

RESEARCH ARTICLE

Development of A Graphic-based Digital Textbook on Biology Learning for Bangladesh Higher Secondary Students

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방글라데시의 고등학교 생물학을 위한 그래픽 기반의 디지털교과서 개발

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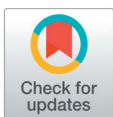
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Abstract

This study was focused on the development of a graphic-based digital textbook for Bangladesh's higher secondary level student's academic success and learning satisfaction in biology learning. In Bangladesh, the teaching method is traditionally traditional like a 'Jug and Mug', called teacher-centered learning; the instructor is at the center of all learning, and students are merely a listener. In the study, the researcher made an interactive digital textbook using Canva on human eyes to facilitate an interactive learning environment through various texts and activities to facilitate student-centered learning. Student-centered learning has not yet been introduced in Bangladesh. The data collection was carried out using the pretest-posttest control design. The researcher used both quantitative and qualitative methodologies in the experiment. The results indicate that the digital textbook is usable in the classroom despite of few infrastructural limitations and the experience digital textbook has been showed a high level of academic success.

Key words: Digital textbook, Canva, Bangladesh, higher secondary school, biology learning, academic success, learning satisfaction



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Introduction

We are on the verge of a technology revolution that drastically changes the way we interact with one another, our lives, and our work (Schwab, 2016). Eventually, The mode of education is changing dramatically both inside and outside of the classroom through technology (Gibson et al., 2014; Malcolm & Roll, 2017) and artificial intelligence. The present government's ideological focus is on creating a digital Bangladesh (Hossain, 2022). The government participated in the fourth industrial revolution in many areas, including education (Nile, 2022). Digital textbooks (DT) and digital classrooms are Bangladesh's most significant concerns regarding the fourth industrial revolution. Multimedia-based digital classes affect students' performance, satisfaction, innate motivation, and cognitive development (Kim & Jung, 2010; Lim et al., 2012; Setiawan & Wiedarti, 2020). In addition, DT- based short online videos have a big impact on learning development (Lancellotti et al., 2016).

However, Bangladesh has a long history of using a traditional and teacher-centered approach to education (Biswas & Roy, 2010; Islam & Paul, 2019). The traditional approach to teaching is one-sided and teacher-centered learning (TCL), and the students serve as the audience only. In most circumstances, the student feels their course material is pointless and becomes bored and uninterested in what they are learning (Al Faruki et al., 2019). Even though some teachers use multimedia-enhanced PowerPoint presentations, they only allow for teacher-centered and one-way instruction. The learning process should be interactive and enjoyable. Students lose interest in learning biology because of the traditional method of teaching and feel difficulty with biological terminology and lessons (Crimer, 2012; Etobro & Fabinu, 2017; Fauzi et al, 2021; Program, 2021). However, student success in activity-based instruction using the computer is better than the traditional instruction (Kareem, 2018; Noreen & Rana, 2019; Ragasa, 2008). The ability of the students to learn the lesson is improved by student-centered instruction (Jony, 2016; McCabe & O'Connor, 2014). In addition, student-centered biology instruction results are significant in terms of student engagement, satisfaction, and academic success (Armbruster, 2009). An interactive DT offers various relevant activities to engage students and monitor the students' work. To help students comprehend a topic more clearly, interactive images, videos, animation, simulations, hyperlinks, the inclusion of media, and shared experiences are needed which are the key elements of the digital textbook (Duncan, 2020). The experimental study focuses to design an interactive digital textbook on human eyes for grade 11-12 higher secondary level students in Bangladesh and explores students' success and satisfaction in comparison with the printed textbook.

Therefore, the purpose of this study was to develop the process of designing an interactive digital textbook on the human eyes to enhance student-centered learning (SCL) and figure out statistical differences in terms of academic success and learning satisfaction with using printed textbook (PT) and digital textbook (DT).

Methodology

Participants and Procedure

Researchers carry out the study in one institution to ensure a uniform degree of knowledge and expertise. The instructor selects 11-12 grade 90 students to take part in the experiment to compare the success and satisfaction of each group. The experiment class (experimental group) was taught using digital textbook (DT)-based multimedia, whereas the traditional class (control group) was taught using a PT. The 30 participants were chosen randomly and put into each group.

The experimental group was modified as the experimental-1 and experimental-2 groups. While the experimental-2 group had been given a chance to experience with DT environment before, experimental-1 group did not. It is crucial to note that only 11 students in the experimental class used computers; the rest students used their smartphones to take part in DT class activities.

Due to a lack of information about the learner-centered teaching strategy using creative activities for the secondary level in Bangladesh, teachers are having some difficulty implementing the biology curriculum. This study was selected the topic of Eye structure and function based on the curriculum's study materials to convey precise and understandable concepts to the students through the use of images, audio, video, animations, and numerous interactive activities using DT.

Data Collection and Analysis

A valid questionnaire was used as a pre-test and post-test tool and followed by a satisfaction survey at the end of class developed by Kim & Kwon (2018). In addition, the instructor was interviewed by the researcher to assess his opinion.

The Analysis of variance (ANOVA) and descriptive statistics are widely used to analyze data in experimental research (Armstrong et al., 2002; Ferreira et al., 2014; Huck & McLean, 1975). The Levene test was conducted to check variances (Nordstokke & Zumbo, 2010; Shear et al., 2018). On basis of the Levene test one way, the ANOVA test was conducted. Tamhane's Post-Hoc Test and LSD Post-Hoc test were run to determine the individual variances for academic success and learning satisfaction respectively.

Selection of DT Tools

Canva is a free online graphic design tool used to make logos, presentations, posters, films, and social media postings. One can quickly create invitations, business cards, posters, lesson plans, zoom backgrounds, social media posts, and more on this free graphic design site. It has a drag-and-drop interface, and templates to easily upload, and work as a presentation maker (Barabash, 2019). It's like having a free, rudimentary version of Photoshop that doesn't require an in-depth understanding of photo editing (Pratiwi et al., 2020). Canva offers tens of thousands of no-cost, expertly crafted templates that are easily editable using a drag-and-drop user interface (Shaw, 2022). Researchers create DT using Canva with other platforms namely Google docs, Google Sheets, Mentimeter, Youtube, Jam board, and Quizlet. In addition,

Canva does not have limitations to use in windows, MacBooks, iPhones, and androids devices (Canva compatible, 2022). That is why the researcher opted for Canva so that teachers and students can easily access and use it on their devices.

The researcher checked the reliability and validity of the research tools and DT instruments (Field, 2005; Fitzner, 2007). The outcomes are followed as the Table 1.

Table 1. Reliability and validity test of research tools

Test Name	Tools	AV	EV	C
Cronbach's alpha	DT	.70	.91	Excellent
I-CVI index	AAT	.78	.98	Valid
Cronbach's alpha		.70	.74	Acceptable

Note. EV=Acceptable value, OV=Experiment value, C=Comment

Development of DT

There are two main components to the development of DT: the description, text, and activity elements, activities. The description of the human eye and its functions is included in the descriptive section, together with text, images, videos, links, hyperlinks, navigation, dictionary, and graphic design. Human eyes, eye glands, eye muscles, eye structure, the process of image production, lens accommodation, binocular vision, and the limitations of human eyes are all covered in the descriptive sections of the DT.

The graphic design, stickers, and symbols were taken from Canva, while the video and images were added from Google and YouTube, respectively. There is a linked dictionary on the text pages to figure out the meaning of unknown words. The activities part, on the other hand, consists of interactive activities based on the descriptive sections, such as voting to know the prior knowledge about the topic, matching eye muscles in accordance with the description of eye muscles and functions, drawing activity to draw diagrammatic pictures of the eyes, thinking activities to think regarding the human eye, quizzes activities to know the eye precisely, creative activities to show creativity on the topic, QnA to solve the problem from teachers, and homework for doing the task at home. The researcher made the activities engaging and interactive by utilizing a variety of platforms, including Mentimeter, Quizlet, Jamboard, Google Sheets, and Google Docs to strengthen SCL.

Results

Design of the Digital Textbook

The structure of the developed digital textbook was shown in the Fig. 1. The first page shows a cover page of the developed digital textbook. The topics as text and activities are listed on page 2 of the content page. The content page has navigation power. By holding on to the page number on the right, the reader can jump to the anticipated topic. Understanding the lesson's goals and objectives is covered on the following page, page 3. To gauge students' prior knowledge the researcher used Mentimeter-based voting activity that improves attitudes and performance and is useful

in making opinions and discussions (Mohin et al., 2020; Sari, 2021) (Fig. 1-b). The exercise sections are offered a variety of interactive options, including games with matching activities, true-false, spelling, and flashcards using the Quizlets app. The use of Quizlet makes better performance than traditional instruction (Setiawan & Wiedarti, 2020; Vargas, 2011). On page 14, there were drawings exercises for leveling the eye anatomy (Fig. 1-c).

The next page has a brief film that describes the image generation process. After watching the film, the following page focuses on the topic's brainstorming for self-evaluation, motivation, judgment, and problem-solving as part of critical thinking (Jindal-Snape et al., 2013; Lai, 2011). The following page contains the Home Work (HW) and Questions and Answers (QnA) (Figure 1-d). To address the study's unsolved problem, the students ask the teacher for assistance. The HW and QnA answers were submitted and collected using Google Docs and Google Sheets that facilitate the collaborative writing activity (Zioga & Bikos, 2020).

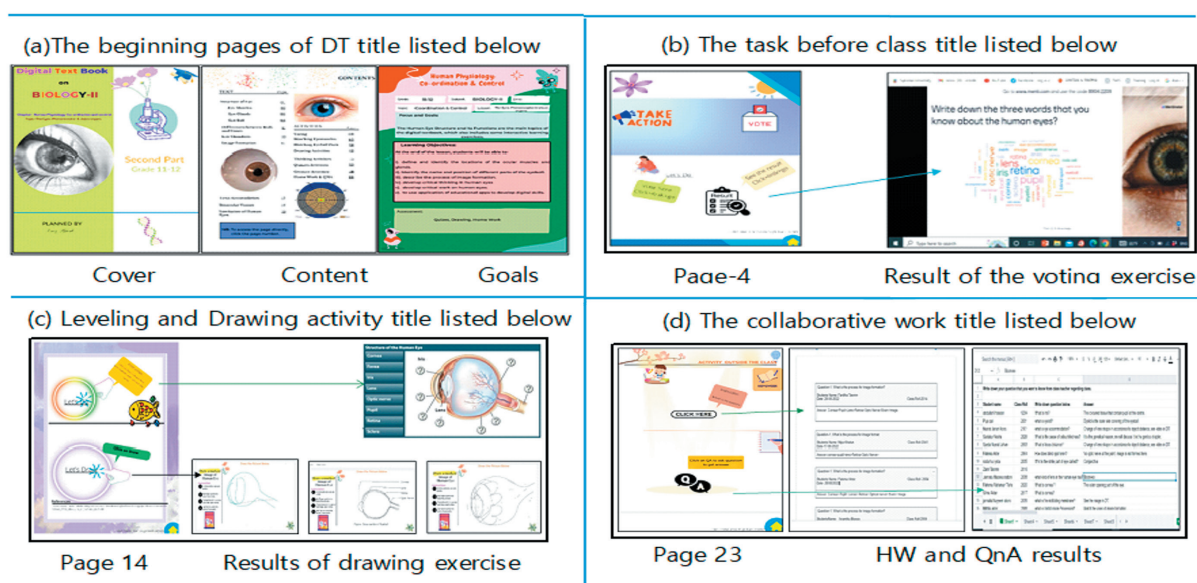


Fig. 1. The developed digital textbook on human eyes for Bangladesh higher secondary students

Comparison of Academic Success in Using Printed Textbook and DT.

The ANOVA test revealed that there was no significant difference in academic success between the control (the printed textbook group) and experimental-1 group, $F(3, 116) = 2.11, p = .103$ (Table 2). The study further compares the academic success among the Control, Experimental-1, and experimental-2 groups and found significant mean differences in academic success $F(5, 174) = 6.55, p = .000$ (Table 2). The individual variances among the mean scores were analyzed using the Tamhane Post-Hoc test on basis of the Levene test result ($p < 0.001$).

Table 2. Mean variances of academic success among three groups (ANOVA)

Domain	Test	N	M	SD	F	df	p
Control	Pre-Test	30	5.83	2.75	6.55	5	.000
	Post-Test	30	6.47	2.58			
Experimental-1	Pre-Test	30	4.97	2.25			
	Post-Test	30	6.03	1.81			
Experimental-2	Pre-Test	30	7.30	1.47			
	Post-Test	30	7.63	1.33			

Note. N=population, M=mean, SD= standard deviation df=degree of freedom, p=significance

The Tamhane's post hoc indicate that the post-test experimental-2 group's (M=7.63, SD=1.33) academic success was significantly different from pre-test control (M= 5.83, SD= 2.75) and pre-test experimental-1(M= 4.97, SD= 2.25), and post-test Experimental-1 (M=6.03, SD=1.81) group's (Table 2). Similarly, the pre-test Experimental-1 group's (M= 4.97, SD= 2.25) academic success was significantly different pre-test experimental-2 (M= 7.30, SD= 1.47).

Comparison of Learning Satisfaction using PT and DT

The subsequent ANOVA and LSD's Post-Hoc test was conducted to analyze student satisfaction among the groups. The ANOVA test showed that the effect of learning satisfaction among control, experimental-1 & experimental-2 groups was significantly different among groups [$F(2, 27) = 5.95, p=.007$] showed in the Table 3. The post hoc analyses using the LSD for significance indicate that the control group's (M= 4.08, SD= .23) learning satisfaction was significantly higher than that of Experimental-1(M=3.70, SD=.41) and Experimental-2 (M= 3.57, SD=.38).

Table 3. Students Learning satisfaction in three groups using ANOVA analysis

Groups	N	M	SD	F	p
Control	30	4.08	0.23	5.95	.007
Experimental-1	30	3.70	0.41		
Experimental-2	30	3.57	0.38		

Note. N=Population, M=mean satisfaction, SD=standard deviation.

The mean score for LS on the survey questions for the Control, Experimental-1, and Experimental-2 groups were showed in the Table 4.

Table 4. Mean of the groups' learning Satisfaction

Groups	Tools	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
C	PT	3.9	4.1	4.0	4.0	4.5	3.7	4.3	4.0	4.0	4.3
Ex. 1	DT	2.3	3.2	3.5	3.6	3.8	3.8	4.0	4.0	4.0	4.2
Ex. 2	DT	2.7	3.4	3.5	3.7	3.3	3.9	3.9	3.8	3.9	3.6

Note. C= control, Ex. 1= Experimental 1, Ex. 2= Experimental 2, Q1...Q10= number of questions

Discussions

Design of Digital Textbook.

To create an interactive digital textbook (DT), the researcher bisects the developed digital textbook into a text component and the activity part. The text component includes descriptive information about eye structure and functions utilizing 2D and 3D images, videos, links, hyperlinks, graphics, stickers, elements, and a dictionary. The activity section, on the other hand, consists of a variety of interactive tasks that facilitates student-centered learning (SCL) through the activities (Moeller & Reitzer, 2011). However, to measure the prior knowledge in the terms of human eyes, the researcher added Mentimeter-based voting activity to provide opinions (Sari, 2021) (see Fig. 1-b). Students participated in the voting process and saw the results collectively, which made the classroom engaging (Anggriani et al., 2022). The following activity involved playing a variety of tests to learn eye muscles using the Quizlet app. Through the Quizlet, students can learn independently or motivationally (Setiawan & Wiedarti, 2020). The next task was to rate their understanding by matching the names of various eye parts. Furthermore, using a jam board, students drew and leveled the eye anatomy (Fig. 1-c). The drawing exercise aroused the students' curiosity, excitement, and playfulness (Virto & López, 2020).

In addition, the researcher employed the Home Work (HW) and the Question and Answer (QnA) exercises for the management of students' work. Teachers can monitor student's progress using the DT (Hamedi & Ezaleila, 2015) through HW and QnA. The use of Google docs and Google sheet for HW and QnA enhance collaborative work (Zioga & Bikos, 2020). The HW and QnA exercise improved student-teacher interaction which enhances student-centered learning (SCL) over teacher-centered learning (TCL).

Comparison of Academic Success among Groups.

Tamhane's Post-Hoc result indicates that the academic success score in the post-test of the DT experience experimental-2 group mean score was 7.63, the highest among all groups (Table 2). It demonstrates that the academic performance was superior for experience DT users compared to others (Santoso et al., 2018; Song et al, 2007) due to prior familiarity with the DT environment. However, there were some variations in academic success among pre-test mean scores for the control, experimental-1, and experimental-2 groups (Table 2).

The instructor claimed that the prior DT knowledge made the variation. In contrast, he continued, the difference in mean scores between the pretest experimental-1 and pre-test control groups was caused by the differing levels of prior knowledge they had. Similarly, the mean score of the pre-test and post-test experimental-2 groups was not statistically different, because students of both groups had prior knowledge of DT instruments before the class. However, the success score increased in the post-test after treatment in the DT-experienced experimental-2 group (Table 2).

Comparison of Students' Learning Satisfaction

Learning satisfaction is referred to the outcomes of the actions taken during the teaching and learning sessions in which the students participated (Wu et al., 2015). The LS survey's results and post-hoc revealed that the traditional class using PT in the control group had a mean satisfaction score of 4.08 which was higher than the other two groups (Table 3). The result indicates that students continue to prefer and be satisfied with paper textbooks over DT (Bao et al., 2018; Jeong, 2012; Seal, 2020; Woody et al., 2010). According to the instructor, due to poor infrastructure and the lack of knowledge in using devices and apps students feel challenged to use DT (Table 3).

On the other hand, students have been using PT for more than ten years, and they were not accustomed to using digital devices in the education field. In consequence, they exhibited greater satisfaction with PT than DT. Moreover, the sluggish speed network took too long to access the videos and activities in the DT-based multimedia session, hence the PT-based Control group demonstrated greater satisfaction with survey question no 5, *"I was satisfied with the amount of time"* than the other two groups (Table 4). To improve student-centered learning, teachers should allot time for activities and make sure that it allows students to learn independently (Çubukçu, 2012).

Dramatically, students in the control group using PT, however, indicated less satisfaction when responding to question number 6, "I have enough feedback on my learning," perhaps as a result of the traditional PT class's lack of interactive activities and feedback mechanisms (Table 4). So, the DT offers SCL through interactive activities. It indicates that DT users need more time to use and students showed more interest in feedback-based activities than PT users.

Instructor's Opinion

To determine how DT was designed in connection to success and satisfaction in the classroom setting, the researcher tries to make sense of this relationship by taking the instructor's interview. The following Table 5 is a summary of the interview:

Table 5. Instructor's opinion on academic success and learning satisfaction

Major areas	Vital points
Challenges for Success & Satisfaction	Poor internet network, interruption of electricity, lack of device and internet data availability (poor family background), first-time use in Bangladesh (sudden use), lack of proper knowledge of app use, seeking apps permission (using hazards), mindset for printed textbook, guardian mindset (to handover smart devices), Lack of ICT skills,
Recommendation	Repeated (consistently) use, practice the way apps use, and proper ICT skills, development of infrastructure (network, continuous power supply), and teachers' training.
Interesting and amazing DT components	Drawing activity, quizzes (Flash card), QnA sheet, and HW sheet, excellent DT design

According to the instructor, the DT design was excellent and students were excited and liked to use various DT features for example quizzes (flashcards), drawings, HW, and QnA. However, low network bandwidth and load shedding interrupt DT-based multimedia classes. In addition, satisfaction with DT was impacted by their lack of the required equipment knowledge and the necessary abilities to use the educational tools. The instructor argued that if we continue the DT use and demonstrate how to use the DT instrument, their satisfaction and success will rise. To break through in the DT field, student and guardian mindset change is important, the instructor added. For future use instructor

said, “*Maybe shortly if these apps can be developed in our own country under our management and at the same time by a package system (using all apps in one package) it can be made a little easier than the implementation will be easier*”.

Conclusions and Implications

This study has been identified that students’ satisfaction for DT was lower than PT due to a few infrastructural, technological, and mindset challenges. However, after getting some DT experience, students showed good academic success in the multimedia-based DT classroom. In the experimental investigation, Academic Achievement Test (AAT) questions were used to gauge the academic success of the pupils. AAT was made on knowledge-based multiple-choice type questions with four possible answers. On basis of AAT, the control, experimental-1, and experimental-2 groups were tested as pre-test and post-test designs. The researcher provided the opportunity to use DT prior to the class in the experimental-2 group as modify methodology to gauge academic success for the DT experience group. Therefore, the students who are familiar with the DT environment showed better performance in academic success.

The digital textbook had unique features that help to manage and operate the teaching and learning process. Both the instructor and the learner found the features to be very engaging and enjoyable. The new idea for teaching and learning about the human eye in biology part II was to use an interactive DT-based multimedia class for SCL and the process of making DT designs for the higher secondary level in Bangladesh. The DT offers some unique activities and remote management in teaching-learning.

In addition, with few limitations, the DT was accessible in the classroom and it can be used as a supportive tool. To overcome the problems this study tries some recommendations to make DT more accessible in the classroom. The recommendations are a continuous supply of electricity, providing a faster networking system, the availability of digital devices, changing the mindset of students and guardians for using devices, minimal training on using educational apps, consistency in the use of DT-based multimedia classes, and own development central Apps.

However, the study was carried out beyond the capital city, in the district areas. The availability of electricity and internet bandwidth varies from rural to city areas in Bangladesh. Further research can be done on the effectiveness of DT in changing the teaching paradigm from TCL to SCL. In conclusion, DT can be used along with PT to enhance SCL in the classroom.

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