as much as they are positively influenced by the five functions of IAVs.

4. CONCLUSION

The descriptive and inferential data analysis indicated that IAVs are effective in elevating the motivation, interest, lesson satisfaction and conceptual understanding of students when biology concepts are taught using IAVs. The students rating for their learning

achievements increased from high (2.51 to 3.25) to very high (3.26 to 4) after the intervention. The average mean score for all four learning achievements increased from high (M = 3.01) to very high (M = 3.48) after the intervention. In consistence, the average score of modes and media also increased from 3 to 3.75 (mode) and 3 to 3.53 (median). Statistical analysis also indicated improvement of motivation; from (Mean = 3.03, SD = .312) to (Mean = 3.52, SD = .366) t (9.956), p < .05 (2-tailed), interest; form (M = 3.11, SD = .340) to (M = 3.51, SD = .336) t (8.55), p< .05 (2-tailed test), lesson satisfaction; from (M = 3.06, SD = .376) to (M = 3.47, SD = .343) t (8.065),p< .05 (2-tailed test) and conceptual understanding from (M = 2.85, SD = .513) to (M = 3.42, SD = .315) t (9.14), p< .05 (2-tailed test).

Based on the effect sizes, students' motivation level (0.49) was influenced the most followed by conceptual understanding (0.44), interest (0.41) and lesson satisfaction (0.38). There were strong positive correlations between the cognitive and affective learning domains but there was no significant gender difference in effects of IAVs on their cognitive and affective learning domains (p>0.05) when taught with IAVs. The research results clearly indicated that integration of IAVs with pedagogy in teaching the biology content is effective in elevating the cognitive and affective learning domains of biology students.

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