The Usefulness of Technology-based Interactive Methods in Teaching Mathematics and Statistics at the College Level

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Abstract
This study aims to investigate the advantages of implementing multimedia resources in the teaching and learning environment of mathematics and statistics. It examines the use of tablet PCs to create video learning resources. Such practices allow lecturers to provide additional learning support to students via the learning platform Moodle. This paper discusses the experiences of three lecturers in developing a technology-based, interactive teaching method to support student learning. The results found that "solved examples" in the video resources are useful in demonstrating topics about statistics. Furthermore, the paper encourages lecturers to learn from their experiences and develop learning resources to enable students to better engage in the learning process.
Keywords: Technology-Enhanced Learning, Camtasia, Video Resources, Tablet PC, Moodle

Introduction

Technology-enhanced learning (TEL) is one of the key tools that enriches educational productivity by integrating technological media into education and also develops a lifelong love of learning in students (Ahmadi, 2018; Goodyear & Retalis, 2010; Kurvinen et al., 2020; Stošić, 2015). TEL provides educators with different means of learning, and they are no longer limited to institutionally provided textbooks. Moreover, TEL tools aim to achieve greater diversity and flexibility in the teaching and learning environment and promote student-centred learning (Walters et al., 2018). Additionally, these technologies can be utilized to promote different pedagogical strategies and empower students to interact with courses, just as empowering them to convey and team up with their companions and instructors (Conole & Wills, 2013).

The popularization of technological media within the so-called "multimedia" has led to endless applications of digital mediums. Historically, these mediums included educational films, radio, and television (Owusu, 2020; Westera, 2010); however, today, TEL is more correlated with the use of computer-based technologies, including smart devices (Shen & Ho, 2020; Wang, 2020). The multimedia resources used in the classroom provide means to engage learners, enhance the learning environment, introduce new interests, and boost

motivation. Thus, integrating technology into the curriculum has become a priority for better knowledge (Kuron & Tompodung, 2020; Walters et al., 2018). In addition, according to Sousa et al. (2017), multimedia-based instruction can be considered an efficient tool for teaching and learning for three primary reasons: firstly, it promotes self-learning, offering students more freedom in learning without any group instructional domain which negatively impacts certain students. Secondly, video and audio production provides well-organized and developed subject resources reducing the students' effort in processing the traditional subject materials. Finally, autonomy in the learning process assists students in becoming self-dependent rather than depending on the instructor for gaining knowledge, which in turn improves the learners' sense of responsibility.

Research across disciplines such as dentistry, nursing, pharmacy, science, political science, psychology, biology, business, computer science, statistics, and mathematics has emphasized the positive impact of applying multimedia resources in teaching (Rackaway, 2012; Terrana et al., 2017; Vagg et al., 2020; Wahidah et al., 2020).

This shows that the appropriate use of technological media can significantly contribute to a deeper understanding of and higher motivation towards learning mathematics, which is typically a challenging subject for students, especially at the college level. Moreover, the use of technology can make teaching mathematics and statistics at the college level more effective because it improves teaching quality, encourages students' active learning, and provides them with psychological incentives (Garfield, 1995; Higazi, 2002). In this regard, the Guidelines for Assessment and Instruction in Statistics Education (GAISE) issued by the American Statistical Association in 2005 (Franklin et al., 2005) recommends using technology for introductory statistics courses at the college level. Furthermore, research has shown that the mathematics and statistics teaching performance is related to the motivation of students (Wong & Wong, 2017). Thus, classroom teaching of these courses should provide an exciting environment that encourages students to think and learn. Teachers of these courses have a great role in attracting their students' attention and motivating them to learn. Technology-based teaching is one method that can be applied by teachers to create a motivating classroom environment for students.

Several studies have highlighted the perceived significance of using technology in teaching mathematics and statistics (Silva et al., 2021). Moreover, technology-based teaching can help constructivist aspects by encouraging students to develop mathematical and statistical concepts by examining regularity and variation (Tomas et al., 2019). Numerous advantages may be attributed to the use of technology in classrooms, such as enhancement of active learning, collaborative learning, student independence, and increasing task-based instruction (Sousa et al., 2017). However, researchers have shown that although the use of technology in mathematics classroom is increasing, the outcomes of its utilization have not lived up to their perceived potential of enhancing the learning experience (Geiger et al., 2010; Lameras & Moumoutzis, 2015; Oates, 2011; Reed et al., 2010; Selwyn, 2011; Wright, 2010). Nevertheless, creation of video resources and use of the learning platform Moodle have proved effective in providing learning support to students.

Moodle

Moodle is a learning platform which makes it easier for educational institutions to administer educational content worldwide (Sabharwal et al., 2018). It is an open-source platform (http://moodle.org/) widely accepted and adopted for online learning. It helps teachers create high-quality online study materials as well as facilitates communication and feedback between learners and instructors (Sharma & Arora, 2020).It has positive benefits in the teaching and learning process of academic environments, as evidenced by several studies (Ahmad &Al-khanjari, 2011; Garcia et al., 2012). Moodle has become an important element of the pedagogy adopted in higher education institutions in developing countries because of the significant improvements it offers in education. Kituyi and Tusubira (2013)and Martín-Blas and Serrano-Fernández (2009) found that students who used Moodle regularly during the semester obtained higher scores than those who did not. Thus, the impact of these web-based applications on students is apparent. The mixed approach of

eLearning and face-to-face lectures in Moodle leads to improved performance of students (Novo-Corti et al., 2013). Liu et al. (2020) underline the functional role of online learning platforms, including Moodle, in enhancing students' understanding and improving their level of efficiency, average grades, and learning. The study lists free access, reduced cost, and academic improvement at all levels among the many advantages of online learning platforms, and thus encourages their implementation in higher education.

Another study aimed to clarify whether the integration of e-Learning with traditional teaching is effective for subjects such as mathematics (Sumarwati et al., 2020). As mathematics involves the study of both applied and rational aspects, students are required to understand abstract as well as real ideas. Using online learning platforms such as Moodle can make this process easier as well as accessible. This may enhance the interest and enthusiasm of students. Sumarwati et al. (2020)found that teaching geometry of flat-sided objects using Moodle has an effective role in encouraging students to think, understand, and interpret to explore solutions for problems. Moreover, teachers can offer multiple resources via Moodle, which usually cannot be provided in classrooms due to time constraints. In addition to conventional classroom instruction, Moodle creates an environment that allows collaborative interaction between students (Kotzer & Elran, 2012). Learning and teaching with Moodle-based e-learning environments, combines learning skills and content in the fields of mathematics, science, and technology. Furthermore, because of the gap that exists between generations, teacher-centred teaching is not the best approach for learning (Viridi et al., 2017). Hence, an increase in students' engagement in learning activities is required to enhance their academic performance.

Communication

Communication is an important component of mathematics education (Vale & Barbosa, 2017). Mathematical communication is the ability to communicate mathematical knowledge properly and effectively (Wood, 2012). It is the means by which ideas are shared and is a vehicle for clarifying understanding (National Council of Teachers of Mathematics, 2000). Technology can be used to increase communication among students and between students and teachers (O'Flaherty & Phillips, 2015). In particular, communication among students can support their reasoning, and enhance their proofing abilities and collaborative skills by providing them a chance to share ideas and perspectives. Furthermore, discussions with instructors during online learning can target students' understanding more effectively than discussions held between students without instructors (Lee, 2014). In another study, researchers found that communication between students and their math teachers results in organizing and strengthening students' mathematical thinking and the ability to analyse and evaluate other students' strategies in math thinking. Furthermore, communication between teachers and students will transform teacher-directed mathematics teaching to student-centred constructive learning, which in turn will improve the teaching process in mathematics classes (Pangaribuan et al., 2020).

Resources and Tools

Through the development of technology and its useful application in education, many resources have been created for online learning with different demands and scope. In mathematics, different resources and tools have been used to achieve the main target of education. For example, "WebMa" helps students practice mathematics online and improve their skills. "ITM"enables teachers to create a mathematics database and share it with their students. "Elluminate Live" has a communication feature which is used to provide tuitions online. "Google Talk" helps students download information (Alyousef, 2019). "Khan Academy" is another popular learning platform. It includes instructional videos, exercises, and a learning dashboard that support and help students learn and gain knowledge without any time constraint. "Aplusmath" is an interactive source that comprises math games, worksheets, and flashcards. It is designed to serve students, teachers, as well as parents. Another online learning resource is "AbsurdMath", which is designed as a game series for mathematical problem solving. It offers a fun environment for learning and thinking (Rajkumar, 2017). This shows that

the integration of information and communication technology (ICT) into the teaching and learning process is critical as it creates a more active and motivating learning environment (Daud & Khalid, 2014; Gabare et al., 2014). Implementing ICT can assist teachers in obtaining resources from outside their networks, thus enabling them to transform the teaching and learning process. Analysing teachers' ability to apply ICT in order to access teaching resources other than textbooks, Keong et al. (2005) found that 68.5% of mathematics teachers use internet searches via websites, 44% use email, and 7.2% participate in online discussion forums.

Furthermore, ICT has been found to increase students' motivation and interest in mathematics (Keong et al., 2005; Neurath & Stephens, 2006). The implementation of ICT tools in mathematics classrooms enhances students' performance (Bature, 2016), as these tools offer various representations of mathematical concepts and procedures for a deeper and better understanding of a concept (Baya'a &Daher, 2013). In addition, ICT tools enhance critical thinking and problem-solving skills by encouraging students to explore and understand mathematical concepts (Agyei &Voogt, 2011).

The development in technology with the addition of new tools every day provides educators with different resources to meet their needs in ICT implementation. Thus, teachers can enhance face-to-face teaching with online learning tools, and use multimedia (digital materials) such as videos, books, and digital notes to enhance students' learning experiences and change their perception of mathematics as an abstract subject. Vale and Barbosa (2017) emphasize that visual contexts provide strong support for the understanding and explanation of concepts and ideas, especially for younger students. Visualization is a powerful tool in mathematical reasoning, which can be explained by the need to think and reason visually in problem solving (Rivera, 2011).

This paper describes an innovative approach for teaching a variety of introductory mathematics and statistics courses, carried out by the current authors in their college in Oman.

This approach comprises an interactive teaching and learning method that includes the creation of videos to enhance students' motivation, understanding, and accessibility to learning resources whenever and wherever they need them.

Materials and Methods

Preparation

First, the authors held a discussion with the subject coordinator of two modules, Probability and Statistics (MASC0007) and Statistics (MASC1002.1), taught at the Middle East College, to identify what resources were provided to students to support their learning. Resources such as question banks and practice questions were made available to students through a learning platform known as Moodle. This discussion led to the suggestion that providing additional video resources through Moodle could be useful in supporting learning.

Next, video resources were created for selected statistics topics, and staff were trained on how to implement this interactive technology-based learning method. Finally, a survey was conducted wherein the students were asked to evaluate the video learning resources provided via Moodle and share whether the resources met their needs and had a positive impact on their learning experience.

Study Area

The Middle East College in Muscat in the Sultanate of Oman (Oman) was the study site for evaluating the effectiveness of using video resources.

Sample

The population of interest was students enrolled in two modules: Probability and Statistics (MASC0007) and Statistics (MASC1002.1). From the end of May 2019 to June 2019, the researchers contacted the students via email and invited them to participate in the survey and share their opinions about the video resources. The aim of this survey was to evaluate the effectiveness of these resources.

The email informed students that the goal of the study was to develop and improve learning resources to enhance student outcomes. Additionally, it was explained that participation in the study was voluntary and that the outcomes of the study would be used to assist future students.

Artefact Analysis of Teaching Delivery

Students were split into groups, each headed by a different lecturer. There were 35 students in each group. Face-to-face teaching took place in two forms: lectures and lab work. Lectures were delivered in units of four hours per week for 15 weeks. The lectures were the major organizational component, with the lab work provided to reinforce what was taught in lectures and give students an active learning space where they undertake the activities or exercises.

The lecture material for the modules paralleled the topics covered in the textbook. In each module, students learnt theory and discussed related practical problems in the classroom. The lab work involved solving problems with the help of Microsoft Excel. All students actively engaged in classroom activities to solve different problems.

The Statistics module carried 15 credit points, and the delivery was split into three hours of theory and one hour of lab work per week. The Probability and Statistics module carried 10 credit points, with its delivery split into two hours of theory and one hour of lab work per week.

Video Creation

Videos, as a part of technology, have been used to motivate and engage students (Chao et al., 2016). The tools used for the creation of videos in this study included "Screencast-O-Matic" software and Microsoft PowerPoint) Figure 1).

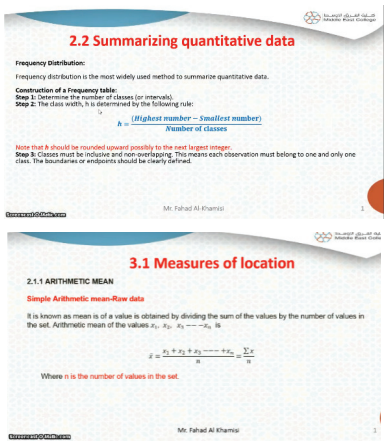

Figure 1: Videos Created using Microsoft PowerPoint and "Screencast-O-Matic" Software

Tablet PCs, which have proven effective in mathematics education (Fisher at el., 2007), were also used to create videos. The various steps involved in this process included creating electronic documents, such as word documents, PowerPoint presentations, and pdf files, and annotating these documents using PDF Annotator while recording screen images, movement, and audio. The final step involved editing these video files using Camtasia Studio, a video editing software with a user-friendly interface (Clark & Kou, 2008) (Figure 2).

In the present study, the lecturers used voice-overs and handwritten notes in the videos to explain solved examples related to different topics in the Probability and Statistics and Statistics modules to the students (Figure 2). The solved examples allow lecturers to demonstrate how to solve problems and explain which steps were taken to solve a given problem and why.

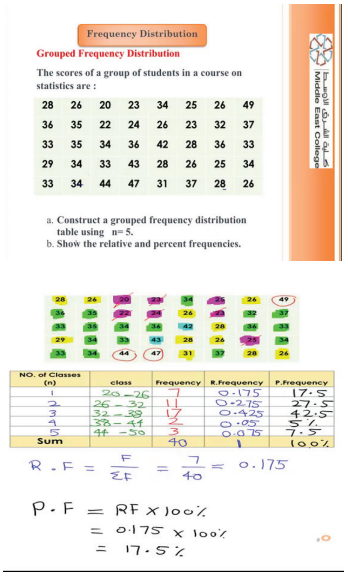

Figure 2: Videos created using Tablet PCs, Microsoft Word, and PDF Annotator

The videos were created during the semester to explain five topics: frequency distribution, mean, median, mode, and variance. Specifically, the topics covered were mean, median, and mode for raw and grouped data, measures of variability (variance and standard deviation), and measures of association between two variables (scatter diagram and correlation coefficient for raw and grouped data). The key component of designing such resources is

to allow students to access these resources when and where they need them and help them understand the topics. The videos were uploaded on Moodle and were typically less than ten minutes in duration for ease of downloading/playing. The Middle East College retains the right to use these teaching materials (Figure 3).

Figure 3: Copyright Ownership of Teaching Materials

Data Collection Tools

A questionnaire was designed to assess students' perceptions regarding the use of video lectures as a means of increasing time for in-class problem-solving activities. The primary purpose of this survey was to obtain feedback that could assist in the development of the subject for future students. Student responses were anonymised, and consent was obtained for the summary of the data to be used in research publications. The survey tool was reviewed by experts in the field, and a few modifications were made based on their suggestions. Google Forms was used to register the student feedback.

Ethical Consideration

The collection of data in this study obtained ethical approval from the Ethics Committee at the Middle East College, Oman.

Results and Discussion

Technology has proven to have a positive effect on enhancing learning performance (Bravo et al., 2011). Videos with diversified learning styles were presented to students, and a survey was conducted to ascertain their opinions about the video resources. Students were asked whether the video resources were effective in helping them understand the topics, and the feedback obtained was mostly positive. Approximately 93% of the students watched the videos, about 63% watched them more than once to review the material (Table 1), and 37% watched them just once.

As for the effectiveness of the video resources, 91% of the students believed that the videos helped them improve their performance in their mathematics and statistics modules. Furthermore, the students preferred videos for other subjects as well. Moreover, they began to depend more on themselves than on their teachers. The majority of the students (80%) found it useful to view videos at their own pace because they could rewind and review the portions they did not understand the first time (Table 1).

Table 1: Effectiveness of video resources

Statements	Strongly Agree/Agree (%)	Strongly Disagree/ Disagree (%)
Do you believe that the videos can improve your performance in mathematics and statistics modules?	91%	9%
If video lectures of topics are available, I would watch the videos before the corresponding problem-solving session.	87.18%	12.82%
I would prefer to watch recorded videos of lectures than attending face-to-face lectures.	86.84%	13.16%
The video is a more effective way to cover lecture material than face-to-face lectures.	82.93%	17.07%
I was able to learn more from the video lecture since I could view the lecture at my own pace and rewind and review portions I did not understand the first time.	80.49%	19.51%

Almost all the students (95%) agreed that video resources supported students' learning by helping them understand the material better, and 91% of the students expressed their satisfaction with the recorded videos and their explanations (Table 2). This result is similar to Breivik (2015), who showed that students watched and re-watched videos at appropriate times to prepare for exams.

Table 2: Student Views on Video Resources

Statements	Strongly Agree/ Agree (%)	Strongly Disagree/ Dsiagree(%)
The instructor-made videos helped me understand the material better.	95%	5%
Are you satisfied with the recorded videos and their explanations?	91%	9%
I wish the instructor had made videos for all topics.	90.25%	9.76%
The instructor- made videos helped me do better on assignments/exams.	83.78%	16.22%
I prefer learning through instructor-made videos to learning in classrooms.	67.5%	32.5%

An analysis of students' comments regarding the video resources indicated that they found the videos to be useful. Students agreed that the instructor-made videos helped them to understand the content better and revise it during exams by viewing videos multiple times and through the ability to pause and rewind videos. However, they also expressed that face-to-face lectures are also important in discussing questions or sharing ideas with teachers. They appreciated being able to revisit materials and have multiple opportunities to learn. Videos helped students recognize their ability to pose questions and smoothen the rough edges of their learning. Regarding the quality of the videos, the students asked for the audio to be clearer.

The following charts (Figures 4 and 5) show how students performed in closed book tests in Statistics during the fall 2018 and spring 2019 semesters. The percentage of students who scored above 75% increased from 16% in fall 2018 (Figure 4) to 42% in spring 2019 (Figure 5), while the percentage of those who scored between 50% and 75% registered an increase of 8%.

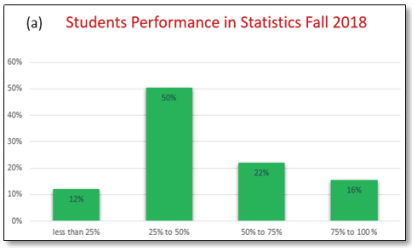

Figure 4: Student Performance in Statistics During Fall 2018

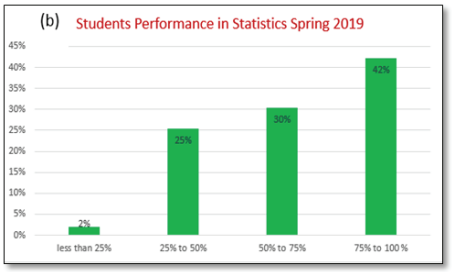

Figure 5: Student Performance in Statistics During Spring 2019

Conclusions

The implemented technology-based interactive method was highly effective, as demonstrated by students' performance and their satisfaction with the video learning resources. Videos can facilitate a good learning environment and enhance students' learning processes (Othman & Amiruddin, 2010). This study agrees with existing literature which states that using technology in teaching mathematics and statistics leads to improved learning and enhances learning performance and quality (Homa & Oliveira, 2020; Kay & Ruttenberg-Rozen, 2020; Slaviša et al., 2019). It was found that the students started to depend more on themselves, leading to student-centred learning. Moreover, students wished for instructors to provide more videos to cover all topics in the modules. This shows that students can deal with technology and benefit from it (Bravo et al., 2011).

Furthermore, this study applied artefact analysis, which can provide descriptions of people and settings, and generate valuable insights (Norum, 2008). DeLong (1998) suggests that artefact

analysis involves four steps: observation, analysis, interpretation, and evaluation. In this study, artefact analysis of subject resources and websites showed that the structure of Moodle needs to be organized to provide appropriate online learning strategies, activities, resources, and support. An e-learning environment should be able to provide "enhanced input and abundant learning resources and aids" (Clark & Kou, 2008, p. 297). Oliver and Herrington (2003) argue that there is a "need to plan learning settings based on meaningful and relevant activities and tasks which are supported in deliberate and proactive ways" (p. 111).

The study was conducted during the semester, and hence, was at times very difficult to execute. However, communication was key to its success. A communication forum was created through which the lecturers could communicate with each other about what they were doing, share video clips, map student needs, and transfer their knowledge to develop and share resources. This shows that resources, particularly digital resources, are needed to provide staff with knowledge and methods to develop and share resources. From the perspective of their professional development, it is important to provide teachers with basic training to use technology to develop additional learning resources and gather evidence to evaluate students' feedback about these resources.

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Disclosure Statement

The authors certify that the manuscript represents original work and has not been submitted for publication, nor has it been published in whole or in part elsewhere. On behalf of all co-authors, the corresponding author shall bear full responsibility for submission. The authors declare no conflict of interest.

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