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Effect of Digitized Textbooks on Secondary School Students' Domains of Learning

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Abstract

In developing countries like Pakistan, digitized textbooks are one of the most recent educational reforms brought about by the educational technology. This study analyzed the effectiveness of Punjab Information Technology Board's (PITB) digitized textbooks on students' cognitive, affective and psychomotor domains of learning. The study was delimited to only those levels of learning domains that were specified in National Curriculum of Pakistan, 2006. The nature of the study was quantitative and employed Quasi Experimental Non-Equivalent Control Group Design. Sample of the study comprised of 56 students studying Chemistry in grade 9 at a public sector school of district Lahore, Pakistan. Experimental group was taught by using digitized Chemistry textbook and control group was taught by using conventional mode of instruction. The intervention lasted for 12 weeks. Data was collected by using three different valid and reliable instruments. Data was then analyzed using descriptive and inferential statistics. All hypotheses were tested at a significance level of 0.05. The results revealed that there was no significant effect of digitized textbooks on students' cognitive domain. But there was statistically significant effect of digitized Chemistry textbook on students' affective and psychomotor domains. Recommendations were made to bring learning in cognitive domain at par with affective and psychomotor domains.

Introduction

To meet the challenges of the digital world and to ensure the access of technology for everyone, PITB initiated E-Learn Punjab project as a joint venture with Punjab Curriculum and Textbook Board and School Education Department (SED) on January 6, 2014. The project aims to facilitate learners and empower educators throughout the province by providing them with technology equipped digitized school textbooks. Free digitized textbooks have been developed by PITB from grades III to grade X. To explain the topics in depth, each book is supplemented with videos, animations and simulations. This helps in learner's concept development. According to PITB, the project has been implemented in 250 classrooms and has influenced 10,000 students across Punjab by providing them with tablets, tablet based smart labs, LEDs and interactive smart boards in classrooms (Digital Punjab Section, 2019, para 2). It is believed by Government of the Punjab that digitized textbooks will prove to be a revolutionary initiative as they will bring an end to tuition culture and will cater to needs of diverse learners. This technology will bring personalization of learning experience.

Student performance and use of digitized textbooks is an emerging area of research in Pakistani context. The rationale for selecting a research study on digitized textbook is researcher's academic background and prior experience in textbook development. The theoretical foundations of several learning theories were used to provide a framework for the study which include cognitive theory, Schema theory, Thorne's Artifact theory and Bloom's taxonomy of Educational Objectives.

Ormrod (2012) stated the cognitive theory focuses on what and how individuals learn from one another, interacting in observational learning, modeling, and imitation. Cognitive theory stemmed from the concept that using concrete learning activities within an environment where a student participates in active exploration and interaction with appropriately designed activities results in the acquisition of knowledge (Wiley, 2014). Schemas are essential in assisting students to comprehend print or digital text. However, digital formats involve new schemas and new comprehension approaches to address the problem of student comprehension of digitized content. Schema theory was initiated by Kant (1929) and then Bartlett (1932) in the effort to recognize how information is stored in the memory. Schema theory focuses on numerous cognitive processes, including recalling, rationalizing, and solving problems.

Thorne (2003, 2016) highlighted the importance of tools (e.g. digitized textbooks) and how their use (including for learning) is determined by society. The way a tool (or artifact) is used leads to a culture-of-use; for example, a tablet can fit into a personal or academic culture-of-use. Thorne (2003) in his theory "Artifacts and cultures-of-use in intercultural communication" explains that a learner's prior artifact-mediated activity can either facilitate or constrain their future learning activity. These cultural artifacts become empowered within specific contexts. It has been observed that when a learner is academically involved with a learning tool such as digitized textbook, it brings out greater learning outcomes along with increased learner's involvement. But these cannot be expected to arise naturally and can benefit from teacher guidance and peer discussions. As such, a poorly developed academic culture-of-use surrounding these texts and a lack of learning strategies may have represented a learning barrier and discouraged learner engagement (Lantolf, Thorne, & Poehner, 2015).

Benjamin Bloom in 1950 with the help of a team of educational psychologists analyzed the behaviors associated with learning. He aimed to make a system with several levels of learning behaviors that can help educators in successful evaluation. The product of his research is what is known today as "Bloom's Taxonomy". It provides a reliable way to measure outcomes of students learning. The learning objectives are divided into three domains which are cognitive, affective and psychomotor domain. The most focused learning domain in public sector Pakistani schools is cognitive which is assessed by formative and summative assessment. The other two domains of learning are not much considered and evaluated though they are inter-related and significant. Thus, to get a holistic picture of students' learning, all three learning domains have been made a part of this study.

There are numerous levels within the three domains. The levels range from basic to complex. Learners learn differently from provided experiences depending on;

1. Kind of the experience
2. Level of development of learners

3. Time and frequency of experiences

Digitized textbooks can be effective tools for teaching and learning. Their effect on all three learning domains have been explored by numerous researchers, however their usefulness and adoption depends on user's perception and acceptance. (Joo, Joung, & Kim, 2014). Learning effectiveness of digitized text books was compared with printed textbooks by Szapkiw, Courduff, Carter and Bennett (2013). No difference was found as both mediums were equally effective. It was also reported that students who preferred learning from digitized text books had higher perceived levels of affective and psychomotor learning than students who opted for paper text books. These studies proposed that in terms of learning effectiveness, digitized text books are comparable to, though not better than paper text books. Students learned more but their academic marks and grades could not improve (Marques, 2012). Keeping in view the Pakistani context, this study can lay a foundation for the future researches in the area of digitized textbooks. As the process of textbook digitisation in Punjab is in implementation phase, it is assumed that findings of the study may serve as helpful guidelines for effective implementation and improvement of the project. The study will also be a pilot study of the project and its effect may highlight how cognitive, affective and psychomotor learning can be promoted by making use of digitized textbooks.

Objectives of the Study

The objectives of the study were to:

1. Find out the effect of Chemistry digitized textbook on cognitive learning domain of secondary school students.
2. Find out the effect of Chemistry digitized textbooks on affective learning domain of secondary school students.
3. Find out the effect of Chemistry digitized textbooks on psychomotor learning domain of secondary school students.

Research Hypotheses

The null hypotheses of the study were following:

1. H01: There was no statistically significant difference between the mean scores of pre-test and post-test of students using digitized textbooks and those using paper textbooks.
 - a. H01.1: There was no statistically significant effect of Chemistry digitized text books on cognitive learning of secondary school students.
2. H02: There was no difference in the perceptions of students about effects of digitized textbooks before and after the intervention.
 - a. H02.1: There was no effect of PITB's digitized textbooks on secondary school students' affective domain.
3. H03: There was no significant effect of digitized Chemistry textbooks on psychomotor learning of secondary school students.

Delimitation of the Study

The study was delimited only to the learning domain levels specified for Grade 9 in National Curriculum for Chemistry, 2006 Pakistan.

Table 1. Learning Domains & Levels specified in National Curriculum for Chemistry Grade IX, 2006

Domains & levels of Learning	Weightage in Curriculum
Cognitive Knowledge, Comprehension, Application, Analysis.	85%
Affective Receiving, Responding, Valuing, Organizing.	5%
Psychomotor Manipulative Skills (performing Lab work)	10%

Method

The study was quantitative in nature and employed quasi experimental non-equivalent control group design. Intervention was applied to experimental group only studying Chemistry in grade IX at a public sector school.

Population and Sample

The target population of the study was all secondary school students of public sector schools in Lahore. According to Report on Annual School Census (PMIU, 2018), population of grade 9 students studying in secondary schools of district Lahore was 58,328. Sample of the study comprised of 56 students studying chemistry in grade 9 at a public sector school of district Lahore. Two intact groups were selected for non-equivalent pre-test post-test control group study. Students of one section served as experimental group while the other section students were the control group.

Both experimental and control groups were taught for twelve weeks. The control group was taught by traditional methods while experimental group was taught by making use of smart board technology. Lessons to experimental group were delivered according to the provided instructions in Teachers' Guides and by making use of interactive devices like smart board and Laptops. The selected school did not have smart board installed so researcher requested the school administration to allow its installation. The school allowed the installation of smart board and provided a separate room where students could take the class.

Instrumentation and Validation

Three different instruments were used to measure academic achievement and students' attitudes towards learning Chemistry.

Achievement Test

Instrument used to measure academic achievement was an achievement test. The test comprised of 20 multiple choice questions and 15 short questions. Same test was used as pre-test and post-test. Test items were selected keeping in view the Table of Specification. The validity of the test items in achievement tests for measuring cognitive learning was ensured by taking experts' opinion from grade 9 subject teachers and assessment experts of IER, University of the Punjab. Pilot testing of achievement test was done by administering it on 42 students of grade 9. Item analysis procedure including item difficulty and item discrimination was carried out. Multiple choice items were analysed for difficulty index (p-value) and discrimination index (DI). Items having p-value between 30-70 and $DI > 0.25$ were considered as having good difficulty and discrimination indices respectively. The test items were then revised.

Instrument to Measure Learning in Affective Domain

Bloom (1956) suggested that an instrument which measures across all three domains could be a better depicter student's learning. Rovai, Wighting, Baker and Grooms (2009) also claimed that grades are not an exact measure of students' learning. They may be related to student's prior knowledge and not what was learned in the course. Thus, they developed Perceived CAP Learning Scale which effectively assessed students' perceived cognitive, affective and psychomotor learning. The CAP scale is a self-reporting instrument to measure learning in the learning domains in traditional and technology enriched education settings. It provides a more holistic picture of educational effectiveness as it focusses on all three domains of learning (Rovai et al., 2009). CAP Scale was used by researcher in this study. The permission for the use of this instrument was taken from its co-developer Wighting. It was a nine-item scale and used a 5-point Likert type scale where students rate learning ranging from score of 1 to a score of 5. Evidence about instrument's validity and reliability was shared by Rovai et al., (2009). The reliability of the original scale was reported to be .79.

Instrument to Measure Learning in Psychomotor Domain

During this study, the science process skills were assessed using assessment criteria rubric for practical related tasks. The rubric has been developed by Hong Kong Assessment and Examination Authority. The authority has permitted its use for educational and research purposes without any needed permission. The rubric has descriptions of four levels of performance for a given standard, each of which is assigned a score. Students' total score on the rubric can be used as a measure of their psychomotor skills.

Intervention

A smart screen was installed in selected public sector school by the researcher. During the period from August to November, 2019 intervention was provided to experimental group by using smart board technology. Lessons were delivered according to developed lesson plans. The period of intervention was approximately 12 weeks.

Data Analysis

Descriptive and inferential statistics were used to analyze and interpret collected data. In inferential statistics an independent sample t-test was used to find the difference in academic achievement of control group and experimental group. Descriptive statistics (Mean and Standard Deviation) were used to find out students' attitude towards use of digitized textbooks.

Results

H₀₁: There was no statistically significant difference between the pre-test and post- test mean scores of students using PITB's digitized textbooks and those using paper textbooks.

An independent sample t-test was conducted to determine the difference in pre assessment scores of students in the experimental and control groups as shown in Table 2. There is no statistically significant difference in mean scores of two groups ($t(54) = 1.015$; $p > 0.05$). This shows that students in both groups had evenly distributed academic performance thus group academic equality was ensured.

Table 2. Results of Pre Achievement Test for Equality of Experimental and Control Group

Pretest Scores	N	M	SD	t	df	p
Control Group	28	9.57	3.99	1.015	54	0.315
Experimental Group	28	10.71	4.42			

An independent sample t-test was conducted to determine the difference in post-assessment results of students in the experimental and control groups as shown in Table 3. Both groups showed improvement in post assessment scores. The experimental group showed higher mean score in post-test ($M = 20.93$, $SD = 6.23$) than the control group ($M = 18.04$, $SD = 4.76$). The mean increase in marks of control group is +8.47 while that of experimental group is +10.22. This implies that the use of digitized textbooks increased the cognitive ability of students but it was statistically not significant. ($t(54) = 1.951$; $p > 0.05$).

Table 3. Results of Post-Test of Experimental and Control Group

Post- test Scores	N	M	SD	t	df	p
Control Group	28	18.04	4.76	1.951	54	0.056
Experimental Group	28	20.93	6.23			

Cohen's values was used to calculate the effect size of the intervention. Effect size shows an indication of differences in magnitudes between the two groups. The following classification was taken into consideration as set forth by Cohen (1992) for interpreting the size of effect: a small effect=0.01; medium effect 0.06 and large effect=0.14. The eta squared statistic (0.06) indicated medium effect size of the intervention carried out on experimental group. As the test results are not significant hence null hypothesis cannot be rejected. This means that there is no statistically significant difference in cognitive abilities of students using paper textbooks or digitized textbooks.

H₀1.1: There was no statistically significant effect of Chemistry digitized text books on cognitive learning of secondary school students.

A paired sample t-test was conducted to determine the effect of Chemistry digitized textbooks on students' cognitive domain of learning (see Table 4). There was statistically significant increase in students' achievement score from ($M= 10.71, SD= 4.421$) to ($M= 20.93, SD= 6.236$), $t(27) = 10.84$, $p < .000$ (two-tailed). The mean score increase was +10.22 with a 95% confidence interval. As the test results are significant hence null hypothesis is rejected which means that there is statistically significant effect of intervention (digitized textbooks) on students' cognitive domain of learning.

Table 4. Analyzing Students' Cognitive Level Before and After Intervention

Achievement score	N	M	SD	t	df	p
Before Intervention	28	10.71	4.421	10.844	27	.000*
After Intervention	28	20.93	6.236			

*=Significant at $P < 0.05$

H₀2: There was no difference in the perceptions of students about effects of digitized textbooks before and after the intervention.

A paired sample t-test was conducted to find difference in students' perceptions before and after intervention. There was statistically significant increase in total CAP score from ($M= 17.62, SD= 3.55$) to ($M= 38.69, SD= 2.75$), $t(50) = 24.03$, $p < 0.05$ (two-tailed). The mean score increase was 21.07 with a 95% confidence interval (see Table 5). Thus, the null hypothesis is rejected which means that there is statistically significant difference in the perceptions of students towards digitized textbooks pre and post intervention.

Table 5. Analyzing Students' Perceptions using CAP (Cognitive, Affective & Psychomotor) Score

Total CAP score	N	M	SD	t	df	p
Before Intervention	26	17.62	3.55	24.039	50	0.000*
After Intervention	26	38.69	2.75			

*=Significant at $P < 0.05$

H₀2.1: There was no effect of digitized textbooks on students' affective domain.

A paired sample t-test was conducted to determine the effect of Chemistry digitized textbooks on students' affective domain of learning. There was statistically significant increase in students' achievement score from ($M= 6.69, SD= 1.828$) to ($M= 13.62, SD= 1.134$), $t(50) = 16.41$, $p < .000$ (two-tailed). The mean score increase was +6.93 with a 95% confidence interval. As the test results are significant hence null hypothesis is rejected which means that there is statistically significant effect of intervention (digitized textbooks) on students' affective domain of learning (see Table 6).

Table 6. Analyzing Students' Affective Learning Level Before and After Intervention

Achievement score	N	M	SD	t	df	p
Before Intervention	26	6.69	1.828	16.410	50	.000*
After Intervention	26	13.62	1.134			

*=Significant at $P < 0.05$

H₀₃: There was no statistically significant effect of PITB's digitized Chemistry textbooks on psychomotor learning of secondary school students.

An independent sample t-test was conducted to determine the difference in psychomotor learning scores of students in the control groups and experimental groups as shown in Table 7. There is statistically significant difference in mean scores of two groups ($t(3) = 3.873$; $p < 0.05$). This shows that students in both groups had different level of proficiency in experiment performing skills. The experimental group who performed experiments by watching practical videos in the digitized book performed better ($M = 8.25$, $SD = .645$) than the control group ($M = 5.75$, $SD = .645$) who performed experiments by reading instructions in the practical manual. Thus the null hypothesis can be rejected. This means that digitized textbooks have statistically significant effect on students' psychomotor learning domain.

Table 7. Analyzing the Psychomotor Learning Domain

Student Groups Performance	N	M	SD	t	df	p
Control Group	4	5.75	.645	3.873	3	0.03*
Experimental Group	4	8.25	.645			

*=Significant at $p < 0.05$ N= Student groups

Discussion

With the beginning of 21st Century, the school cultures experienced a major drift towards technology. It was expected from schools to integrate technology in order to cater to demands of digital world. Black boards were replaced by white boards and then interactive smart boards, notebooks were replaced by note pads and printed text books replaced by their digitized versions. While it was easier to adopt to other logical reforms, digitization of text books caused concern. This is because a text book is much more than a simple educational resource. It is a tool for implementing the curriculum and has strong social, religious, and ideological foundations (Mardis, 2010).

The findings of this study revealed that digitized text books have no significant effect on cognitive learning when compared with paper textbooks. Achievement scores of students in the experimental group improved as a result of intervention but similar increase was also observed in scores of students not using digitized textbooks. This finding is in line with the previous international studies conducted by Annand, (2008), Douglas and Willingham, (2012), Douglas and Daniel (2013), Mardis (2010) and Marqués, 2012.

The results of the study do not align with Azmi and Moradny (2010) who stated that students who studied from digitized textbooks scored higher in achievement tests than the students studying from paper textbooks. Amari and Shabl study (2012) showed in its results the effectiveness of digitized text book and its educational effect on students' performance via increasing their achievement. The findings of this study also misalign with results of studies of Mubarez (2008) and Jamali, Nicholas and Rowlands (2010).

The researchers believe that there are many underlying reasons for low cognitive learning using digitized textbooks. Students in the experimental group could not perform and score higher than control group in post-test because learn by use of rote memorization. They lack the ability to recapitulate a concept in their own words. This reason is supported by Marqués (2012). His research on digitized textbooks showed that while most students learn more, their marks are not higher. With respect to this, he claims: "We had already identified this paradox — students learning more without improving their academic marks". He concluded that this phenomenon occurs because examinations continue to involve memorization and do not evaluate much of the competence learning facilitated by digitized resources and methodologies. Therefore, examinations should focus more on the assessment of competencies, both general and subject-specific, that students develop by using digitized textbooks without rejecting essential aspects of memorization.

Another problem that we face when using digitized textbooks, as pointed out by Slater (2010) is unawareness about them. Only one teacher in the public sector school where intervention was conducted knew that digitized textbooks exist and are developed according to National Curriculum. Students had no idea about them or their usage despite of the fact that PITB launched the project in 2014. E-Learn project is still not recognized in public sector.

Another reason of low cognitive learning is students' reluctance to use technology. Researchers observed this while using simulations for explaining the concept of Boyles' law during intervention, only two students willingly participated. Rest of students were hesitant due to technical difficulties they encountered. Moreover, it is difficult for students to read electronic text. This was also discussed by Mardis et al. (2010), in his study that it is difficult to read detailed texts from digitized textbooks. This goes in favor of paper textbooks as non-digital text is fixed and easy to read. Reading from a digitized textbook is different as more than one form of texts are displayed as images, hyper texts and visual cues (Liu, 2009). That is why perhaps, students prefer reading and learning from a paper textbook.

A number of studies have reported that students are very receptive to use digitized textbooks and their attitudes towards learning from digital content is very positive. It was also observed during this research study as measured by the CAP scale. The scores of affective learning improved significantly before and after the intervention. This is in accordance with findings of Rodrigues, Plax and Kearney (1996) who suggested that digitized textbooks promote affective learning by motivating students to involve and take interest in assigned tasks.

The greater affective learning is also supported by findings of Kim and Jung (2010) who compared digital textbooks with paper textbooks with respect to learning attitude. Students using digitized textbooks showed an

improvement by 7.5% in attitude towards learning versus students using paper textbooks. The finding of this study about increased affective learning also aligns with Weisberg (2011). His findings reported that students enjoy the use of digitized textbooks and prefer their use.

In subjects such as Chemistry, learning in the psychomotor domain is as important as cognitive and affective learning. This is because performing experiments is associated with physical skills and requires level of dexterity. The findings of this study have revealed that students who used digitized textbooks for their Chemistry course had significantly higher perceived affective and psychomotor learning than students used traditional print textbooks. This is in accordance with findings of Daniel and Woody, (2013), Murray & Perez, (2011), Szapkiw, Courduff, Carter and Bennett, (2013).

Conclusion

The current study concludes that digitized textbooks have significant effect on secondary school students' affective and psychomotor learning. They developed liking for the subject and learnt manipulative skills for performing experiments. But the cognitive learning of students who studied from digitized textbooks was not much higher than those studying from paper textbooks. The orientation of educational institutions towards using e-learning systems and the easiest access to digitized textbooks will increase the chances of their usage in future. Digital materials do not in themselves deliver the changes that are promised and needed. So, it is important to evaluate and discuss the innovative potential of digitized textbooks in order to promote learning in cognitive, affective and psychomotor domains.

Recommendations

To bring cognitive learning at par with affective and psychomotor learning, and to fully utilize this advancement, following recommendations are made:

1. In order to improve learning in cognitive domain, students may have individualized access to digitized textbooks. Due to socioeconomic gaps in education, all families cannot assume the cost of acquiring devices for accessing these resources (i.e. tablets, computers, smartphones, and internet access). So besides providing smart screens in schools, devices such as Tablets can be provided.
2. In order to promote learning in affective domain and maintain students' interest in the digitized content during the class, there should be uninterrupted access to internet. Current internet connectivity does not allow the use of digitized textbook as public sector schools have either no or low broadband internet. Video streaming takes a lot of time. So, speedy internet access should be provided to public sector schools.
3. Teachers' expertise in use of digitized content can affect the learning in cognitive, affective and psychomotor domain. Currently, teachers are not trained to exploit the full potential of digitized textbooks. The inclusion of a new technology in an institution must go hand in hand with instruction on the technology. So teachers' training on digitized content must be made part of pre-service and in-service teacher trainings.

4. Punjab Information Technology Board should work diligently with Quaid-e-Azam Academy for Educational Development to promote teachers' professional development in this area.
5. Punjab Curriculum and Textbook Board should revise the current textbooks and include components that require students to use digitized textbooks such as assessment exercises, or projects. Standards and benchmarks in the National Curriculum may be revised to integrate the component of technology.
6. Future studies may be conducted to explore other dimensions and different contexts of digitized textbooks such as the effect of digitized textbooks on curriculum development, teacher training, school culture and assessment. Only through positive critical exploration, together with reflection and research in different contexts, we can transform our classrooms into technological hubs of learning.

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