Combining 2D Animation With Lectures For STEM Education

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ABSTRACT

There is a significant difference in the performance of students in government schools and urban private schools. The lack of facilities and supervision leads to a poor standard of learning in government schools, and only those who do not have the resources to transition to urban private ones are subjected to sub-par educational norms. There is a need to uplift these communities by integrating tech in educational institutions in these backwaters. The present study compares the efficacy of augmenting lectures with animated videos in teaching STEM concepts with that of traditional methods based solely on oral explanation. The secondary goal is to determine which pedagogical methodology generates more interest in the concerned field. The experimental data was generated through lessons with animated videos and lectures. The effectiveness of each method was calculated from analyzing sample performance on lesson-based tests. Since the research was conducted at an NGO, the sample mainly consisted of students (n = 38) from lower-tier socioeconomic classes. Likert scale questions were implemented to gauge interest and engagement. The Blended approach yielded higher scores indicating a higher level of understanding. It was revealed that blended learning through animation led to greater interest and engagement of students in the subjects.

Keywords: Animation, education, specificity, private, government, schools, visual media, technology, STEM, lectures, pedagogy, interest

INTRODUCTION

Even after numerous reforms and governmental schemes, educational inequality persists within different sections of the community in India. An extremely high extent of inequality - above 50% on the Gini index - in this regard has been observed between underprivileged and urban areas. Students enrolled in urban private schools perform significantly better relative to those in government ones. (Agrawal, 2014).

Although low-fee private schools have been established to curb this inequality, their benefits remain statistically insignificant (Chudar & Quin, 2012). Studies have found this disparity to be the primary reason for the lack of financial development of the lower economic classes, which have insufficient resources and are obligated to subject their children to suboptimal education (Chakrabarty, 2017).

With the rapid integration of computers in education in the past decade, there are feasible alternatives that can alleviate these

discrepancies using educational technologies. E-learning that creates and manages appropriate technological processes and resources to produce performance improvement is facilitated by educational technologies (Goswami, 2014). Educational technology has many facets, mainly focused on Visual Learning. It is a well-established fact that visual learning leads to better understanding and retaining information (Raiyn, 2016).

Studies report that about 75% of all the information processed by the brain is derived from visual formats and augment the mapping of information in mind (Williams, 2009). It has also been proven that students remember information better when taught with a hybrid of methodologies, i.e., both visually and verbally (Rodger et al., 2009).

An approach to education that combines online educational materials ranging from animations, presentations and quizzes with the traditional oral method of imparting knowledge is called Blended Learning (Hockly, 2018). It can also be referred to as the strategic integration of Information and Communication Technologies (ICT) into academic courses. One of the most significant advantages is that it is parallel to an active learning environment (Tayebinik & Puteh, 2013). The effectiveness of a number of blended learning methodologies has been confirmed, showing a positive influence on student attention, classmates' participation, interest, and learning, and is effective at accommodating diverse student populations while enriching the learning space (Serrano et al., 2019).

There are a plethora of facets of blended learning, with some being more effective than others. This study focuses on only one of those facets - traditional teaching assisted with computer animation. Computer animation is a method of presentation of computer-based graphics. In contrast to static graphics, animated graphics use dynamic 2D or 3D models for a simplified depiction of real life. With motion, a higher degree of visual complexity is achieved by animated graphics relative to stationary, static ones (Mansor et al., 2020). Animation provides learners with explicit dynamic information that is usually implicit or unavailable in static graphics. However, the mental processing demands of animation are called into question due to the inclusion of a temporal dimension that may increase the cognitive load (Lowe, 2003)-(Lowe, 2004).

The study conducted by Kainz in 2013 to analyze the role of animation in education was inconclusive, with all trials leading to a variegated result, hence lacking a pattern (Kainz, 2013).

In another experimental study conducted in Dhaka, it was concluded that the students who were taught using both animation and lectures

fared better than those taught using either one (Islam et al., 2014).

The majority of the studies only analyze the effectiveness of a particular teaching methodology based on students' performance on tests. They lack specificity in terms of the subject being taught, the quality and type of animation, and covariates like the socioeconomic background of the sample. Furthermore, the only comparative quantity measured is the performance on the test, overlooking essential factors like the preference of methodology and the level of interest generated. To cover this knowledge gap, this study is focused on the effectiveness of 2D animation in teaching students from underprivileged economic backgrounds.

Science fields are rapidly becoming the most important fields of higher education, focusing on solving real-world problems (Reinhold, 2018). Hence, this study will determine the effectiveness of the pedagogical models in impairing STEM knowledge.

It is the direct costs of schooling in the private sector and the subpar quality of the public sector that reduce student interest, primarily accounting for educational deprivation (Bhatty, 1998). It may also be caused by the incompetence of the teaching staff in government schools. It is not uncommon for teachers to take regular unwarranted leaves (Singh, 2015).

As these schools do not have the funds, resources, or infrastructure to tackle these issues, there is a need to employ more innovative solutions that automate the process of education without raising the costs.

An example of these solutions is blended learning that beneficially impacts engagement, flexibility, and the learning experience from the existing infrastructure (Bouilheres et al., 2020). As research has previously succeeded in enhancing educational standards through interactive media (Edgcomb & Vahid, 2014), this research will identify the virtue of animation in resolving those issues,
Given the emphasis placed by these methodologies on the understanding of the subject, they could help mitigate the rote-learning culture that's rooted deeply in the Indian educational system (Leach, 2020)-(Apoorvanand, 2015)-(Bhatty, 1998).

Furthermore, this research is concentrated on the benefits of STEM education. Currently, the number of STEM jobs is growing fast, outstripping the number of STEM graduates. It is predicted that 80% of the jobs created in the next decade will require some form of math and science skills (Jack & Lin, 2017). Looking forward, the implementation of an effective STEM teaching model could lead to the development of the country as a whole.

In the present study, children belonging to low socioeconomic backgrounds were divided into

two groups - one subjected to the animated video series, while the other was subjected to a lecture on the same topic. A questionnaire follows this to evaluate their performance, which indicates the efficacy of a particular methodology. The success of each methodology is also measured by the level of interest generated in the subject taught with the help of a survey.

The objective of this paper was to take a novel approach in assessing the efficacy of blended learning in terms of not only understanding and retention of knowledge but also comparing the preference and engagement of each teaching methodology. This study focuses on 2D animation in teaching STEM to underprivileged children of India, hence being unique in terms of the subject specificity, the type of blended learning, and covariates like socioeconomic background.

It was hypothesized that blended learning with animation would achieve much higher levels of test performance and interest in the subject in comparison to traditional methodologies. This model of education could be employed in poor-performing schools for automation and enhancement of standards.

METHODOLOGY

Aim of study

The present study examines the efficacy of blended learning via animated videos compared to traditional oral pedagogical methods. This study focuses on the virtue of both methodologies in imparting STEM knowledge.

The success of each methodology is gauged based on two factors – understanding and interest. Understanding has been measured through an assessment test, whereas interest through a survey.

Research design

The research design of the study is based on an experimental approach comprising of two parts: ones based on a performance test, and the other on a survey

In the first part, a given sample of students was divided into two sets. One was exposed to a blended lesson comprising an animated video and a lecture – and the other was taught with the traditional oral methodology on the same topic. The lessons were followed by a small test to compare the effectiveness of each pedagogical model.

Variable	Name	Description
Independent	Teaching Model	The teaching model was varied between blended and traditional
Dependent	Scores	The scores of students on the test

Control	Assessment Test	The test remained constant across both the teaching models

In the second part, a voluntary survey, consisting of both general informational and comparative questions, was deployed to each student on a voluntary basis. The survey was used for two purposes:

- To collect general data on the sample with regards to gender, age, socioeconomic background
- To collect comparative data for the two different teaching models in order to differentiate the levels of generation of interest in the topic taught.

Variable	Name	Description
Independent	Teaching Model	The teaching model was varied between blended and traditional
Dependent	Answers to comparative questions	Comparative questions to gauge how interesting the students found a topic
Control	Survey	The survey remained constant across both the teaching models

Hypothesis

Null Hypothesis 1: The students exposed to blended learning will not perform significantly better than those exposed to traditional methods.

Alternative Hypothesis 1: The students exposed to blended learning will perform significantly better than those exposed to traditional methods.

Null Hypothesis 2: The difference in the pedagogical methodologies employed will not have a significant effect on the level of generation of interest in the concerned subject.

Alternative Hypothesis 2: The difference in the pedagogical methodologies employed will have a significant effect on the level of generation of interest in the concerned subject.

Null Hypothesis 3: The difference in the pedagogical methodologies employed will not have significant effect on the future outlook of students with regards to career

Alternative Hypothesis 3: The difference in the pedagogical methodologies employed will have a significant effect on the future outlook of students with regards to career

Consent and ethical issues

All ethical considerations were followed for the current study. The experimental workshops were conducted on a voluntary basis: All the participants were informed that their decision to participate in the study would not affect future care and that participation could be terminated at any time without penalties. All the extraneous variables such as noise, sound, etc. were taken care of.

Informed consent was taken from the participating students for data collection and from the NGO OM Foundation where the study was conducted. Confidentiality and privacy of the respondents were maintained; no data would be disclosed to a third party. No identifiers such as names or pictures were disclosed in the article or while conducting the study. The research complied with all the necessary ethical guidelines.

Sampling

Data were collected from middle school children studying at the Non – Profit Organization OM Foundation in the NCR region of New Delhi, India. We acknowledge them here with their full consent. The data was collected over one month in October 2021 through a total of four sessions of collection.

The **inclusion criteria** included students of class 8th, within the age group of 12 – 14 years. Only one class of students was made eligible to reduce discrepancies in previous knowledge that may affect the test results. The total sample size of participation was 38 students, out of which 24 were males and 14 were females

Quota sampling was employed to gather the eligible participants in order to minimize the sample bias and maximize uniformity between different sets of samples. This was done with the assistance of school teachers affiliated with OM Foundation, who recommended an extensive array of students of different levels of capability. Assessed based on previous performance in school, each sample set consisted of a nearly equal number of high achieving and low achieving students. The lessons were conducted in a hybrid of Hindi and English for maximum understanding.

Since the overarching theme of the study is to find ways to uplift lower classes of the population, the sampling was done from OM Foundation, an NGO that focuses on the education of underprivileged children. The range of the samples' socioeconomic background was a determining factor for participation. Monthly income was used to classify socioeconomic background, with the total range set at Rs 0 – Rs 1.5 lakhs per month.

Scales used

Two essential tools were used during the entire study – assessment, and survey. Each of the lesson-based tests employed in the study contained ten questions on the topic taught, with the tests remaining the same across either of the learning methodologies. The questions in the assessment were based on the lesson, and none of the questions asked for information beyond what had been taught. Every single question was an MCQ (Multiple Choice Question) question, with only one correct answer for each. For each correct answer, one point was awarded, and no points were deducted for incorrect answers.

The survey was split into two sections. The first section pertained to questions regarding the sample demographic (name, age, gender, socioeconomic background). The second section was focused primarily on collecting comparative data for the two pedagogical models. The respondents were asked to rate the lesson on a variety of factors, including interest in the lesson (polar), interest in Science (Likert scale), future career propensity to science (Likert Scale), and their preferred model of teaching (MCQ).

The lessons and animated videos employed in the study were made from scratch by the author. The topics covered throughout the study were Atomic Theory and Sound.

Data collection

The tests and surveys were distributed through Google Forms for online sessions, and the lessons were conducted on Zoom. For offline sessions, the tests and surveys were handed to the students as paper-based forms. The lessons were taught on a whiteboard, and the animated video was displayed using a projector and screen.

A total of four workshops were conducted throughout the study, wherein the sample of students was split in half for blended and traditional lessons. A test followed each workshop.

A total of 20 students were taught Atomic Theory in the first workshop, divided into groups of 10 for blended and traditional. In the second workshop, the same group of students was taught Sound; however, those exposed to blended learning in the previous workshop were now taught using the traditional method and vice versa.

The third and fourth workshops were conducted with 18 new students, and none of the students from the first and second workshops were repeated. Divided into groups of 9, the same procedure was carried out as in the first and second workshops.

The survey was given after the test only once to each and every student through the entire study, once in the first workshop (n=20) and

once in the third workshop (n=18). Hence, the total number of respondents was 38 for the survey.

Data analysis

The results of tests from all the workshops were compiled into a single table, categorized by learning model. A t-test was conducted on the data to evaluate the statistical significance of the differences in scores between the two models.

This was followed by qualitative analysis. The Likert scale data sets from the surveys were plotted on a double bar graph (blended and traditional) for descriptive analyses and empirical comparison of the methodologies.

The Polar questions data was converted into a pie chart for empirical comparison and descriptive analysis.

RESULTS

Table 1*: Number of students who scored points out of 10 for the two different methods*

Score	**Method**	
	Blended	**Traditional**
1	0	1
2	2	3
3	4	5
4	5	8
5	5	7
6	5	7
7	7	4
8	6	2
9	3	1
10	0	0
Total	38	38

Note, maximum score is 10

Table 2:

Summary of Independent T-test Analysis between blended and traditional learning respondents on the variable Test Scores (N=38)

Source	**Blended**		**Traditional**		**t**	**p**
	M	**SD**	**M**	**SD**		
Test Scores	5.84	2.02	4.84	1.85	1.66	.01

Note.*p < .05

Figure 1: *Number of students who preferred blended and traditional methods (N=38)*

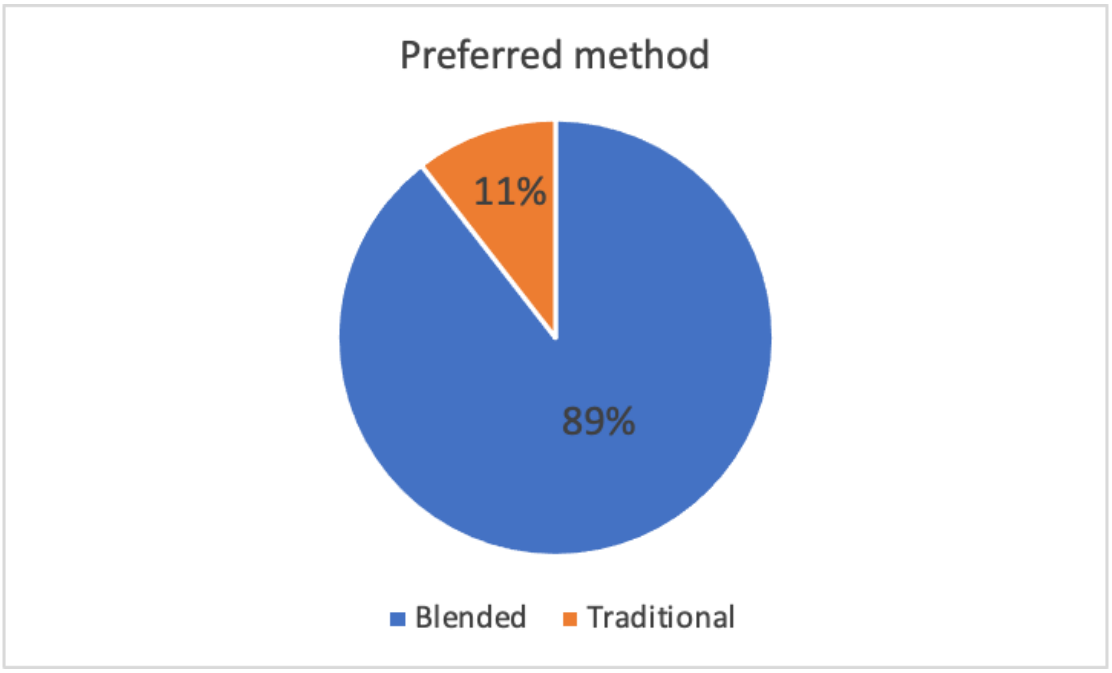
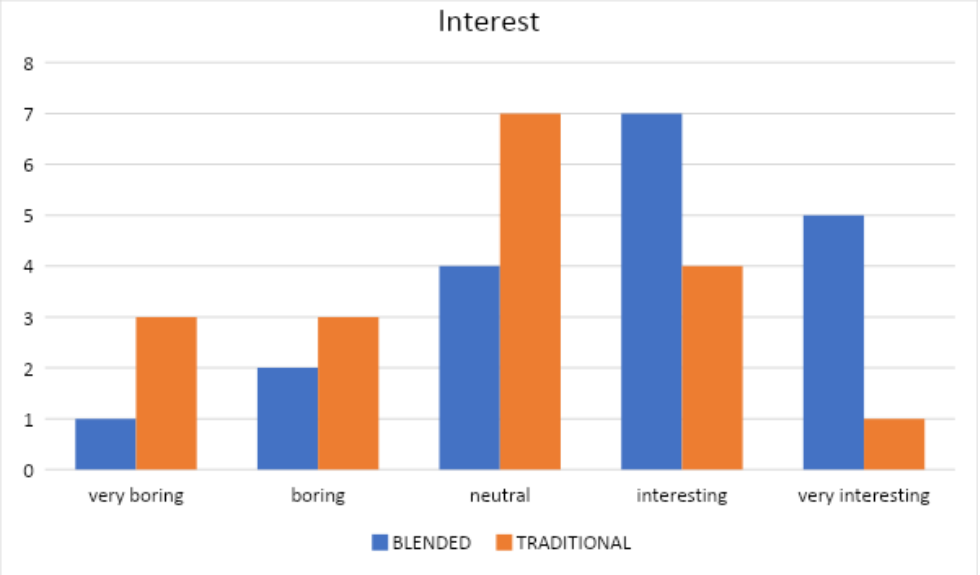
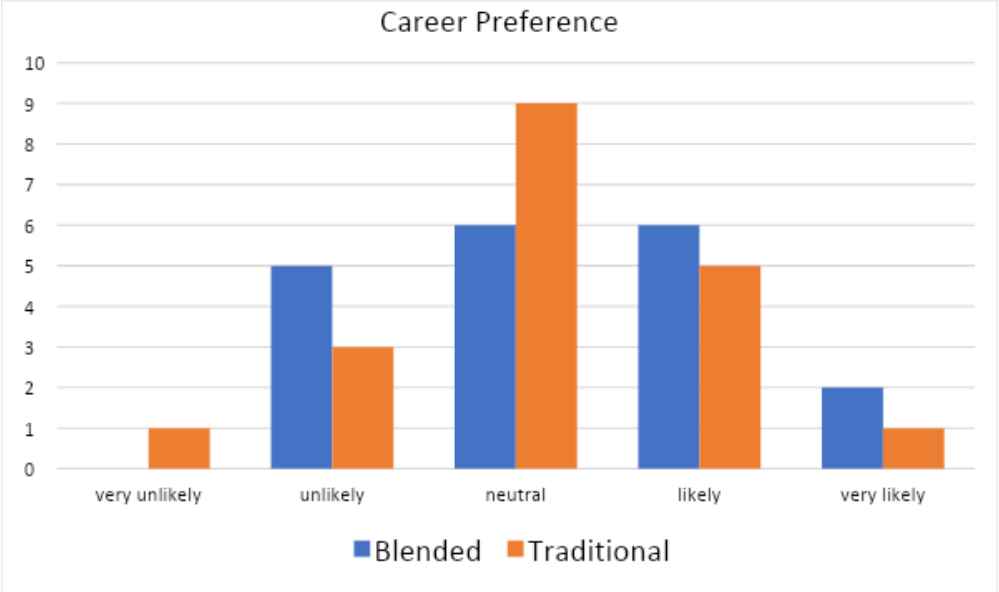


Figure 2: *Ratings of students about their interest in science, exposed either to blended or traditional methods (N = 38)*



Note. Blended = 19, Traditional = 19

Figure 3: *Number of students (N = 38), each exposed to only one of the two methods: blended and traditional, rated their likelihood to pursue science as a career on the given Likert scale.*



Note. Blended = 19, Traditional = 19

Table 1 shows that an equal number of children were exposed to both the methods. More students scored higher marks with the blended method than the traditional method.

Table 2 indicates that blended learning respondents (M = 5.84, SD = 2.02) reported significantly higher test scores than traditional learning ones (M = 4.84, SD = 1.85), t(1) = 1.66, p < .05 (Table 2). Hence, the Null hypothesis 1 is rejected and Alternative hypothesis 1 is accepted as the difference in performance is statistically significant.

Figure 1 indicates that out of the total 38 students, a majority (89%) of students preferred the blended method of teaching over the traditional one (11%).

Figure 2 indicates that more of the blended learning respondents gave high ratings to their interest in science than traditional ones.It also indicates that more of the traditional learning respondents gave lower ratings to their interest in science than blended ones.

Figure 3 indicates that almost an equal number of blended learning respondents are likely and unlikely to choose a career in science.A majority of the traditional learning respondents chose neutral, indicating they remain undecided.

Figure 3 indicates that there is not much difference between the responses of the two groups

DISCUSSION

The present study examines the efficacy of blended learning via animated videos compared to traditional oral pedagogical methods in imparting STEM knowledge.

The results of the experimental part of the study show that the students who were taught using blended teaching, i.e., a combination of a lecture on the topic aided with an animated video for visualization, performed better than the students taught with the traditional oral lecture method. The difference in the performance is statistically significant as the p-value in the t-test comes out to be < .05 (.01). Hence, we reject Null Hypothesis 1 and accept Alternative Hypothesis 1: The students exposed to blended learning will perform significantly better than those exposed to traditional methods. These results support the claims made by Serrano on the effectiveness of blended learning in increasing depth of understanding (Serrano, 2020).

The interpretation of the data collected from the survey questions highlights the other important aspect of the study – the effectiveness of a given model of education in the generation of interest in science. Most of the students (89%) preferred the blended animation model over the traditional, showing the students' strong inclination towards visual media. Furthermore, the Likert scale ratings imply that the blended method was more successful in generating interest in the subject taught. So the Null Hypothesis 2 is rejected and Alternative Hypothesis 2 is accepted. Hence, the blended model has much greater virtue in sparking interest in the given

subjects. It was known that diagrams assist in understanding of text, but static images fail to command attention as well as dynamic ones do where there is scope of more information due to continuous change. Therefore, animated graphics enjoy more curiosity and contemplation (Rodger, 2002).

The survey also indicates that there is only a marginal difference in the students' future goals between the two methodologies, which leads to the conclusion that the independent variables (teaching method) do not have any effect on the dependent variables (future career goals). This warrants the acceptance of Null Hypothesis 3.

The great difference in the effects of the two methodologies has far-reaching implications. The experimental results correspond to the studies conducted by Islam and Barak, confirming the superiority of blended education to traditional methods (Islam, 2014) – (Barak & Dori, 2011). The results of this study support the dynamic graphics subset of blended learning in the form of animation. They project animation as a tool with positive consequences, rejecting the claims of cognitive and processing overloads (Lowe, 2003) – (Lowe, 2004).

Since the study was focused on STEM knowledge, blended learning through animation has been identified as a valuable means of scientific education that augments understanding, visualization, and retention of topics. Since sciences require a high degree of visual thinking, graphical models and images supplement the learners in retaining and understanding of information (Salomon, 1984).

Teaching without the aid of visual media can lead to suboptimal learner response due to lack of captivity (Jack & Lin, 2017). The survey provides new insight on the role of type of teaching method in developing interest, enthusiasm, and engagement of students in the topics being taught. When aided with animation or other similar graphical/interactive interfaces, there is a perceptible increment in the attentiveness and engrossment of those taught.

With the confirmation of animation as an asset to education, the results of this study can be implemented further to test the use of other forms of blended learning models. Moreover, this also opens the gateway to testing the effectiveness of this model in teaching subjects other than STEM that do not require the same magnitude of visualization.

CONCLUSION

In this study, the efficacy of two different models of education – the traditional oral methodology and lectures aided with animated videos (a form of blended learning) – was examined in imparting education. The blended model yielded better results than the traditional model in terms of the understanding of the subject and the relative engagement of the students.

More specifically, the study reveals that science requires visualization and the blended approach makes this feasible for the students. Animation, with dynamic graphics, goes a step further in enhancing learning and retention. This model of education can be employed to raise the education standards in backward communities.

LIMITATIONS OF THE STUDY

The different samples of students may have reacted differently to the two methods, thereby affecting the study results. The results can also be affected if the students in the sample have some amount of prior knowledge of the topic being taught. As one cannot ensure the same intellectual level in the samples, some students may have been sharper than the average level, causing abnormalities in the scores. Since the workshops covered two different topics, some may have found one topic more difficult than the other. The study was conducted on a small sample over a short period of time, hence, more data is needed to draw better conclusions.

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