

Integrating interactive multimedia into mathematics course modules for distance education

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Abstract

This study investigated the validity and perceived effectiveness of multimedia courseware designed to deliver lessons to students learning mathematics by distance. The study employed a cross sectional survey design in which 50 volunteered distance education students pursuing diploma in basic education at one of 23 study centers of the University of Education, Winneba participated. After students have used the multimedia courseware developed on CD-ROMs within twelve weeks, a perceived learning effectiveness questionnaire was used to collect data. Data was analyzed descriptively. The result indicates that courseware was a suitable complementary medium for mathematics lesson delivery by distance in terms of content delivery style; evaluation exercises presentation; motivation; and multimedia effects. It was also revealed that majority of the students learning mathematics by distance perceived multimedia courseware as effective in their learning successes. The inclusion of validated multimedia set-ups to printed text materials for learning mathematics contents by distance is recommended.

Keywords: mathematics multimedia courseware, perceived effectiveness, distance education

Introduction

The continuous reliance on technology combined with the knowledge about brain processing has made technology highly germane for instructional delivery in recent times. Research has shown how the brain processes information using two channels-visual and auditory (Sweller, 2005). As a result when information is presented using both channels, the brain has a great ability to accommodate more new information. To achieve this, SEG (2008) argues for the integration of multimedia in teaching and learning settings. Multimedia learning involves the delivery of instructional content using multiple modes that include visual and auditory information which students use to construct knowledge (SEG, 2008). In this advent of rich technologies, multimedia resources offer exciting possibilities for meeting the needs of learners including distance learning programmes (Mayer, 2001). Research reports show that multimedia lessons can significantly enhance student learning if they are properly designed and implemented.

Though limited in Ghanaian educational setting, there is substantial evidence in literature which support the integration of multimedia into mathematics instructional strategies in the classrooms and in distance education (Ogochukwu, 2010; Mayer, 2005). Such evidence is as a

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result of the quest by many learning institutions to find new means apart from the traditional methods, to bridge learning efficiency via technology. Franklin and Peat (2001) indicated that much of the instructional change observed in recent times is driven by economic pressures and demands for graduates who will be able to function in a knowledge society. These demands have consequently resulted in the greater expansion of learning and teaching methods toward student-centred approach and instructional technology (Damoense, 2003). Though the traditional face-to-face teaching has its merits, Siaw (2000) maintains that it does not provide the skills necessary in today's fast-paced environment.

Nooriafshar and Todhunter (2004) in line with Beerman, Brown and Evans (1998) indicated that interactive multimedia can stimulate students' interest toward successful learning when used as a complementary source of information. With interactive multimedia modules, students are able to navigate through module at their own pace and interact with the content in a visually rich environment. This according to Sims (2000) leads to a fundamental drift toward a more participatory learning process. The interactive aspect of multimedia makes it more suitable for distance education since students often have limited or no contact at all with their tutors as in a typical traditional face-to-face classroom setting.

Theoretical framework

This study hinges on the multiple-channel communication and the dual code theories of learning. The former involves simultaneous presentations of stimuli “. . . through different sensory channels (i.e., sight, sound, touch, etc.) which will provide additional stimuli reinforcement” (Dwyer, 1978, p. 22). According to this theory, human beings are able to deal with the complex types of data from the environment through their perceptual system. Optimum learning therefore takes place when multiple senses are employed. Theoretically, the use of multiple conduits for delivery of educational content is grounded on the theory of multi-channel communication. This theory upholds that when information is presented by more than one channel, there will be reinforcement, resulting in greater retention and improved learning (Bagui, 1998). The theory of multi-channel communication which has its prime focus on reinforcing learning is recently been applied in distance learning programmes as alternative or complement content delivery mode to printed modules to bring about successful learning. In this study, the researchers seek to establish a connection between multiple conduits for delivery of educational content with distance education.

In line with multiple-channel of communication, theorists for dual code differentiate between codes for images and that for verbal information. According to Paivio (1971, 1986) who developed the dual code model, two types of information are encoded by separate subsystems, one for sensory images and the other for verbal language. The provision of learning environment to reflect a dual code model ensures that learners construct much of what they learn from their own perceptual experience. This learning theory gives students the opportunity to use an array of digital tools and resources to reach their goals by solving their learning problems. Through the digital resources learners become enthusiastic to explore, discover, and compile knowledge.

The theoretical foundations of individual learning styles have also influenced instructional design (Mayer & Massa, 2003). Krippel, Mckee & Moody (2009) reported that average students outperformed high-prior-knowledge students and were most benefited by use of multimedia. Other beneficiaries of multimedia include surface learners who are those that are externally

motivated to implement strategies to avoid working too hard or failing. For surface learners, it is argued that standard multimedia can be effective. Hence instructors are urged to add interactivity to challenge learners to learn. The prospects in active participation by learners in their own learning can easily be accomplished with multimedia.

There is a close relationship with cognitive and information processing theories which has implications for the development multimedia resources for learning. For instance, Smith (2001) claims that learners can be over burdened with so many detractors which could hinder their absorption of the content if the multimedia resources are so complex to lead to learner's cognitive load.

Through this study it is expected that multimedia technology would be useful conduit that DE students would require to acquire new knowledge, develop new concepts, and express strong understanding. Again, through the integration of the interactive multimedia into the mathematics course modules for DE, students' enthusiasm towards learning mathematics will make them active participants in their own learning.

Statement of the problem

Distance education is currently advocated as a preferred option for the delivery of tertiary education in Ghana. In the University of Education, Winneba (UEW) for instance, the distance education (DE) students' enrollment grew from below 20% of the total enrollment in 2004/05 to 49.8% in 2010/11 academic years (Vice-Chancellor's Annual Report and Statistics, 2010; UEW Basic Statistics, 2011). However, a major problem confronting DE delivery is the design of study materials that can attract and affect students' responsibility, responsiveness and ownership of their learning. This becomes more critical in the study of Mathematics which requires more interaction between the instructor and the students. Thus, the traditional approach to the design of study modules, in printed text and graphics though useful, is challenged with alternative or complementary instructional delivery systems for distance education. For instance, the use of multimedia courseware is currently advocated as they appear more interactive and engaging to both the affective and cognitive domains of students. In spite of the above-mentioned benefits of multimedia in facilitating learning, nothing is done yet to integrate multimedia materials into the UEW DE programme. Perhaps, the limited or lack of empirical evidence on the practicality of integrating multimedia in distance education course modules particularly in Ghana appears to be the limiting factor.

Thus, the purpose of the study is to design mathematics course module using multimedia tools and evaluate the suitability and effectiveness as perceived by DE students' who have hitherto used printed course modules in learning mathematics. Perceived learning effectiveness has been considered in this study because it affects the responsibility and responsiveness to learning. These are relevant study attributes for students learning by distance since they study on their own pace and time.

Significance of the study

When students are not taught but are expected to learn by themselves as it pertains to distance learning, they have to gain the knowledge through various media and tutoring. Thus module planners on DE programme will find it more useful if findings of experiments on alternative or complementary forms of distance education delivery systems such as multimedia learning prove plausible.

Research questions

The following research questions have been formulated for the study:

1. What is the validity of the multimedia courseware in terms of motivation, content delivery, evaluation exercises and multimedia effects as perceived by expert lecturers?
2. What is the perceived learning effectiveness of students using multimedia courseware in learning mathematics by distance?

Methodology

The study was designed as a cross sectional survey. The study sought to examine the suitability and perceived effectiveness of multimedia courseware among students learning mathematics by distance. Multimedia courseware on two content areas were designed and produced to be used as standalone CD-ROMs to deliver DE lessons in mathematics. The design of the multimedia courseware followed ADDIE model which comprises of Analysis of course requirements, Design of concepts and interactivity, Development of the learning material with multimedia tools, Implementation and Evaluation (Weerasinghe, Ramberg & Hewagamage, 2008, 2007).

First, a need analysis of students' learning needs and mathematics content required was done prior to the design and development of the courseware. One significant characteristics of the students' pursuing the diploma in basic education is that most had struggled to learn mathematics during their secondary levels. To present the concepts to cater for multiple senses of learners and optimize understanding, video, voice overlay on text, diagrams and animations were synchronized with the content. Out of the 6 mathematics content areas for the diploma programme of UEW, two areas - Relations and functions and Series and Sequences - were chosen for development of the multimedia courseware. The design and development of the multimedia courseware was in line with Mayer's (2005) multimedia learning principles guiding the content delivery, presentation of learning activities and assessments of learning outcomes. The application software used for the development of the courseware included PowerPoint, Science Word 6.0, Window movie maker and CamStudio 4.

Population

The population included all DE students of the UEW which are in the 23 study centers across Ghana. However, those pursuing Diploma in Basic Education constituted the target population. These students have used the printed course modules to learn mathematics during their first semester work of Diploma in Basic Education programme in the 2009/2010 academic year.

Sample

The Winneba study center was selected based on convenience and accessibility to the researchers. There were 59 students pursuing the diploma programme at the Winneba study center but 50 were supplied with the courseware in CD-ROMs. These students volunteered to participate in the study.

Instrumentation

A perceived learning effectiveness questionnaire (PLE) was adapted from Computer Assisted Learning Evaluation questionnaire developed by Gregor Kennedy, University Of Melbourne (1998). The questionnaire was modified and used to collect data. The questionnaire contained 16 items grouped into five different constructs. The first four constructs including motivation,

content delivery, evaluation exercises and multimedia effects was answered by expert lecturers in mathematics and technology integration. And fifth construct -perceived learning – was determined from students' responses. The questionnaire was structured on a five-point Likert's scale from strongly disagree to strongly agree.

Data collection procedure

Students on the DE programme hold monthly meetings with their tutors (in this case the mathematics tutors). This occurs once every month for tutorials. On the first tutorial session, the 50 volunteered students from the Winneba study center were supplied with the interactive CD-ROMs on Relations and functions to use for the study in their homes. After a month when the students returned for second tutorial session, the PLE was distributed to students to complete. All the questionnaires were received immediately after students have responded to them that same day. Another CD-ROM on Sequence and series was supplied to the students for the next session. After another month - during students' third tutorial session - the same questionnaire was completed by the 47 students. Three of the students were absent and did not respond to the second survey questionnaire.

Four lecturers were asked to assess the validity of the courseware using the questionnaire. The constructs used to predict the validity of using the interactive courseware included the extent of agreement to the content delivery, the level of motivation to use the courseware, level of multimedia appeal of the courseware and the appropriateness of the evaluation exercises used in the courseware. Table 1 presents the mean ratings of the extent of agreement of lecturers after assessing the courseware.

Validation process

The courseware were assessed and validated by four mathematics education lecturers of Department of Mathematics Education, UEW. One of the lecturers also teaches courseware development using multimedia tools. Areas examined included the appropriateness of the content delivery, the evaluation exercises and the multimedia effects on users.

Data analysis

Descriptive analysis was employed in analyzing responses to the PLE questionnaire. Expert lecturers and students' responses on the five-point Likert scale were coded as strongly disagree (1), disagree (2), neither (3), agree (4) and strongly agree (5). This was fed into SPSS software for processing and analysis. To determine the expert judgment about the validity of the multimedia courseware, the individual items were grouped into motivation, content delivery, evaluation exercises and multimedia effects. The mean ratings of responses on the grouped items based on the two mathematics content areas were computed and presented in Table 1. The percentage of students responses to items on perceived learning effectiveness were also obtained for the two surveys and displayed in Table 2. This was done to be able to illustrate in terms of percentages, the proportion of students who perceive the use of the multimedia courseware to have contributed significantly to their successful learning of mathematics.

Results

Research Question 1: What is the validity of the multimedia courseware in terms of motivation, content delivery style, evaluation exercises and multimedia interactivity as perceived by expert lecturers?

The validity of the interactive courseware was examined in terms of experts' judgment of the appropriateness of content delivery approaches, the suitability of the evaluation exercises and the multimedia effects on student users. Table 1 displays the mean ratings of lecturers' assessment on multimedia presentation constructs in the two mathematics content areas.

Table 1 Means and standard deviations of assessment on the suitability of the courseware on two mathematics content areas

Constructs	Relations and functions		Series and Sequences	
	Mean	Std. Dev.	Mean	Std. Dev.
Motivation to learn mathematics	4.58	.504	4.44	.512
Appropriateness of the content delivery	3.75	.794	3.91	.617
Suitability of the evaluation exercises	3.88	.612	4.24	.321
Multimedia effects on users	4.12	.338	4.82	.308

N/B: strongly disagree 1, disagree 2, neither 3, agree 4 and strongly agree 5

On content areas (Table 1), the mean ratings of 3.75 and 3.91 shows that the four lecturers generally agreed that the lesson delivery style via multimedia was appropriate for their learning. Specifically, the courseware on relations and functions was found to contain adequate amount of content information for lessons on each screen of the CD (3.66); important information, objectives or key concepts were easy to discover (3.35) and the content was clear and logically organized (4.24) to aid understanding. Also, on the appropriateness of the content and scope of coverage of the topics "Series and sequence" the result also revealed the mean rating of 3.91.

The suitability of the exercises as presented on the courseware was also assessed over the two content areas. As indicated in Table 1, the mean ratings of Relations and Function (3.88) and Series and Sequence (4.24) showed that lecturers agreed that the evaluation exercises could encourage learners to learn.

In terms of motivation, the mean response ratings of 4.58 for Relations and Functions and 4.44 for Series and Sequences as shown in Table 1 indicate that the lecturers agreed that the courseware was useful and could make the learning of mathematics much interesting and engaging.

On multimedia effects of the courseware on users, the results on individual items show a strong agreement that the courseware contained answers that were meaningful (4.8), graphics and multimedia helped them to clearly visualize the mathematical concepts (4.04), the voice and video were appropriate (3.93), multimedia increased their motivation to learn (3.97) and interactivity helped in learning mathematics better (3.86). As shown in Table 1, the mean rating of agreement of 4.12 suggests the courseware contains appropriate multimedia effects on users.

Research Question 2: What is the perceived learning effectiveness of distance education students using multimedia courseware in mathematics learning?

The perceived effectiveness of the use of the courseware on students learning was surveyed based on whether the use of multiple media elements (video, sound animations and words) in the presentation of the mathematical concepts contributed significantly to students' active and successful learning. From Table 2 the survey 1 shows that as much as 67.2% of students agreed that they could retain concepts better when using the courseware to study relations and functions than the printed text. A higher proportion (72.9%) of students was even recorded in survey 2 for the courseware on series and sequence. Very high proportions of the students also agreed that the use of the courseware added value to their conceptual understanding of relations and functions (86.2%) and series and sequence (90.8%). Also majority of the students agreed that they became more responsive and motivated to learn relations and functions (89.4%) as well as series and sequences (90.4%) through the courseware provided. The results in Table 2 also showed that significant proportions of the students agreed that the synchronization of voice, animations and text/video enhanced their learning a lot in both relations and functions (86.3%) and series and sequence (67.8%). In general, 80.9% and 74.4% of the students perceived the courseware on relations and functions, and series and sequence respectively as effective as they knew better about the topics through the use of the courseware.

Table 2: Percentage distribution of students' responses on perceived learning effectiveness with the use of interactive CDs

Perceived learning effectiveness	Survey 1	Survey 2
I found that I can retain better than printed textbook	67.2%	79.2%
The use of the CD added value to my conceptual understanding of math	86.2%	90.8%
The CD mode made me more responsive to learn	89.4%	90.0%
The voice/video enhanced my learning a lot	86.3%	67.8%
I know better about the subject after using the CDs.	80.9%	74.4%

Discussion

There are substantial evidences supporting the design and delivery of mathematics lesson using multimedia tools (Ogochukwu, 2010; Mayer, 2005) but the use of multimedia courseware is limited in Ghana. The study basically investigated the perceived learning effectiveness of distance education students who employ validated multimedia interactive CD-ROMs in learning mathematics. The finding in this study clearly revealed consistency in the suitability of the multimedia courseware as a mode of lesson delivery to students learning mathematics by distance.

The result revealed that majority of the distance education students perceived the multimedia courseware as effective in their learning successes. As shown in Table 2, high proportions of the students in the two surveys perceived the courseware on relations and functions, and series and sequence respectively as effective in making them responsive to better understand and retain the mathematics concepts. This result supported that of SEG (2000) and Mayer (2005) assertion that multimedia courseware when properly designed and delivered could enhance mathematics learning. The result is also in line with the findings of Nooriafshar and Todhunter

(2004) and Ogochukwu (2010) that interactive multimedia can stimulate students' interest toward successful learning when used as a complementary source of information. The result thus reinforces the views expressed by those who support the multi-channels communication and dual code theories of learning (Sweller, 2005; SEG, 2008) that the integration of sound, animations, video and textual presentation ensures that learners construct much of what they learn from multiple senses.

Conclusion

The study revealed that students undertaking mathematics by distance perceived multimedia courseware as suitable and effective in their learning successes. The findings in this study offer empirical evidence of some connection between multiple channels for delivery of mathematics content with distance education. The implication is that students pursuing their course of study by distance could benefit significantly if multimedia courseware is used as a complementary medium for the delivery of mathematics lessons. It is thus recommended that rather than solely relying on printed text materials for learning by distance, mathematics contents should as well be delivered via multimedia set-ups.

This study was limited to standalone CD-ROMs and one study center of the distance learning programme in Ghana. The main variable examined was the perceived learning effectiveness. Further study should examine perhaps the relationship between mathematical achievement of distance education students and the use of multimedia courseware at various centers or the use of online learning environment which is a relatively new area of research in Ghana.

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