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An Electronic Collaborative Learning Environment for Standardized Tests

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Abstract: The National Center for Measurement (Qiyas) was established for the purpose of conducting standardized tests in Saudi Arabia. The center has developed multiple Qiyas tests such as the General Aptitude Test (GAT) and the Scholastic Achievement Admission Test (SAAT). Qiyas tests are used as a pre-requisite requirement for applying to universities and to certain kinds of jobs in Saudi Arabia. Currently, students use traditional methods to prepare for these tests, e.g., studying from books and searching for available learning resources on the internet. These web-based resources are mostly static and only have general guidelines about the tests and a history of available test samples. This research proposes a computer-based collaborative learning (CL) environment that helps support learners during their preparation for the Qiyas tests. A four-stage approach is used in this research: (1) an intensive review of 30 CL platforms is carried out to investigate the available features, (2) two workshops are conducted to evaluate the appropriateness of the features identified in Stage 1 as well as to investigate what other features would be appropriate for Qiyas tests, (3) a CL platform is developed for Qiyas tests for a total of 21 features, (4) and, lastly, the platform is evaluated using two methods, in-depth interviews with experts and an empirical study with instructors and learners. The results show that the platform helps support learners in the participative, cognitive, interactive, and social dimensions of the learning processes. The results also help instructors promote the teaching experience.

Keywords: E-Learning, Collaborative Learning, Qiyas, Standardized Tests, Evaluation

1. Introduction

The National Center for Measurement (Qiyas) was established in 2001 for the purpose of conducting standardized tests in Saudi Arabia (National Center for Assessment, 2019). The center has developed multiple Qiyas tests such as the General Aptitude Test (GAT) and the Scholastic Achievement Admission Test (SAAT). In Saudi Arabia, Qiyas tests are used as a pre-requisite requirement for applying to universities and to certain kinds of jobs. For example, students are required to take the GAT and SAAT before seeking admission to Saudi universities (Hendrickson, 2012). A combination of student scores on these tests along with their high school GPA are used to generate a single score for each candidate, and this determines the individual competency for admission. Many local universities give a weight of 70% for Qiyas tests (Alnahdi, 2015; Bajammal et al., 2008).

Approximately 90s% of university students believe they did not receive adequate preparation before taking the tests (Kaki and Alaskar, 2014). Currently, students use traditional methods to prepare for the tests, e.g., studying from books and searching for available learning resources on the internet (Almajed, 2010). These web-based resources are mostly static and have just general guidelines about the tests and a history of available test samples (Almajed, 2010). Using these web-based resources, students are more likely to just be passively "reading online" rather than learning or creating knowledge actively online (Lin and Kuo, 2005). Since they are published on the website of the National Center for Assessment, the test results are not viewed as satisfying (Qiyas Statistics and Data, 2019). Consequently, there have been many calls to provide more advanced learning methods for the Qiyas tests (e.g., Ghazi, 2018; Al-Ozaizy, 2016).

Several studies encourage the use of the Collaborative Learning (CL) style (e.g. Bennett, 2004; Lin, 2015). A collaborative learning approach provides an environment that enlivens and enriches the learning process where learners can interact with one or more collaborating peers to solve a given problem (Bennett, 2004). Moreover, those using collaborative learning can construct knowledge in a collaborative learning system by actively interacting with each other through the process of searching for, understanding, negotiating, and finding solutions, etc. (Lin, 2015).

A study conducted by Thompson and Ku (2006) has shown that there is a relation between the degree of collaboration and the quality of learning. In addition, CL has been used in many fields such as medical education and the results show that the performance of students have improved (Bow et al., 2013).

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The rise of the Internet over the last few decades has enabled learners to work collaboratively from different locations (Kimball, 2001; Bennett, 2004). Online collaborative learning has many key benefits, e.g., it gives learners the opportunities to have an exposure to differing opinions, perspectives, and experiences while providing interactive opportunities with other learners. It also permits learners to move out from their private world and create a shared understanding of meaning (Luo, 2013).

Keeping this in mind, this research proposes a computer-based collaborative learning environment. The proposed platform would enhance the learning experience of users and help support learners during their preparation for Qiyas tests. Although there are currently many platforms that make use of the collaborative learning approach, they are general-purpose platforms and are not designed particularly for Qiyas tests. Moreover, it is unlikely that a single platform could provide all of the features appropriate for those preparing for the Qiyas tests. In addition, those preparing for the Qiyas tests might suggest other favorite collaborative features that have not been developed for any current platform.

The rest of this paper is divided as follows: Section 2 provides an overview of the research related to this work. Section 3 describe the approach we take, and the four components of this approach are described in sections 4, 5, 6, and 7. Finally, Section 8 concludes the paper.

2. Related Work

2.1 Collaborative Learning (CL)

The concept of Collaborative Learning (CL) was coined in the 1950s and 1960s by a group of British secondary school teachers and researchers (Bruffee, 2006; Zahirović et al., 2019). Smith et al. (1992) define CL as an umbrella term for a variety of educational approaches involving a joint intellectual effort to be made by students on their own or by students and teachers together. Usually, students work in groups of two or more and mutually search for understanding, solutions, or meanings, or work to create a product (Smith et al., 1992).

Johnson et al. (1990) note that CL is not simply having a group of students work together. It must include five basic elements as follows:

- Clear interdependence: team members must rely on each other to achieve a goal. The team will suffer if any member fails to do his or her part.
- Considerable amount of interaction: members should support and help each other to learn by gathering and sharing knowledge.
- Personal responsibility: all members of the group are obliged to do their work.
- Social skills: team members gain leadership, decision-making, communication, and conflict management skills through group work.
- Group self-evaluation: team members should point out the goals in order to evaluate the group periodically.

In the past, due to difficulties in finding time and space for students to work together, collaborative learning activities have been restricted to full-time students in on-campus environments (Kimball, 2001). Today, education has been transformed for both teachers and learners due to a rise in Internet-based communication technologies (Bennett, 2004), which has resulted in the rise of Online Collaborative Learning (OCL). Harris (2001) defines online collaboration as an educational endeavor that involves people in different locations using Internet-based tools and resources in order to work together.

A case study conducted by Zhu (2012) indicates that OCL can enhance student knowledge construction through group interactions. Bow et al. (2013) used a collaborative model for creating study tools for preclinical medical education. All through the preclinical course, the medical students must recall massive amounts of information within a limited time, then they should be able to recall this information for the exam. They also need this information for when they are making diagnostic decisions. The results show that students who actively participate in the content while studying attain a higher score on the exam.

Benbunan-Fich, Hiltz, and Harasim (2004) explained that in order to have successful OCL learning outcomes, the following input and process factors need to be considered. The input factors are technology, the students, the instructor, and the course. The technology factor includes technical terms such as functionality, usability, and synchronous and asynchronous communication modes. The student factor is described by the degree of

motivation, cognitive ability, and learning style. The instructor factor is identified by the teachers' actions and experiences in online teaching. The course factor is characterized by the number of students involved, the organization of the group, the size of the group, and the type of group leadership. The process factor highlights the mode of the learning processes as well as the amount and types of activities or interactions.

2.2 Qiyas Tests

Qiyas tests are measurements that are offered by the National Center for Assessment in Saudi Arabia. The center develops multiple tests under the following categories: educational tests, language tests, and vocational tests. The educational tests include the General Aptitude Test (GAT) (which is provided in both English and Arabic), the Scholastic Achievement Admission test (SAAT), the Post-Graduate Aptitude Test, and a variety of educational attainment tests (National Center for Assessment, 2019). Among these, the GAT is considered to be the most important educational test (Kaki and Alaskar, 2014). This is a standardized measurement that consists of two sections: verbal and quantitative. The abilities tested in the GAT include reading comprehension, the recognition of logical relations, problem solving using mathematics, inference, and measuring capacity (National Center for Assessment, 2019; Sulphey, Al Kahtani and Syed, 2018). The second most important educational test is the SAAT, which is used as a requirement for admission to science and health colleges (Sulphey, AlKahtani and Syed, 2018) and examines student skills with regard to the knowledge they learned in high school through questions developed from the content of school books (Al-Owidha, 2013; Alnahdi, 2015; Khoshaim, 2017).

Language tests are another type of assessment that is provided by the center. The center provides the Standardized Test for English proficiency (STEP) as well as an Arabic language test for non-native speakers. Moreover, the center has developed vocational tests such as a teachers test, the Saudi council of engineers exam, and an educational supervision test (National Center for Assessment, 2019).

The online collaborative learning support currently used for Qiyas tests is limited. Our review shows that there are only two platforms that support learners who are preparing for Qiyas tests. These are described below along with their main functionalities.

Noon Academy:
This is an online learning platform implemented in 2016. It provides learners with information and recourses. The following list includes the main functions provided by the Noon Academy:

- Practice tests: the platform provides multiple samples of exams that learners can take to practice and improve their skills before taking the real exam.
- The lessons: each lesson consists of two sections. The first section includes multiple flashcards to explain the theories and to provide simple examples. The second section includes multiple choice questions. Once the learner submits his or her answer, the platform will provide the learner with the correct answer and a simple explanation immediately.
- Group session: this function provides learners with the ability to select a lesson. After doing this, the learner can share the invitation link with friends. After that, the learner can select a teacher and wait for the lesson to begin.

The content is managed and updated by the Noon Academy only. For this reason, the content is for the most part not up to date. If a learner has a question, he or she needs to open a group session with a minimum of five learners in order to get help from the teachers or other learners.

The Initialization and Training Program prepared by Qiyas:
This is an online learning platform that aims to train learners for the GAT and SAAT before taking the tests. The platform includes three training types as listed below:

- The first training type teaches scientific concepts. In this section, the basic concepts are explained in an attractive and interactive way by using Adobe Flash.
- The second training type provides the learner with three practice tests and the platform provides learners with automatic feedback regarding the correct answer.
- The last type includes experimental tests. These tests allow learners to evaluate his or her level. Once the learner finishes the experimental test, the platform will provide the learner with his or her grade.

The content for this platform is managed by Qiyas and therefore the content is fixed. In addition, the platform does not provide for any kind of active learning experience through discussions, collaboration, or critical thinking and joint problem-solving.

3. Approach

The aim of this research is to develop a computer-based collaborative learning environment that supports learners during their preparation for Qiyas tests. This aim is achieved by following these four stages:
Stage 1: Reviewing CL platforms: by reviewing CL tools, we explore the commonly used functions of collaborative learning environments. This helps us to understand the nature of the functions that should be provided. In order to achieve this goal, a total of 30 tools have been reviewed, which resulted in our identifying 23 potential features (F1, F2 … F23).

Stage 2: Determining the appropriate features: two workshops are conducted in this stage. The main purpose of the workshops is to discuss the extracted features from Stage 1 with the workshops' participants in order to obtain their opinions. Another purpose is to check if they have any other favorite collaborative features that were not discovered during the review of the existing collaborative platforms.

Stage 3: Developing a CL platform for Qiyas tests: a web-based system has been developed. This system includes all of the features identified by the learners participating in Stage 2.

Stage 4: Final evaluation: after implementing the system, we conducted a final evaluation for the system using two methods: in-depth interviews with experts and an empirical study with instructors and learners.

4. Stage 1: Reviewing CL platforms

This section reviews a number of selected collaborative learning platforms. Thirty selected platforms are reviewed in order to analyze the most commonly used collaborative learning features. The list of tools includes the most recommended platforms, which is based on the Best MOOC Platforms (2018). A detailed features matrix of the selected collaborative learning platforms is provided in Table 1 and described below.

F1: Create a User Profile
All the surveyed platforms require a user registration and the creation of a user profile. Usually, the profile page contains the basic information about the user such as name, educational level, country, role, and enrolled courses. Moreover, some platforms such as Maharah, Eliademy, and Simpliv allow the user to link his or her account with the social media accounts such as LinkedIn, Facebook, and Twitter. Rwaq enables users to add and share their resumes. Some tools, such as Coursera and Udacity, provide profiles of course providers.

F2: Changing the User Profile to Private Mode
Changing the user profile to private mode has different meanings. In some platforms, like Future Learn, there are two options. First, the user can make his or her profile partially private. Only learners who are signed into the platform can see the profile. Second, the user can make his or her profile completely private. In this case, even other learners on the site will not be able to see the profile. The Codeacademy platform provides two options: allowing other Codeacademy users to view the profile or allowing everyone to view the profile. Rwaq allows a user to make his or her profile page publicly available only for the instructors of the courses that the user is taking or for everyone. Coursera has a list of three options: allowing only the user, only the Coursera community, or everyone on the web to view the profile.

F3: Providing a General Discussion Forum
A discussion forum, such as one found in Simplilearn and Codecademy, is known by a variety of names, such as community in the DataCamp platform. A discussion forum is a general term for a place where users can leave messages or questions and expect to see responses from other users. Moreover, a discussion forum is a place in which people can exchange ideas and discuss issues not related to any course. Therefore, users can post general questions. On some platforms such as Cognitive Class and Eliademy, the discussion forum includes two sections: contact support and give feedback. Users can post in both sections and receive responses from either other users or from the platform's team.

F4: Send Private Messages to Instructors and Other Learners
The private message (i.e. or direct message) is a type of message that is sent between different members on a given platform. It can only be seen and accessed by the users who are participating in the message. Many CL platforms allow learners to send private messages through the platform to instructors. Edlal and iversity allows a learner to send a message to other learners as well.

F5: Enroll in a Course
Most platforms enable users to enroll in courses. They can be free or need to be paid for.

F6: Award Points/Badges to indicate Active and Collaborative Learners
Most of the CL platforms support making a distinction between active and non-active learners through the use of award points or badges. To indicate an active learner, some platforms such as DataCamp count the number of courses completed and the number of the solved exercises. Other platforms such as Khan Academy and Cognitive Class use badges to indicate the collaborative learners. For example, on the Khan Academy platform, there is a badge if a learner posts 100 answers that have three votes each. There is also another badge for achieving mastery points in the course. For Future Learn, the "follow" feature is used to indicate collaborative learners. In this case, the active learner will have a higher number of followers. On the Openlearning platform, learners receive kudos points if they contribute a high quality level of content via comments that might be helpful and informative for other people.

F7: Sharing the Learners' Success Stories
In order to motivate other learners to register on the platform and enroll in the courses, some collaborative platforms share the success stories of their learners. A story could include a picture, video, audio, or text. This feature is supported by some selected collaborative platforms such as Codecademy. In this platform, a learner can share his or her success story using a video or text. Also, this feature is available for Jigsaw Academy, Lynda, IntelliPaat, Eliademy, Edureka, Teamie, and Alison.

F8: Sharing Courses on Social Media
Some collaborative learning platforms such as the Canvas Network allow learners to share the courses they are enrolled-in on social media sites such as Facebook, Twitter, and LinkedIn. This feature facilitates the ability to increase the number of new learners. On the Future Learn platform, there is a section under each course with the title "Do you know someone who'd love this course? Tell them about it." In this section, a learner can share the course on social media. On the Skillshare platform, a learner can earn one free month for each friend who signs up.

F9: Like or Follow Other Learners' Posts
This is an important social feature that is supported by most of the selected collaborative platforms. Using this feature, a learner is encouraged and motivated to add his or her rich and helpful posts. On the Open2Study, Edraak, and Khan Academy platforms, in order to indicate the important posts, a learner can increase the number of votes. On the Future Learn platform, a learner can like, follow, or bookmark other learners' posts. The iversity, Rwaq, Maharah, and Openlearning platforms have only the "like" feature for other learners' posts. The SkillShare, edX, and Coursera platforms have like (or upvotes) and follow thread features. The Udemy platform allows a learner to follow other learners' posts only. The Alison platform permits learners to provide a thumb up or thumb down for other learners' posts.

F10: Classify Courses
Most collaborative learning platforms classify their courses under specific categories in order to make them easier to find.

F11: Create Courses by Instructor
On some collaborative learning platforms, only a specific user such as an instructor or an author can create a course and upload content. The instructor can upload a variety of types of files, e.g. documents, images, videos, and audio files. When the platform applies this feature, this means that their content will be reliable and there is no need for a verification step before publishing the course on the platform.

F12: Create Courses by any User
For Maharah, Eliademy, and Google Classroom, every user can create a course and upload content. In these cases, the verification step is mandatory.

F13: Display Course Details
The course details are available for learners who wish to get a comprehensive view of the course. For each course, the following information should be shown: instructor details, course topics, course description, prerequisites, output of the course, suggested references, etc.

F14: Provide a certificate
Some collaborative learning platforms provide the learner with a certificate when he or she passes the course. This feature can encourage the learner to study and complete the course. On the DataCamp platform, when a learner completes a course, the learner will receive a statement of accomplishment that can be downloaded or shared on Linkedin.

F15: Add Announcements
Most CL platforms dedicate a single section for each course to show the announcements that are posted by the instructor. This feature allows the learner to find the important posts from the instructor easily.

F16: Receive Notifications
Most CL platforms support the notification feature and have a special icon where a user can access the notification page. From the account settings, users can customize notifications (i.e., determine the types of events that he or she is notified about).

F17: Send/Receive Email Messages
On some platforms, the user can send and receive emails to and from instructors, learners, or the platform administrative. Users are allowed to customize and turn on/off emails.

F18: Post a Question and Add a Reply
Many CL platforms support and encourage learners to post their questions. When a question is asked, other learners for the same course or the course instructor are able to answer.

F19: Add an Anonymous Post
Sometimes people feel more comfortable initiating discussions anonymously in these courses. This feature is supported and used on some collaborative platforms such as edX and Edraak.

F20: Review and Rate Courses
Usually, learners check other learners' reviews and ratings before enrolling in any course. Based on this, most collaborative learning platforms support allowing learners to select a rating level (usually on a five-star scale) and to give a review. On some platforms such as the Khan Academy, there is a "thanks" tab under each course. Using this tab, learners can post their reviews and comments about the course.

F21: Show Learners' Progress in the Online Learning Process
Some platforms provide learners with a dashboard that they can use to check their progress in the learning process.

F22: Show Number of Participants in a Course
Some platforms show the total number of people who participate in a course. This feature may encourage other learners to enroll in the same course.

F23: Showing the Number of Courses and Registered Learners
Some platforms such as Tamkeen, Alison, and New Skills Academy display a dashboard on the home page that displays the total number of learners, courses, and lessons. Other platforms such as Lynda, edX, and Rwaq display only the total number of courses under each course category.

5. Stage 2: Determining the Appropriate Features

Two workshops were conducted during this stage (i) to evaluate the appropriateness of the features identified in Stage 1, and (ii) to investigate what other features might be appropriate for the Qiyas tests. We followed the instructions for conducting workshops as identified by Tiberius and Silver (2001). The instructions include guidelines such as that participants should be in a small group and that they should involve people who have real experience in the subject under discussion.

The participants have completed various types of Qiyas tests. The first workshop included seven persons, all of whom had taken the STEP and Post-Graduate General Aptitude Test. The second workshop included nine persons, seven of whom had taken the GAT and SAAT tests and two of whom had taken the Educational Supervision Test. For both workshops, a PowerPoint presentation was used to explain the current features more clearly.

The following list shows the features that were suggested by the workshop's participants and were not already discovered during Stage 1:

F 24: Vote for Offering a Course
Workshop participants suggested that we add course voting. This would allow learners to vote for the courses that are needed and can be created by the instructors. Therefore, the instructors would check this information before creating any new course.

F 25: Add Lessons into Course
The participants suggested dividing each course into separate lessons. They believe that this partitioning will help learners to better understand the courses and also help them to focus on the lessons they particularly need to study more.

F 26: Provide a Question Bank
The participants suggested adding a question bank. When a learner takes any of the Qiyas tests, the learner can then share the questions by posting them in the question bank along with the correct answer.

F 27: Approve an Answer
The participants asked that we add a tag to identify the correct answer for a question that is written by a learner. Instructors would have the ability to approve the answers.

F 28: Complete a lesson
The participants suggested that we also add a button that says "complete a lesson." A learner would click on this button once he or she understood a lesson well.

Table 2 and Figure 1 below illustrate the number of workshop participants who agreed, disagreed, or were undecided about each collaborative feature. The list includes their votes for the 23 features identified in Stage 1 as well as the seven new features. Although some features were mentioned first by the participants in one workshop and were not mentioned by the other, we asked everyone in both workshops whether or not they agree that these features are worth adding into a CL environment for Qiyas tests. We have applied the 50% Rule to determine which features should be supported by our proposed system. This means that if at least 50% of the respondents are in the support of an opinion, then that opinion should be accepted. This method has been followed by other researchers (Alyahya and Alsayyari, 2020; Rainer and Hall, 2002; Niazi, Wilson and Zowghi, 2005; Cox, Niazi and Verner, 2009). As a result, 21 features were picked and seven features were eliminated (F2, F7, F12, F14, F17, F19, and F23).

Table 1: Detailed Features Matrix of the Selected Collaborative Learning Platforms (a highlighted cell indicates that the platform supports the feature).

CL Platforms	Features																					
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23
DataCamp	■		■		■	■				■	■		■	■		■	■				■	■	
Google Classroom	■											■	■		■			■				■	
Teamie	■			■	■	■	■			■	■		■		■			■	■		■	■	
Rwaq	■	■		■	■			■	■	■	■		■	■	■		■	■			■		■
Maharah	■	■						■	■	■		■	■	■	■	■		■		■	■	■	■
Simpliv	■			■	■			■		■	■		■	■		■		■		■	■	■	
Edraak	■				■			■	■	■	■		■	■	■			■	■		■		■
Tamkeen	■				■			■		■	■		■	■		■		■		■	■		■
edX	■	■			■			■	■	■	■		■	■				■	■				■
Udemy	■	■		■	■			■	■	■	■		■	■	■	■		■		■	■	■	
Udacity	■		■	■	■					■	■		■	■	■		■	■		■			
New Skills Academy	■				■					■	■		■	■						■	■		■
Coursera	■	■	■		■	■	■		■	■	■		■	■			■	■		■			
Khan Academy	■		■		■	■		■	■	■	■		■			■	■	■		■			
Canvas Network	■				■	■		■		■	■		■	■				■		■	■		
Future Learn	■	■			■	■		■	■	■	■		■	■		■	■	■			■		
Cognitive Class	■		■		■	■		■			■		■	■				■					
iversity	■			■	■				■	■	■		■	■	■		■	■			■	■	
openlearning	■	■		■		■		■	■	■		■	■	■	■	■		■			■	■	■
Alison	■	■			■	■		■	■	■	■		■	■		■	■			■	■	■	■
Skillshare	■	■			■	■		■	■	■	■		■			■	■	■		■	■	■	
Jigsaw	■				■		■			■	■		■	■	■	■				■			
Edureka	■				■		■			■	■		■	■		■		■		■	■	■	■
Eliademy	■		■				■	■		■		■	■	■			■	■		■	■	■	■
Simplilearn	■		■		■					■	■		■	■		■				■	■	■	
Codecademy	■	■	■		■	■	■			■	■		■			■	■	■			■	■	
Lynda	■				■		■	■		■	■		■	■							■	■	■
IntelliPaat	■				■		■			■	■		■	■				■		■	■	■	■
Open2Study	■			■	■	■		■	■	■	■		■	■	■	■				■	■	■	
Edlal	■	■		■	■			■		■	■		■	■		■	■	■		■	■	■	

Table 2: Results of workshop participants' opinions (the highlighted feature indicates that it is not selected)

No.	Feature	Agree	Disagree	Undecided
F1	Create user profile	15	0	1
F2	Change user profile to private mode	5	7	4
F3	Provide general discussion forum	13	0	3
F4	Send private message to instructors and other learners	11	3	2
F5	Enroll in a course	14	1	1
F6	Award points/badges to indicate active and collaborative learners	14	0	2
F7	Share the learners' success stories	5	7	4
F8	Share course in social media	16	0	0
F9	Like or follow other learners' posts	16	0	0
F10	Classify courses	14	1	1
F11	Create course by instructor	16	0	0
F12	Create course by any user	7	9	0
F13	Display course details	16	0	0
F14	Provide a certificate	4	8	4
F15	Add announcements	15	0	1
F16	Receive notifications	15	0	1
F17	Send/Receive email messages	6	8	2
F18	Post a question and add a reply	16	0	0
F19	Add an anonymous post	3	8	5
F20	Review and rate courses	13	1	2
F21	Show learner progress in online learning process	14	2	0
F22	Show number of participants in a course	16	0	0
F23	Show number of courses and registered learners	6	9	1
F24	Vote for offering a course	13	1	2

No.	Feature	Agree	Disagree	Undecided
F25	Add lessons into course	13	2	1
F26	Provide Question Bank	16	0	0
F27	Approve an answer	16	0	0
F28	Complete a lesson	14	1	1

6. Stage 3: Developing a CL Platform for Qiyas Tests

This section proposes a CL platform. The design was made using the activity diagrams that represent system processes. An activity diagram is one of the UML diagrams that is used to model the possible behavior of a system. It consists of the detailed activities that make up the features. It is also used to understand the workflow of an object or component in order to help visualize the interactions among different actors (Lethbridge and Laganière, 2004). At an early stage of developing the design, we involved workshop participants in order to make sure that the design was reflecting user preferences.

Table 3 shows the developed system processes and what features are covered for each process. All of the features determined during Stage 2 are covered except for F8, "share course in social media," which was deemed simple and which could be implemented directly using ready APIs.

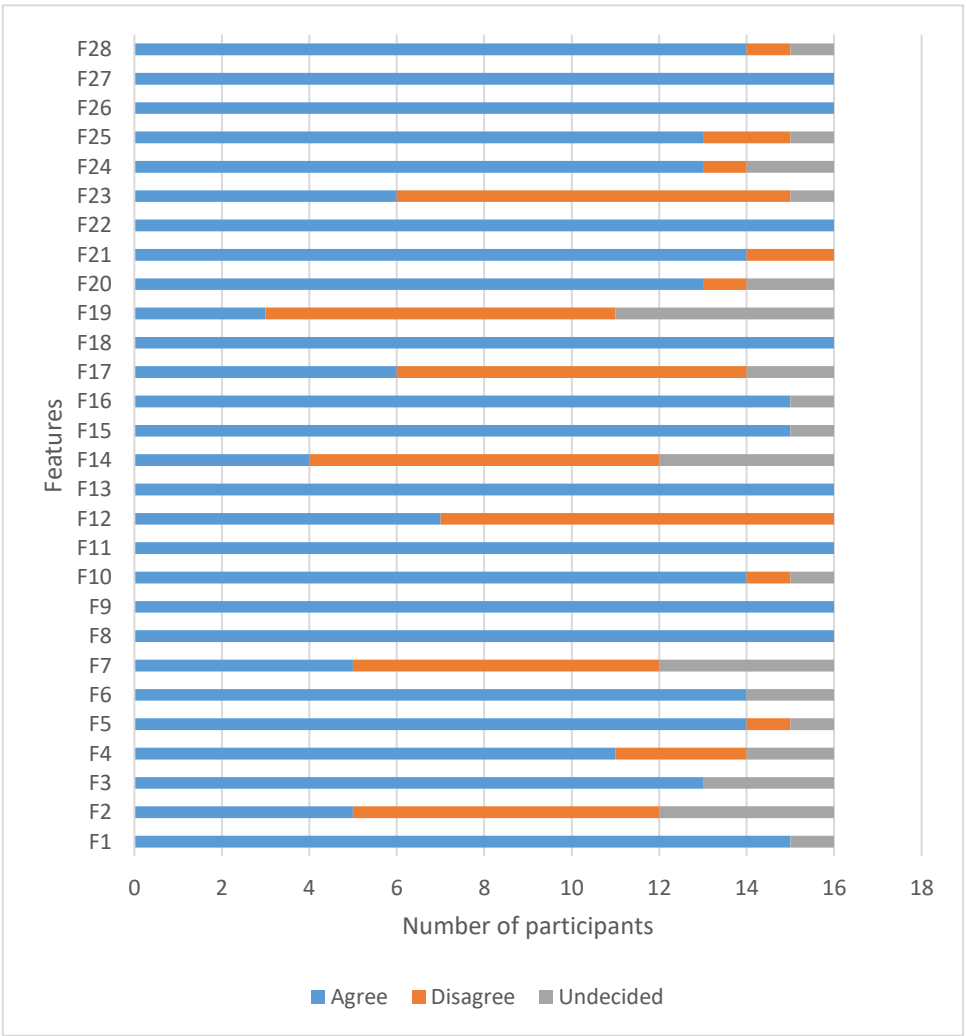

Figure 1: Histogram of workshop participants' opinions

Table 3: System processes

No	Process Name	Covered Features
P1	*Create/update user profile*	F1, F16
P2	*Manage course by instructor*	F10,F11,F13,F16
P3	*Manage a lesson by instructor*	F25
P4	*Manage an announcement by instructor*	F15,F16
P5	*Enroll in a course, complete a lesson, and update the progress line*	F5, F21,F30, F22
P6	*Post a question and add a reply*	F18, F16
P7	*Approve an answer and add Award points/badges*	F6,F29
P8	*Complete a course, review/rate a course, and add Award points/badges*	F6,F20
P9	*Send private message to instructor or other learners*	F4
P10	*Post a new question in the discussion forum, like a reply, and add Award points/badges*	F3,F9,F6,F16
P11	*Vote for offering a new course*	F24, F16
P12	*Add question to the questions bank*	F16, F26

Figure 2 presents the process P2 ("Manage course by instructor") while other processes are described in *Process Models* (2020). For this process, once an instructor logs into the platform, he or she can create a new course. To create a new course, the instructor selects the name of the test (i.e., the courses are classified based on the type of test). Moreover, the instructor must set up some initial details such as the course title, the course description, the prerequisites, and the output expected from the course. After that, the admin will verify the course and change its status from "initial" to "approved." Afterwards, a notification will be sent to learners who are interested in the same type of test as the one that the instructor selected.

In order to implement our collaborative learning platform, the C# language was used. Moreover, in order to develop and build the database, SQL Server Data Tools (SSDT) for Visual Studio was used. For the sake of brevity, the details of the implementation are omitted from this paper but they can be accessed through *Platform Implementation* (2019).

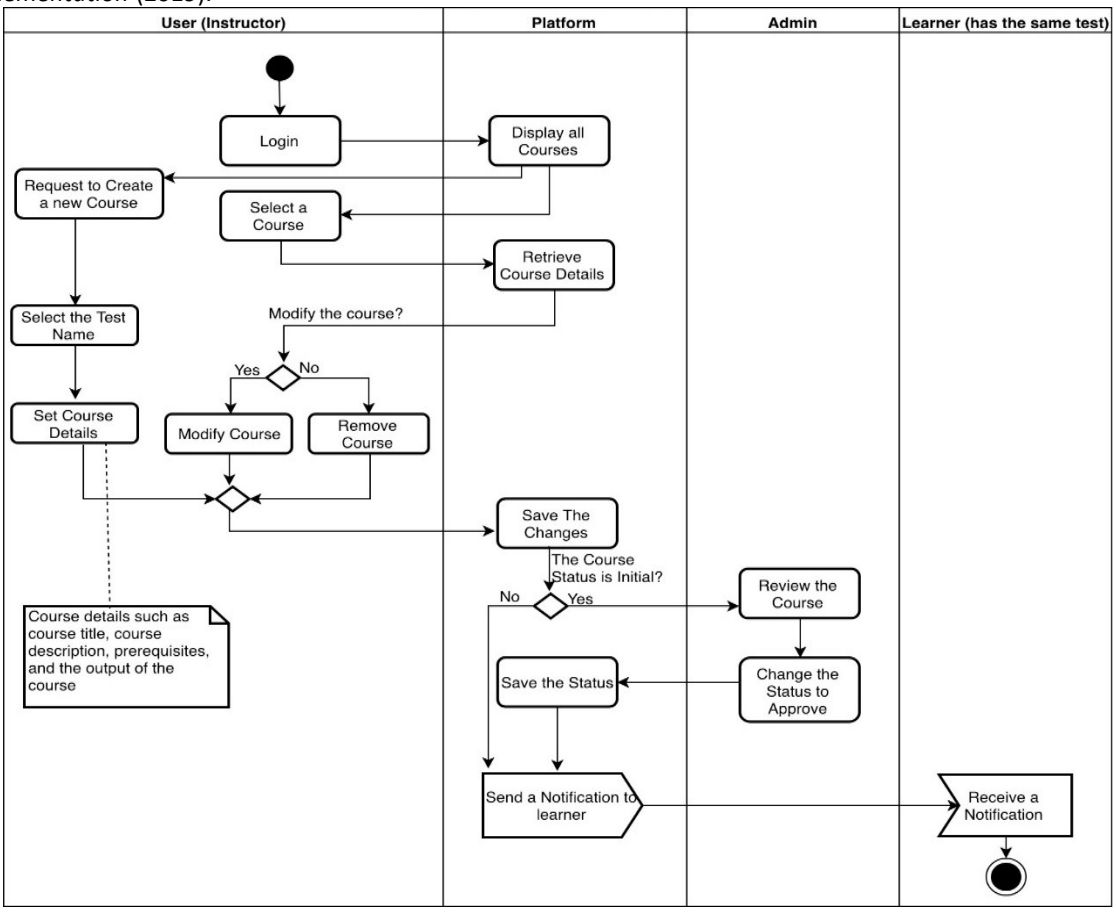

Figure 2: The process model for P2 ("Manage course by instructor")

7. Stage 4: Final Evaluation

In this section, we evaluate the proposed collaborative platform for Qiyas tests. Two evaluation techniques have been used: in-depth interviews and an empirical study. They are presented below.

7.1 In-Depth Interviews

According to Boyce and Neale (2006), the in-depth interview is "a qualitative research technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program, or situation." The primary advantage of using in-depth interviews is that interviewees are able to provide much more detailed information while they are in a more relaxed atmosphere. To conduct and design the interviews, the processes and guidelines described by Boyce and Neale (2006) were followed.

Two expert interviewees were selected. The first interviewee is an associate professor in computer education and instructional systems design. The second interviewee is a teacher who has a master's degree in educational technology.

The goal of the interviews was to assess the value of the provided functions from an educational perspective. The interviewees classified the features based on the general framework of evaluation for learning processes in computer-supported collaborative work (CSCL) presented by Pozzi et al. (2007). This framework was selected since it is a well-known framework for evaluating learning processes that use CSCL and since it is frequently used by other researchers (e.g. Wang, 2009; Persico, Manca and Pozzi, 2014; Björnsdóttir, Garfield and Everson, 2015).

This framework is based on a five-dimensional model. The first dimension is the participative dimension (P). It refers to taking part in an online collaborative experience and demonstrates that one is there, independently from any other action. The second dimension is the interactive dimension (I), which refers to the relationships that participants build during the learning processes (e.g., the interactivity between pairs). The third dimension is the social dimension (S), which is defined as the ability of participants in a community of inquiry to project themselves socially and emotionally as "real" people through the medium of communication being used. The fourth dimension is the cognitive dimension (C). This is defined as the extent to which learners are able to construct and confirm meaning through a sustained reflection and their discourse in a critical community of inquiry. The last dimension is the teaching dimension (T). This refers to the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes.

The interviewees believe the platform functions provide support for all of the five dimensions shown in Table 4. Four features provide support for the (P) dimension, seven features provide support for the (C) dimension, nine features provide support for the (I) dimension, and finally the (S) and (T) dimensions are supported by eight features each.

Both interviewees believe that the implemented platform will have a good impact on learners' performance since it will be a knowledge base for preparing and studying for the Qiyas tests. The interviewees believe from their own point of view that the most supportive features are F3, providing discussion forum (i.e., what we call "Qiyas community" in the implementation); F5, enroll in a course; and F26, providing a question bank.

Furthermore, the interviewees suggested that before the course enrollment (F5), all participants should have to read and agree on the terms of service. In addition, they mentioned that instructors should have the authority to ban or un-enroll students from their courses.

They also suggested creating a new role called a "moderator." This new role would be responsible for assisting the instructors in filtering or deleting inappropriate responses in the discussion threads. He or she could also be responsible for elevating the best posts or replies.

Concerning F6 (award points/badges to indicate active and collaborative learners), they believe that this feature will encourage learners to continue the learning process. Moreover, one of the interviewees suggested that instructors should have the ability to add a badge for a learner.

From the interviews, we can conclude that the feedback was positive. The interviewees revealed good impressions about the implemented features on the platform.

Table 4: The classification of features based on the five-dimensional model

No.	Feature	P	C	I	S	T
F1	Create user profile	✓				
F3	Provide general discussion forum	✓	✓	✓	✓	
F4	Send private message to instructors and other learners			✓	✓	
F5	Enroll in a course	✓	✓			
F6	Award points/badges to indicate active and collaborative learners				✓	✓
F8	Share course in social media				✓	
F9	Like or follow other learners' posts				✓	
F10	Classify courses					✓
F11	Create course by instructor					✓
F13	Display course details					✓
F15	Add Announcements			✓		✓
F16	Receive notifications	✓				
F18	Post a question and add a reply		✓	✓		✓
F20	Review and rate courses			✓	✓	
F21	Show learner progress in online learning process			✓		
F22	Show number of participants in a course				✓	
F24	Vote for offering a course			✓	✓	
F25	Add lessons into course		✓			✓
F26	Provide Question Bank		✓	✓		
F27	Approve an answer		✓	✓		✓
F28	Complete a lesson		✓			

7.2 Empirical Evaluation

In order to provide a deeper evaluation of the platform, an empirical study was carried out with three instructors and 26 learners. All of the instructors are teachers at the high school level. The participants have at least taken the GAT and SAAT tests. We guided the participants to focus on these two tests only while using the platform.

The participants were given two hours training in advance. We requested that they try all of the developed features. The experiment duration was 14 days. Table 5 shows the system usage at the end of the experiment.

After completing the experiment, we asked the participants to evaluate the value of the features using a five-point Likert scale. The instructors evaluated the features that related just to the teaching dimension (T) while the learners evaluated the features that related to the other dimensions. The features F6, F15, F18, F25, and F27 were evaluated by both types of participants since they include multiple dimensions. The instructors' evaluation is provided in Table 6 and Figure 3 while the learners' evaluation is provided in Table 7 and Figure 4.

Table 5: System usage

	Count	Relevant Features
User profiles	29 (3 instructors and 26 learners)	F1
Adding discussion threads	12	F3
Average posts per thread	3.25	F3
Private message to instructors and other learners	43	F4
Enrolled learners in courses	26 learners enrolled in courses, 10 of them enrolled in two courses.	F5
number of badges obtained	6	F6
Sharing course in social media	22 (14 shares in Twitter, 5 in Facebook, 3 in LinkedIn)	F8
Like or follow other learners' posts	82 Likes and 16 Follows	F9
Number of course classifications	2	F10
Number of courses	2	F11
course details displayed	2	F13
Announcements	11	F15
Notifications	270	F16
Posted questions (under lessons)	42	F18
Posted replies (under lessons)	71	F18
Number of reviews for courses	21	F20
Number of ratings for all courses	53	F20
Number of learner progress bars created	26	F21
Number of participants completing courses	36 (for 2 courses)	F22
Votes for offering a course (avg. per course)	12	F24
Number of lessons per course	6	F25
Added questions in Question Bank	32	F26
Approved answers in Question Bank	32	F27
Number of completed lessons (for all participants in all courses)	216	F28

It is clear from the data that most of the features received positive feedback. The instructors preferred features F11 and F25 the most followed by features F10 and F18. The learners believe that F5, F27, and F26 in order are the three most valuable features. We also calculated the scores for the five dimensions of the collaborative learning experience. For each dimension, we calculated the overall average for all of the features supporting the dimension. The results of the instructors' evaluation is only considered for the teaching dimension while the results of the learners' evaluation is considered for the other four dimensions. The results are shown in Table 8 and Figure 5. They show that the platform highly supports all of the dimensions. The results for all of the dimensions are relatively close to one another but the maximum values are the cognitive and participative dimensions (87.6% and 87.4% respectively) and the minimum value is associated with the social dimension (78.6%).

Table 6: Evaluation of the instructors

No.	Feature	Score Avg.	Standard Deviation
F6	Award points/badges to indicate active and collaborative learners	4.33	0.58
F10	Classify courses	3.67	0.58
F11	Create course by instructor	5	0
F13	Display course details	3.67	0.58
F15	Add Announcements	4	1
F18	Post a question and add a reply	4.67	0.58
F25	Add lessons into course	5	0
F27	Approve an answer	4.33	0.58

Table 7: Evaluation of the learners

No.	Feature	Score Avg.	Standard Deviation
F1	Create user profile	3.92	1.13
F3	Provide general discussion forum	4.38	0.75
F4	Send private message to instructors and other learners	4.35	0.63
F5	Enroll in a course	4.81	0.4
F6	Award points/badges to indicate active and collaborative learners	3.96	0.92
F8	Share course in social media	3.73	0.78
F9	Like or follow other learners' posts	3.69	0.93
F15	Add Announcements	3.62	0.8
F16	Receive notifications	4.35	0.63
F18	Post a question and add a reply	4.19	0.69
F20	Review and rate courses	3.81	0.85
F21	Show learner progress in online learning process	3.62	0.94
F22	Show number of participants in a course	3.23	0.82
F24	Vote for offering a course	4.27	0.78
F25	Add lessons into course	4.42	0.76
F26	Provide Question Bank	4.54	0.71
F27	Approve an answer	4.73	0.45
F28	Complete a lesson	3.62	0.85

Table 8: The results per dimension

Dimension	**No. of Votes**	**No. of Features**	**Overall Score Average**	**Percentage**
Participative	26	4	4.37	87.4 %
Cognitive	26	7	4.38	87.6 %
Interactive	26	9	4.17	83.4 %
Social	26	8	3.93	78.6 %
Teaching	3	8	4.33	86.6 %

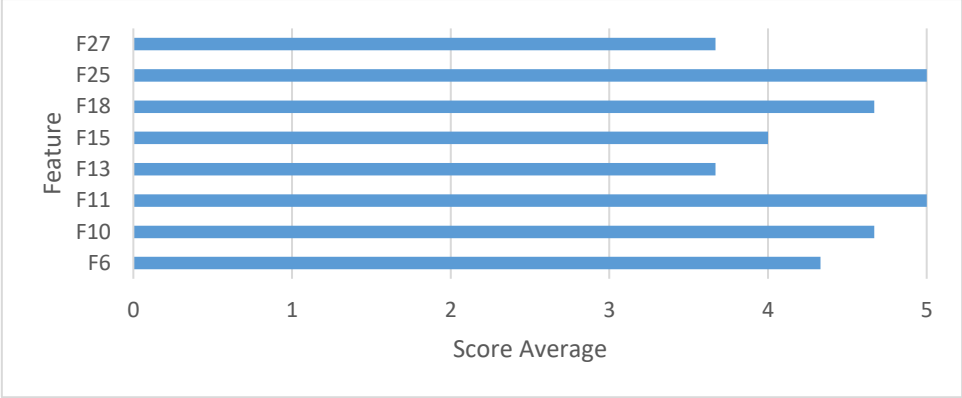

Figure 3: Histogram showing the evaluation of the instructors

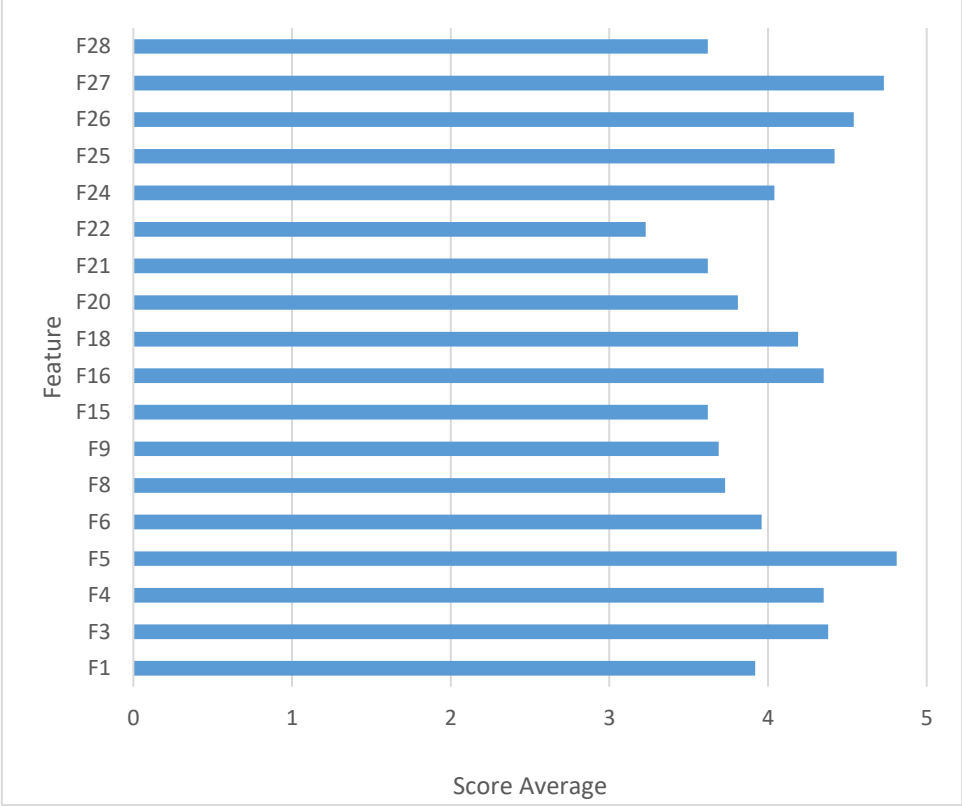

Figure 4: Histogram showing the evaluation of the learners

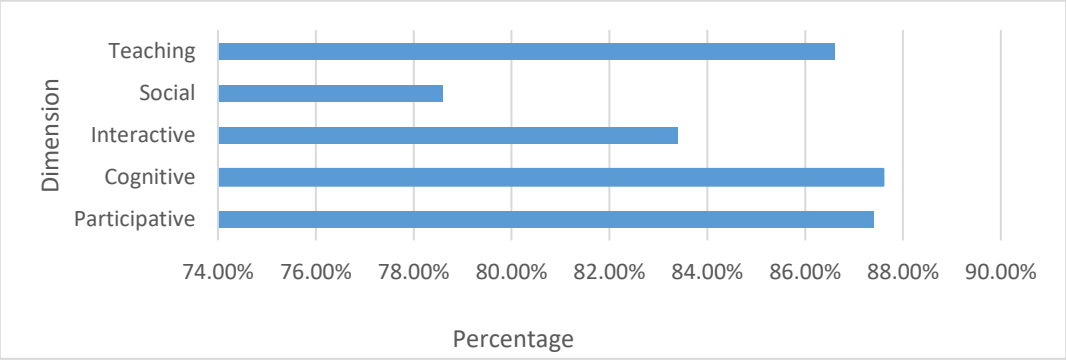

Figure 5: Histogram of the results per dimension

7.3 Further Discussion

The proposed platform was designed for the Qiyas tests in particular. It includes 21 features support by the concept of collaborative learning. In comparison to the other platforms, the closest ones that support similar features are Open2Study, Udemy, and Skillshare. Open2Study supports 15 features that form 71% of the total features offered in our system, Udemy supports 14 features that form 67%, and Skillshare supports 13 features that form 62%. However, the quantity of the similar features on these platforms does not necessarily mean that they are able to provide the same amount of value. This is because most of the other platforms were developed using process logics different than the ones created for our platform. For instance, Open2Study was developed to be a mediator between established institutions (not individuals) in Australia and students for whom the institution could provide online courses, while our platform supports the registration of individual freelance instructors. Furthermore, all three of the platforms do not support the Arabic language. Therefore, it would not be possible currently to serve Qiyas users by providing courses in their first language. This also prevents one from making evaluations that provide comparisons between any of those platforms and our own platform. Nevertheless, all of the platforms discussed in this study were helpful for learning what kind of collaborative learning features could be potentially appropriate for our proposed platform, and this allowed us to offer a wider range of interesting options for participants who joined the two workshops discussed in Section 5.

8. Conclusions

In this paper, we have introduced an electronic collaborative learning environment for the Qiyas tests offered by the Saudi National Center for Assessment. This research was completed in four main stages: (1) by carrying out an intensive review of 30 CL platforms in order to investigate the available features, (2) by conducting two workshops in order to evaluate the appropriateness of the features identified in Stage 1 and to investigate what other features could be appropriate for the Qiyas tests, (3) by developing a CL environment for the Qiyas tests that uses a total of 21 features, (4) and by evaluating the platform using two methods, in-depth interviews with experts and an empirical evaluation with instructors and learners.

The results show that the platform helps to support learners in the participative, cognitive, interactive, and social dimensions of the learning processes. The platform also helps instructors to promote the teaching experience.

We focused in this study on evaluating the usefulness of the features but we did not consider the usability of the system, which is left for future research. We also plan to develop and test some of the features requested by participants during the evaluation such as practicing a test, adding a search function, reporting inappropriate posts, uploading a CV in the instructor's profile, and setting dates for new announcements. A beta version of the platform will be published by the beginning of 2020.

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Advantages and Disadvantages of Using e-Learning in University Education: Analyzing Students' Perspectives

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Abstract: The architecture of a learning system implies a heavy task for e-learning to be integrated into a complicated system that is flexible, time scalable, and capable of lasting, even though there are many diverse tools. Currently, higher education in United Arab Emirates is experiencing a major transformation, considering increased accessibility. Therefore, the study aims to identify the advantages and disadvantages of e-learning in university education in United Arab Emirates. A descriptive study design was used to randomly select students from Ajman university, who were enrolled in 2018/2019 academic year. A close-ended structured questionnaire was constructed to collect data from students. Frequencies and percentages were used to analyse the data collected. 81% students stated that e-learning provides scientific material in an interesting way. Similarly, 80% students have responded that e-learning increases the possibility of contact between students among themselves and between the students and the teacher. 73% students indicated that due to increasing social isolation, they spend more time in front of the technical means of social interaction account and face-to-face with others. 70% students have indicated that there is a presence of electronic illiteracy among parents, which reduces their ability to follow their children electronically. It is essential for potential e-learners to understand the differences between an e-learning classroom setting and a conventional classroom setting as there are both advantages and disadvantages of e-learning to both environments that can probably influence their overall performance as a student.

Keywords: Advantages, Disadvantages, E-learning, University Education

1. Introduction

Electronic learning or e-learning is used to offer instructional programs to distant learners (Arkorful and Abaidoo, 2015). It is an online learning platform that emerges in a formal context and utilizes a variety of multimedia technologies. Electronic hardware and software support this system either offline or online. A personal computer is usually used for delivering training or computer-enhanced learning related to e-learning (Samsuri, Nadzri and Rom, 2014). Other communication technologies deliver learning based on tutorials, learning support systems, and online lectures (Kattoua, Al-Lozi and Alrowwad, 2016). It is based on technology for improving classroom engagement through positive environment, where students are deliberately engaged in online tutorials for completing a task assigned to them.

E-learning ensures that students are completely involved as learning takes place together with texts, videos, sounds, collaborative sharing, and interactive graphics. It may enhance the quality of teaching and learning, report the need for higher institutions for maintaining competitive advantage, and access to education and training in this globalizing marketplace for students (Islam, Beer and Slack, 2015). The integration of information technology (IT) in the form of e-learning has resulted in the reduction of students cost while improving the quality of learning and teaching (Songkram, 2015). This shows that e-learning can be economical for students using it, and they can perform other useful activities in their spare time (Aparicio, Bacao and Oliveira, 2016).

Flexibility is another major advantage of e-learning as it provides learners the benefit to take classes anywhere and anytime. Furthermore, e-learning cater different types and varieties of learning approaches by utilizing much interactive content available on the internet (Songkram et al., 2015). The accessibility of technology and

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wide nature of the internet have generated a surge in the need for web-based learning and teaching. Distance learning is an increasingly expanding environment, which enable users the flexibility to operate outside the barriers of place and time. In university education, online learning is explained as learning that takes place completely or partially over the internet (Gilbert, 2015). Online learning is beneficial to a number of learners and appears as more common in settings from elementary schools to high schools and into post-secondary education.

The role of engagement in e-learning is important for effective learning as it is not merely student-student interaction that matters. There are six different forms of engagement that can be identified in distance learning education: (1) teacher-content (2) content-content (3) student-teacher (4) student-student (5) teacher-teacher and (6) student-content (Talebian, Mohammadi and Rezvanfar, 2014). Theories that encourage adoption of new technologies in the learning process are based on the postulation that students are active participants who pursue and create knowledge throughout a meaningful context. Different means of collaborative tools can be used for communication and collaborative learning (Sarkar, 2012). The architecture of a learning system implies a heavy task for e-learning to be integrated into a complicated system that is flexible, time scalable, and capable of lasting, even though there are many diverse tools. The learning space is left under the control of the instructors and institutions using conventional learning management system (LMS) irrespective of any external tools (Sarrab, Al-Shihi and Rehman, 2013). In particular, this leaves minimal space for learners to organize their digital learning space and to carry-forward their activities.

Currently, higher education in United Arab Emirates is experiencing a major transformation, considering increased accessibility. Knowledge is being created and implemented to the higher education setting with innovative ways to obtain and share information and changes in technology at a rapid rate. Educational institutions are providing online classes or courses using online elements and a face-to-face course delivery. Universities deliver almost all courses using web-based technology to facilitate course contents' delivery, assessments, and assignments. Therefore, it becomes essential for understanding the advantages and disadvantages as perceived by the learners and further act upon the enhancement areas for a successful integration of online learning, based on the increasing importance of online learning programs. Hence, the study aims to identify the advantages and disadvantages of e-learning in university education in United Arab Emirates (UAE). The study further highlights the barreirs that students face in the use of e-learning, which are outlined in the form of disadvantages highlighted by students through their responses. Considering the study aim, following questions will be answered in this study.

1. What are some advantages and disadvantages of using e-learning when implemented in the university education?
2. What are some major barreirs identified by students in the e-learning?

2. Literature Review

Sociocultural theory and constructivism are beneficial to explain the use of social networks in online learning, collaborative learning, and importance of social integration in online social learning environments. Lev Vygotsky (1987) has explained that children learn effectively in a social environment, and create meaning using engagement with others. A child is able to perform and solve more complicated tasks that he/she can autonomously with direction, support, and collaboration. Students can actively participate in the learning process, if the classes are managed to support learning using discovery. This type of learning offer students to inductively and independently provide conclusions, lead to the development of intellectual abilities, and increase the quality of durability and knowledge.

2.1 Advantages of E-learning

The implementation of e-learning in education has been favourable in multiple contexts. Previous studies, have presented several advantages associated by the implementation of e-learning technologies into university education (Raspopovic et al., 2017). E-learning has been viewed as the ability to focus on the requirements of individual learners. For instance, focusing on the needs of individual learners can deliver knowledge in digital age effectively as compared to educational institutions' needs or instructors (Huang and Chiu, 2015). Objectives can be achieved in the shortest time with least efforts through e-learning. When managing the e-learning environment, its effect on educational learning are observed in providing equal access to the information regardless of the users' locations, their ethnic origins, races, and ages. The environment for

e-learning also help students or learners to rely on themselves so that instructors are no longer the solitary knowledge source rather they serve as guides and advisors (Joshua et al., 2016).

Several studies have shown the positive effects of e-learning from the insights of learners or students (Gautam and Tiwari, 2016; Martínez-Caro, Cegarra-Navarro and Cepeda-Carrión, 2015; Chang, 2016). For instance; e-learning allows to observe much flexible learning ways to go for classes with much reduced need for travel. Learners are allowed to get deeper insights of the information through activities that are carried-out in the classroom through interactive video facility (Gautam and Tiwari, 2016; Martínez-Caro, Cegarra-Navarro and Cepeda-Carrión, 2015). This allow learners to respond promptly toward the activities.

It is important for instructors to embrace the advanced technology throughout the process of teaching and; therefore, learning has a range of skills in information and communication technology (ICT) (Aithal and Aithal, 2016). It is also observed that e-learning systems allow enhanced communication between students, and instructors. Part time and full-time students can actively participate in the online degree courses selected from any location or place, providing people who are traveling or relocated, an easily accessible resource for experience and learning (Radu, Radu and Croitoru, 2015). The integration and use of e-learning offers disabled people an opportunity for advancing their education from any location. Four common types of e-learning systems have been developed which includes; Learning Content Management System (LCMS), Learning Support System (LSS), Learning Design System (LDS), and Learning Management System (LMS) (Adzharuddin and Ling, 2013). Although all the system has a similar name, however, the function of each system is different. In the process of e-learning, LMS has been widely used by various education institutions. It is further regarded as a platform that is used to manage user's experience while interacting with e-learning content. LMS in general perform three common functions, which include; presenting and systematizing training content, create assignments to test and solidify knowledge, to evaluate progress (Rietsema, 2016). The LMS software is further used to publish, plan, deliver, and place self placed online courses. Muruthy & Yamin (2017) in their study examined how LMS is effective for students enrolled in higher education institutions, along with their usage in the learning process. A number of advantages were outlined in this study. First include flexibility, as the use of LMS resulted in increased collaboration between faculty and students. It is further effective in enhancing the institutional practices which requires learner's involvement. LMS is also effective in promoting centralized learning, easy upgrades, simplified learning process, low cost, centralized learning etc (Muruthy & Yamin, 2017).

Other important benefits as highlighted by Al-Handhali, Al-Rasbi, & Sherimon (2020) indicated several benefits of LMS, making it user friendly, effective in managing time, provide ease in the management of courses, teachers, facilities, generate reports. It further provides timely reminder to users which include; date of deliveries, answering questions, test dates etc. Aydin & Tirkes (2010) in their study analyzed the usefulness of LMS and Moodle. Findings of the study indicated that Moodle, undoubtedly is one of the effective tools of LMS. Some of the identified advantages include its flexibility following the modules employed and help in any in teaching through any style or environment mode. Considering the modular design and its user interface, Moodle's superior rate of usability along with its competitors. However, considering the learning environment Moodle has been recognized as easy to use due to variety of options available. Besides, increase in the user authentication options, easy installation process along with the maintenance in Moodle helps in increasing the frequency of usage (Aydin & Tirkes, 2010).

2.2 Disadvantages of E-learning

Despite of the significant advantages of e-learning, students encounter several challenges which ultimately lead towards either limited or negative outcomes. Such as; Arkorful and Abaidoo (2015) in their study outlined that e-learning, in certain cases is held through remoteness and contemplation resulting in lack of student's interaction. In comparison with the contemporary mode of education, e-learning might result in being less effective due to the absence of face to face encounter with instructions or teachers. Since in e-learning method, assessments are generally held online which reduces the possibility of restricting illegitimate activities such as; cheating, plagiarism etc (Arkorful and Abaidoo, 2015). The absence of essential personal interactions is the most noticeable drawback of e-learning, not only among colleague learners, but also between instructors and learners (Islam, Beer and Slack, 2015). There is a scarcity of community in the online learning environment as student-student engagement is much less of a concern when compared with student-instructor interaction. Gilbert (2015) highlighted that most of the students wish to work autonomously to avoid the need to interact with their classmates. Cultural barrier is another important disadvantage of

introducing an online course. Aparicio, Bacao and Oliveira, (2016) in their study evaluated the influence of cultural characteristics which includes individualism and collectivism in determining the perceived success of e-learning. Findings of the study indicated a significant influence of individualism and collectivism on organizational and individual impacts.

Technology is a platform that can be easily acquired for granted when it is engaged into daily life, but it is not widely used because of the lack of monetary benefits for achieving access. The global knowledge available on the internet is led by increasing the proportion of computers and other electronic devices to students (Talebian, Mohammadi and Rezvanfar, 2014). Another disadvantage is maintaining motivation in an online course that online learners experience. Students who lack self-motivation and independence had reduced success rates as compared to their counterparts (Sarkar, 2012). Learners that lack self-regulation have a tendency to not assign sufficient time for completing assignments; therefore, switching in poor quality work or late assignments. Overall, successful students have stronger beliefs that they will succeed, better technology skills and access, higher self-responsibility, and higher self-organization skills (Sarrab, Al-Shihi and Rehman, 2013). Students must be able to assess the motivating factors to continue the momentum throughout the duration of the course. Students lack motivation and can easily lose sight of their original objective, rapidly become lost within the course, and consequently withdraw from the course (Raspopovic et al., 2017). Therefore, it is pertinent to determine the success of an individual to undertake an online course by understanding learning styles and self-behaviour.

3. Material and Methods

3.1 Study Design and Setting

A cross sectional study design is adopted to identify the advantages and disadvantages of e-learning in university education. Higher education institutes were focused in this study while UAE was targeted as preferred study setting.

3.2 Population and Sampling

University students in UAE have been considered as population for this study and; thus, students enrolled in Ajman University in the second semester of the academic year 2018-2019 were considered as study population. Students in other semesters and academic years were excluded from the inclusion criteria. None of the faculty staff was considered as a part of this study. Based on the sample size calculation and number of students studying in second semester, 100 students were randomly selected as a sample for this study, with an equal male and female ratio.

3.3 Procedure

Prior to the data collection, a permission was acquired from the academic's director of Ajman university and the nature and objective of the study was explained in a formal arranged meeting. After obtaining permission and ethical approval from Ajman University ethical committee, consent forms were signed from students who wish to participate in the study. All the students were ensured that their participation and personal information will be kept confidential. A close-ended structured questionnaire was constructed to collect data from students.

3.4 Instrument

The questionnaire comprised of two sections; first section presents information about age, gender, department, program, place of residence, nationality, and social status. Second part was further subdivided into two sections; (1) advantages, and (2) disadvantages of e-learning. 18 items comprised in the first sub-section and 16 items comprised in the second sub-section.

3.5 Reliability and Validity

The questionnaire was evaluated from experts in the sociological department of Ajman University before using it for data collection. Corrections were made in the questionnaire, considering the suggestions of experts to ensure its validity. On the other hand, Cronbach alpha was used to measure the reliability of the questionnaire items. In this regard, 15 students were included in the pilot study to check the reliability of the questionnaire. The participants included in the pilot study were excluded from the final sample. After performing pilot study, Cronbach alpha confirmed the reliability of the study as its coefficient exceeds the standard benchmark of 70% to show high reliability of the questionnaire items.

3.6 Data Analysis

Data collected were analysed using frequencies and percentages as part of descriptive statistics through statistical package for social sciences (SPSS) version 20.0.

4. Results

Table 1 shows demographic characteristics. The findings show an equal proportion of students (50% male and 50% female). Most of the study sample was in the age group 20-22 years (43%), 24% in the age group of 23–25 years, 15% in the age group of 17-19 years while 8% in the age group of 26-28 years.

Table 1: Demographics

Variables	Frequency	Percentage
Gender		
Male	50	50%
Female	50	50%
Age		
17-19 years	15	15%
20-22 years	43	43%
23-25 years	24	24%
26-28 years	8	8%
Greater than 28	10	10%
Department		
Science (Engineering, Medicine, Pharmacy, IT)	69	69%
Humanity (Law, Administration, Humanities and Science, Media)	31	31%
Program		
Bachelor	93	93%
Post-graduate	7	7 %
Overall Ranking of School in Learning and Development		
Acceptable	6	6%
Good	33	33%
Very Good	43	43%
Excellent	18	18%
Place of Residence		
Dubai	8	8%
Sharjah	29	29%
Ras Al Khaimah	7	7%
Ajman	56	56%
Nationality		
Emirates	30	30%
Non-Emirati	70	70%
Social Status		
Unmarried	82	82%
Married	18	18%
Absolute	0	0%
Widowed	0	0%
Practical Status		
Works	23	23%
Does not work	77	77%

Findings in Table 2 of the study show that the majority of the study members agree that there are positives to the use of e-learning. 81% students have stated that e-learning provides scientific material in an interesting way. Similarly, 80% students have responded that e-learning increases the possibility of communication and interaction between students and with teacher. Furthermore, 78% students indicate that e-learning enable students to communicate with the teacher by e-mail at any time and any place and provides the subject throughout the day and all days of the week.

Table 2: Advantages of E-learning

Rank	Items	Agree %	Somewhat agree %	Not agree %
4	The use of computers raises the level of students' culture and skills	77	16	7
1	Provides scientific material in an interesting way	81	15	4
8	Help students in retaining information for long periods. Provides immediate and continuous feedback to the learner	71	21	8
6	Increases the learner's motivation to learn	75	20	5
7	Encourage students to participate rather than listen	72	21	7
10	Raise the level of students' achievement of the scientific subject	68	19	13
7	Helps increase student-teacher interaction	72	20	8
10	Helps in increasing student-teacher interaction	68	20	12
11	Increases students' capacity of learning	66	22	12
9	Enriches the curriculum	69	17	14
5	Students can self-learn through digital vessels such as CDs or the internet	76	16	8
3	Students can communicate with the teacher by e-mail anytime and anywhere.	78	13	9
12	Helps family communicate with the university to follow and guide their children	63	20	17
13	Take into account individual differences between students' levels.	57	28	15
9	Helps minimize tutoring.	69	16	15
4	Reduces administrative burdens for university and faculty member	77	14	9
3	The course is available7/24	78	15	7
2	Increase the possibility of communication between students among themselves and between students and teachers	80	16	4

Table 3 shows that the study members agree that there are drawbacks to the use of e-learning at Ajman University. 73% students indicate that due to increasing social isolation, they spend more time in front of the

technical means of social interaction account and face-to-face with others. 70% students have indicated that there is a presence of electronic illiteracy among parents, which reduces their ability to follow their children electronically. 68% students have revealed that the application of e-learning needs to a certain extent of qualified users to deal with technological developments used in this type of education.

Table 3: Disadvantages of E-learning

Rank	Items	Agree %	Somewhat agree %	Not agree %
2	The presence of electronic illiteracy among parents reduces their ability to follow their children electronically	70	18	21
4	Effectively affects students (radiation, electromagnetic field, obesity, etc).	66	25	9
4	Hinder technical failures in educational scientific devices	66	25	9
1	Increases students' social isolation (spends longer time in front of technology at the expense of social interaction face to face with others)	73	17	10
8	Difficulty in providing extracurricular classroom activity classes	59	24	17
9	Difficulty applying calendar methods and tools.	58	22	20
5	Students focus on technology without paying attention to scientific content, which reduces their understanding	64	18	18
12	Increases students' burdens and responsibilities	50	28	22
11	Increases the phenomenon of cheating in tests	51	22	27
10	Limit the role of the teacher in guiding students, which affects their behaviour and ethics	57	23	20
8	The greater focus of e-learning on the cognitive side rather than the skill and emotional side	59	27	14
3	The application of e-learning needs a certain type of qualified users to deal with the technological developments used in	68	24	8

Rank	Items	Agree %	Somewhat agree %	Not agree %
	this type of education			
7	The cost of e-learning, especially in the initial stages of its application	60	28	12
6	E-learning lacks the presence of humanity between teachers and students	61	21	18
7	Another person can play the intended role of the learner in the learning process	60	26	14
7	E-learning does not focus on all senses, but on the senses of hearing and vision only without the rest of the senses	60	19	21
2	The presence of electronic illiteracy among parents reduces their ability to follow their children electronically	70	18	2 1
4	Effectively affects students (radiation, electromagnetic field, obesity, etc)	66	25	9

Table 4: Other Advantages and Disadvantages

	Advantages	Disadvantages
1	Easy to communicate	Difficulty for the beginner
2	Develop individual skills	Lack of availability at times and It needs more time
3	Increase students' skill in education	Addiction using electronics and dependence
4	Our cartons provide heavy book carry	When using electronics, we don't seem to be studying for parents and they think we're playing and wasting time
5	Opening the field to increase the level of education / culture in general and development by taking courses through the Internet and dialogue sessions and participation in discussions there are those who ask students to participate in a voice and this limits all the negatives mentioned above	It is according to the teacher or the recipient of the scientific material and his ability to communicate information and respond to his students and seized and enforce respect
6	Helping students among themselves, especially at the time of the exam	Reduces teachers' interest in the material
7	Facilitate study and communication with teachers in all comfort	Upgrading of devices is possible to lead to delay in dealing
8	Teach the learner and the teacher with ease with each other at any time	The material is defined in a particular framework and the difficulty of absorption because of the same way reading from PowerPoint, for example, this becomes a very boring routine unlike the explanation without electronic devices is better and education is in a wide range and discussions

	Advantages	Disadvantages
9		You cannot be called for recording his pen and needs to buy sophisticated tools expensive price to enable it to reverse the paper book ,which only needs a pen to record notes

5. Discussion

Students are progressively achieving access to the far-reaching environment of online learning, specifically in the university setting. The strategy to increase technology in university setting across the UAE has consequently driven to an increasing accessibility for students to online courses in a range of subjects. The competitive atmosphere of university entry is another potential factor that has contributed to the increase of online courses being offered at the university setting. Students are taking university level courses for maintaining a competitive edge. Many of the university level courses offered to students are in an online setting. Therefore, the study has identified the advantages and disadvantages of e-learning in supporting e-learners to become successful students using interactive online platforms.

Findings revealed that there were commonalities among the students' response, which links to common attributes of effective learners while each student is unique in their approach to online learning. It is observed that perceptions of students toward the advantages and disadvantages of the e-learning in university education. The findings have emphasized the aspects of the e-learning courses that potential online learners should take into account when realizing their individual preference. Based on these findings, it is essential for potential e-learners to understand the differences between an e-learning classroom setting and a conventional classroom setting as there are both advantages and disadvantages of e-learning to both environments that can probably influence their overall performance as a student (Rashid et al., 2016).

These findings have been supported through previous studies where a wide range of learning styles is one of the advantages of e-learning to students (Rusu and Tudose, 2018; Raspopovic, Cvetanovic and Jankulovic, 2016). Students also prefer what they like and e-learning allows them to prefer subjects they like and enjoy. It is also identified that students are independent to select the types of e-learning tools they preferred to use. In a number of cases, CD-ROM and internet are used as their main e-learning tools. This occurs because mostly students can get easy access to the Internet as they have the connection at home (Chang, 2016). Similarly, it has been found that a wide-range of multimedia inputs allow learners to seek knowledge that would associate to their personal and prior experiences, and involve them in interdisciplinary training.

E-learning can be a potential platform in providing a number of delivery methods for different types of learners, when compared to conventional classrooms. Furthermore, e-learning is an influential tool as it can provide unique learning styles and improve academic performances of students. Students can actively participate in e-learning environment where they can increase their thinking ability and learn independently (Dumford and Miller, 2018). Students can have systematic lessons as it provides content and exercises portrayed in animations, sounds, and videos.

Among the students, the lack of face-to-face interaction in their studies was the major disadvantage of e-learning, while collaborative learning among peers is essential for the students as they improve their knowledge and exchange ideas. Students by nature are social learners who often prefer to learn and interact with their peers in groups. The tendency to surf social web extensively such as Twitter and Facebook, download games, and watch movies on YouTube was considered as another disadvantage of e-learning to students. It has been observed that social web excessively can affect the brain to shrink and the condition may lead to decline in concentration.

Alghizzawi et al. (2019) identified some of the major advantages of e-learning, as it delivers education in the virtual environment by the inclusion of different devices which include; mobile phones, personal computers, and tablets (Salloum & Al-Emran, 2018; Salloum et al. 2019). This virtual learning method help teachers and students in providing access to course contents in digital form, share knowledge, while making learning more effective with increased interaction among teachers and learners through online forums, knowledge and content sharing. These platforms stimulate learning through different features which includes, development of online courses, evaluation and monitoring of activities for students and teachers (Alghizzawi et al., 2019).

Araújo Júnior and Marquesi (2009) further added that e-learning methods such as LMS help in enabling a synchronized communication, by promoting the use of different strategies while promoting a dialogue and students' active participation. In relation to the assessment methods employed in e-learning systems, Rahrouh, Taleb & Mohamed (2018) added that LMS in general has been effective, usable, efficient, manageable, and reliable. The respondents further showed a positive attitude towards the use of LMS and its effectiveness in students' assessment. While, Yilmaz (2017) identified some of the commonly used techniques in the online assessment of students in virtual learning. According to the study, the commonly used methods include; multiple choice questions, open ended questions, short answer questions, true and false statements related exercises. The researchers further examined that online exams include assignments. Upon examining the lecturer's opinion and alternative techniques of students' performance assessment, it was observed that majority of the lecturer's follow latest developed trends in evaluation and assessment of student's performance. In addition, the respondents further favoured the use of student-centered evaluation techniques (Yilmaz, 2017).

6. Conclusion

E-learning is an effective tool to transfer knowledge and it has the potential for overtaking the conventional teaching method. E-learning training help learners and instructors in educational environment. Students' needs are becoming priority for instructors and; thus, universities and colleges are implementing e-learning system in their own training programs. Through the study findings, it has been identified that e-learning has been advantageous to its users in many ways. One of the most dominant characteristics of e-learning is that it ensures ease of communication between teachers and students, and contributes in developing students' skills. It further contributes in providing scientific material to students in an interesting manner. In contrast to this, e-learner has developed negative influence on students as it promotes social isolation due to increase in screen time.

The study has concluded that students prefer to use e-learning since it provides chances to enhance their learning and increase their abilities. On the contrary, the support of e-learning is not adequate for assuring the advantages for effective learning students to socially interact with their fellowship and mentors during their academic year. In particular, there is an actual need for a well-established e-learning environment, which learners and instructors can rely on. E-learning will become more popular to make the users feel secure and comfortable with the complement of instructors and mentors. Future studies are required on a larger scale, including additional online courses, professors, and students to better assess the advantages, disadvantages, and useful strategies of successful students.

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Pathways to a Knowledge Society: A Proposal for a Hierarchical Model for Measuring Digital Literacy Among Israeli pre-service Teachers

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Abstract: This paper presents the results of an empirical study on validation of performance statements for an inventory of the digital literacy skills required for learning. These skills are used to determine digital readiness of pre-service teachers. The paper reports on validation of an adjusted set of 54 performance statements which were categorized into seven digital learning domains. The seven digital learning domains were validated based on structural equation modelling which was then confirmed by factor analysis using AMOS software. The results of the analysis indicate the existence of a multi-layered model where all digital learning domains are positively connected to each other. Our findings therefore suggest a strong statistical validity of the performance statement inventory. The findings also point to the fact that pre-service teachers are in a transit phase from digital immigrants to digital natives. That, in the context of Covid-19 pandemic, implies the need to invest in appropriate preparation and training of pre-service teachers to teach in an online environment. The inventory for measuring digital literacy can be used to assess teachers' digital readiness on a regular basis, thereby enabling them to adjust the teaching materials and pedagogy to achieve the required level of digital readiness, as defined by the school.

Keywords: digital literacies, digital readiness, students majoring in education, higher education.

1. Introduction

Digital literacy is one of the most important 21st-century competencies (Vavik and Salomon, 2016; Voogt et al., 2013). Teachers should possess digital literacy skills (DLs) so that they will be able to integrate these skills into their teaching. There is a growing gap between required classroom practices in the 21st century and teachers' use of digital technologies (Ata and Yıldırım, 2019). It is no longer sufficient for teachers and pre-service teachers to know how to use existing digital tools. They also need to be digitally literate, in order to critically evaluate such tools and platforms for safe, wise, and productive use (Akayoglu et al., 2020). A digitally literate teacher is expected to have numerous competencies, such as integrating technology into their teaching, based on a deep understanding of their subject matter pedagogy to improve teaching. To do so, they need to be familiar with a variety of relevant technology tools (Watt, 2019; Indriyani, 2019; Olurinola, 2020).

With the rapid changes in information and communication technologies, research in teacher education should focus on competencies in terms of digital literacy, and consider other variables that are related to digital literacy (Güneş and Bahçivan, 2018; Lawrence et al., 2020).

The emergence of smartphones, which began in 2007, represent, most of all, the influence of technology on society and social behaviour, which reflects on the Digital Literacy terminology. As digital literacy evolved, one can find various definitions for digital literacy (DL) (e.g., see Bawden, 2001; Gilster, 1997; Lankshear and Knobel, 2015; Mioduser, Nachmias and Forkosh-Baruch, 2008). Various research offered different explanations as to what constitutes the needed DLs for a learner (e.g., see Dede, 2010; Hockly, Dudeney and Pegrum, 2014; Eshet-Alkali and Amichai-Hamburger, 2004; Porat, Blau and Barak, 2018; Vinther and Lauridsen, 2018). There are only a few tools available to measure what DLs a learner possesses (e.g., see Jung and Latchem, 2011), thus there is an increased demand for DL assessment. This paper concludes the results of a second and final validation process of 54 performance statements (PSs), which represent seven digital learning domains (DLD's) out of the 64 original PSs of the digital literacy skills required for learning, which were described in a previous article (see Kurtz and Peled, 2016). The main purpose of the current research was to gather additional empirical evidence regarding the firmness of a digital literacies inventory of the 54 digital literacy skills developed by the research team, and test the study's theoretical model in order to confirm the DL assessment tool developed by Kurtz and

Reference this paper: Peled, Y., Kurtz, G., and Avidov-Ungar, O., 2021. Pathways to a Knowledge Society: A Proposal for a Hierarchical Model for Measuring Digital Literacy Among Israeli pre-service Teachers. *The Electronic Journal of e-Learning,* 19(3), pp. 118-132, available online at www.ejel.org

Peled, (2016).The remainder of this current paper is succinctly articulated as follows: Section 2 discusses the related literature that is of immediate relevance to the current study. Section 3 presents the theoretical foundation that has guided the development of the proposed structural model. Section 4 presents the study methods, highlighting data collection and analysis. The details of the results are presented in Section 5. Section 6 consists of a discussion on the implications, limitations, and conclusion of the paper.

2. Literature Review

There is an increased demand for DL assessment. For instance Chetty et al. (2018) and Lyons et al. (2019) recommend that the G20 countries institute a digital literacy assessment, as standardized assessment tools are essential to consistently measure digital literacy, identify gaps and track progress towards narrowing them.

The plethora of definitions and conceptualizations of what digital literacies mean, reflect on the diversity in tools that aim to measure digital literacy practices. However, the majority of the existing digital literacy measuring tools are targeting a specific objective, occupation, or age group. One such tool is the digital literacy survey (http://www.digitalliteracy.eu), developed specifically for the European citizens and by the European Computer Driving Licence (ECDL) foundation. In this survey, there are two sections - first section includes questions regarding the perceptions of the participants, the second section includes questions for actual practices, but it fails to go beyond measuring technical skills. Similarly, Tyger (2011) developed a perceived digital literacy scale to measure teacher candidates' digital literacy, yet the scale items only ask participants' understanding of several ICT terms, such as spyware, weblog, tagging, hence focusing only on perceived ICT knowledge. Other similar instruments also use ICT competence scales (e.g., Hsu, 2010; Tondeur et al., 2017). A report written by Covello and Lei (2010) for a research project titled Analysis for Human Performance Technology Decisions demonstrates this tendency to focus on ICT skills for the measurement of digital literacies as well as the necessity to revise existing instruments regularly as technologies and learners' digital practices continue to evolve.

Some developed test efforts to measure students' ability to handle digital information, and to communicate and collaborate during problem solving (Siddiq, Gochyyev, and Wilson, 2017). Other research investigated digital literacy among junior high school students, with the aim of comparing perceptions of participants' digital literacy competencies and their actual performance in relevant digital tasks (Porat et al., 2018). A review of literature on assessment instruments of primary and secondary school students' ICT literacy, done by Siddiq et al. (2016), found a total of 38 ICT literacy tests reported in 66 studies. The results indicate that most of the tests target lower secondary students, thus making this instrument age specific. In regard to the feasibility of implementation of an assessment instrument, Fraenkel, Wallen and Hyun (2011) point out that the key features are validity, reliability, and some other factors to be considered for an ideal assessment instrument. They claim that the number of items and practicality of implementation are directly related to feasibility. Many of the current digital literacy assessment tools require lengthy time and effort in order to be implemented. For this reason, there is a need for a valid, reliable, and feasible digital literacy assessment scale.

Yang (2019) asserts that an assessment tool is needed to measure student digital literacy. Perdana, et al. (2019a) developed an open-ended test for measuring digital literacy skills of students, which was based on five components of digital literacy skill: information, communication, content creation, safety, and problem-solving – thus, missing some of the essential digital literacy components. In addition, we have identified a number of instruments measuring various aspects of digital literacies: a scale designed to measure self-efficacy for information literacy (Kurbanoglu et al., 2006); a self-report instrument to measure pre-service teachers' ICT competencies in education, comprising competencies to support pupils for ICT use in class, and competencies to use ICT for instructional design (Tondeur et al., 2017); an information literacy test for higher education, which aims to assess different levels of thinking skills (Boh Podgornik et al., 2016); an information literacy test to predict the strength of some attributes of digital nativeness (ICT ownership, ICT experiences, internet confidence and number of ICT-rich university courses) on the information literacy of university students (Šorgo et al., 2017), and a digital literacy scale for teenagers (Rodríguez-de-Dios et al., 2016). Literat's (2014, pp.15) instrument on new media literacy measures individuals' "new media literacy skills, media exposure, digital participation, and civic engagement", and considers both online and offline student behaviours. There's an endless report of digital literacy measurements without specifying the instrument used for acquiring the data (see: Promsri, 2019; Perdana et al., 2019b; Kuek and Hakkennes, 2019). Apart from Promsri (2019) who developed a scale called "Digital Literacy Awareness" to identify the association between digital literacy and social intelligence, none of the above are sufficiently broad to measure digital readiness in an ever changing technological environment.

In 2017, G20 policy makers (a group of finance ministers and central bank governors from 19 of the world's largest economies and the European Union) argued that it is essential not to introduce a universal indicator to measure digital literacy, because, unlike literacy, the definition of digital literacy is contested, leading to the development of different and inconsistent sets of indicators for measuring digital literacy; instead, implement a "standardized, multidimensional [set of measures] of digital literacy" (Chetty et al., 2018). Following that, the UNESCO Institute for Statistics (UIS) undertook a mapping exercise to show countries how existing data collection instruments can be linked and used to produce internationally comparable results of digital literacies. The findings show that only a few of the existing 44 assessments which were reviewed are suitable to measure minimum proficiency in digital literacy on a global scale. Not even one single assessment tool to measure digital literacy has been endorsed by the report (Laanpere, 2019).

3. A Digital Literacy Framework

First, we will define the broad concept of digital literacy and then we will discuss various frameworks of digital competencies.

The rationale for formulating "21st Century Skills" is that unlike the 20th century, the capabilities people require in the 21st century for work, leisure and citizenship, are very different (Dede, 2010). Thus, today's children need to learn new skills, "soft skills", namely, 21st century skills, which will enable them to cope with a continually changing world. As the Partnership for 21st Century Skills (Bishop, 2015) states in its mission statement[1]: 1) Learning takes place throughout life in many places and spaces. From birth through their careers, learners need a broad range of experiences that develop their skills, dispositions, and abilities to succeed. A strong foundation for success is rooted in learning that happens in and out of school; 2) 21st-century learning environments and opportunities are essential to prepare all students for the challenges of work, life, and citizenship in the 21st century and beyond. Thus, "learning to learn" is one of the required 21st-century skills (Binkley et al., 2012).

Among the set of skills required for the 21st century are digital literacies, which might best be defined as "those capabilities which fit an individual for living, learning and working in a digital society" (Hibberson et al., 2015). In addition, the research literature includes a variety of definitions and criteria for digital literacy – some even overlap (Šorgo et al., 2017).

Kurtz and Peled (2016), aided by six educational technology researchers and seven ICT graduate students, identified seven digital learning domains (DLDs): (A) *Information Collection*; (B) *Information Evaluation*; (C) *Information Management*; (D) *Information Processing*; (E) *Teamwork*; (F) *Integrity Awareness*; and (G) *Social Responsibility*. These DLDs establish the framework for the self-assessment tool. The digital competencies and conceptual items described by Gilster (1997), Hobbs (2010), Mills (2010), Rheingold (2012), Janssen et al. (2013), Ribble (2016), Park (2016), and Roxin and Rusitoru (2016) easily map to the DLDs developed by Kurtz and Peled (2016).

Therefore, the organization of competencies and skill sets described in this section follows Kurtz and Peled's seven DLDs.

3.1 Information Collection

Foundational to most new literacies, is the ability to seek and find information within digital sites (Gilster, 1997; Hobbs, 2010; Kurtz and Peled, 2016; Ribble, 2016). This most basic skill expands to include initial considerations of actual need for information and know-how related to searching digital systems. Kurtz and Peled (2016) address this initial ability to identify and articulate the need for information, a task required before a search. In addition, Janssen et al. (2013) address the need for informed decisions supporting the use of appropriate digital technologies for researching.

3.2 Information Evaluation

Information Evaluation is a digital learning domain that, while foundational, can be a more cognitively demanding skill than Information Collection, Retrieval and Management. Not only do Kurtz and Peled (2016) support the ability to determine a source's credibility, they also include the skill required to determine if the information will meet the intended needs of a given task. Critical thinking is required (Gilster, 1997; Park, 2016;

[1] http://www.p21.org/about-us/our-mission

Rheingold, 2012), as is mindful reflection (Gilster, 1997; Rheingold, 2012) and the ability to problem-solve (Roxin and Rusitoru, 2016). A digitally literate individual must be able to analyse, evaluate, understand and reflect on a given task and the information required to meet the need (Gilster, 1997; Hobbs, 2010).

3.3 Information Management

Kurtz and Peled (2016) describe information management from a very basic level referencing the ability to organize digital files. Like Information Collection and Retrieval, this is another foundational skill to many new literacies. However, Gilster (1997) and Janssen et al. (2013) extend this foundational concept a bit further. They speak of the need for self-efficacy of an individual in the ability to seamlessly navigate in a digital environment, while at the same time having the ability to process information received from multiple formats. They also express the need for digitally literate individuals to have the ability to learn about and with digital technologies, an increasing necessity as available technologies are evolving rapidly.

3.4 Information Processing

At its most basic level, processing, managing and presenting information involves content creation and knowledge assembly (Gilster, 1997; Hobbs, 2010; Park, 2016). Hobbs (2010, pp.31) explains that active participation in digital literacy practices "cultivate[s] an active approach to the process of meaning making". Yet, digital literacy includes more, moving beyond basic representation toward the use of multiple forms of digital media for creative expression (Janssen et al., 2013; Kurtz and Peled, 2016; Mills, 2010; Roxin and Rusitoru, 2016). There is Janssen et al., (2013) note, an intricate relationship between digital technologies and creative expression.

3.5 Teamwork

Team-based learning, like social responsibility, links to the need of individuals to work collaboratively in this participatory culture. Kurtz and Peled (2016) look closely at individual team members' awareness of their role, the roles of other team members, and the alignment of individual roles for the work of the group. Concern for collaborative engagement and the ability to construct social groups (Mills, 2010; Rheingold, 2012), as well as having the ability to share individual thoughts with group members (Gilster, 1997; Hobbs, 2010; Kurtz and Peled, 2016), are noted in the literature as being important competencies of digital literacy.

3.6 Integrity Awareness

Digital integrity encompasses the knowledge of common practices and compliance with copyright and the legal and ethical aspects associated with the use of digital media, including awareness and understanding of Creative Commons licenses and how to provide attribution (Gilster, 1997; Hobbs, 2010; Kurtz and Peled, 2016). Similarly, Janssen et al. (2013) include privacy and security, and legal and ethical aspects as competencies of digital literacy. They state the following for each, respectively:

The digitally competent person has the capacity to protect personal data and take appropriate security measures; [and] the digitally competent person behaves appropriately and in a socially responsible way in digital environments, demonstrating awareness and knowledge of legal and ethical aspects on the use of ICT and digital content (Janssen et al., 2013, pp.477).

Park (2016) provides details specific to digital literacy and security, including password protection, and Internet and mobile security related to hacking, scams and malware detection.

3.7 Social Responsibility

Social responsibility is a key component necessary for life in a participatory culture (Jenkins et al., 2006) in this emerging fourth industrial revolution driven by the digital economy (Baller, Dutta and Lanvin, 2016). Kurtz and Peled (2016) describe social responsibility as an awareness of threatening situations and understanding of social consequences related to one's actions, as do Ribble (2016) and Roxin and Rusitoru (2016), who refer to the need for social awareness and concern for individual rights and responsibilities. Social etiquette, which is necessary for all social groups, even those that are online, is also considered a standard of conduct (Ribble, 2016) and is comparable to Hobbs (2010) identified need for making responsible choices with social actions. Park (2016) separates what she refers to as digital emotional intelligence from digital literacy in a broader conversation on digital skills. She refers to the need for an emotional awareness, self-regulation, and empathy for others. It is with an awareness and understanding of the role of ICT in a society, that individuals can balance their perceptions of, and actions with, ICT in society (Janssen et al., 2013).

The seven digital learning domains (DLD's) described above, constitute the whole set of learning digital literacy competencies needed for learning at any age. In order to further validate the digital literacies inventory of 54 digital literacy skills developed by the research team, and test the study's theoretical model, it is necessary to examine the ties between each of the domains.

From the above, we drew the following **research question**: To what extent are the seven DLD's linked to each other?

Digital Literacy Competencies Catagorized using Kurtz and Peled's 7 Digital Learning Domains	Gilster (1997)	Hobbs (2010)	Mills (2010)	Rheingold (2012)	Janssen et al. (2013)	Ribble (2016)	Roxin & Rusitoru (2016)	Park (2016)	Kurtz and Peled (2016)
Information Research and Retrieval									x
Articulate need									x
Search; Access	x	x				x			x
Informed decisions on appropriate digital technologies					x				
General knowledge and functional skills; Aquire	x				x				
Information Validation									x
Critical Thinking	x			x			x		
Computational thinking; Problem solving							x	x	
Mindful reflection	x			x				x	
Analyze; Evaluate quality; Understand and reflect	x	x							x
Information Management									x
Learning about and with digital techologies					x				
Use information in multuple formats in everyday life	x	x			x				
Seamless use demonstrating self-efficacy	x				x				
Information processing and management					x				x
Processing and Presentation of Information									x
Content creation; Knowledge assembley	x	x					x		x
Creative production of digital media			x					x	
Specialized competence for creative expression					x				x
Information processing and management					x	x			
Team-based Learning in Digital Environments									x
Collaborative engagement; Social group construction			x	x					x
Engage; Sharing; Pooling knowledge		x						x	x
Digital co-creator							x		
Technology mediated communication and collaboration					x		x		
Awareness of Digital Integrity									x
Privacy and security					x		x		
Legal and ethical aspects	x	x			x		x		x
Social Responsibility									x
Concern or individual rights, responsibilities, etiquette						x	x	x	x
Social action; Responsible choices		x					x		
Balanced attitude towards technology					x				
Understanding and awareness of role of ICT in society					x	x	x	x	x

Figure 1 represents the many overlapping points outlined here and provides a visual reference for how the competencies described in the literature align with Kurtz and Peled (2016) digital learning domains (Shannon, 2017)..

Digital Literacy Competencies Catagorized using Kurtz and Peled's 7 Digital Learning Domains	Gilster (1997)	Hobbs (2010)	Mills (2010)	Rheingold (2012)	Janssen et al. (2013)	Ribble (2016)	Park (2016)	Roxin & Rusitoru (2016)	Kurtz and Peled (2016)
Information Research and Retrieval									x
Articulate need									x
Search; Access	x	x				x			x
Informed decisions on appropriate digital technologies					x				
General knowledge and functional skills; Aquire	x				x				
Information Validation									x
Critical Thinking	x			x			x		
Computational thinking; Problem solving							x	x	
Mindful reflection	x			x				x	
Analyze; Evaluate quality; Understand and reflect	x	x							x
Information Management									x
Learning about and with digital techologies					x				
Use information in multuple formats in everyday life	x	x			x				
Seamless use demonstrating self-efficacy	x				x				
Information processing and management					x				x
Processing and Presentation of Information									x
Content creation; Knowledge assembley	x	x					x		x
Creative production of digital media			x					x	
Specialized competence for creative expression					x				x
Information processing and management					x	x			
Team-based Learning in Digital Environments									x
Collaborative engagement; Social group construction			x	x					x
Engage; Sharing; Pooling knowledge		x						x	x
Digital co-creator							x		
Technology mediated communication and collaboration					x		x		
Awareness of Digital Integrity									x
Privacy and security					x		x		
Legal and ethical aspects	x	x			x		x		x
Social Responsibility									x
Concern or individual rights, responsibilities, etiquette						x	x	x	x
Social action; Responsible choices		x					x		
Balanced attitude towards technology					x				
Understanding and awareness of role of ICT in society					x	x	x	x	x

Figure 1: DL Competencies: Categorized by Kurtz and Peled's seven DLD's Conceptual Model and Hypotheses (Shannon, 2017).

4. Method

4.1 Purpose of the research

In light of the above, the main purpose of the current research was to gather empirical evidence regarding the firmness of a digital literacies inventory of 54 digital literacy skills developed by the research team, and test the study's theoretical model.

The validation presented in this study is based on the digital literacy competencies of pre-service Israeli teachers (Peled, 2020) and didacts their digital readiness. The purpose of this deduction was to assess the degree to which Israeli pre-service teachers are ready to prepare and lead their students into the digital world.

4.2 Development of the research instrument

The research instrument - The Self-Report Digital Literacies (SRDL) was initially developed by Kurtz and Peled (2016) in a two phase process:

- Phase 1 - compilation of PS's and DLD's which yielded 64 PS's.
- Phase 2 – validation of the 64 PS's left 54 valid PS's.

Phase 1 – was based on an exhaustive literature research, a list of DLD's and PS's was compiled (see table 1) and distributed for pre-validation review and comments to six expert researchers in the educational technology field, and to seven graduate students of ICT studying at the College of Academic Studies in Israel. The experts and the students were asked to provide a critical review of the DLD's and PS's. More specifically, they were requested to respond to open-ended questions concerning the fitness, appropriateness, missing items, revision, rephrasing, and clarity of the items. Their comments were analysed by the research team to determine what revisions of the DLD's (if any) were to be included in the survey. Based on respondent input, a final set of seven DLD and sixty-five Likert-type scale items from 1 to 5 was listed. The 64-item survey was administered to 1,889 students at the Western Galilee College in Israel. The analysis of the data showed that 10 items had low compatibility and were accordingly excluded (see appendix 2).

Table 1: Origin of Domains

Domain	**Literacy**	**Source**
Information Collection	The ability to recognize information needs, access, understand and use effectively and efficiently information using Internet, professional organization databases and search engines	(Ala-Mutka, 2011; Chandra, 2013; Lau and Yuen, 2014; Lester, 1995; Mioduser et al., 2008; Nelson et al., 2011)
Information Evaluation	The ability to evaluate the quality, reliability, relevance, timeliness, completeness, credibility, usefulness, and efficiency of digital resources	(Brouwer, 1996; Eshet-Alkali and Amichai-Hamburger, 2004; Henry, 2005; Lau and Yuen, 2014; Nelson et al., 2011)
Information Management	The ability to save, retrieve and to tag digital information while including knowledge about copyright and plagiarism issues	(Dudeney et al., 2014; Mioduser et al., 2008; Nelson et al., 2011)
	The ability to protect personal data and information from threats such as unauthorized access, destruction, identity theft, impersonation, unauthorized alteration of data, or fictitious creation	(Lau and Yuen, 2014; Nelson et al., 2011)
Information Processing	The ability to use ICT to design or create new information from information already acquired	(Lau and Yuen, 2014)
Teamwork	The ability to work with others (instructor and peers) toward a common intended learning goal through, discourse, collaboration, cooperation, RBL and PBL	(Harasim, 2012; Henry, 2005; Jung and Latchem, 2011; Nelson et al., 2011; Panitz, 1999)
Integrity Awareness	Maintain digital integrity & ethical standards	
Social Responsibility	Understanding the social and ethical implications/ consequences of the use of digital resources	(Nelson et al., 2011)

Phase 2 – The remaining 54 PS's were retested for reliability showing a relatively high Cronbach's alpha values as it can be attested in table 3. The current report relates to phase 2 of the research.
The seven domains and the number of statements pertaining to each domain can be seen in Table 2.

Table 2: The seven domains and the number of statements pertaining to each domain

Domain	# of statements	Refers to questions such as:
Information collection	12	objectively search effectively; how to distinguish between different types of search, sources, and information
Information evaluation	5	judging the information gathered and assessing its credibility
Information management	3	personal storage for posterior retrieval
Information processing	8	assessing, interpreting, analysing and synthesizing information from multiple sources for later usage
Teamwork	8	participation levels of different peers in a studying task

Domain	# of statements	Refers to questions such as:
Integrity awareness	15	concern of ethical, moral, and social consequences of usage, or mis-usage, of digital information
Social responsibility	3	proper behaviour in the social digital environment

(All items were assigned a 5-point Likert scale from 1 (not at all) to 5 (to a very large extent).

A further evaluation of students' digital readiness is based on Horrigan's (2016) work. For the purpose of this study, we categorized the original seven domains of the digital literacy questionnaire (Kurtz and Peled, 2016) into four types of digital readiness: (a) basic order readiness (information collection, information processing); (b) advanced order readiness (information management, information evaluation); (c) preparedness for teamwork (teamwork); and (d) ethical readiness (integrity awareness, social responsibility). The background characteristics of the participants are examined using the following questions: (a) school of study; (b) degree; (c) gender; (d) age; and (e) sense of control of Internet technologies.

4.3 Procedure/Information Collection and Participants

We used an online questionnaire to anonymously collect information from five teachers' colleges/colleges of education in the north, centre, and south of Israel. The recruitment was done with the assistance of the different institution's managements, which sent the questionnaires, via email, to their students. The information collection was carried out from the spring of 2015 to the spring of 2017.

4.3.1 Participants

A total of 1,265 undergraduate pre-service teachers and in-service teachers, studying for their graduate degree, completed an online questionnaire. Four hundred and eighty-one students (38.0%) were from college A, 375 (29.6%) from college B, 165 (13%) from college C, 133 (10.5%) from college D and 90 (7.1%) from college E. Twenty-one students (1.8%) did not identify their college. The overall response rate was 25.9%, with the individual rates varying as follows: 37.2% (college A), 75% (college B), 16.5% (college C), 4% (college D) and l6.6% (college E); 57.5% were undergraduate students and 38.5% were graduate students. Most of the respondents (79%) were women. The average age was 33.4 years (*SD* = 10.4; *M* = 32).

4.4 Data Analysis

The data was analysed in two stages.

In the first stage, the internal consistency (reliability) of the questionnaire was explored (Table 3). In the second stage, structural equation modelling (SEM) was used to conduct a path analysis that tested the study's theoretical model.

Table 3: Internal consistency (reliability) of the Questionnaire

Name		Number of items	Cronbach's alpha
A.	Information Collection	12	.939
B.	Information Evaluation	5	.885
C.	Information Management	3	.758
D.	Information Processing	8	.917
E.	Teamwork	8	.911
F.	Integrity Awareness	15	.934
G.	Social Responsibility	3	.888

5. Results

The interactions between the seven DLD's were evaluated with structural equation modelling through AMOS 25.0 software.

For this analysis, responders which one of the variables were not calculated for them were excluded from the analysis, as were respondents who did not specify their gender or level of education. In total, the sample included 950 respondents.

5.1 Model analysis

Full information maximum likelihood estimates were computed by means of the Analysis of Moment Structures (AMOS) program (Arbuckle and Wothke, 1999). Structural models linking Information Collection, Information Evaluation, Information Management, Information Processing, Teamwork, Integrity Awareness and Social Responsibility were tested, the results of which are summarized in Figure 2. The model was examined for goodness of fit using χ2, comparative fit index (CFI) and root mean square error of approximation (RMSEA) fit indices. CFI values above .90 and .95 indicate adequate and good model fit, respectively, and RMSEA values below .08 and .05 indicate adequate and good model fit, respectively (Browne and Cudeck, 1992; Hu and Bentler, 1999; Kline, 2015) (see Table 4). According to Awang (2012), it is customary to use three sets of estimations for level of compatibility: absolute compatibility (χ^2, RMSEA, PClose), incremental (NFI, TLI, CFI) and parsimonious ($\chi^2/_{\mathrm{df}}$).

The first stage of the estimation was to examine the extent to which the model is compatible with the data using the maximum-likelihood (ML) model.

Table 4: Fit measures of the proposed research models testing the relations between Information Collection, Information Evaluation, Information Management, Information Processing, Teamwork, Integrity Awareness and Social Responsibility for the entire sample (N=950)

Fit measures		**Recommended levels of fit (Awang, 2012)**	**Value of the measure**
	χ^2	n.s. at p<.05	$6.918_{(df=3)}$, p>.05
Absolute Fit	RMSEA	<.08	.037
	PCLOSE	>.05	.664
	CFI	>.90	.999
Incremental Fit	TLI	>.90	.993
	NFI	>.90	.998
Parsimonious Fit	$\chi^2/_{df}$	<3.0	2.306

The results detailed in Table 5 indicate a good correlation between the proposed research model and the data. The second stage in the analysis of structural equations includes an assessment of the interactions between the variables using a path analysis model. In general, the evaluation of a structural equation model allows us to examine the quality of fit for a model between two types of variables: exogenous variables, that are independent variables unrelated to other variables in the model, and endogenous variables associated with other variables in the model. In the current model, there are no exogenous variables, and all of the variables are endogenous, while they may be related to each other. Figure 2 displays the standardized effect coefficients (β) of the dimensions and the explained variance rate (R2), and accordingly, Table 5 includes a breakdown of the aggregate cumulative effect (β) among the variables in the study. The model shows that the size of the effect, as can be seen from the level of explanation of the variance of the variables in the model, is high (R2>.25 for all the variables) (Cohen, 1992).

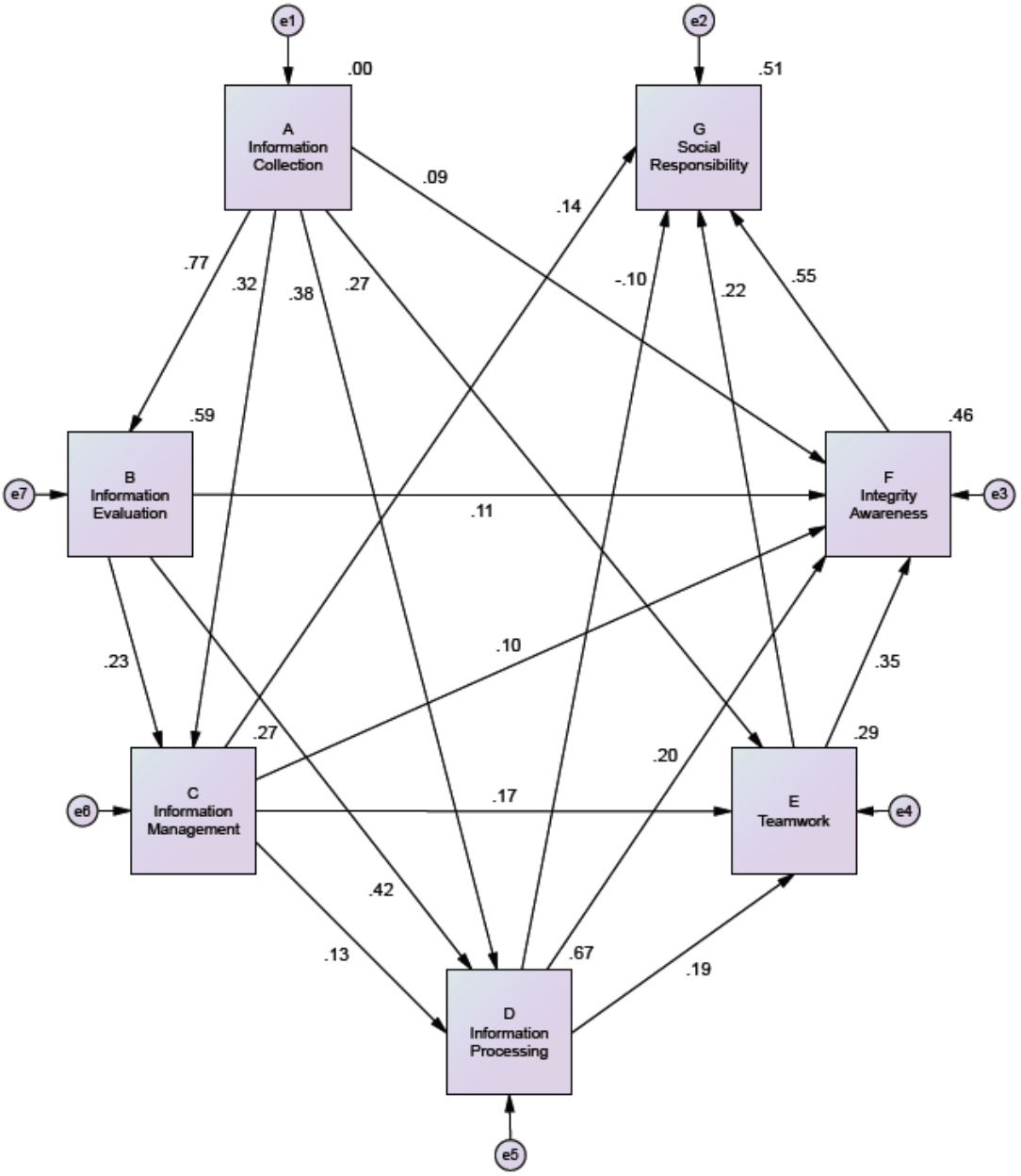

Figure 2: Path analysis for the proposed research models testing the relations between Information Collection, Information Evaluation, Information Management, Information Processing, Teamwork, Integrity Awareness and Social Responsibility for the entire sample (N=950).

The analysis (Figure 2) shows that most of the variables are directly related apart from a non-direct effect between *Information Collection* (A) and *Social Responsibility* (G) and between *Information Evaluation* (B) and *Teamwork* (E) and *Social Responsibility* (G). The interaction between the variables is only indirect. Furthermore, analysis of the direct effects between the variables shows that all of them are positive; that is, the correlation between the variables is positive. An exception to this rule is the connection between *Information Processing* (D) and *Social Responsibility* (G) (β=-.10), which indicates a negative correlation between the two variables, even though, as can be seen from Table , the connection between *Information Processing* (D) and *Social Responsibility* (G) is positive but low (β=.09).

Table 5: Standardized total effects for the proposed research models testing the relations between Information Collection, Information Evaluation, Information Management, Information Processing, Teamwork, Integrity Awareness and Social Responsibility for the entire sample (N=950)

		A Information Collection	B Information Evaluation	C Information Management	D Information Processing	E Teamwork	F Integrity Awareness
B	Information Evaluation	0.77					
C	Information Management	0.50	0.23				
D	Information Processing	0.76	0.45	0.13			
E	Teamwork	0.50	0.12	0.19	0.19		
F	Integrity Awareness	0.55	0.26	0.19	0.26	0.35	
G	Social Responsibility	0.41	0.16	0.28	0.09	0.41	0.55

The results of the analysis indicate the existence of a multi-layered model where all the variables are affected by the variables at the lower levels. Within this framework:

- The variable *Information Collection* (A) has a direct effect on the variable *Information Evaluation* (B) (β=.77).
- The variable *Information Management* (C) is affected directly by *Information Evaluation* (B), which is at the second level (β=.23) but also positively by the variable at the first level *Information Collection* (A), directly (β=.32) but also through the effect of the variable *Information Evaluation* (B) on the variable *Information Management* (C) such as the overall effect is β=.50.
- The variable *Information Processing* (D) is directly influenced from the variable *Information Management* (C) (β=.13), which is at the previous level and is positively affected, directly and indirectly, from the variables at previous levels: *Information Collection* (A) (β=.76) and *Information Evaluation* (B) (β=.45).
- The variable *Teamwork* (E) is directly affected by the variable *Information Processing* (D) (β=.19) at the previous level, and is positively influenced from the variables at previous levels: directly and indirectly from the variable *Information Collection* (A) (β=.50): only indirectly from the variable *Information Evaluation* (B) (β=.12) and directly and indirectly from the variable *Information Management* (C) (β=.19).
- The variable *Integrity Awareness* (F) is positively affected by the variable at the previous level *Teamwork* (E) (β=.35), and is directly and indirectly affected by the variable *Information Collection* (A) (β=.55); directly and indirectly from the variable *Information Evaluation* (B) (β=.26); directly and indirectly from the variable *Information Management* (C) (β=.19) and directly and indirectly from the variable *Information Processing* (β=.26).
- The variable *Social Responsibility* (G) at the highest level is positively and directly affected by the variable at its previous level *Integrity Awareness* (F) (β=.55). Also, this variable is only indirectly affected by the variables *Information Collection* (A) (β=.41) and *Information Evaluation* (B) (β=.16).
- The variable *Social Responsibility* (G) is directly and indirectly affected by the variable *Information Management* (C) (β=.28) and directly and indirectly from the variable *Teamwork* (E) (β=.41).
- As noted above, despite the direct and negative effect of the variable *Information Processing* (D) (β=-.10), the overall effect of this variable on the variable *Social Responsibility* (G) is completely balanced by the indirect effect, so that in the end, this effect is positive, even if it is low (β=.09).

From the analysis, it appears that at the basis of the multi-level model is the variable Information Collection (A) on variables at higher levels. Also, it was found that the three "old world" variables are based on Teamwork (E), Integrity Awareness (F) and the effect of these to variables on Social Responsibility (G).

6. Conclusions, implications, and limitations

The main purpose of the current research was to gather empirical evidence regarding the firmness of a digital literacies inventory of 54 digital literacy skills developed by the research team. This is a second phase; while in the first phase an inventory of 64 digital literacy skills were evaluated and validated (Kurtz and Peled, 2016), in the second phase a further reduction to the digital skills was done; thus finally a set of 54 digital literacy skills represents the seven DLD's. This inventory was initially built based upon an extensive review of the literature, along with an examination of definitions, concepts, case studies and theoretical models that deal with the 21st century digital skills required for learning.

The results of the analysis indicate the existence of a multi-layered model, where all of the variables are affected by the variables at the lower levels, meaning that the model elements which are the different DLD's are positively connected to each other. Thus, our findings suggest a strong statistical validation of the inventory. The connection between the DLD's, as the model indicates, show that the initial process of which the DLD's were determined was correct, and that the DLD's representing the sphere of digital literacy do represent that sphere of competences.

As there is a research gap on pre-service teacher's digital literacy perception, usage, and posterior readiness to include digital environments in the transfer of subject knowledge (Peled, 2020) the proposed inventory can serve as a valid and strong instrument by which pre-service teachers' digital readiness can be measured. The findings show a distinction between the types of preparedness that have developed in the digital sphere and those that existed in the pre-digital sphere: of the four types of digital readiness: (a) basic order readiness (information collection, information processing); (b) advanced order readiness (information management, information evaluation); (c) preparedness for teamwork (teamwork); and (d) ethical readiness (integrity awareness, social responsibility) students report a high level of readiness for teamwork and ethical conduct relevant to both offline and online environments. On the other hand, the participants reported a medium to low level of preparedness for the types of preparedness relevant to an online environment only: readiness of a basic and advanced order. These findings point to the fact that pre-service teachers are in a transit phase from digital immigrants to digital natives (Prensky 2001).

As "*The Israeli National ICT Programme"* aims to promote innovative pedagogy in schools by encouraging teachers to intelligently integrate content worlds, books, tools, and digital environments into teaching, learning and evaluation processes. The programme develops technological and digital literacy through a broad and rich array of projects, online activities and alternative learning frameworks (Ministry of Education, 2018). Thus, the *digital literacies inventory for measuring digital literacy*, which was found to be reliable, can be used to assess teachers' ability to teach in the manner mentioned above by the Israeli Ministry of Education and achieve its objectives.

An international implication of the study is that as reported by UNESCO's *Recommendations on Assessment Tools for Monitoring Digital Literacy within Digital Literacy Global Framework* (Laanpere, 2019) which reviewed 44 different digital literacy skills assessment instruments and could not recommend a suitable solution for the UNESCO Institute for Statistics, contrary to that, the *digital literacies inventory* offer a robust assessment instrument which can be used internationally in any educational context (the inventory have been tested in 9 different countries in Europe, U.S.A., Asia, Middle East, and some countries in the Far-East - ongoing research).

The digital literacies inventory for measuring digital literacy can be used to assess students' digital readiness on a regular basis, thereby enabling the various levels at school to adjust the teaching materials and pedagogy to achieve the required level of digital readiness defined by the school.

Additional research is needed in order to shed more light on some of the connections between the various domains. For instance, the connection between Information Processing and Social Responsibility indicates a negative correlation between the two variables, even though the connection between them is positive but low.

Statements on open data, ethics, and conflict of interest:

1. The data cannot be accessed as it is not stored online.
2. A permission was granted to carry-out this research by the IRB of the Western Galilee College, Israel.
3. There is no conflict of interest in the work we are reporting here.
4. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Appendices

Appendix 1: Digital literacies survey

Instructions: This questionnaire is designed to learn about your digital literacies by using the following scale: 1. Strongly disagree; 2. Somewhat disagree 3. Neither disagree nor agree; 4. Somewhat agree; 5. Strongly agree.

1. Data Collection

1.	I know when I need to look for information
2.	I am able to identify information for research
3.	I am able to collect information from the web
4.	I can define the objective of the search
5.	I can articulate what information I need
6.	I know how to search effectively
7.	I can define research terms
8.	I can distinguish between types of search
9.	I can retrieve information from various sources
10.	I am able to collect information from databases
11.	I am able to re-locate information
12.	I can re-locate a specific web page

2. Evaluation of Data

1.	I am able to judge the degree to which information is practical or satisfies the needs of the task
2.	I am able to determine the information required for a specific task
3.	I am able to assess the accuracy of information
4.	I am able to assess the credibility of information
5.	I am aware of the difference in credibility of information from various sources

3. Data Management

1.	When I store a file, I give it a specific name
2.	I store my files in designated folders
3.	I tag my information

4. Data processing

1.	I am able to interpret information from multiple sources
2.	I am able to analyse information from multiple sources
3.	I am able to synthesize information from multiple sources
4.	I am able to write an appropriate response to a post
5.	I am able to use ICT to design or create new information from information already acquired
6.	I am able to visually organize data for learning purposes
7.	I can represent knowledge in a variety of ways such as PPT, website, blogs, etc.
8.	I am aware of the difference in written, graphic or video representations

5. Teamwork

1.	During the preparation of a joint task I know how to fit in among team members
2.	During the preparation of a joint task I share my thoughts and insights with my peers
3.	During the preparation of a joint task I know that I have an influence on the work process
4.	During the preparation of a joint task I know what is expected of me
5.	While performing a joint task I feel that my contribution to the team is meaningful
6.	My peers are aware of my abilities and of what I can contribute
7.	I have no reservation regarding joint tasks
8.	I like to work with my peers on a joint task

6. Integrity awareness

1.	I understand the ethical consequences of the use of technology
2.	I understand the social consequences of the use of technology
3.	I do not acquire digital information, files, programs, databases, etc., via illegal means
4.	I do not use technology for purposes that are intimidating or threatening
5.	I am aware of the prohibition of illegal file download
6.	I am aware of copyright issues
7.	I am aware of appropriate acknowledgement of sources I use
8.	I am aware of the danger to my data of being online
9.	I am aware of cyberbullying issues
10.	I am aware of identity theft issues
11.	I am aware of e-theft issues
12.	I am aware of the danger of my online activities
13.	I am aware of the influence my online data has
14.	I am able to identify/avoid online fraud or identity theft situation
15.	I am able to protect myself from online predators

7. Social Responsibility

1.	I adhere to the rules of discourse and proper behaviour in social networks
2.	I make sure not to reveal information about organizations without consent
3.	I make sure not to hurt others – people and organizations – online

Appendix 2: Items with low compatibility that were excluded from the final questionnaire

1. I can gather information from online databases
2. I know how to identify file types by their extension
3. Usually, I do not settle for just the results I get on the first page of search results (I also look at the following pages)
4. I can retrieve an item of information that I have previously stored on each of the devices I use (computer, phone, disk-on-key, iPad, etc.)
5. I can display information in a variety of digital configurations (such as text, graphic form, video)
6. I prefer to prepare an assignment alone rather than with friends
7. I know how to set my own schedule in order to perform tasks
8. I know the principle of Creative Commons
9. I download music and / or movies illegally
10. I do not use the web for illegal purposes

Moodle and Problem-Based Learning: Pedagogical Designs and Contradictions in the Activity System

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Abstract: This paper presents an empirical study and related activity system analysis regarding the implementation and use of Moodle specifically, and learning management systems in general, in problem-based learning. The research involved an exploration of the characteristics that defined use of Moodle at a Danish university, the reasons why Moodle was or was not used in specific contexts and the way in which Moodle use was perceived by students. Some of the obstacles and challenges identified through this study highlighted the need for a deeper analysis of the elements that characterised the activity system(s) and their contradictions in this contextual setting, leading to a consideration of possible implications for change processes. The investigation consisted of a literature review, a survey of 345 students regarding their experiences with Moodle in conjunction with a nomination for the best Moodle course, an analysis of the 178 nominated courses and interviews with four university teachers about their use of Moodle. This examination revealed that many existing Moodle activities at Aalborg University focus more on sharing information and teaching materials and less on the students' problem-based learning activities and projects. This finding is intriguing, as use of Moodle does not reflect that problem-based learning comprises the pedagogical foundation of Aalborg University's academic programme. The investigation uncovered several reasons for the lack of focus on problem-based learning in Moodle structures and content and explored them through the contradictions identified within the activity systems and between the double contextual frame surrounding the interacting activity system.

Keywords: Moodle, problem-based learning, higher education, design, literature review, empirical findings, activity system

1. Introduction

This paper rests on an empirical case study that involved a project, the objective of which was to elicit research-based insight on factors impact the use of Moodle (or similar eLearning platforms/learning management systems) for problem-based learning at the university level. We worked with a concrete level of pedagogical design factors, guided by the following two research questions: 1) What characterises the current use of Moodle at Aalborg University (AAU)? 2) How can teachers use Moodle to support problem-based learning (PBL) activities?

The case study was based on the AAU-funded PBL development project titled 'Learner-Centred Moodle Course Design: Design Factors, Differences in Perceptions and Best Practices'. In this paper, it is referred to as the Moodle Course Design (MCD) project. The project ran from January 1, 2018, to December 31, 2018, and in the early months of 2019, the first version of an online resource was finalised.

Through this work we found that the complex organisational structure, which encompasses university teaching and learning, often presents challenges to the implementation of the project's results. After the project ended, we recognised the need for more profound analytical insight and thus, we investigated the organisational implementation structures and processes through an activity system analysis to uncover the contradictions that impacted the use of Moodle for PBL within AAU. We therefore expanded our investigation with the following research questions: 1) What characterises the activity system(s) and their contradictions in this contextual setting? 2) What are the implications for change processes of this manner?

In Part 1 of this paper, we present the case study, that is, the original MCD project, its research design, the theoretical frame and the empirical investigations, as well as lessons learned from this project. This led to interesting results that provide new knowledge to this field. From the lessons learned, we developed a small online resource for the application of Moodle in problem-based and project-based learning settings like AAU. This also uncovered interesting results on an organisational note; therefore, in Part 2, we present our organisational mapping using activity theory. Here, the method applied, the activity systems analysis, and the special settings in which universities are situated that are tightly regulated by governing bodies – which we

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identify as a double contextual frame – are described. Finally, we reflect on the contradictions found in the interacting activity systems and relate them to the more concrete level of the original case study. We also relate to the actions and non-actions the university took after the project's completion. We end by highlighting the challenges and potential courses of action when working with change management structures that pertain to IT-supported learning in university teaching with respect to PBL in a learning management system (LMS) such as Moodle.

PART 1

The objective of the MCD project, according to the project application, was to create 'multimedia resources demonstrating Moodle courses and activities as the best cases nominated by students across study programmes'. AAU defines itself as a PBL university. The project was intended to create materials to facilitate the professional development of AAU teachers, for example, during the university's pedagogy course for assistant professors. Next, we outline the PBL setting in which the case study lived and describe the project's research design.

2. The case study

A case study describes how participants, researchers and others perceive a phenomenon that requires 'thick descriptions' to illustrate its diversity. If the researchers examine areas within their areas of expertise, their knowledge of the case is an advantage in the case study because they have better access to data and a deeper understanding of related issues than people 'outside' the situation, so the research benefits from the researchers' conscious and subconscious knowledge. Case studies may include one or more cases but not a traditional sample (Flyvbjerg, 2006); they are often divided into two categories: extreme cases and paradigmatic cases. Extreme cases are, for example, 'black swans' that would disappear in the statistics in quantitative research, although they certainly exist and provide insights into the diversity of the swans. Paradigmatic cases show general tendencies in a specific case that cannot be generalised but may uncover new knowledge and create new understandings about the case itself (Flyvbjerg, 2006). Case studies do not intend for researchers to be neutral and objective; rather, they should know the case intimately and describe their pre-assumptions and their biases to allow others to understand their position.

In this case, the researchers' pre-assumptions included a positive attitude about IT in general and LMS systems as supportive for teaching and learning. The researchers of this specific case were employed at AAU and, therefore, were committed to PBL, preferring this pedagogy over more traditional methods of university instruction. Hence, the researchers were biased regarding the case, as they were personally involved in the university as well as in the specific pedagogy of this university. To create distance in the study to the LMS in their workplace, the researchers excluded their own instruction and materials from consideration and based the study on mixed methods to enhance ambiguity.

The authors considered ethical issues, such as their role in interviewing colleagues, formulation of the questionnaire items and the implications of asking students to participate. As interviewers, it was important to involve colleagues with whom they did not normally collaborate in the work of the university and clarify for colleagues that they were free to decline participation. The researchers ensured informed consent to use the anonymised interviews for publication and were highly aware of the interviewees' vulnerability, which allowed the interviewers to ask about ways of teaching and utilising Moodle (Kvale, 1997; Brinkmann and Tanggaard, 2010).

2.1 Problem-based learning

AAU was established in 1974 in the rural city of Aalborg, Denmark, and now has two additional campuses in Esbjerg and in Copenhagen. The university employs approximately 2,500 academics who conduct research and teach over 20,000 students. AAU faculty represent the humanities, social sciences, engineering/science, medicine, information technology (IT) and design. Like most universities, AAU collaborates with external organisations, both private and public. However, AAU's pedagogical approach to problem- and project-based learning, known as the 'Aalborg PBL Model' (Barge, 2010), extends collaborative relationships to also involve external organisations and students when the students are working on their PBL-projects. AAU employs Moodle as their LMS.

The Aalborg PBL Model requires student learning to be based in real-life situations, often within external organisations, comparable to what Sipes (2017) called 'authentic problems'. Students formulate a question (i.e. problem definition) that addresses a practical situation and perceive the problem through the lens of their curriculum. They approach the question through relevant theories and select appropriate methods to gather empirical data. Their analyses and conclusions should answer the initial question/problem definition by providing solutions, which are often presented to the external organisation.

Problem-based learning encompasses numerous types of problems and practices. Sipes (2017) provided an overview of various PBL practices as an analytical framework and showed that a wide variety of PBL types exist, ranging from the presentation of small case examples in lectures, to assigning students to work on an entire problem case and engage in free inquiry in attempting to solve the problem for example on a given design or policy problem (Sipes, 2017, p.4). Jonassen and Hung (2015) demonstrated that varying complexity levels require multiple levels of knowledge; they argued for more attention to the problem difficulty level when designing PBL activities, asserting that PBL requires students to possess or gain insights into subject matter theories and methods through the PBL process.

Semesters at AAU are predominantly divided into traditional modules that focus on subject matter supplemented by a semester-project module that works across modules. PBL activities may take place in both modules. For example, during a software development module, students may be required to solve predefined and relatively small programme dilemmas using a few lines of code, whereas in the semester-project, they may have to contact a company, define an area of potential development and develop and theoretically address the chosen solution in the project report. During traditional modules, full-time students typically attend lectures and classes about 20+ hours/week, while during the semester-project, they take responsibility for their learning by working on their problems in groups, attending few to no lectures and instead attending supervision meetings and sometimes plenary Q&A and peer-feedback sessions.

2.2 Research design

The research design for analysing the MCD project comprised seven activities, carried out sequentially but also with overlaps, particularly between the literature review and more empirically grounded activities. The systematic literature review (Hart, 2018), conducted first, identified challenges to, potential benefits of and useful guidance for using Moodle in PBL teaching. Two types of searches were performed for the literature review: a library database search using ProQuest and a Google Scholar search using Harzing's Publish or Perish software. To ensure the review would be useful for AAU teachers, only papers containing up-to-date research that investigated the most recent versions of Moodle were included. The systematic searches were, therefore, restricted to papers published in the six years spanning 2013 through 2018 that included the words: 'Moodle' and 'problem-based learning' (plus variations) in the titles and/or subtitles. The search produced only a few research papers with concrete examples of the relationship between Moodle and PBL; several papers investigated Moodle as a technologically enhanced educational tool, but almost none specifically investigated PBL use in Moodle. Similarly, numerous studies investigated PBL and university teaching, but few explored the practical level of design and implementation of PBL in Moodle. These findings, which we carried into the ongoing project, reflected the issues of organisational technology implementation and acceptance discussed in the second part of the current paper.

As the second activity for this research, the project team held four in-depth interviews (Kvale, 1997; Brinkmann and Tanggaard, 2010) with AAU faculty. Burden, Topping and O'Halloran (2015) revealed (through a literature review and empirical investigation) that artefacts can aid in comprehensive retrospective examination of decision-making, and Akama et al. (2007) reported that artefacts in a show-and-tell format '*enabled each participant to communicate an individual understanding of complex interactions with others from within, and reflexively display their understanding of those interactions to others'* (Akama et al., 2007, p.180). During the interviews, the project members, in collaboration with the teachers, investigated the Moodle design and use strategies employed by the teachers interviewed, applying the platform as an investigative artefact. Another option available for data collection was to survey the broad teacher faculty population, but we believed the interviews extended data gathering beyond that approach. Selecting the interview strategy stemmed from our case design (Flyvbjerg, 2006), for which collecting rich and thick descriptions of everyday practices and insights into the argumentations behind actions was viewed as an important research step. Thus, to obtain a broader picture, as our third research activity we incorporated a student survey into the research design. For this survey, conducted using SurveyXact, 345 students nominated their best Moodle course and identified their motivation

for their choice. The nomination survey did not represent a traditional survey style, involving several questions to be analysed. Though the survey gleaned many responses, semi-statistical analysis was only performed to determine which course(s) received the most nominations.

Based on these results, we investigated the structure and content of the most nominated courses and the wording students used to justify these nominations. (Students had the option to nominate a course without providing qualitative details to the explain the reasons for their choice, but many did provide such details.) Therefore, an analysis (Brandi and Sprogøe, 2019) of the nominated Moodle courses and students' answers that investigated how the courses were designed in Moodle, why the students liked them and whether the students had any negative aspects to convey constituted our fourth research activity.

In addition to these pre-planned activities, the project members, during the project lifecycle, recognised a need to include experiences and materials from other sources rather than exclusively relying on knowledge from journals and similar academic research publications. Therefore, for our fifth activity, the team searched for existing practical materials at AAU and online that could support AAU teachers when using Moodle for PBL activities. As the sixth activity, the team visited Delft University of Technology (TU Delft) in the Netherlands and conducted and edited (audio-recorded) interview with a project manager for the collaborative learning environment to inspire strategies for implementing and supporting faculty in their use of Moodle. The seventh and final activity consisted of developing the concrete pedagogical findings into teaching and learning materials of various formats. These materials were posted in an online resource in Moodle.

Generally, these investigations and the analyses that followed provided new knowledge about the use of Moodle relative to PBL teaching and, more specifically, about the implementation strategies of AAU teachers and coordinators and how these strategies were perceived by AAU students.

3. Literature review

The findings of the literature review are presented according to three categories: challenges, potential benefits and useful pointers for utilising Moodle for PBL.

3.1 The challenges of utilising Moodle for PBL

Mbuva (2015) identified the following challenges associated with online teaching: hidden costs, lack of computer literacy, lack of self-discipline, not suitable for all learning styles, minimal social interaction, difficulties in staying motivated, difficulties in improving oral communication, technical problems and lack of adequate training for faculty. In general, more faculty training is needed on the use of Moodle, while onsite support and reliable Internet connections are important for both students and teachers (Mbuva, 2015).

Students are generally not pleased with their initial experiences with using Moodle, but their level of satisfaction with the platform frequently changes as they become more familiar with its functions and structures. Research shows that the more experienced students are with using the Internet, the faster they can familiarise themselves with Moodle (Mbuva, 2015; Orfanou, Tselios and Katsanos, 2015).

Most LMSs, including Moodle and even those that do not support dialogue, are designed with traditional lecture-based instruction in mind. Thus, they are not intrinsically conducive to a PBL approach (Ali, Dous and Samaka, 2015). When teaching is conducted exclusively online, non-verbal and informal communication are often missing (Stockleben et al., 2017), and with no physical presence in a classroom and communication occurring as a one-way communication system (i.e. from the teacher to the students), students find it challenging to collaborate; to ask teachers for help, guidance and supervision; and to receive meaningful feedback from teachers and fellow students (O'Sullivan and Krewer, 2015; Yu and Lee, 2016). Combining synchronised and asynchronous teaching can be difficult, but several studies show that synchronised teaching is important, as it reduces the rate of dropouts and has a positive impact on exam results (Moreillon, 2015).

Regarding the focus of this study, it appears that teachers find it difficult to define, design and structure the specifications of project and problem-solving online activities, which then makes it difficult for students to understand the goal or purpose of the project and/or activities. This situation can hinder teachers' ability to engage students in the associated online activities, which creates obstacles for the teacher in terms of following the students' progress and offering relevant feedback (Agüera et al., 2015; O'Sullivan and Krewer, 2015). Moodle

is an open-source platform that allows for the inclusion and development of plug-ins. However, creating a full PBL environment in one plug-in for Moodle is also complicated by variations in the PBL models used by educators (Ali et al., 2015).

3.2 The potential benefits of utilising Moodle for PBL

Online activities can support students in their reflections and provide teachers with insights into their students' progress. This requires the teacher to be present (visible and active) on Moodle (Mbuva, 2015). For example, if the teacher, through Moodle, becomes aware of individual or groups of students who lack knowledge about a subject, they can add material to Moodle that is relevant to that specific student or group to address the deficiency (Orfanou et al., 2015). When students can easily access learning materials and they use those materials frequently, their grades improve, according to some studies (Cardozo de Castro Junior et al., 2017). Feedback can occur within faster loops in Moodle, and long email communications can be replaced with discussion forums (Mbuva, 2015). According to Yu and Lee, '*Research shows that online peer feedback provides a less threatening environment that encourages greater and more equal member participation than face-to-face peer feedback*' (2016, p.469). As such, students will perceive the process of receiving peer feedback as less stressful when that feedback is provided online because no non-verbal communication is involved, they can read the feedback multiple times and they have more time to reflect on it. The results of most of these studies showed that Moodle can offer considerable support to students in terms of their learning (Cardozo de Castro Junior et al., 2017) when PBL pedagogies are applied and when the teacher acts as a facilitator of a learning space by applying a democratic learning approach (Stockleben et al., 2017).

When creating and using modules based on metacognitive, conceptual, strategic and procedural scaffolding, Moodle can be designed to support students in a PBL environment and enable activities that promote the development of problem-solving skills (Tiantong and Teemuangsai, 2013). Some find that essential tools for PBL environments, such as collaborative and communicative tools, are already available in the core Moodle system. Brabazon et al. (2012) developed a plug-in that supports PBL by providing personalised and context-specific learning episodes; indeed, hundreds of freely available plug-ins have been created by the Moodle community that can support the building of learning environments (Ali et al., 2015).

3.3 Useful pointers for utilising Moodle for PBL

Moodle supports various types of tools; moreover, linking to other external tools from within Moodle is a relatively straightforward process. Teachers should explore the possibilities in Moodle that best support their teaching (e.g. quizzes for training-specific terminologies, wikis and blogs through which students can share additional literature, YouTube videos) (Moreillon, 2015). Teachers can also experiment with Moodle together with their students to inspire the students to explore, on their own, what Moodle has to offer without fear of failing (Moreillon, 2015). Teachers have been encouraged to provide students with an opportunity to be co-designers of the Moodle space, as applicable to the nature of the course and project work. Engaging students in such design activities may increase their motivation and use of the materials and tools applied (Stockleben et al., 2017). Such opportunities may also be advantageous if students can provide each other with feedback and learn from each other's writings (O'Sullivan and Krewer, 2015).

According to Ali et al. (2015), advantages are associated with using Moodle's existing features and developing PBL plug-ins. First, the PBL approach benefits from Moodle's existing infrastructure, tools and features. Second, development efforts and resources are minimised. Third, the development process can benefit from the internal IT support that Moodle offers. Fourth, the approach can potentially be disseminated to other institutions (Ali et al., 2015).

Teaching goals, project information, course structure, dates and deadlines need to be communicated clearly, preferably from the beginning of the course (O'Sullivan and Krewer, 2015). When activities take place online, a facilitator must be present to support and move those activities in the desired direction (Stockleben et al., 2017), for example, being active in the students' discussion forums, which also provides the teacher with insights into the students' progress. Teachers also need to foster open dialogue, so students feel welcome to give and receive feedback, build on each other's statements and come up with wild ideas (Stockleben et al., 2017). In this vein, teachers should be equally explorative in their approach. For instance, instead of giving live presentations in class, students can prepare video presentations in advance that they then post on Moodle; their fellow students can then watch the videos multiple times, which can lead to feedback that has been better formulated and reflected upon (Moreillon, 2015).

In summary, various factors that teachers can consider when designing and carrying out the teaching process using Moodle emerged through the literature review. However, the review also revealed that some actions may lead to varied results, depending on the context in which they take place. For example, although teacher involvement in activating students is important, simply inviting students to participate in an online exchange of ideas may not in itself foster dialogue. In some situations, where the objective is unclear or where the predominant culture of the course comprises one-way communication, students can be reluctant to engage in online dialogue. In other situations, if the teacher's pedagogical teaching style (whether in a physical location or a video meeting and in the Moodle activities) generally seek student involvement, then students may be more active in responding to such invitations. Therefore, before everything else, pedagogical choices and strategies need to be clearly defined and explained to students.

4. Results of the empirical study at AAU

Next, we present the findings of the empirical study, organised according to the three points of analysis: teacher input, student input and nominated courses.

4.1 Findings from the teachers

The first phase of the MCD project involved an empirical investigation intended to discover more about existing teaching practices at AAU, including teachers' motivations for their choice of design for Moodle modules and their experiences during and after implementation of the modules. To collect these data, four in-depth interviews were conducted, which included discussions about, and post-analysis of these teacher's Moodle rooms. The interview data revealed the following about the teachers interviewed:

- They lacked information about Moodle features and the potential of the specific AAU version (as each organisation decides which elements are installed into its Moodle system).
- They lacked knowledge or inspiration about how to work with these features pedagogically and within the framework of PBL.
- They felt quite alone in terms of designing their own Moodle rooms.
- They reused the prior year's module structure, even when a different teacher had taught the course previously.
- They met with their students on campus regularly; therefore, not everyone realised the benefits of using Moodle beyond information dissemination (such as sharing slides or similar activities).

Though these findings are not generalisable to all AAU faculty, the interviewed teachers noted that the issues they had with Moodle were similar to those that their colleagues experienced and similar to what the MCD project members had heard as teachers and supervisors for assistant professors throughout the years.

4.2 Findings from the students

The second phase of the project was designed to obtain a more detailed understanding of student Moodle use and experiences. The project team (with the IT department) arranged a nomination campaign in the format of a SurveyXact questionnaire; a banner appeared on the AAU Moodle main page in June 2018 that contained a link to the questionnaire. Students could nominate their favourite Moodle course and present an argument to defend their choice. These written arguments provided insights into the students' priorities in relation to the use of courses on Moodle. A total of 345 students completed the questionnaire, and 178 Moodle courses were nominated. The nominated courses were exceptionally varied in their subject matter, faculty, length, number of students (class size) and European credit transfer system (ECTS) size. Although the nominations provided a significant amount of data, they may not be statistically representative of the 20,000 students at AAU. However, they did provide in-depth understandings of the elements of AAU Moodle courses that students like and find meaningful.

The students' written arguments supporting their nominations were analysed. Most students answered directly to the objective of the survey, indicating the courses they nominated made good use of Moodle. However, a closer examination of the survey responses showed that some students were also critical. One student wrote: *'This way of collecting information is biased. You only want positive feedback. Moodle works very badly. There is not one single module where Moodle is used well'.* Another student stated: '*None of them [teachers] have used it much, and none of them have done it well. Therefore, no module can be nominated'.* The survey provided space in which students could provide such critical feedback, which the answers themselves reflect, and we found this

information from the students quite valuable. Also, in the preliminary analysis of Moodle courses, we discovered some courses that reflected almost no activity; moreover, in some courses, the few activities that did exist were not explicitly presented (with purpose or introduction), nor did they appear to be pedagogically designed. Thus, from these two data points (the students and the course analyses), we discovered that many AAU courses did not utilise Moodle to its full potential as a learning resource. Rather than further investigating the modules that did not make the best use of Moodle, the team turned to further identifying and analysing the courses that seemed to effectively incorporate Moodle, according to the student survey respondents.

Most nominations were submitted by students who had had positive experiences with Moodle. One student claimed: '*I have used Moodle during all of my semesters, and in my opinion, the teachers use Moodle diligently and effectively for the benefit of my learning experience'.* Another wrote, '*Most courses used it well – can't really pick ONE since most people structured the courses in lectures (some with dates) and gave the course materials under each lecture*'. The analysis also illustrated that some students did not recommend a single course but recognised a specific teacher or group of teachers, commenting on the teachers' excellent pedagogical skills in general more so than on their use of Moodle.

4.3 Findings from the nominated courses

At AAU, Moodle rooms are used for courses that contain small-scale PBL activities and exercises and for large-scale semester projects. Some of the Moodle rooms, related to the traditional modules, contained PDFs, PowerPoints and links to digital tools and exercises that supported the subject matter of the course through teacher-defined problems and exercises. However, use of these activities on Moodle in relation to the large-scale semester projects seemed to be limited; instead, knowledge-sharing between students and teachers primarily took place on campus or, perhaps, through other platforms, such as Facebook, that were not linked through Moodle.

The students who nominated a course for exemplary use of Moodle often, in fact, actually nominated their teacher(s). The analysis evidenced that nominated Moodle rooms did not necessarily display advanced use of Moodle or of its use in relation to student-oriented PBL activities. Teachers who communicated clearly, structured the course plan in relation to its learning objectives and then organised materials and formulated assignments and other activities according to this plan generally motivated the students. The students also appreciated the use of a wide range of Moodle activities, such as discussion forums, quizzes and interactive videos. Very few of the Moodle rooms contained external links to other activities, such as further interactive materials, collaborative resources like google documents, video conference rooms or similar external activities.

The analysis showed that, in general, the AAU courses did not make use of activities that can activate and inspire students' activities through Moodle, and only a few employed collaborative or peer-to-peer activities. Most of the Moodle rooms instead were used to provide students with an overview of the course and predominantly worked as one-way communication channels. Most rooms also contained a forum through which teachers could broadcast messages to all students enrolled in the course. However, only a few rooms exhibited evidence of communication 'loops', in which students interacted with the teacher and other students, asked questions and received responses and evaluations. Collaborative communication patterns that allow students to answer other students' questions and comments and partake in dialogue were rarely present in the Moodle rooms.

5. What was developed

Communicating the findings and results of this study to AAU teachers and programme coordinators was a central goal of the project. Consequently, an online resource was developed called 'How to do PBL in Moodle'. This online resource addressed some of the issues and needs identified during the research process. Figure 1 presents a poster that illustrates the project and resulting Moodle resources generated. The Moodle room was designed to inspire teachers in designing their courses on Moodle and for use in other pedagogical contexts, such as AAU pedagogical courses or one-to-one sessions between teachers and IT-pedagogical consultants. The design was based on a micro-pedagogical perspective that focused on how Moodle and its functions can be used in relation to the findings of the literature review (Section 3) and the analysis of the empirical data (Section 4).

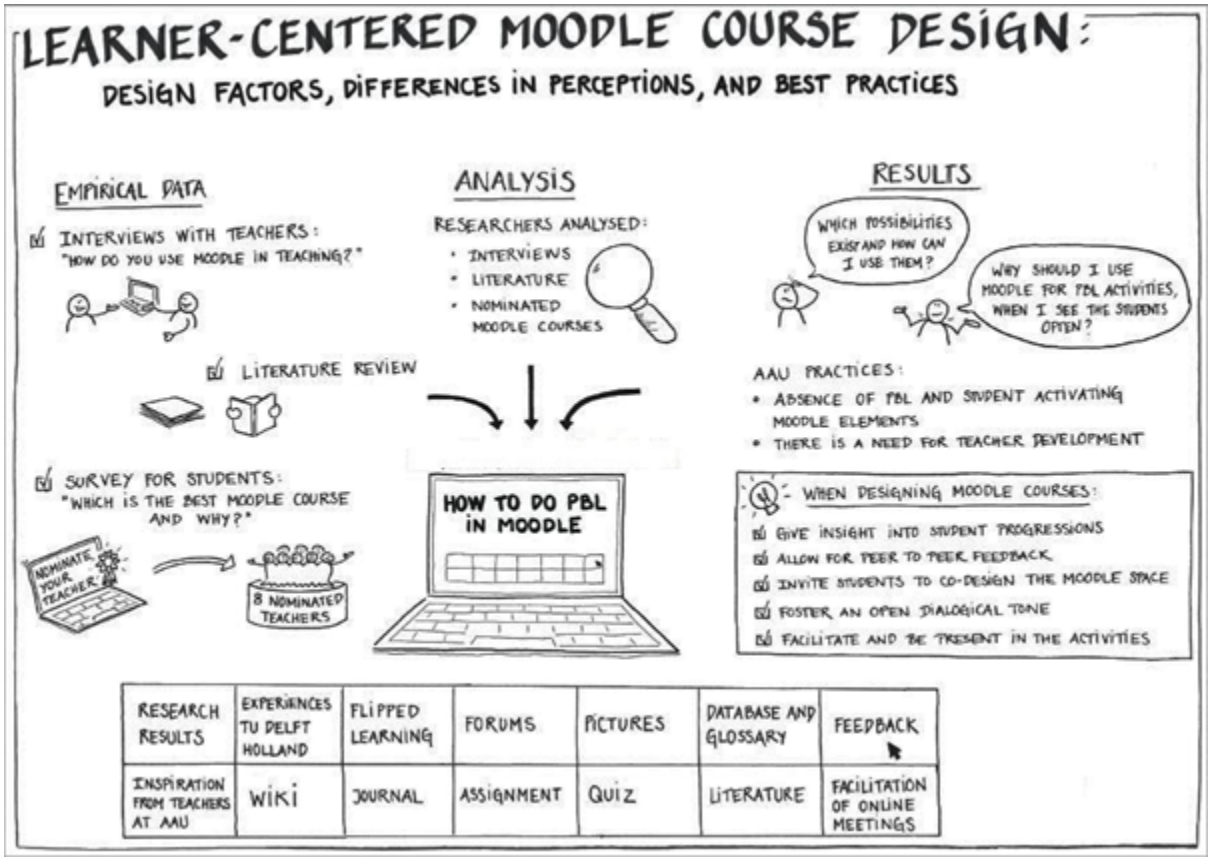

Figure 1: The MCD project, process and products (Source: Created by Heidi Hautopp and the team through a graphic facilitation process). ©MCD Team, 2019

With permission from the nominated teachers, direct links to the eight Moodle courses that received the most nominations were included in the Moodle room designed as part of this project, thus enabling other AAU teachers and coordinators to view and draw inspiration from these real cases. The project members also added appropriate materials and developed videos and texts to illustrate how to utilise specific Moodle functions and tools for student-oriented and PBL activities (e.g., blended learning formats and digitally supported campus teaching), as these elements were not prevalent in the nominated modules. Also included in the room were materials linked to existing internal and external AAU sources, while other materials drew on the experiences of the project members' own use of PBL-supporting activities in Moodle. Results and findings from the investigations and videos from the project members' visit to TU Delft University were also added to the room.

6. Lessons learned from the MCD case study

The analysis of the MCD empirical material shows that many AAU Moodle rooms did not use student-based or PBL-inclusive activities. Instead, the rooms primarily served solely as content holders. This poses a challenge for both teachers and students, similar to what Ryberg, Buus and Georgsen (2011) referred to as content silos that promote teacher-centred pedagogies, not collaborative learning and project-based pedagogies. The use of Moodle rooms as content holders may also constitute a problem for AAU students during their large-scale semester projects. Here, they are supposed to use knowledge gleaned from the traditional modules, though such knowledge was not easy to locate across the different Moodle rooms (modules). Perhaps this situation is a consequence of what Ali et al. (2015) referred to, namely, that Moodle was designed with traditional teaching in mind and that the traditional teaching approach does not necessarily adapt well to PBL approaches.

The findings raise the question as to how Moodle can be used for PBL activities when many educational programmes at AAU are full-time, day study programmes. Employing technologically enhanced learning via Moodle for PBL activities does not seem to be a natural choice for faculty when they teach and meet with students in real life. At AAU, students visit the campus almost every day during the semester. Teachers may find that students' physical presence makes them reluctant to utilise Moodle to a greater extent. Also, a large

proportion of the instruction at AAU takes the form of supervisory teachings due to the PBL model. Though some use Skype or similar tools, supervision primarily takes place on campus.

Thus, both opportunities and challenges were present in the application of PBL activities to Moodle. If teachers feel competent using Moodle tools and can foresee a meaningful strategy for these tools within their teaching, then Moodle can support their overall learning approach, as highlighted by Cardozo de Castro Junior et al. (2017) and provide a meaningful space for students' PBL activities.

During the MCD project, multiple local AAU-developed guidelines and experiences were located regarding the use of Moodle, such as technical materials (on the AAU website); additionally, we were directed to pedagogical materials from past AAU PBL development projects. We discovered that relatively few from the faculty appeared to be aware of these materials, as they seemed to be unused. From our research conducted with other universities and educational institutions, both nationally and internationally, we found that this situation is the norm rather than the exception in most such settings. Although these materials are sometimes known to management, teachers are not aware of them. This raises the need to discuss and determine a strategy for how to assemble, communicate and make the most of such initiatives.

PART 2

7. Investigating organisational implementations through an activity system analysis

Learnings from the MCD project pointed to a complex organisational structure as the basis for using Moodle at a PBL university. We used Engeström's activity theory to map the organisational structure in order to investigate and uncover the contradictions revealed in our project that impacted the use of Moodle for PBL within AAU.

7.1 Human activity theory

Yrjö Engeström developed the theory of the human activity system, upon which this investigation built (Engeström, 1987; 2001; 2011). Problems, contradictions and conflicts caused by the historical development of the organisation prompt a need for change and can act as starting points from which members of the organisation can learn. Figure 2 illustrates the human activity system that comprises six components: subject, object, instruments, rules, community and division of labour.

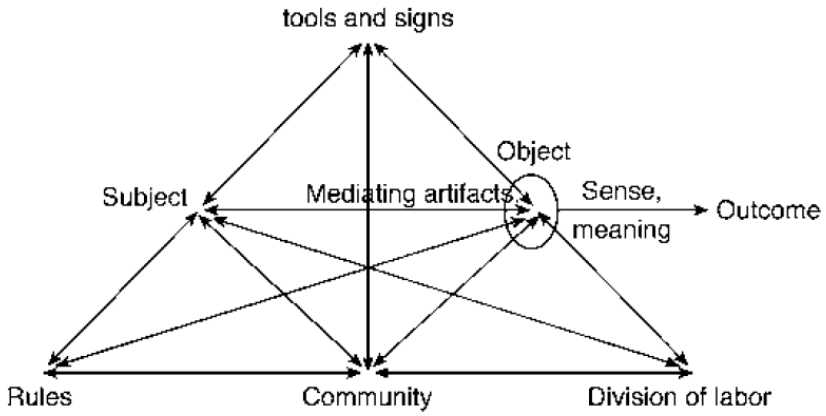

Figure 2. The human activity system (Source: Engeström, 1987, p.78)

A *subject* may be a person or group of persons striving to achieve a shared object; this process is influenced by the instruments, rules, community and division of labour. The *object* initiates and motivates the subject's activity, as the object is the purpose and the meaning of the human activity system. The object defines the direction in which the subject moves, and the object motivates the subject to strive against this object. When the subject moves against the object, learning is created. The object has the potential to change the other five elements, and it reveals internal contradictions in habits, working processes and historical development (Engeström, 1987). *Instruments* include physical tools, IT systems and language. The instruments define obstacles and enablers for the subject to achieve the object. *Rules* equate to formal guidelines and regulations as well as habits and norms. The *community* is the organisation, the line of business or the working group in

which the learning is constructed. Finally, the *division of labour* describes different community roles and obligations.

7.2 Interacting activity systems

In more complex organisations, several activity systems exist. The model in Figure 3 shows how they can relate to each other. The interesting part is that such systems do not necessarily have a shared vision or object. According to Engeström (2001), the object of activity within the interacting activity system is a moving target – the different states of the object are represented in the model by Object 1, Object 2 and Object 3 (see Figure 3). The object moves from an initial state (Object 1) to a 'collectively meaningful object constructed by the activity system' (Object 2) and, finally, to 'a potentially shared or jointly constructed object' (Object 3) (Engeström, 2001, p.136).

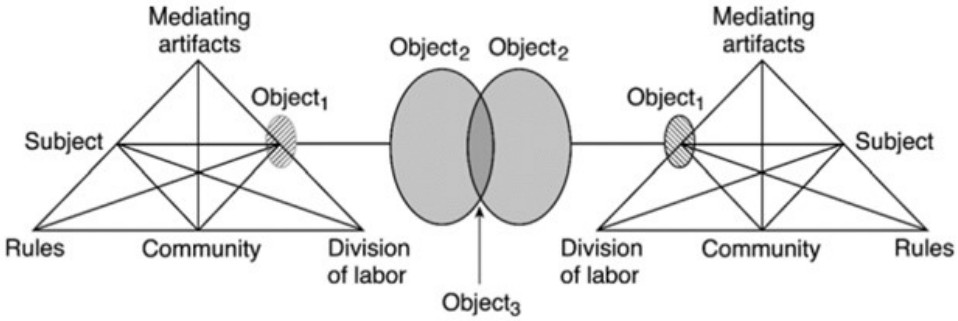

Figure 3: Model of the interacting activity system (Source: Engeström, 2001, p.136).

Engeström (2001) stressed that the human activity system provides a spectra of multi-voices, as the subject most often comprises a group of people with different experiences and perspectives, which they express in varying ways, and that changes in the activity system are driven by the following four types of contradictions:

1. Primary: Contradictions within a component
2. Secondary: Contradictions between different components
3. Tertiary: A culturally advanced object externally influencing the system
4. Quaternary: Contradictions in the relations between different systems (Engeström, 1987)

8. Analysis of the AAU activity systems as it pertains to PBL and digital teaching/learning

Data from the project reflected four systems but primarily informed about two activity systems: the teacher system (T-system) and the student system (S-system). The other two systems indicated in the data were the educational programmes (EP) and AAU. Certainly, more systems exist within such a large, complex organisation, but from a PBL and digital teaching/learning perspective, we found these systems to relay important factors. The subject of the T-system consists of the people at AAU who are in contact with students through teaching and/or supervision. The subject of the S-system is the people who attended the different educational programmes offered at AAU. The relation between the T-system and S-system can be considered asymmetrical due to the inherent authority that the T-system has over the S-system. On the other hand, the S-system, due to the impact that passing an exam/module has on a student's education, can make demands of the T-system related to preparing them accordingly.

8.1 The Educational Programmes and Aalborg University as a double contextual frame

The data in this project primarily informed about teachers and students using Moodle for PBL; they did not provide enough information to describe the activity systems of EP and AAU in detail. It was, however, apparent in the data and the tensions we encountered that these activity systems had an impact on the T-system and S-system. Therefore, we have represented the EP and AAU activity systems as a double contextual frame surrounding the teacher and student activity systems. On a broad level, AAU is influenced and governed by the laws pertaining to universities in Denmark as well as by the economical setting. The frame in some ways acts like a 'culturally advanced object' influencing the T-system and S-system, and tertiary contradictions arise when it is introduced, which we expand upon in our discussion. Analysing the impact between this frame and the two activity systems adds to a better understanding the use of Moodle for PBL at AAU.

8.2 The objects of the interacting activity systems

Like most universities, AAU maintains a digital strategy (AAU, 2018), and through the frame, it impacts on the T-system; therefore, Object 1 in this situation can be defined as 'digitally supported teaching'. From the perspective of the S-system, the students chose to attend this specific university, which, like most others, offers digitally supported teaching; therefore, Object 1 can be defined as 'digitally supported learning'. As described previously, Moodle was selected by AAU as the university's primary technological tool and the official LMS. Through the frame, the use of Moodle impacts the interacting activity systems – T-system and S-system – and all teachers are required to use the AAU version of Moodle with the chosen templates and plugins for their classes. Moodle then becomes an access point for all students when attending AAU. For the T-system, Object 2 can be defined as 'use of Moodle in one's own teaching practices - with Moodle as a prerequisite' and for the S-system Object 2 can be defined as 'Moodle as an access point to learning – with Moodle as a prerequisite'. As described in Part 1, AAU uses PBL as its primary pedagogical approach, and student learning is required to be based in real-life situations; thus, Moodle becomes a tool for PBL. For the interacting activity system and through the impact of the frame, Object 3, the potentially shared jointly constructed object (Engeström, 2001, p.136), therefore, can be defined as '(joint understanding of how) Moodle supports PBL'.

8.3 Mediating artefacts

In educational research that applies Engeström's work, we see how artefacts pertain to different levels of use, (and here as inspired by among others Leadbetter, 2004). One level is Mediating Artefacts as methods, where artefacts are used as signs which guide and direct processes and procedures towards the objective. The other level, is Mediating Artefacts as tools, which are used to identify and describe the objects.

In this light, within the T-system, PBL can be considered a mediating artefact as methods. PBL is a pedagogical method, and includes both teaching approaches as well as student participation. In addition to PBL, each teacher employs different methods and didactics to support PBL within their education and specific topic. They also supply students with theories from their areas of expertise in alignment with the curriculum of the education. Digital tools are also part of the Mediating artefacts in use at AAU, both hardware as mobile devices, computers, and also different software, as the LMS Moodle. Teachers can exert control over some artefacts and choose whether to use them; others are dictated by the frame.

Students attending AAU have chosen to attend a PBL university (for some probably a more explicit choice than for others), which makes PBL an essential part of the mediating artefacts within the S-system. They share the digital tools described previously, although they often have different prerequisites for using them than teachers, which can be due to knowledge, experience and attitudes towards technology.

8.4 Rules

The T-system is impacted by the frame EP and AAU as well as by rules dictated from outside the systems of AAU. This is seen in how the Ministry of Education & Research and AAU direct educational programmes via economical support and regulations about preparation time per type of teaching method, or in how PBL and digitalisation must be visible in the study regulations. However, teachers are also able to impact the frame as coordinators and members of study boards, where they, on a micro level, can decide the educational design. Also, pedagogies and teaching methods chosen within the specific module, and even within each session, are largely decided by teachers, provided they fall within the broader frame of PBL and comply with the study regulations. In addition, norms form over time (historicity, Engeström, 2001, p.136) concerning teacher–student relationships, groupwork and how to approach teaching within an education and/or faculty. Some of the rules impact the T-system from outside the activity system of AAU; moreover, some rules, such as General Data Protection Regulation (GDPR), apply to both research (when applying research-based teaching), students' projects and handling students in general.

The rules of the S-system are both explicit and implicit (Engeström, 1987) and heavily impacted by rules from outside the activity system of AAU, such as GDPR, and the factors mentioned concerning the frame. The rules of what it means to be a student at a university in Denmark, from the application process to earning a degree, are largely governed by laws and guidelines dictated by the Ministry of Education. As in the T-system, students can impact the frame on a micro level by joining study boards and taking an active role in evaluations, which can impact the educational design of the programmes. In addition to the rules from outside the activity system of

AAU, PBL, groupwork, the curriculum of the different programmes and the norms of the faculty all affect the rules within the S-system through the frame and, similarly, the historicity of norms and values.

8.5 Division of labour

The conditions of the frame (see Section 7.1) and the rules (see Section 7.4) constitute how the organisation is structured. Due to the organisation's size and the lack of homogeneity among teachers (different disciplines, department cultures and employment positions), this area is quite complex. We have found in this context both horizontal and vertical divisions of labour (Engeström, 1987). Horizontally, teachers are assigned to teach courses in varied academic programmes and multiple semesters, though often within their research field or at least within a related subject area. Vertically, there are different roles when teaching, such as being responsible for a semester or module and consequently the Moodle content, or being a guest teacher within another teacher's Moodle room. Furthermore, teachers are also often vertically distributed to other tasks, such as research or administrative/managerial tasks at AAU. A smaller group are part-time teachers, who have jobs outside AAU (in companies or at other universities/colleges). As described in rules, impact can be made on the frame regarding divisions of labour as coordinators and members of study boards.

Academic programmes at AAU are separated by faculties and study boards, the S-system is as such influenced by the same conditions and the vertical division of labour as in the T-System. Due to the vertical separation students primarily work within their own education and rarely across different disciplines. Within the fields of study you have a more horizontal division of labour as the students are separated into semesters, and here work with other students within the same semester. Again, through evaluations and joining study boards students can, as describe in rules impact the frame.

8.6 Community

Within the T-system, a teacher can be a member of several communities, some aligned with each other, others more at odds with each other due to differing priorities. A teacher operates within one or more academic programmes, an institute, a faculty and the university. In addition, as a researcher, a teacher is also part of one or more research groups and laboratories that can be developed across institutes and academic departments. The priorities of the research community may not agree with those of the teaching-oriented communities, and although teaching experience is a prerequisite for a tenure position, it is the faculty member's research that gives true merit to a career path towards tenure and professorships.

As described in the section on division of labour, students are divided into semesters and study groups, which affects the community within the S-system. They are also affiliated with the institute and faculty, but usually more loosely. Through social activities, they can also be part of student organisations both within and outside the university.

9. Discussion

In the following we only touch upon the contradictions in a way that highlights the use of Moodle for PBL both within the interacting activity system and between the systems and the frame. Within the mediating artefacts, rules, division of labour and community in the S- and T-systems, and between the two interacting activity systems, several primary, secondary and quaternary contradictions arose based on priorities, attitudes and experiences with using Moodle for PBL. For example, the priority placed on research (in the teachers' career paths and the frames with explicit attention on external funding) as described can be at odds with the T- and S-systems' objectives to fully utilise Moodle for PBL, causing contradictions within the system. The impact of the frame as well as from outside the AAU system can also promote various contradictions, especially when it comes up against the individual approaches regarding both teaching and research. This can also lead to contradictions involving other components of the system, such as community. Similarly, students have implicit rules about what it means to be a student as it pertains to participation in class, groupwork and social activities, which also can cause contradictions.

Several of the contradictions can be traced back to the impact of the frame on the interacting activity T-system and S-system, such as an impact that acts like a 'culturally advanced object' (tertiary contradiction). We can conclude that many of the contradictions that arise within the interacting activity system do so because decisions often are made within the frame and outside the system. Due to the great influence and impact of the frame, as well as influences outside the AAU system on the interacting system and on the individual system, it can be

difficult for both the individual systems and the interacting system to engage in expansive learning because the model of expansive learning is based on the premise that the setup of the activity system can be changed and the potentially shared jointly constructed object (Engeström, 2001, p.136), based on what has been described, can be questioned.

During the end of the MCD project and in the months that followed, AAU investigated and established a centre for digitally supported learning with central and local members at the faculty level, identifying the objective to work on the macro, meso and micro level of the university (Horst, 2012, p.7). So far initiatives from the central unit have mainly been concentrated on the macro level, that is, related to the strategic level of the university. The centre works from an understanding of the micro level and develops recommendations for the macro level based on the frame of anchoring PBL and the use of Moodle. The frame then determines the suggestions to be implemented throughout all of AAU, providing knowledge and suggestions to the strategic educational board on how to work with and integrate PBL and how to incorporate digitisation into the AAU academic programmes, which the strategic board then initialises work on, via the study boards and the study regulations. Initiatives from the local unit that we are members of (humanities faculty) have primarily worked on a micro level supporting teachers in their teaching approaches, via courses and mentoring in specific modules, i.e. how to use peer grade pedagogies for a specific topic. Our activity system analysis suggests, however, the need to address the meso level more systematically, which could be a constructive next step. Such a next step requires profound knowledge of the contradictions in the system.

As part of the project, we visited TU Delft, which has changed its LMS within the last two-three years and which is also characterised by a PBL approach. The decision makers at that university implemented the new LMS according to two central guidelines: how the LMS can make teaching easier for teachers and how the LMS can make learning better and easier for students. These guidelines turned the usual approach to selecting an LMS based, first and foremost, on economic and technical constraints and possibilities on its head. This selection criteria can act as inspiration for addressing some of the contradictions we have pointed to in this analysis and what to keep in mind, especially at the meso level.

Thus, it would be fruitful for the AAU study boards, programmes and semester coordinators to discuss the identified challenges and opportunities presented in this paper (Parts 1 and 2) to investigate how the future use of Moodle from a PBL perspective can be incorporated into their specific programme. Such developments should, according to Tiantong and Teemuangsai (2013), rely on knowledge of the subject matter and a close theory–practice relationship as well as knowledge of IT-based learning pedagogies and learning design processes, to scaffold the students' progress.

10. Conclusion

Based on the research questions, an important finding from the project is that regardless of which Moodle course design or activities teachers choose, the choice must be rooted in pedagogical reflection, as highlighted by Tiantong and Teemuangsai (2013), and the content and activities used in Moodle must be clearly communicated, whether this is on a micro, meso or macro level (Horst, 2012), not only to ensure clear objectives and expectations for students' work, but also to exhibit these to the students in Moodle, as suggested in O'Sullivan and Krewer (2015).

The paper presents insights into teachers' and students' experiences with Moodle, especially in relation to PBL-activities at universities. The discussion raised questions of concern as to how the organisation can support faculty in using Moodle for PBL activities, addressing the contradictions found in our activity system analysis. Furthermore, contradictions arose as dilemmas or challenges in priority, such as when implementation of a new pedagogical use of technologies requires efforts that may conflict with endeavours to secure research merit. Perhaps the unfortunate coronavirus pandemic crisis that triggered the fastest and most comprehensive implementation of online learning, including PBL across AAU, can, from a long-term perspective, provide a basis for investigation into the many practises and their potentials and challenges.

Finally, the paper provides other higher education institutions with knowledge on Moodle use, including what is at stake; defining areas to discuss, highlighting competence-development initiatives and design strategies to consider; and illustrating that there are contradictions that educators, the leaders \ management and also the administration should be informed of.

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The Convergence of Online Teaching and Problem Based Learning Modules amid the COVID-19 Pandemic

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Abstract: There is a convergence unfolding between two formerly unique and separate areas of teaching research methodology: distance education and problem-based learning (PBL) environments. Much has been published on each field independently, however, in the modern-era of online, distance, and hybrid educational programs there is a need for more case and experiential-based learning activities which can effectively measure stated learning objectives. Trends in education have led to the development of various methods to instruct courses and conduct research online. Teaching research methodology and pedagogy have evolved to include video capture, remote conferencing, and other real-time communications techniques allowing faculty and students to collaborate across great distances. Meanwhile, PBL environments have been used extensively in teaching medicine, clinical practice, law, business/management, and many other disciplines to improve student learning. This has been further accelerated during the COVID-19 pandemic through the use of technologies like Zoom, WebEx, GoToMeeting, Google Hangout Meet, etc. and the availability of PBL-ready environments in breakout rooms and asynchronous simulated projects. Student preference data from 2020 are reported as part of this study. One example of this merger between online delivery and PBLs was the development of a PBL statistical process control (PBL-SPC) module. A cross-functional academic team was created across both a college of business and college of education in which a PBL-SPC module was developed based on a real-life situation in which students immerse themselves in a potato chip factory environment. The motivation for the PBL-SPC was that this is a challenging topic to cover which students often find difficult to relate to and/or boring. Three different scenarios were developed and students, as individuals or in teams, must traverse the simulated factory to assess the situation. Learning outcomes are measured by the course instructors and the PBL environment is being used by faculty around the world. Additionally, the PBL-SPC module has now been scaled to other applications such as six-sigma simulated project training during the COVID-19 pandemic. Pedagogical methods should be interactive, stimulate learning, improve the learning outcomes / critical thinking, and enhance student experience. This paper proposes that merging the effective and tech-friendly pedagogical methods of PBL-SPC, with the right modalities and model of online delivery, can help achieve these aforesaid goals. Even more, it can deliver a great opportunity to educators and institutions worldwide for advancing the reach of education.

Keywords: Online Education, Distance Education, Hybrid Educational Models, Problem Based Learning Modules, Teaching, Pedagogy, COVID-19 Pandemic

1. Introduction

The COVID-19 pandemic has dramatically spurred the adoption of online learning. This is a positive trend for educators and institutions worldwide, as it will help them move closer to achieving two vital aims: make education a public good and make quality education accessible for all. However, the spread of e-learning on its own cannot help one achieve the desired objectives. It needs to be accompanied by teaching methods that have the dual capability of improving learning outcomes and a seamless integration with current and emerging digital platforms and technologies.

Students' learning outcomes are closely related to their perceived learning experience (Prosser and Trigwell 1999), therefore it is important that the convergence of the pedagogical methods and digital technologies should be such that it enhances student experience. Secondly, a seamless technological integration is only possible when the teaching method is compatible with different modes and methods of online content consumption such as synchronous and asynchronous delivery formats, and peer-to-peer collaboration. Such a convergence will deliver an incredible opportunity for learners and institutions alike.

Historically, Higher Education Institutions (HEIs) have served as grounds for development of various mediums and methods of instructions and research, that lend themselves to wider dissemination through Information and Communications Technologies (ICT). The broader framework of Higher Education Excellence System, HEES (Vyas, 2019), discussed how HEI is on inflection points and pedagogical innovation along with the teaching

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modality which must be adopted to improve learning outcomes. Major HEIs in the United States created extension and distance education programs in the late nineteenth and early twentieth centuries to address the growing need to educate students remotely (Nasseh, 1997). Universities around the world have developed programs aimed at serving domestic and global educational markets. Some of these universities have been leaders in online education and created best-in-class programs. Many universities have extension and outreach departments which serve the local community and states in which they are based.

In the United States, the University of Phoenix is the largest private distance education provider and university in the United States (University of Phoenix, 2009; Altbach and Knight, 2007). There has been much written about Southern New Hampshire University, Kaplan University, Purdue Global, Arizona State University and others that have embraced new models for online learning.

Engineering and business distance education programs have offered an organic growth opportunity for online education. For example, in 1998 Stanford University's Stanford Center for Professional Development announced the first entirely online degree program in electrical engineering (Salisburg, 1998). In addition to entirely online degree programs, hybrid programs which include both on-campus and off-campus work remain popular. The communication mediums available have historically included traditional classroom instruction, correspondence via mail, radio, television, VHS cassette tape, CD-ROM, DVD, the Internet (e.g., streaming video and media), and most recently online meetings (e.g., Zoom, WebEx, GoToMeeting, Google Hangout Meet, etc.). There is also much to be said about synchronous and asynchronous delivery (Miller and Webster, 1997; Davidson-Shivers et al., 2001).

The years following the 2008 financial crisis saw a surge in the growth of e-learning. The primary drivers for this growth have been the ballooning cost of education, globalization, and the advent of disruptive technologies like big data analytics, artificial intelligence, and the Internet of Things (Kortuem et al., 2013). The COVID-19 pandemic in 2019-2020 acted as a super-catalyst for e-learning's growth, seen in the exponential increase in the usage of remote-conferencing software such as Zoom.

1.1 PBL for improved outcomes

One major learning that many universities and their faculty can use to further advance their online education offerings is the use of problem-based learning (PBL) models. In PBL, students use "triggers" – in the form of images, media clips, or a simulated environment – from the problem case or scenario to define their own learning objectives (Wood, 2003). PBL uses appropriate problems to increase knowledge and understanding. This application based and PBL models provide students with an immersive experience. It also shifts pedagogy from conventional test-based education programs offered by most on-campus and online institutions to a method of solving problems that has a real-world application. Moreover, the PBL method can be integrated with – and attuned for – the required university, college, program, and course-level learning objectives and outcomes. PBL is an application-based learning system designed to cultivate discussions and increase retention rates amongst students, with numerous examples from medicine (Razzak, Hasan, and Stephen, 2020), veterinary medicine (Howell et al., 2002), physical therapy (Van Duijn, 2004; Walker and Leary, 2009), business (Bumblauskas, 2017), general contexts (Hung et al., 2008), etc. Further, PBL lends itself to a seamless integration with digital platforms like Zoom, WebEx, GoToMeeting, etc. and their specific features like breakout rooms and asynchronous simulated projects.

This paper presents the findings from the utilization of a PBL module in both in-person and online courses. This article also provides a roadmap for deploying online education programs with PBL modules that can be used both synchronously or asynchronously with modern technologies such as Zoom and the various learning management systems (LMS), such as Blackboard, Canvas, Moodle, D2L, etc.

2. Literature Review

Over the past 20 years, improvements in video capturing technologies and delivery methods have created a marketplace for undergraduate and graduate coursework and research, particularly for engineering, medicine, and business education. Research has been conducted on the positive and negative aspects of hybrid and online programs for students (El Mansour and Mupinga, 2007), where flexibility in the class schedule, instructor availability, and online interactions were cited as positives for both online and hybrid courses while technology hiccups and a sense of unfamiliarity with the online environment were cited as negatives. While initially

contained to executive and corporate business programs -- with a specific case study on the Harvard Business School Executive Education model (DeLacey and Leonard, 2002) -- it has been shown that new on-campus residency components can enrich the student experience providing the ability for students to complete some coursework and requirements remotely while still providing on-campus work to stay connected to the institution, faculty, and peers. In addressing restrictions due to the COVID-19 pandemic, virtual offerings are being used to replicate the on-campus experience as much as possible. This is being done in conjunction with, or in place of, the face-to-face instruction mode as the latter will continue to remain a challenge until the U.S. returns to normalcy.

There has also been research conducted more specifically related to the typical business school case study method delivered through hybrid modes and formats (Webb et al., 2005) and with respect to perceptions of e-learning tools and techniques (Ahmed, 2010). Examples of project types delivered through these formats include senior design, capstone projects, and live client projects. A comprehensive review of live-client project literature has been published (Bumblauskas et al., 2015; Bumblauskas, 2018). Design research has also been explored by Cronje (2020a).

Howell et al. (2003) propose that programs need to accommodate the needs of their 'customers' such as full-time employees and students who need to fulfill family obligations. This notion of the student being considered a customer is a controversial subject in higher education (Browne et al., 1998; Wallace, 1999). However, as noted in the surveys detailed below in section 3, students exercise their choices as consumers when selecting from a menu of options between face-to-face, synchronous online, and asynchronous on-demand content. This is an example of the type of market pressure that is likely to compel universities to "adapt or die (McCallum, 2001)" as students will increasingly seek out providers that will offer multiple delivery modes. Statistics and trends cited in the Howell et al. (2003) study include the educational background of students, their demographic profiles, the impact and required transition of faculty, the role of technology, and competition in the workplace provide – datasets and insights such as ones presented in a consumer survey report. For example, the authors note that female and adult students constitute a larger share of the college age population -- with the University of Texas-Austin (Wong, 2016) being one of the first major universities to report on this back in 2003 -- over-shadowing their male peers across the U.S.

Descoteaux et al. (2009) discuss the importance of on-campus residency in detail, where they show that the incorporation of on-campus residency components, either mandatory or optional, helps build a sense of community involvement with the institution and colleagues. Business schools often utilize residency requirements to bring students together to work on cases or practical examples. The same concept can be applied to engineering education to solve problems or investigate specific scenarios, education students in practicums and student teaching, etc.

The growth in demand for continuing education through executive programs and certificate courses has inherently required vast changes in all educational and training infrastructures for corporations and HEIs, with Allen and Seaman (2011) publishing the results of a contemporary online education survey study. Continuing education has been gaining both notoriety and acceptance (Haynie, 2014), suggesting that institutions need to continue to rapidly improve their offerings to stay both financially and qualitatively competitive. The HEIs pioneering continuing and distance-education programs will continue to have a first-mover competitive advantage. There have been some studies conducted on the perceived learning outcomes from online education which "may be useful as a pedagogical tool for instructors planning learning ventures or to justify technological expenditures at the administrative level" (Eom et al, 2006, p.229).

Today, terminologies such as blended learning (Cronje, 2020b), hybrid delivery, flipped classrooms, etc. are prevalent in pedagogy and the literature. In terms of the impact of the COVID-19 pandemic and trends in e-Learning, at least one comprehensive literature review has been conducted by Valverde-Berrocoso, Garrido-Arroyo, Burgos-Videla, and Morales-Cevallos (2020). It showed that MOOC (Massive Open Online Course) was the most researched e-learning modality and that the case study was the most frequently used methodology.

3. Distance Education Methods, Marketing, and Study Findings

Computer technology and streaming have been among the most influential drivers in the growth of distance education. One staggering statistic illustrates its potential: 50 percent of all Chinese engineering graduate in

their profession via a distance education program (Capper and Potashnik, 1998). But there are challenges in scaling technologies and not all countries have access to the same technology and communication resources and instructor training (Prasojo et al., 2019). Students entering the job market today are no longer only competing locally; in a global economy, students are competing against their peers across the world. This increase in the global availability of business students and engineers will require leaders to differentiate themselves by continuing their education with non-traditional delivery methods.

Marketing is key to success particularly for this branch of the higher education system: to attract students to such programs, HEI must effectively pitch the benefits and skills gained through the respective training programs to their potential students. When browsing any professional periodical e.g., technical trade journals, magazines, newspapers, readers are bombarded with advertisements from providers of distance education. Social media campaigns contain frequent advertisements for online education providers. No matter who the provider is, the methods today call for frequent communication between students and instructors via discussion-board postings and providing students situational vignettes, motivating them to solve the given problems in each scenario. The University of Phoenix and Upper Iowa University are examples of institutions that utilize such an application-based learning model. However, students and educators must be aware of the potential hazards created by this system. While discussion postings spell a wonderful approach for bringing course topics into a collaborative environment, they can detract from the actual teaching of course topics. Many online institutions do not have instructors. Instead, they have 'co-workers' or 'facilitators.' Interested students should carefully review these instructors' credentials, as some of the most frequent complaints from online students include their dissatisfaction with the program format, a misunderstanding of what is involved in the program, and a feeling that they are not learning as much as they could have through face-to-face interactions.

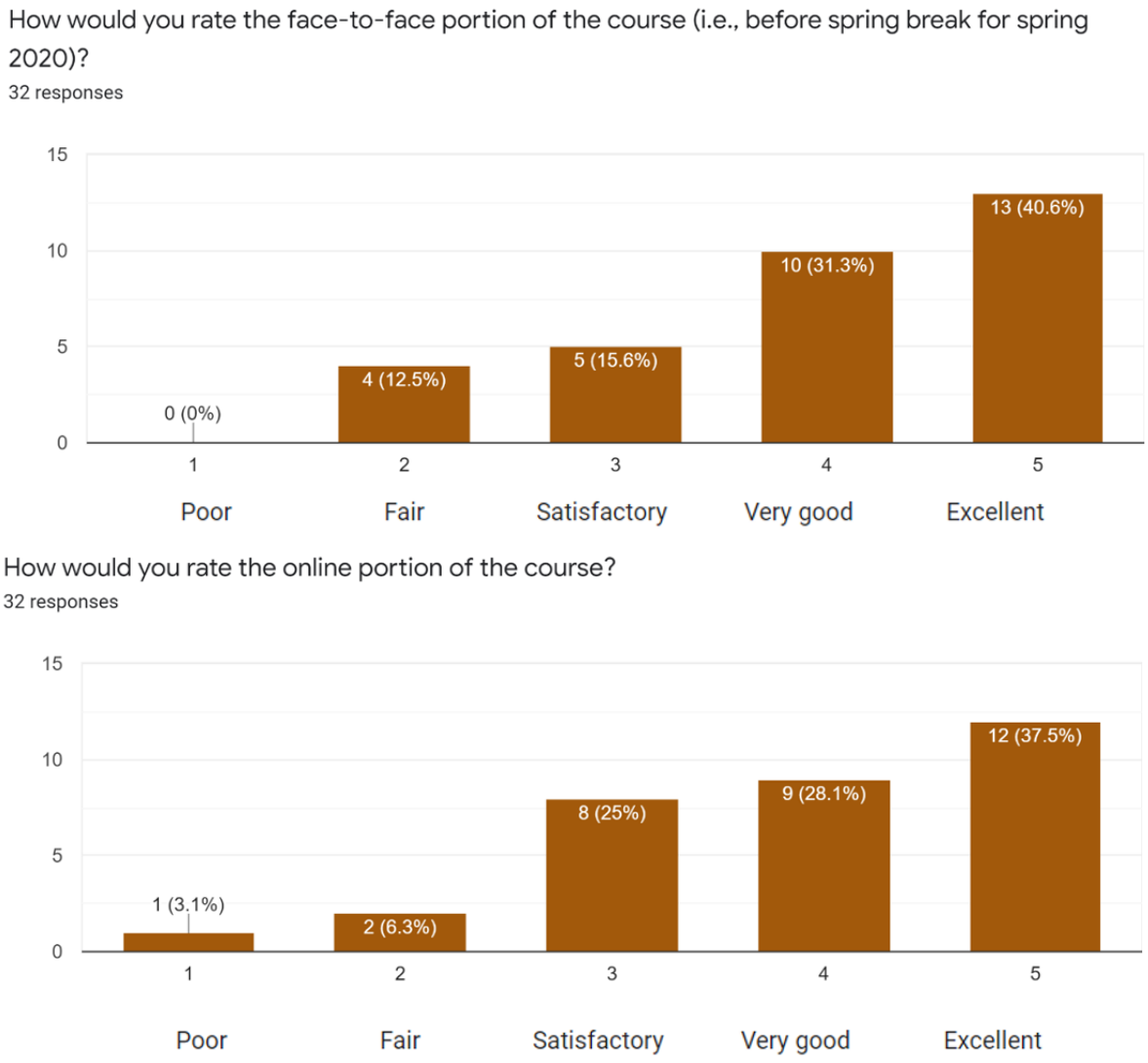
The marketing of online education is heavily dependent on student experience and testimonials; therefore, it is imperative that continuing education programs retain the same level of quality and discipline as their traditional on-campus counterparts. In fact, one of the primary concerns of educators is the poorer quality of both the material and instruction of distance and online learning. Capper and Potashnik (1998) note that this can be combated primarily by reputation and accreditation. One commonly used quality management platform for HEIs is the Quality Matters program (https://www.qualitymatters.org/). A reason for the low quality of online instructional methods and material is institutions' unwavering focus on keeping the costs low and therefore affordable for their potential audience present globally. However, the rules of economies of scale do not directly apply in this case, because of regular innovations and adoption of newer technologies is a key requisite. As the number of students increase, delivery costs are mitigated, but support costs are increased in the way of employing, for example, technical support staff and training of instructors and administrators. The emergence of instructional development or technology teams consisting of course designers, web developers, and educational technologists is becoming more prevalent every day.

How do universities market their programs to prospective students and what should students consider when evaluating potential candidates? Reputation stills appears to reign as the dominant variable in evaluating an individual's educational credentials. According to Russell (2004), surveys indicate that private and public sector analysts – including publications that rank HEI – stigmatize online degrees, obtained especially from institutions that do not have brick-and-mortar campuses. This stigma may be starting to subside (Haynie, 2014) with employers. But students still heavily weigh this factor to evaluate the quality of programs for potential enrollment. The HEI which is the subject of the article, the University of Southern California, has been an extremely aggressive marketer for their online Global Supply Chain Management programs.

Bourne, Harris and Mayadas (2005) reference the Sloan Consortium's members which offer over 600 online programs and the use of "blended" on-campus and online educational programs; reiterating the supply and demand market which has emerged from online distance education. There is fierce competition between institutions offering programs (suppliers) and students (demand), with the demand chain for any organization being particularly important (Bumblauskas, 2015), and in this case the client or customer is the student. After selecting a program, a student must consider the availability of resources to successfully complete coursework and research activities. As is the case with most academic programs, student learning outcomes are greatly impacted by the effort put into completing the requirements of the program.

The COVID-19 pandemic presented an opportunity to understand the preference of students for different modes and formats of delivery. Two different surveys were conducted using Google Forms. These surveys were deemed

unofficial course surveys as formal evaluations were suspended due to the COVID-19 pandemic. The surveys were originally conducted for teaching informational purposes only at the University of Northern Iowa. The students surveyed (n = 32 and n = 45) were undergraduates in operations management and six sigma consulting courses. We asked students to pick their preferred mode and time of the day for e-learning. It is noteworthy that, when asked to choose between face-to-face, synchronous, and asynchronous modes, significantly higher number of students preferred a recording of the teaching they could peruse when they wished, that is, through the asynchronous mode. Figure 1A and Figure 1B show rating preferences for face-to-face (before spring break) vs. online class sessions (after spring break 2020). The scale of the surveys was 1 = very poor, 2 = fair, 3 = satisfactory, 4 = very good, 5 = excellent. Figure 2 shows results of a 'desired class-time' survey (summer 2020). The survey results were indicative of a major shift towards a desire for asynchronous mode of delivery i.e., for educational content to be consumed 'on-demand' much in the way that media and entertainment contents are delivered by Netflix, Amazon Music, and other streaming content service providers.



Figures 1A and 1B: Student Ratings for face-to-face vs. online class sessions (spring 2020, unofficial course surveys)

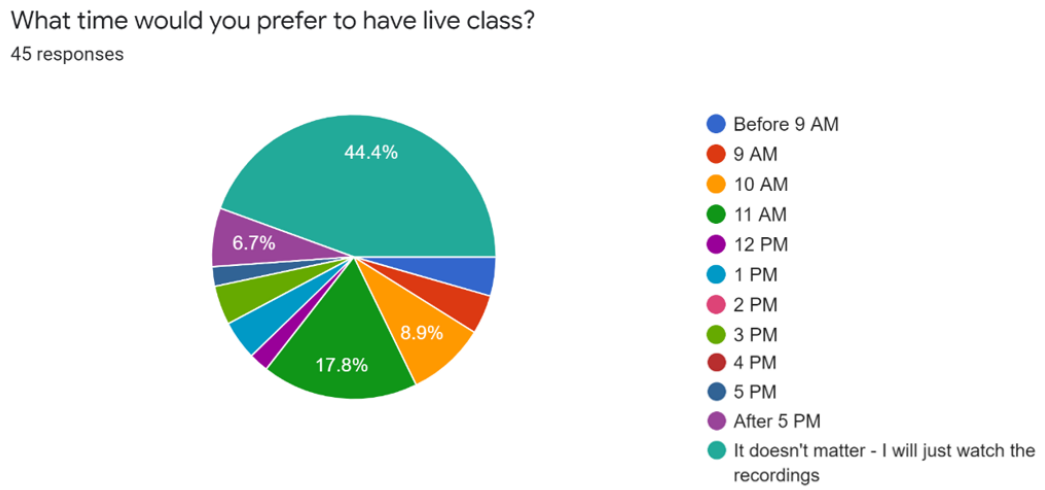


Figure 2: Student Preference for online class sessions (summer 2020, unofficial course survey)

4. Globalization and Distance Education

Institutions offering courses, certificates, and degrees via these channels include traditional brick-and-mortar universities, online or virtual universities, professional organizations, and corporations. Remote coursework has enabled the globalization of education as students anywhere in the world can access the best educational resources. The University of Northern Iowa's Continuing & Distance Education unit, Iowa State University's Engineering Distance Education, Harvard University's Division of Continuing Education, the University of Phoenix, ABB University, Eaton University, Open University (UK), Khan Academy, etc. are examples of partially remote, entirely remote domestic, entirely remote foreign, and corporate educational solutions. For non-degree seeking students, open-source initiatives such as those of MIT Open Courseware (now MITx, EdX, HarvardX, etc.), Yale University's Open Yale Courses, LinkedIn Learning (formerly Lynda), Coursera, Udacity, etc. are gaining attention from prospective students considering the ever-increasing costs of higher education. All these entities have been quite successful in their target or niche markets.

In Europe, Open University is a British university dedicated to researching and providing distance learning services to the world (The Open University, 2009). Having taught more two million international students to date, since its inception in 1969, Open University has shown that the world is ready to embrace the idea of borderless global education. The European Union, on its part, has a plan in place called e-Europe (European ODL Liaison Committee, 2004), which revolves around the growth and utilization of e-learning programs throughout the union. This policy employs information and communication technologies (ICT's, further defined by Prasojo et al., 2019) to instruct students through various sources such as radio, television, and the Internet.,

As noted above, China educates a substantial percentage of its students via distance education (Capper and Potashnik, 1998). One technique China has utilized to educate the masses is the implementation of The China Education and Research Network, or TV University System (CERNIC). Universities such as the CERNIC, which enroll many students and educate those students utilizing distance-learning curriculum, are known as mega-universities. A formal definition of mega-universities and a list of mega-universities across the globe are available from the United Nations Educational Scientific and Cultural Organization (UNESCO) (United Nations, 2005) and other researchers have studied such universities and the quality of their knowledge delivery and output (Daniel, 1995; Daniel, 1996; Jung, 2005). The largest mega-universities by enrollment are shown in figure 3 (Capper and Potashnik, 1998; University of Phoenix, 2009). It is recommended that countries continue to expand their higher education infrastructure in terms of their distance education offerings.

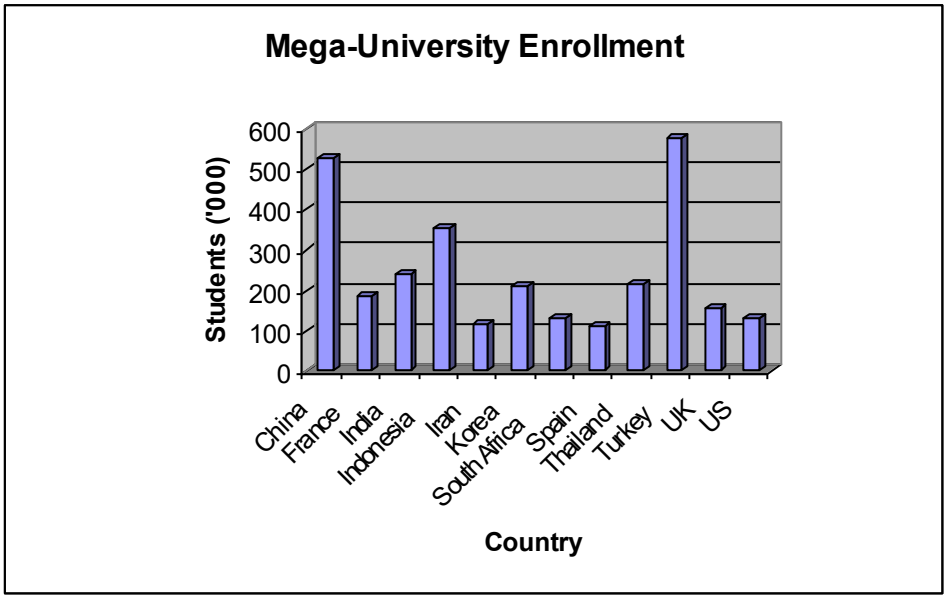


Figure 3: Mega-University Enrollment Statistics by Country as of 2005

5. Student Experience

Many distance learning programs are designed for students who may have multiple work/life commitments. The programs, therefore, provide a sufficient degree of flexibility for students to enable them to participate in coursework and research at their convenience. The most common contemporary mode of communication is Internet-enabled online coursework, delivered synchronously or asynchronously. The question of which mode – synchronous or asynchronous – will be preferred more in the future depends on a factor that plays an important role in remote learning and is unique to education: active participation of customers, that is, students. There is an on-going debate regarding the participation of remote students; some believe that online interactions reduce the level participation compared to face-to-face interactions, while others believe that they enable greater participation (e.g., students are less nervous behind a keyboard, some instructors require students to turn on their web cameras to ensure engagement, etc.). Another perceived drawback to online courses is that there are also fewer networking and relationship building opportunities. There is little doubt that face-to-face interactions remain one of the most powerful means of communication as one can pick up on body language, verbal cues (e.g., such as tone, pitch, and inflection), and the physical demeanor of others.

Emerging digital solutions offer features that address some of these gaps. Remote conferencing software such as Zoom, for example, have a reporting feature that allows for webcams to track perceived engagement and some instructors require cameras to be left on. Some of these (reportingg) features mimic traditional benefits of engagement,(observable in face-to-face meetings) to increase participation. Certain courses, for example those involving negotiations with suppliers, benefit from Zoom breakout rooms which realistically mimic today's web-based procurement process. Other examples where greater interaction has been made possible is in the use of social networking sites (e.g., Facebook, LinkedIn, Twitter) and avatar-based communities (e.g., Second Life) for education. It is generally believed that online courses facilitate greater interaction from students that would normally be perceived as introverted during a classroom formatted discussion.

The biggest advantage of online education is the unmatched flexibility of consumption that it offers. Video captures and streamed lectures and coursework allow students the ability to watch course lectures on-demand. Downloads allow students to watch lectures while traveling virtually anywhere (e.g., site offices, automobiles, airplanes, trains, home, etc.). To highlight some examples, Iowa State University's Engineering Distance Education Department allows students to download or video-stream lecture content. Harvard University's Extension School allows student to video-stream lecture content. Course learning management software (LMS) suites, such as Blackboard, Canvas, Moodle, etc. provide an interface for the coursework and serve to distribute materials with videos often hosted by Panopto. Conferencing mediums such as traditional teleconferencing services, free web-based teleconferencing services (e.g., Instant Conference), Microsoft Teams and formerly Net Meeting, Sametime Meeting, Skype, Cisco WebEx, Adobe Connect, GoToMeeting, Zoom, etc. provide tools to

have remote collaboration on projects. Skype remains a useful web-based video-conferencing tool which allows remote participants to join in real-time meetings but is quickly being transformed under Microsoft's acquisition and with MS teams.

The next frontier in online education is enablement of research that could be done remotely and collaboratively. The primary requirement for the enablement of remote research will be access to the institutional library system and laboratories. To conduct an appropriate literature review in any research area, it is critical that the student have access to adequate library resources. Most universities have some form of an e-library available to students (e.g., University e-Library, University Libraries, University Digital Repositories, etc.) and search capabilities (e.g., Google Scholar, etc.).

A lack of virtual laboratory spaces has been one of the roadblocks for online programs in engineering and medicine. To combat this issue, some instructors have begun to develop experiment kits which can be mailed to students in advance for completion of laboratory work (Moltz, 2009). The required scaling of lab-based courses, or lack thereof, has been a major challenge for institutions, during the COVID-19 pandemic.

It is important that a student can work with faculty and staff remotely following the protocols and social etiquettes as one does in a professional environment. Students need to respect the faculty, especially their time, as they would in an on-campus interaction. Likewise, faculty members need to understand the demands faced by remote students studying in an environment which is new for them, as has been for the millions of students worldwide during the last year (2020-21 in the United States). For such hybrid programs to flourish, a hassle-free crossover of traditional processes and protocols is critical. For example, the requirements established by university administrative offices, such as forms, need to be accessible for completion by off-campus students. To prevent the deterrence of prospective students, cumbersome and archaic requirements should be revised or relaxed for ease of completion. However, this must be accomplished without sacrificing any of the program requirements and quality. Any such compromise could irreversibly tarnish the institute's credibility and reputation. An effective way to ensure a successful transition is to make use of resources and recommendations provided by industry advisory boards formed by universities and the faculty of continuing education and learning programs. At many universities, for example, there are on-campus Centers for Excellence in Learning and Teaching which provide resources, services, and recommendations for academic activities and innovations.

6. Problem Based Learning Modules: A Case Study

As discussed, there are many types of contemporary online teaching methodologies being deployed across disciplines. One technique that could be deployed to improve the online learning experience is the PBL-SPC (Problem-Based Learning – Statistical Process Control), detailed by Bumblauskas (2017). A team comprised of faculty members and graduate students at the University of Missouri, with representatives from both the colleges of business and college of education, collaborated for the development of a web-based simulation. The simulation allows students to immerse themselves in a Frito-Lay ® potato chip factory environment based on Heizer and Render (2013) in their OM (Operations Management) textbook. Little did the team realize at the time how powerful this environment could be during a pandemic; as COVID-19 hit restricting travel and site visitors, this PBL model provided a great substitute to being on-site at a physical location. The original motivation for the PBL focusing on SPC was that students found this to be a challenging topic which was also difficult to relate to and boring.

The PBL-SPC – hosted at the following URL: https://sites.uni.edu/bumblaud -- provides the user with three poor-quality scenarios: crushed chips, stale chips, and poor tasting or nasty chips. Students, as individuals or in teams, must traverse the simulated environment to assess the situation. By "speaking," with the fictitious characters created in the simulation, the students get the perspectives of the manufacturing supervisors for each area. In addition, some stations have datasets which can be downloaded as .csv spreadsheets to be further analyzed using statistical process control (SPC) techniques, often in software such as MS Excel. Visitors to the PBL-SPC site can find the project's mission statement, the production line schematic, staff profiles, an operational overview and a production video produced by Heizer and Render (2013) and Munson, Heizer and Render (2017). There are supplemental materials available for the PBL-SPC such as a sample assignment description, scoring rubric, and MS Excel SPC 'solution,' spreadsheet. Individually or in teams, students work on one, two or three of the PBL-SPC scenarios available on the website (crushed chips, stale chips, and nasty taste). The deliverables

required often include an analysis of the nasty taste case and submission of the following three items: (1) executive summary or an abstract describing the problem and how the students applied the SPC to solve the PBL, (2) provide an MS Excel SPC solution spreadsheet, and (3) provide and present MS PowerPoint slides. Data analytics courses can also consider deliverables that build more sophisticated dashboards to convey metrics to be used for management decision making.

The PBL-SPC model has since been scaled and used as part of a six-sigma yellow belt program for university and industry students during the COVID-19 pandemic. The PBL environment provides for a rich simulated landscape for students to explore like a real facility or job site. There are other models of creating learning environments such as the Texas A&M's Second Life campus (Lastovica, 2012) and gamification (López Carrillo et al., 2019). The runway for this activity and the richness of the environment has proven more significant than any of the original design team could have imagined. While this is just one-use case, PBL can be scaled for all disciplines including those mentioned above (e.g., medicine, veterinary medicine, the sciences, etc.).

7. Conclusion and Future Work

This paper provides historical context, a roadmap, and a case for a PBL environment that should be considered by faculty and administrators focused on online, distance, hybrid, and blended education programs. The historical context of online and distance education programs in engineering, business, and executive delivery modes has been provided. Recommendations for ways to improve engagement such as via application based and PBL methods, face-to-face meetings and web-based substitute technologies for faculty-student engagement have been discussed. The development and growth of programs by EdX, HarvardX, massively open online courses (MOOCs), etc. create opportunities for data analytics not yet seen for online education providers. A snapshot of the type of student feedback that can mold online programs is provided (i.e., delivery mode and instructional time of day). However, online education, delivery modes, and activities also create challenges such as preventing cheating (Northcutt et al., 2016). Respondus Lockdown Browser and Respondus [Camera] Monitor are two examples of technologies in this space that are currently being deployed. More research in this area will allow for a better user (student) experience and optimization of delivery methods in the best system for the student, faculty, and administration. One specific item to be considered moving forward is the collection of additional student evaluations to gather feedback on the PBL-SPC activity. This lends itself towards the possible used of mixed methods (Azorin and Cameron, 2010) pedagogical research, linking online distance education component and the PBL-SPC.

Further, being a prominent global hub of the two important drivers that make this trend – education and technology – the U.S. can play a pivotal role in the spread of quality education to millions at home and abroad, much in the way it has helped expand the scope and reach of media and entertainment. At home this could also help address an issue that has been plaguing the U.S. education system for a long time – the escalating cost of higher education. The concept of lecturing for hours today, where attention spans are continuing to shrink, needs to be reinvented. Post-COVID world will demand that learning modality should be changed and adapted in different ways.

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Analysis of Factors Affecting the Auditory Attention of Non-native Speakers in e-Learning Environments

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Abstract: One of the most striking characteristics of e-Learning audiences is their diversity. Native and non-native learners can be expected among such audiences and therefore, when developing e-Learning courses it is important to consider the impact of the language level on learning. Specifically, non-native learners are expected to have a diminished auditory perception compared to native ones and hence reduced attention capabilities that could result in a poorer performance. In this study, we assess the impact of linguistic and auditory factors on the attention of non-native learners, namely semanticity, sentence length and noise level. An English language platform mimicking real e-Learning environments is used and attention is quantified by measuring the number of English words correctly identified during a listening task. Our results show that changes in each factor affect the attention score significantly. Interestingly, the effects of semanticity are apparent in noiseless environment, but vanish in noisy ones. Results also show that in noiseless environments, a change in the length of semantic sentences from small or medium to long causes a significant drop in the attention score. Our results demonstrate the importance of carefully accounting for linguistic and auditory factors when designing effective e-Learning courses, especially when they target global audiences and learners with different language abilities are expected.

Keywords: Auditory attention, e-Learning environment, non-native speakers, cognitive psychology, listening task

1. Introduction

The widespread use of multimedia contents and an increasing internationalisation of the classroom are two of the most prominent features of the current education landscape. Understanding their impact on learning can be critical to design effective learning experiences, especially in e-Learning environments where both features play such a central role. Multimedia contents and the internationalisation of the classroom have been a focus of interest in the education community and their impact on learning and student performance has been investigated empirically (Chang and Lehman, 2002; Guo, Kim and Rubin, 2014; Chen and Wu, 2015) and analysed based on cognitive theories (Moreno and Mayer, 1999; Cierniak, Scheiter, and Gerjets, 2009). From a cognitive perspective, multimedia approaches force learners to switch their attention between different sources and subsequently to carry out integration work. The cognitive strain associated to multimedia contents has led to a number of empirical studies that have investigated the impact of multimedia contents on learning (Fisher, Godwin, and Seltman, 2014; Aagaard, 2015) and to the formulation of guiding principles to be considered during the design of multimedia material, such as the split-attention principle (Ayres and Sweller, 2014) and the seductive detail principle (Rey, 2014). The role of the linguistic dimension in international learning environments has also awaken interest amongst the education community. Previous studies have focused on learning environments with native learners and non-native instructors (Nord, 1980; Evans and Alexander, 1984; Tseng, 1987). Adverse listening conditions such as accented speech and noise and their impact on intelligibility have been investigated by McLaughlin, et al. (2018) and the role of listeners' previous exposures to accented speech and the semantic context in the intelligibility of non-native speech has been studied by Kennedy and Trofimovich (2008). Language processing in non-native learners has also been explored. A study (Clahsen and Felser, 2006) concluded that even when non-native learners have an excellent grasp of the grammar, real-time processing of language, such as the one expected in a classroom environment, might still be a considerable challenge.

As with any other sensory modality, attention plays an important role when processing auditory information and therefore can have an impact on language processing and learning. For instance, it is well known that task-irrelevant auditory stimuli can undermine short-term memory and have a negative impact on language comprehension and learning (Hughes, et al., 2016; Marsh, et al., 2018). In addition, it has been suggested that

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the mechanism of auditory selective attention might depend on the perceptual load (Murphy and Greene, 2017; Murphy, Spence, and Dalton, 2017).

E-Learning platforms are preferred over conventional ones by younger generations (Generation Z) (Rothman, 2016) and their use has increased as a result of the COVID-19 pandemic. As e-Learning is becoming widespread, it is vital to investigate on effective ways to design e-Learning environments. Recent studies suggest that Generation Z has a limited attention span and is easily distracted by visual stimuli (Shatto and Erwin, 2017; Poláková and Klímová, 2019). In contrast to other passive process, auditory perception is an adaptive process that continuously evolves to improve the identification of new sounds, a feature that is known as auditory learning (Heald, Van Hedger, and Nusbaum, 2017). Auditory learning is even more crucial for non-native learners that are interacting with e-Learning environment, as they are continuously exposed to new sounds from a second language. Auditory attention has been linked to learning and development in children (Gomes, et al., 2000) and considered as an important factor to understand complex acoustic scenes such as the multimedia ones used in e-Learning and classroom teaching environments (King, Teki, and Willmore., 2018). Thus, understanding auditory attention in non-native audiences is critical for designing effective e-Learning environments. However, the current literature shows a lack of quantitative studies focusing on the factors to be considered when designing learning environments or giving a lecture. In this article, we investigate how auditory attention of non-native speakers in an e-Learning environment is affected by linguistic and auditory factors. As part of our design of an e-Learning experience, we create a lab controlled experiment and identify potential factors affecting auditory attention, namely background noise, semanticity and length of auditory stimuli (Compton, 1967; Killion, 2002). We conduct the study with 25 healthy participants. Our study is relevant both to the education community, as we provide additional insight that can be used when designing learning experiences, and to the cognitive psychology community, as by focusing on non-native listeners our results extend previous findings in auditory attention.

The rest of the article is organized as follows. Section 2 reviews previous literature on auditory attention. Section 3 describes our experimental setting and Section 4 our experimental procedure. In Section 5, we present the statistical methods used for analysing our data. In Section 6 we analyse the results of our experiments and Section 7 provides our main conclusions.

2. Related Work on Auditory Attention

Auditory attention became a topic of great interest in cognitive and neuroscience circles in the years following the Second World War, aroused by the documentation of cases where audible messages failed to be perceived by fighter pilots (Spence and Santangelo, 2010). Most of the studies focusing on auditory attention involved simulated multi-message environments (Anderson, 1985) and among them, the dichotic listening task has become one of the most popular settings. In the dichotic listening task, two different auditory stimuli are presented to the participants, who are asked to attend to only one of them (Ingram, 2007). After listening to the stimuli, participants are asked to write down the messages that have been previously presented to them, and the written messages are used as an indication of the level of auditory attention (Cherry, 1953).

A major focus of research in auditory attention has been the understanding of selective attention, change deafness and spatial attention. Selective attention investigates why and when the brain selects and pays attention to one of the many stimuli available (Mayer, et al., 2006; Wu, et al., 2007) and is a concept that has also been successfully applied to other sensory systems, such as the visual (Shinn-Cunningham and Barbara, 2008; Dalton and Spence, 2008). Two main theories have been proposed for explaining the mechanism of attention. The first one is known as filter theory and suggests that the brain filters useful information over useless information (Broadbent, 2013). Two opposing mechanisms have been proposed in the context of filter theory, namely early selection theory and late selection theory (Treisman, 1964). According to the early selection theory, the brain selects stimuli at early stages of information processing, whereas late selection theory suggests that the brain selects stimuli after semantic decoding only, i.e. at a later stage of information processing (Deutsch and Deutsch., 1963). The second theory which provides a model for auditory attention is load theory and it gives a plausible unifying framework for early and late selection theory (Lavie, 2005). According to load theory, selection can be at early or late stages, depending on the perceptual load of the stimuli (Lavie, 2005). Specifically, if the perceptual load of the stimuli is high, the brain will filter out useless information at early stages, whereas if the perceptual load of stimulus is low, then all the stimuli are processed before being filtered out, which corresponds to a late selection process (Deutsch and Deutsch., 1963).

Auditory change deafness refers to the mechanisms by which the brain misses information in auditory stimuli during short time intervals. Auditory change deafness is analogous to the phenomenon of psychogenic blackout or transient loss of consciousness (Fitzpatrick and Cooper, 2006) in that there is a short interval in continuous listening processes, during which the brain does not process any auditory information. Previous auditory attention studies have focused on the effect of the length of stimulus and the complexity of sentence (Compton, 1967) and background noise (Killion, 2002). The authors in (Compton, 1967) demonstrated that simple structural English sentences were more easily perceived than complex structural ones, however the length of the sentence did not have a considerable impact on it. In (Killion, 2002) it was concluded that the effect of noise on perception of speech diminishes with increased signal to noise ratio (SNR). Teraoka, et al. (2018) investigated how the spatial origin of auditory signals affect word intelligibility in complex acoustic scenes. In (Bai, Zhao, and Xie, 2019), the subjective auditory attention saliency of 20 pieces of sound material was evaluated in a psychoacoustic experiment. Their results show the importance of adapting computational models based on the characteristics of the targeted sound types. Another important aspect for education concerns joint attention, which consists of two people simultaneously and jointly focusing on an item. While our work does not touch this point, we acknowledge the key importance of human relations for learning. In the present study we extend previous experimental results by investigating auditory attention in a group of non-native listeners who are subjected to different auditory conditions in a simulated e-Learning environment.

3. Methods and materials

3.1 Participants

A group of 25 (21 male, 4 female) healthy, university students of science and technology, with no known auditory processing disorder were chosen for the study. The participants came from different nationalities (see Table 1) and their first language was different from English (see Table 2). The age distribution of the group of participants is shown in table 3.

Table 1: Nationality of the participants

Nationality	Number of participants
Algerian	1
Indian	8
Iranian	3
Italian	4
Kazakh	1
Lebanese	4
Moroccan	1
Nepalese	1
Pakistani	1
Tunisian	1

Table 2: First language of the participants

First language	Number of participants
Arabic	7
Farsi	3
Italian	4
Kannada	1
Kazakh	1
Mathili	1
Malayalam	4
Marathi	1
Tamil	1
Telgu	1
Urdu	1

Table 3: Age groups

Age Group (years)	Number of participants
16-20	1
21-25	6
26-30	16
31-35	2

3.2 Audio stimuli

A total of 5000 audio clips were obtained from the Tatoeba Project (Trang Ho, 2006) along with their corresponding text. All audio clips were English sentences of length ranging from 3 words to 13 words per sentence, one sentence per audio clip, and used the same male voice to ensure consistency in the physical properties of the audio signal (e.g. pitch, rate of speech). From this collection of audio clips, 1700 non-semantic audio clips were generated by suitably inserting isolated words in the original, semantic sentences. We ensured that the length of non-semantic sentences also ranged from 3 words to 13 words. The following sentences S1, S2, S3, and S4 are examples of semantic and non-semantic sentences:

S1: *She looks unhappy*.
S2: *You should have left half an hour earlier.*
S3: *Let's intelligent next go.*
S4: *I can hour ski so late.*

Sentences S1 and S2 are semantic whereas S3 and S4 are non-semantic. The generated non-semantic sentences are partially semantic, as they are made from semantic sentences. For example; sentence S4 is made by inserting the words hour, so and late to the semantic sentence I can ski.

We used this approach for generating non-semantic sentences rather than simply listing unrelated words as in (Baddeley, 1966), to mimic a real-world scenario in learning environment, where a few words that are unknown to the listener (out of vocabulary of listener) might make a sentence meaningless. This situation is commonly experienced by non-native speakers due to a limited vocabulary. In learning environments, a reduced subject-specific vocabulary can make semantic sentences be perceived by students as non-semantic. In addition, our approach for constructing non-semantic sentences can also reproduce other prominent features of live speech, notably stuttering.

Finally, background noise of different levels was also added to both semantic and non-semantic audio clip groups. SNR values of -6 dB, -3 dB, 0 dB, 3 dB, 6 dB and ∞ dB (noise-free case) were considered. In summary, we produced two groups of audio stimuli, i.e. the semantic and non-semantic groups, which were reproduced with six levels of background noise.

3.3 Length of sentence

Sentences were grouped according to their length in three categories, namely small (L1), medium (L2) and long (L3) sentences with average lengths of 4, 8 and 12 words respectively with variation of ±1 word. In this, we followed closely the sentence lengths used in (Compton, 1967) for investigating aural perception. In allowing different sentence lengths within each group, we recognized that some words are phonetically longer than others, i.e. 'I' and 'Congratulation', and assumed that a difference of one word in sentence length does not have any significant impact on the listening task (Neath and Nairne, 1995; Page and Norris, 1998).

3.4 Case generation

A total of 144 English sentences were generated for each participant by extracting 72 sentences from the pool of 5000 semantic sentences and 72 more sentences from the pool of 1700 non-semantic sentences. Specifically, the semantic (resp. non-semantic) group consisted of 30, 24, and 18 sentences of lengths L1, L2 and L3 that were extracted randomly without replacement from the pool of semantic (resp. non-semantic) sentences. Each length sub-group was further subdivided into six equal-sized sub-groups, each one of which was assigned one of the six noise levels described in Section 3.2. Each sub-group was ensured to have the respective average length of sentence, for instance, the average length of L1 sub-groups is 4 words. This resulted in a total of 36 experimental conditions, corresponding to six levels of noise, three sentence lengths, and two semanticity levels ($6 \times 3 \times 2 = 36$). The number of audio stimuli per experimental condition was five for the L1 group ($30/6 = 5$), four for the L2 group ($24/6 = 4$) and three for the L3 group ($18/6 = 3$). This description is summarized in Table 4.

For readability purposes, each experimental condition is labeled as 'xxdByLz', where xxdB indicates the noise level, y is a binary digit 0 or 1 indicating respectively semanticity or non-semanticity, and Lz corresponds to the length of the sentence, namely L1, L2 or L3. For example, the label -6dB0L1 indicates the condition with -6dB SNR for semantic sentences of length L1.

Table 4: Number of sentences per experimental condition

	Semantic			Non-Semantic		
SNR	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**
-6 dB	5	4	3	5	4	3
-3 dB	5	4	3	5	4	3
0 dB	5	4	3	5	4	3
3 dB	5	4	3	5	4	3
6 dB	5	4	3	5	4	3
∞ dB	5	4	3	5	4	3
Subtotal	30	24	18	30	24	18
Total	72			72		

4. Experiment procedure

Participants were presented with a computer interface and were given a passive headphone set. After entering basic demographic information, namely sex, nationality, age-group and first language, participants could initiate the listening task by clicking a play button. During the listening task, the computer interface remained disabled so as to prevent participants from engaging in other activities. Once the audio file had finished no more reproductions were permitted and participants were allowed to submit a transcription of the audio sentence. Upon submission, participants could reproduce the next audio file. This procedure was carefully explained to each participant.

On the average, the procedure involving the 144 audio files described in Section 3.4 took 35 minutes for a participant. At the end of each experiment, text transcriptions were collected and labelled according to the noise level, the length of the original English sentence and its semanticity.

5. Statistical analysis

5.1 Attention score computation

Based on an original English sentence and the text transcription of its corresponding audio, the attention score of the text transcription was calculated as follows. Let $T_{i,p,k}$ denote the $i-th$ transcription produced by the $p-th$ participant under the $k-th$ experimental condition. Then, its attention score, which we denote by $A_{i,p,k}$ was calculated as

$$A_{i,p,k} = \frac{N_{C(i,p,k)}}{N_{T(i,p,k)}} \times 100, \quad (1)$$

where $N_{C(i,p,k)}$ is number of correct words in $T_{i,p,k}$ and $N_{T(i,p,k)}$ is number of total words in the original sentence. When establishing the number of correct words in a transcription, minor errors in spelling and other typos were ignored, for example *looks*/*look*, *beautiful/beutiful* or *designed/disegned*.

Based on the attention score of each individual transcription, the average attention score $A_{p,k}$ of the transcriptions produced by the $p-th$ participant under the $k-th$ experimental condition was calculated as

$$A_{p,k} = \frac{1}{I_k}\sum_{i=1}^{I_k} A_{i,p,k}\,, \quad (2)$$

where I_k is the total number of stimuli in $k-th$ experimental condition (see Table 4). Each computed average attention score $A_{p,k}$ was used as an individual sample for statistical analysis. As $N_P = 25$ participants were involved in the experiment and each participant produced a total of $N_K = 36$ attention score samples (one sample per experimental condition), a total of 900 samples $(36 \times 25 = 900)$ were available for further analysis.

5.2 Descriptive statistics

Firstly, the mean A_k and standard deviation S_k of the attention score $A_{p,k}$ across all the participants were calculated:

$$A_k = \frac{1}{N_p}\sum_{p=1}^{N_p} A_{p.k}\,, \tag{3}$$

$$S_k = \left(\frac{1}{N_p - 1}\sum_{p=1}^{N_p}\left(A_{p,k} - A_k\right)^2\right)^{\frac{1}{2}}. \tag{4}$$

Secondly, the mean attention score A_p for the $p-th$ participant across all the conditions was computed. The mean attention score A_p was defined as

$$A_p = \frac{1}{N_k}\sum_{k=1}^{N_k} A_{p.k}\,. \tag{5}$$

Finally, box-and-whisker plots were obtained for analysing the impact of the noise level, the length of stimuli, and sentence semanticity on the attention score of the transcriptions from each experimental condition.

5.3 Pairwise Analysis

A repeated measure ANOVA test was firstly applied to analyse the variation of attention score under each experimental condition (Lawal, 2014). The student t-test was used to determine whether the mean of the attention score was significantly different under two different experimental conditions. Since, there are 36 different conditions, the p-values resulting from comparing each pair of experimental conditions were represented in a 36×36 P-matrix. By definition, this P-matrix is symmetric, and its diagonal represents the comparison of an experimental group with itself, hence the values in the diagonal are 1. In order to facilitate the analysis of the p-values, heat maps were used to visually represent the values of the entries of the P-matrix. Thresholding with a value of 0.05 was next applied to the P-matrix, producing a binary matrix in which significant differences with a 95% confidence level can be readily identified. The binary P-matrix allowed us to further arrange the experimental conditions in a hierarchical manner, following a bottom-up agglomerative method (Hastie, Tibshirani, and Friedman, 2001), where related experimental conditions are located close to one another.

6. Results and discussions

The mean A_k and standard deviation S_k of the attention score, across all the participants under each experimental condition are presented in Table 5. As expected, our results show that the lowest attention score was achieved for low SNR, whereas the high SNR was associated to high levels of attention. In general, an increase in the noise level produces a decrease in the attention score. This suggests a negative correlation between noise and attention, indicating the noise as a primary factor of diminished attention level. It is interesting to note that an increase in the length of a sentence resulted in a decrease in the attention score for any given noise level in both semantic and non-semantic groups. This suggests that the shorter sentences are, the easier to follow by listeners.

Table 5: Mean and standard deviation of the average attention score $A_{p,k}$ in each experimental condition

SNR	Mean ($n = 25$)						SD ($n = 25$)					
	Semantic			Non-Semantic			Semantic			Non-Semantic		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
-6 dB	13.03	5.86	4.85	10.41	8.21	6.91	14.03	6.53	6.74	9.74	6.51	7.10
-3 dB	33.41	21.12	15.56	21.57	15.13	11.61	23.02	17.02	8.21	14.96	10.04	7.40
0 dB	40.49	37.11	24.63	30.48	28.81	16.32	20.27	22.63	20.09	15	18.06	12.10
3 dB	57.09	49.17	43.24	38.91	32.9	22.38	24.88	26.21	25.74	18.17	19.19	14.54
6 dB	72.04	62.82	48.82	50.22	40.15	26.75	21.34	23.28	24.8	20.25	18.36	15.86
∞ dB	85.17	86.48	72.8	67.03	56.2	39.45	16.1	17.25	22.48	17.78	18.82	18.77

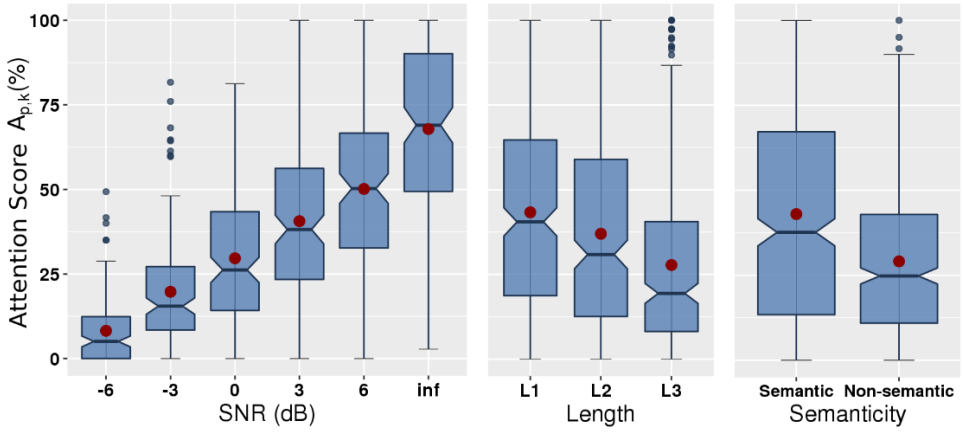
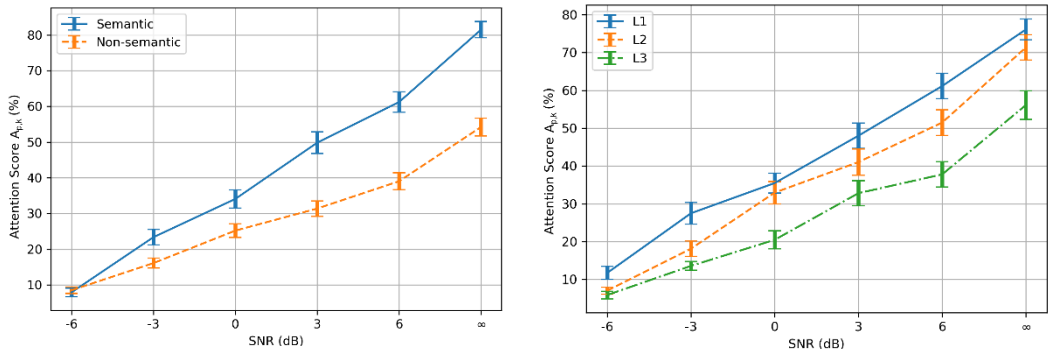


Figure 1: Average attention score $A_{p,k}$ versus SNR, length and semanticity of stimulus



(a) Noise and semanticity of stimuli *(b) Noise and length of stimuli*

Figure 2: Interaction between independent variables

The effects of noise level and length of sentence on the attention score are shown in the box-and-whisker plots presented in Figure 1, demonstrating a clear dependence of the attention score on the SNR, sentence length, and semanticity. It is interesting to observe that in addition to noise level and semanticity, the length of sentence also affects the attention score.

The impact of semanticity and length of sentence on attention score, under different noise level was investigated, and results are shown in Figure 2. Interestingly, Figure 2 (a) indicates that the rate of increase of the attention score with increases in SNR is higher for the semantic group than for the non-semantic group. In other words, background noise has higher impact on semantic sentences than non-semantic. As a result, the effect of semanticity is more apparent in a noise-free environment and vanishes in a noisy environment. This effect can be explained by the cognitive neuroscience and linguistics Gap-Filling theory (Frazier, Godwin, and Seltman, 1983), according to which the brain is capable of predicting linguistic gaps by using syntactic or semantic priors (Tanenhaus, 1985; Frazier and d'Arcais, 1989). In other words, when the brain does not perceive a sentence correctly, as is the case in noisy environment, prior knowledge is used to infer it and fill the gaps. However, in noise-free environment, the brain is not forced to fill the gaps. The above observations suggest that the importance of semanticity is higher in noise-free environments. The non-overlapping error bars in Figure 2 (a) indicate that semanticity has a significant impact ($p < 0.05$) on attention score from -3 dB onward.

From Figure 2 (b), it can be concluded that the rate of change of the attention score for all the lengths is almost similar and smaller lengths produce consistently higher average attention scores. It suggests the length of a sentence always has an impact on the attention score for non-native speakers, irrespective to noise level. For native speakers, the length of sentence might not have such a significant impact.

Table 6: Results of the repeated measure ANOVA, where df denotes the degrees of freedom, SSq is sum of the squared differences, MSq is the mean sum of squares

Source	df	SSq	MSq	F-value	p-value
Between	35	456255.1	13035.86	72.77	10^{-16}
Subject	24	121625.8	5067.74	28.29	
Within	864	272098.9	314.93		
Error	840	150473	179.14		
Total	889	728354			

The results from our descriptive analysis suggest that the attention score is affected by noise level, semanticity, and length of sentence. The results from the repeated-measure ANOVA (Table 6), carried out for 36 experimental groups, indicate a strong evidence that there is a significant ($p \ll 0.001$) difference between at least two experimental groups. The resulting $\eta^2_{partial} = 0.752$, indicates that 75.2% differences in the experimental groups were due to different experimental conditions. In other words, the variation in the independent factors is largely responsible for the differences in the attention score.

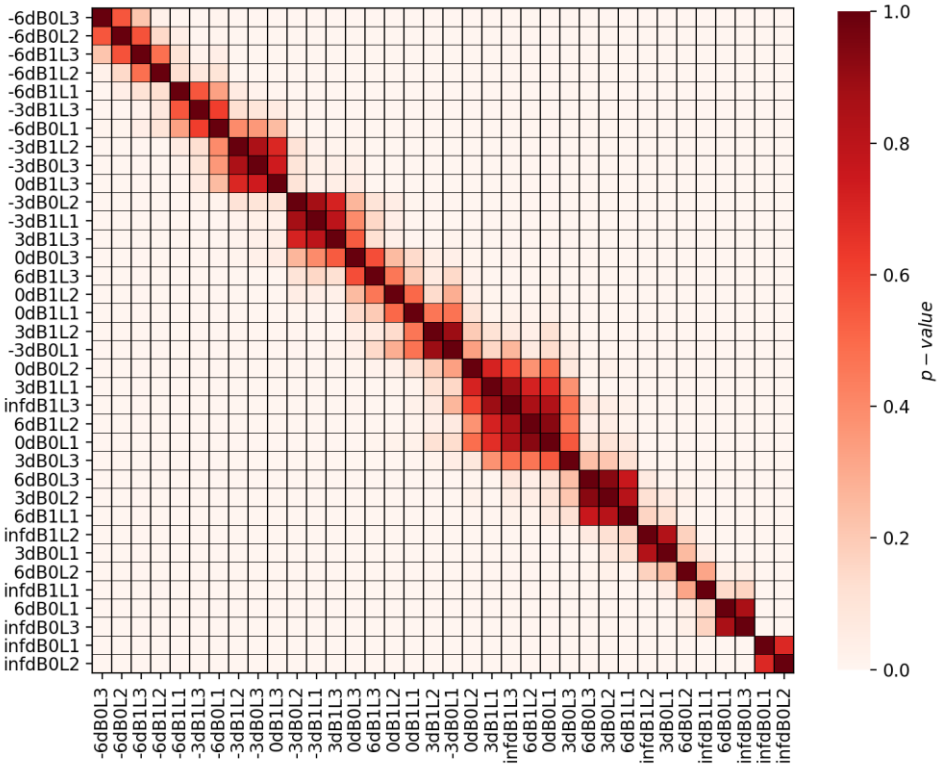


Figure 3: P-Matrix obtained from the pairwise t-test

Figure 3 shows the obtained P-matrix (36×36), sorted by the average attention score A_k of each experimental condition. As previously mentioned, by its definition the P-matrix is symmetric, and the values of the diagonal are identical to 1. In Figure 3, the thickness of diagonal represents the closeness of one experimental condition to other conditions. The thicker the diagonal, the more experimental conditions are closer to each-other. In an ideal situation where all the experimental conditions are significantly different from one another, the matrix would be close to a diagonal one. From Figure 3, it is apparent that a major fraction of pairwise comparisons have a low p-value, which suggests a significant difference between those respective pairs.

From Figure 3, clusters of experimental conditions can be identified by analysing the thickness of the diagonal. To analyse these clusters, a hierarchical clustering method is applied on the binary P-matrix obtained from thresholding with $p < 0.05$. Figure 4 illustrates the hierarchical tree obtained.

Given a branching point in the hierarchical tree, a cluster is defined as the collection of all the experimental conditions below the branching point. For instance, the branching point *R* in Figure 4 defines a cluster consisting

of two groups, namely *infdB0L1* and *infdB0L2*, and both groups are close in the sense that the impact on the attention score by changing the experimental conditions from *infdB0L1* to *infdB0L2* is smaller than changing to an experimental condition outside the cluster *R*. The analysis of the hierarchical tree reveals interesting relationships about the experimental conditions in this study. For example, cluster *R* suggests that changing the length of semantic sentences in noiseless environment from small to medium or vice-versa has no significant impact on the attention level, however changing length to long sentence, switching semanticity or increasing noise level drop the attention level significantly ($p < 0.05$). This can also be confirmed from Figure 3, by looking at the rightmost bottom cluster of 2×2 cells.

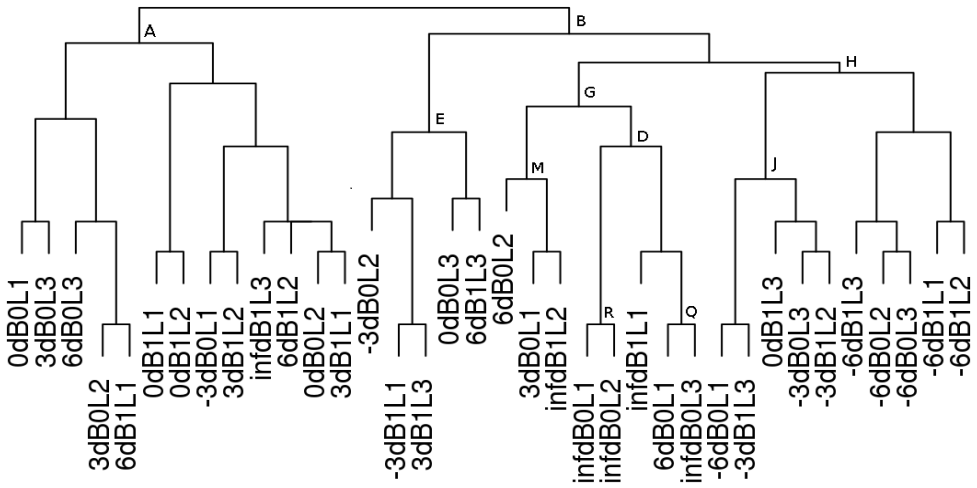


Figure 4: Hierarchically clustering of experimental conditions obtained after applying threshold $p < 0.05$ on P-Matrix

Furthermore, cluster Q (6dB0L1, infdB0L3) shows that long semantic sentences in noiseless environment have a similar impact on attention as small semantic sentences in low-noise (6 dB) environment. Similarly, cluster M suggests that the impact of small semantic sentences with SNR = 3 dB, is similar to medium-length non-semantic sentences in noiseless environments and semantic sentences in low-noise (6 dB) environments.

Cluster G includes the experimental conditions that lead to the highest performance. The mean attention score (A_k) of these groups is above 55. By contrast, cluster H includes the experimental conditions with the lowest mean attention score ($A_k < 17$). Interestingly, clusters H and A appear far from each other in the hierarchy and mostly differ in the noise level. Cluster H includes almost all the experimental conditions with low SNR, whereas cluster A includes experimental groups with high SNR and their mean attention score ranges from 27 to 51. Overall, the hierarchical tree can be decomposed into four major clusters, A, E, G, and H.

7. Conclusions

Auditory attention plays a vital role in students' performance and it is critical for non-native learners. The increasing number of international students require that education professionals carefully reflect on the design of their learning environments and their suitability for such an audience. However, the literature lacks quantitative results in the area. In this study, we have analysed the impact of three factors (noise level, length of sentences and semanticity) on the level of auditory attention of non-native learners in an English language environment. Following existing literature, we have used the number of correctly identified words in a transcribed sentence to quantify the level of auditory attention.

Our analysis emphasises the importance of conveniently designing lectures and learning environments and shows that linguistic and auditory factors such as background noise, length of sentences and lexical complexity should be carefully considered. In addition to the importance of an obvious factor such as background noise, our results demonstrate that reducing the length of sentences always improves the level of auditory attention of non-native speakers. The impact of linguistic complexity on the auditory attention of non-native learners can be analysed by considering sentence semanticity. In our experiment, non-semantic sentences were created by

inserting unrelated words in-between semantic sentences. This model of non-semantic sentence simulates a semantic sentence that contains one or more words that are unknown to the listener, which is close to real-world scenarios. Our results show that semanticity has a dramatic impact on auditory attention of non-native learners and the significance of semanticity is higher in less noisy environment. This experimental observation supports the view that simple, accessible vocabulary should be consistently used in non-native learning environments, whenever this does not compromise the meaning of the message. Our results suggest that in practice, while delivering a lecture, shorter sentences should be preferred over longer ones. To keep the sentences meaningful to an audience, simplified and easily understandable (or well explained) terms should be preferred over new and complex terminology, whenever possible, and noise level should be controlled and kept as minimum as possible. Our analysis provides novel quantitative indications that should be useful to researchers, practitioners and designers for maximizing a students' experience in a learning environment. We focused our study on auditory attention, because it is fundamental for learning. Future research may expand on our results by including visual spatial attention and the relevant relationships that originate in real environments. The impact on lecture performance and instructional environment design can also be further investigated. Finally, future research work may analyse the possible differences in impact among students with different language abilities.

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Effects of Video Lecture Design and Production Quality on Student Outcomes: A Quasi-Experiment Exploiting Change in Online Course Development Principles

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Abstract: In seeking competitive advantage, many online graduate programs have turned to improving the quality of video lectures by investing in instructional designers and in-studio production. However, it is unclear how much video lecture design and production quality improve student outcomes. We used a regression discontinuity to evaluate how video lecture design and production practices that adhere to principles of multimedia learning affect perceived learning and student satisfaction. The study involved 300 students taking an online graduate course at a large, public research university, where 194 students were exposed to video lectures designed and produced by the instructor and 106 students were exposed to video lectures designed in collaboration between the instructor and instructional designers and produced in studio. Our findings indicate that designing and producing video lectures in accordance with principles of multimedia learning has a meaningful causal effect on students' perceived learning and a marginal effect on student satisfaction. We discuss the theoretical and practical implications of our findings for video lecture development and design in the context of online business education and the COVID-19 pandemic.

Keywords: Video lectures; Online learning; Cognitive Theory of Multimedia Learning; Instructional design; MBA program

1. Introduction

As of 2019, 46 percent of faculty members in the United States reported having taught an online course for credit (Jaschik and Lederman, 2019). In 2020, the experience became nearly universal when educational institutions transitioned to remote teaching. Yet there is a substantial disparity in how faculty members develop and design online course content (Fiorella, et al., 2017). *Inside Higher Ed*'s 2019 Survey of Faculty Attitudes on Technology indicates that 62 percent of faculty members developed and designed online courses on their own, while 17 percent of faculty members created all or most of their courses in collaboration with instructional designers (Jaschik and Lederman, 2019). *Quality Matters*' 2019 survey of Chief Online Officers at U.S. higher education institutions concluded that use of instructional design support remains low due to two factors: "Cost is an ongoing constraint, and entrenched faculty … resistant to surrendering any of their autonomy in the online or on-ground classroom persist in many institutions." (Garrett, Legon and Fredericksen, 2019, p.24)

The apparent disconnect between theory and practice of online course development, design, and production is puzzling given the substantial advances in online learning research. Unlike two decades ago when educational theory for online learning was in its infancy, today there is increasing convergence in scientific thought on best practices in online learning (e.g., Clark and Mayer (2011); Mayer (2009); Mayer (2005); Jenlink (2019), among others).

We examine how much adopting best practices matters for student outcomes in the context of designing and producing online video lectures. Video lectures are a central element in online learning. They are instructors' primary means of presenting information (de Koning, Hoogerheide and Boucheix, 2018) and students rank them as the most valuable class activity for learning and success (Magda and Aslanian, 2018). Importantly, video lectures increase instructors' teaching and social presence in the virtual classroom (Draus, Curran and Trempus, 2014; Ke, 2010). Teaching and social presence are in turn linked to key outcomes such as student participation, engagement, and satisfaction (Garrison and Arbaugh, 2007).

Best practices in video lecture design and production are informed by principles of multimedia learning (Mayer, 2014a), which were developed for the purpose of optimizing learning from visual and verbal content using theories of learning and cognition (Baddeley, 1986; Paivio, 1990; Sweller, 1988, 1994). We define professionally-produced video lectures as those created in collaboration between instructors as the subject matter experts and

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instructional designers whose primary role is to advise on pedagogical principles (Kenny, et al., 2005). They are recorded in studio by digital media production professionals. Yet instructors face few barriers to producing video lectures on their own (Kizilcec, Bailenson and Gomez, 2015; de Koning, Hoogerheide and Boucheix, 2018). Using commonly available technology, such as computers, smartphones, video or web cameras, video recording software, video-editing applications, and a high-speed internet connection, instructors can create and disseminate video lectures quite easily and cost efficiently.

Indeed, the seemingly low barriers to producing online learning content have enabled institutions of higher education to respond to the COVID-19 pandemic by asking instructors to transform courses previously taught face-to-face into an online format, virtually overnight. But, just as conducting education at a distance is not the same as delivering a quality education online, exposing students to instructors' best efforts to design and produce video lectures is not the same as exposing them to video lectures designed and produced in accordance with principles of multimedia learning. Moreover, institutions vary greatly in how they prepare and support instructors who are teaching online and instructors themselves vary in their abilities to create engaging and effective video lectures. Consequently, "the quality of faculty-created videos varies from magical to marginal." (Mosley, 2017, p.92) Given these realities, the purpose of our study is to measure the difference in student outcomes among students exposed to video lectures that are designed and produced in adherence with basic principles of multimedia learning compared to video lectures that are developed by the instructor.

This study identifies the causal effect of video lecture design and production on perceived learning and student satisfaction using a discontinuity in online course development standards at a large, public research university. A 2017 decision put into effect a requirement that all online courses in the Master of Business Administration (MBA) program be designed and developed in collaboration between instructors, instructional designers, and digital media professionals. Importantly, the requirement applied not only to new courses yet to be developed, but also to existing courses previously developed by instructors. Our research design takes advantage of this discontinuous change in development standards to assess the effect of a change in video lecture design and production quality in the context of a single online course that was taught nine times between the years 2016 and 2019. In this core MBA course, all course components remained the same over this four-year period, apart from the video lectures. This feature allows us to employ a regression discontinuity design to measure and compare student satisfaction and perceived learning pre- and post-intervention in video lecture design and production.

We make several contributions to multimedia and online learning literature. First, our research informs the current scholarly debate on video lecture efficacy by examining the combined effect of instructional design and professional production of video lectures on student outcomes. As such, it answers a call in the literature for examining how video lecture design features relate to learning outcomes (Crook and Shofield, 2017). Second, our study provides much needed empirical evidence from graduate students taking full-semester online courses. There is currently a dearth of research on the impact of video lectures in graduate education. Our understanding of how video lectures affect student outcomes rests on findings from laboratory studies of Amazon Mechanical Turk participants (e.g., Wilson, et al. (2018)), undergraduate students (often outside the United States) (e.g., van Wermeskerken, Ravensbergen and van Gog (2018); van Wermeskerken and van Gog (2017); Hong, Pi and Yang (2018); Chen and Wu (2015)), and massive open online courses (MOOCs) (Kizilcec, Bailenson and Gomez, 2015; Bhat, Chinprutthiwong and Perry, 2015). The generalizability of the available research on video lectures to online graduate education is debatable. Our field research, in contrast, is highly relevant for other graduate-level online business programs as it assesses satisfaction and learning outcomes of students taking a core course at an AACSB-accredited and nationally ranked MBA program.

This study also has important practical implications for institutions offering online courses. Given our field setting, our findings can inform future institutional decision making about resource allocation. If our findings indicate that video lecture design and production quality improve student outcomes, then institutions can better justify expenditures into instructional designers, production studios, and related staff – and these costs are far from trivial. Indeed, after accounting for key resources (such as subject matter experts, instructional designers, and technical staff) estimates suggest that designing and developing one hour of online learning content in adherence with online education best practices can range from $7,800 up to $37,400 (Movchan, et al., 2019). Of this sum, the costliest component is the time and money spent on designing, producing, and editing the video lecture (Movchan, et al., 2019).

Finally, our findings contribute much needed data and evidence to faculty members and administrators as they manage the new academic landscape created by the COVID-19 pandemic. During the forced emergency transition to online instruction this spring, faculty members self-produced entire online courses at extremely short notice. While the quality of online instruction sufficed for the moment, students' expectations are already rising ahead of the Fall 2020 semester and institutions are under pressure to increase the quality of online instruction during the summer months. This study is timely and relevant to the current global conversation about online learning as it quantifies the effect of instructional design and professional production of online course content on student outcomes.

Theory and Hypothesis Development

Video lectures are a central component of online education. They are the primary means of delivering instruction in online undergraduate and graduate courses (de Koning, Hoogerheide and Boucheix, 2018). The most common video lecture types can be summarized as follows: slides (slide presentation with voice-over lecture by the instructor); Khan whiteboard (full-screen video of instructor drawing or writing freehand on a digital tablet); classroom (video recording of a classroom lecture); office desk (video recording of instructor's head or torso speaking at an office desk); and studio (instructor is recorded in a studio with no audience) (Crook and Shofield, 2017; Guo, Kim and Rubin, 2014). A video lecture can include multiple styles either in sequence or simultaneously by embedding separate windows with different styles.

An important theoretical perspective that informs research on the effects of design and production in video lectures is the Cognitive Theory of Multimedia Learning (CTML, Mayer (2014a)). CTML is an evidence-based theory that joins the science of learning with the science of instruction. Its theoretical foundations are rooted in learning and cognition science, including working memory (Baddeley, 1986), dual-coding (Paivio, 1990), and cognitive load theory (CLT, Sweller (1988; 2005)).

The premise of CTML is that "people learn more deeply from words and pictures than from words alone" (Mayer, 2014b, p.43). In cognitive theories of learning, learners have limited capacity and information processing ability (Miller, 1956). They are constrained by their cognitive ability to select and organize information and integrate it into long-term memory (Paas and Sweller, 2014; Sweller, 1988). How to optimize the presentation of words and pictures to guide people's learning processes most effectively and efficiently is thus the central question that CTML scholars seek to answer (Mayer, 2014a).

Three assumptions developed in cognitive science underlie CTML. First, the *dual channels* assumption states that people process visual and auditory information through separate channels (Paivio, 1990; Baddeley, 1992). Multimedia that uses both channels can therefore increase the amount of information a learner's brain can process (Mayer, 2009; Penney, 1989), leading to quicker comprehension and richer mental representations than would be possible through verbal or pictorial presentations alone (Sweller, 2005). Second, the *active processing* assumption states that active learning is the outcome of selecting, organizing, and integrating information with other knowledge (Wittrock, 1989). In other words, learners do not interpret words, pictures, and auditory information in an independent and mutually exclusive fashion. Instead, learners select, organize, and integrate elements in relation to prior knowledge. Multimedia presentations that organize and introduce new knowledge in ways that build on existing mental schemas and logical constructs are more effective.

Finally, the *limited capacity* assumption states that people are constrained in the amount of information that visual and auditory channels can each process at once (Baddeley, 1992; Chandler and Sweller, 1991; Miller, 1956). Multimedia thus needs to be designed to not overwhelm either channel. Of course, all instructional material imposes demands on learners' ability to process information. This demand is referred to by cognitive scientists as cognitive load. Cognitive load can be divided into three categories: intrinsic, extraneous, and germane (Sweller, 1994). Intrinsic load represents the natural, unalterable difficulty of the material to be learned and it is independent of instructional design efforts (Sweller, 1994). Extraneous load is the processing strain on the learner created by sub-optimal instructional design choices, and it represents the type of load that CLT and CTML researchers strive to minimize. The third category, germane load, represents the cognitive effort required to organize and integrate information into long-term memory (Sweller, 2010). While both intrinsic and extraneous load are determined entirely or in part by the characteristics of the instructional material, germane load depends on the characteristics of the learner and on instructional design choices that enhance the learner's ability structure and encode knowledge into memory. Instructional design of multimedia therefore aims to reduce extraneous cognitive processing and free capacity for knowledge integration.

Given CTML's emphasis on optimizing the presentation of words and pictures for learning, its principles are highly salient for video lectures. Indeed, CTML serves as the theoretical foundation for numerous empirical studies of the effects of video lectures on student outcomes (for example, Wang and Antonenko (2017); Kizilcec, Bailenson and Gomez (2015); Chen and Wu (2015); Hughes, Costley and Lange (2019), among others). Over the last three decades, CTML scholars have iterated between theory and evidence to develop basic and advanced principles of multimedia learning (e.g., Mayer (2009); Mayer and Moreno (2003; 1998); Mayer (2008); Mayer and Anderson (1992)). Although advanced principles can also be incorporated into video lectures, we applied the following seven basic principles during the video lecture redesign event that is at the center of this study: Coherence, Modality, Redundancy, Signaling, Segmenting, Split-Attention, and Personalization. A description of each principle and its underlying logic is presented in Table 1.

Table 1: Multimedia learning principles implemented in video lecture redesign and rerecording

Coherence Principle:	People learn better when extraneous narration, sounds, printed text, and visual content are excluded rather than included. Removing unneeded elements reduces extraneous load (Mayer, et al., 1996; Harp and Mayer, 1997, 1998).
Modality Principle:	People learn better from a combination of pictures and narration than from a combination of pictures and printed text because processing pictures and narration utilizes dual channels whereas processing pictures and printed text can overload the visual channel (Mayer and Moreno, 1998; Moreno and Mayer, 1999; Mousavi, Low and Sweller, 1995).
Redundancy Principle:	People learn better when the same information is presented with pictures and narration rather than with pictures, narration, as well as printed text (Mousavi, Low and Sweller, 1995) because the printed text is redundant and adds to extraneous load.
Signaling Principle:	People learn better when cues are added to direct attention toward essential material because cues limit extraneous load (Jeung, Chandler and Sweller, 1997; Harp and Mayer, 1998).
Segmenting Principle:	People learn better when multimedia instruction is presented or broken into learner-paced segments rather than when it is presented as a single, continuous unit (Mayer and Chandler, 2001).
Split-Attention Principle:	People learn better when corresponding visual content and verbal content is presented in physical and/or temporal proximity. When multimedia is designed such that corresponding text or narration and visual content are not nearby, the cognitive processing demand created by searching and integrating separate pieces of information creates extraneous load for the learner (Mayer and Anderson, 1992; Mayer and Anderson, 1991; Moreno and Mayer, 1999; Tarmizi and Sweller, 1988).
Personalization Principle:	People learn better from multimedia instruction when the instructor's tone and style are conversational rather than formal because the conversational style is more engaging and promotes germane load (Moreno and Mayer, 2000; Mayer, et al., 2004).

Using the logic of CTML, it stands to reason that designing and producing video lectures in line with the principles of multimedia learning will positively affect students' perceptions of learning and satisfaction. For instance, video lectures designed to not overload the auditory or visual channel and to take advantage of learners' dual channel processing (in line with the *Modality Principle*) will ease extraneous load and allow the learner to process information more easily. Similarly, video lectures designed in accordance with the *Coherence*, *Redundancy*, and *Signaling Principles* will lighten extraneous load by focusing learners' attention on essential material and by eliminating distracting or redundant elements. In line with the *Segmentation Principle*, partitioning material into multiple, shorter video lectures will promote cognitive processing by decreasing the material's intrinsic load. Video lectures where related visual and verbal content is presented in proximity (in line with the *Split-Attention Principle*) will reduce extraneous load by curtailing learners' need to search for and integrate separate pieces of information. In line with the *Personalization Principle*, video lectures where the instructor's body language and vocal color remain conversational and open bolster germane load and learners' ability to integrate knowledge into long-term memory. In sum, video lecture design and production decisions that limit extraneous and intrinsic load and promote germane load can be expected to reduce cognitive load and free up capacity for knowledge integration. This, in turn, will increase students' perceived learning and feelings of satisfaction. Therefore, we hypothesize:

Hypothesis 1: Perceived learning will be higher among students exposed to video lectures that are designed and produced in adherence with basic principles of multimedia learning.

Hypothesis 2: Satisfaction will be higher among students exposed to video lectures that are designed and produced in adherence with basic principles of multimedia learning.

2. Research Context

2.1 The Course

The research context of our study is an online Professional MBA course in Strategic Management at a large, public research university. Nine sections of the course were offered by the program in the years 2016-2019, and all were taught by the same instructor over seven semesters. In 2017, a program-wide decision required that all online MBA courses be designed and developed in collaboration between instructors and instructional designers in accordance with best practices in online instruction. Importantly, the requirement applied not only to new courses yet to be developed, but also to existing online courses previously developed by instructors.

During the initial meeting between the instructor and the instructional designers in 2018, it was agreed that all components of the Strategic Management course could and would remain the same *except for the video lectures*, which would be redesigned to adhere with best practices and rerecorded in studio by digital media professionals. The video lectures were redesigned and rerecorded during the summer and fall of 2018 with the first students experiencing the redesigned lectures in the Spring semester of 2019. The following course components remained unchanged pre- and post-redesign: assigned readings and cases, discussion boards, quizzes, individual written assignments, group oral presentations, and exams. All course sections also included mandatory, weekly 90-minute synchronous sessions that were oriented toward case discussion and debriefs and were conducted using *Zoom* (Zoom Video Communications Inc., n.d.). The only difference between the pre- and post-redesign version of the course was therefore the design and production of the video lectures.

2.2 The Video Lectures

Unlike existing laboratory experiments which manipulate one or perhaps two multimedia characteristics and measure their effect on learner outcomes, our field study assesses the causal effect of a more comprehensive application of multimedia learning principles in the context of a full-semester course. Given that instructional designers and instructors would also implement all relevant principles of multimedia learning (and not just one) to multimedia content, our findings are realistic and relevant for institutions as they consider adopting video lecture development standards. But, in order to reasonably interpret our findings, it is important to provide context and transparency about the state of the video lectures pre- and post-redesign, and to describe the steps that were taken to improve quality in line with principles of multimedia learning. Below, we outline the implemented changes and specify how each principle was implemented either through redesign or production.

To illustrate how the seven principles described in the Theory and Hypotheses section manifested in the redesigned and rerecorded video lectures, we offer three illustrative examples: presentation of Topic A (in Figures 1a and 1b), Topic B (in Figures 2a and 2b), and Topic C (in Figures 3a and 3b). The same information is being presented for each topic pre- and post-redesign and rerecording – but the difference is in *how* the information is presented.

For instance, the *Modality Principle*, which says that people learn better from a combination of pictures and narration than from a combination of pictures and printed text, was implemented during the design process by thoughtfully evaluating what should be presented as printed text what should instead be presented using graphics and narration. For example, the printed text that appears in Figure 1a (but does not appear in Figure 1b) was verbalized by the instructor in the post-redesign version. The printed text that appears in Figure 2a (but does not appear in Figure 2b) was presented as a graphic post-redesign.

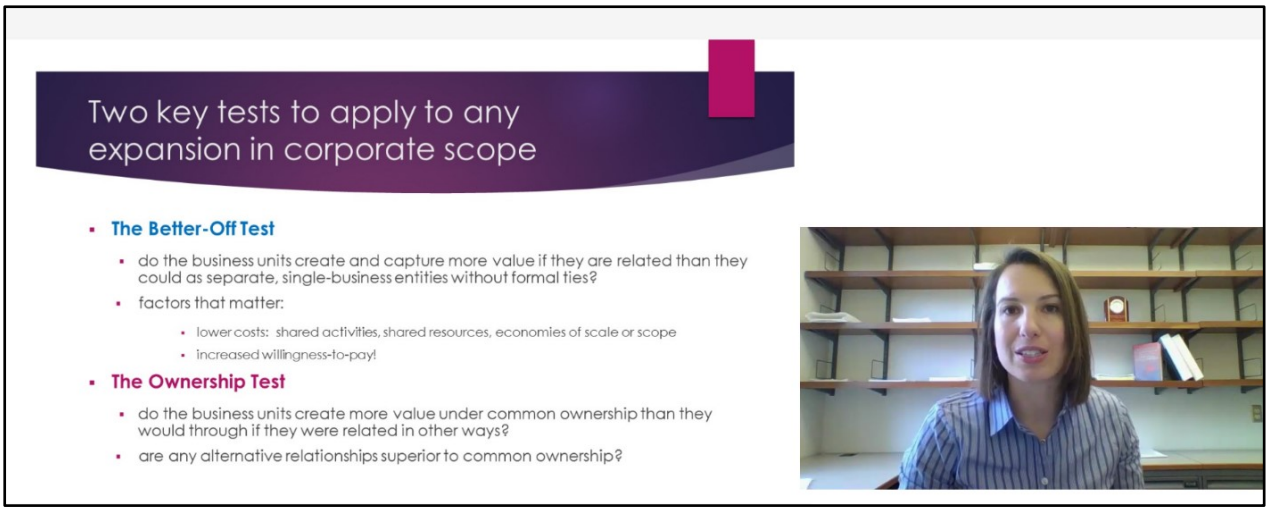

Figure 1a: Screenshot of pre-redesign video lecture on Topic A

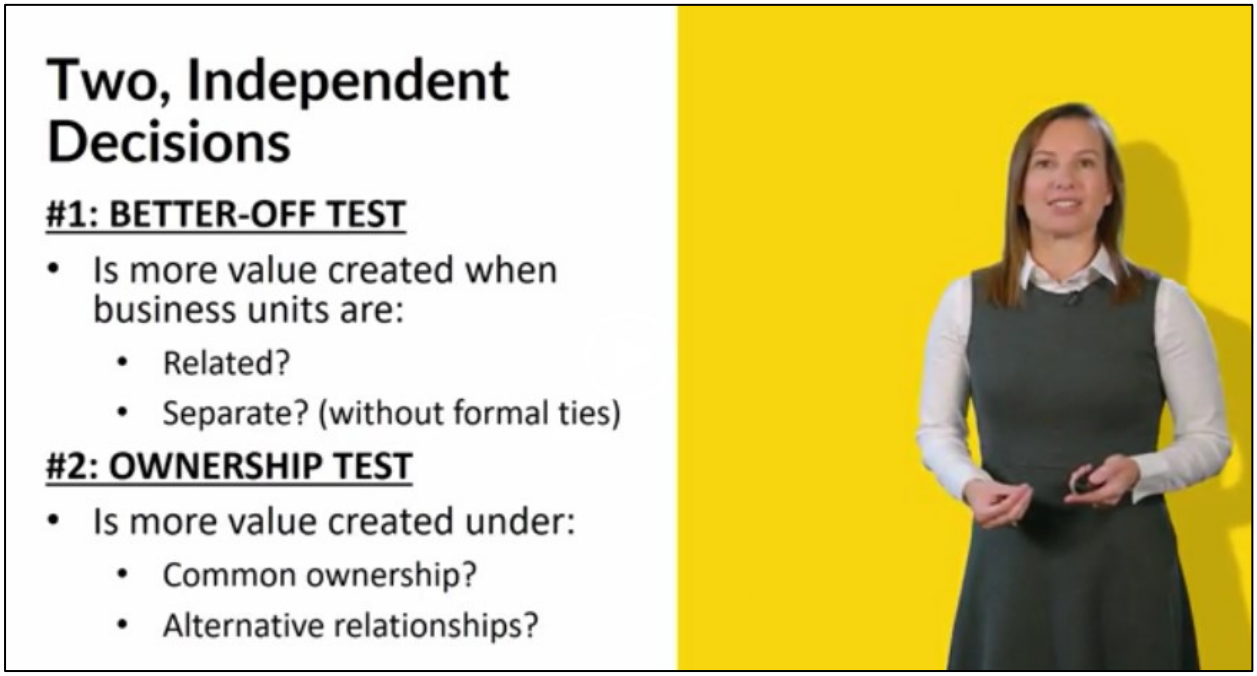

Figure 1b: Screenshot of post-redesign video lecture on Topic A

In line with the *Coherence Principle* (i.e., people learn better when extraneous narration, sounds, printed text, and visual content are excluded rather than included), extraneous words were removed from the slide title and the bullet points during the redesign (see Figure 1b, compared to Figure 1a). Another example of the *Coherence Principle* is evident when juxtaposing Figures 2a and 2b. Written text and equations that were included in the pre-redesign version (Figure 2a) were removed and replaced in the post-redesign version with a simple graphic illustrating the same concept (Figure 2b). Overall, during the redesign, the instructor and the instructional designer emphasized clarity, conservative use of bullet points, impactful graphics, and informative narration in the video lectures.

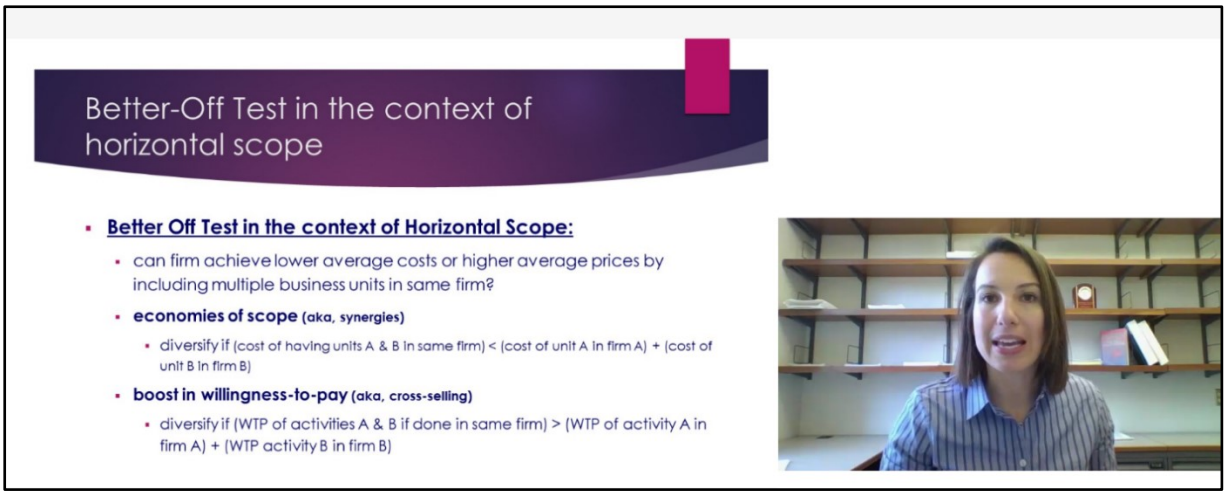

Figure 2a: Screenshot of pre-redesign video lecture on Topic B

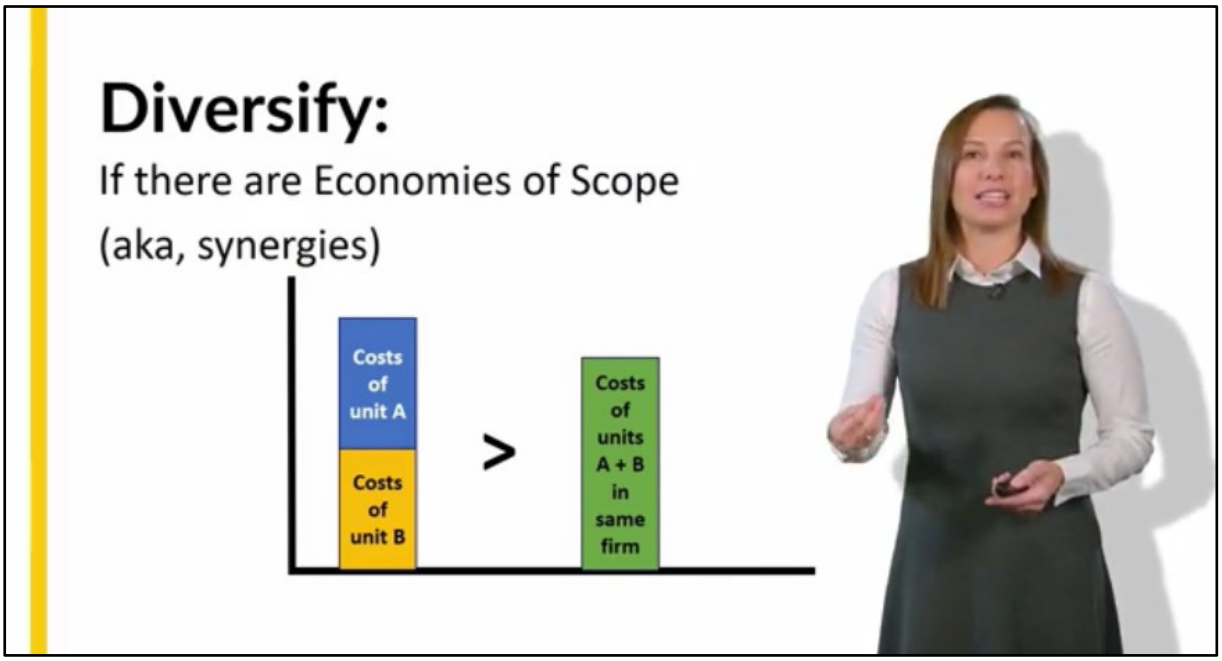

Figure 2b: Screenshot of post-redesign video lecture on Topic B

A comparison of Figures 3a and 3b illustrates how we implemented the *Redundancy Principle* (i.e., people learn better when the same information is presented with pictures and narration rather than with pictures, narration, as well as printed text). For example, pre-redesign, the video lecture on Topic C included a graphic, narration describing the graphic, and redundant printed text describing the graphic (Figure 3a). The post-redesign version eases extraneous load by removing the redundant printed text but retaining the graphic and the accompanying narration (Figure 3b).

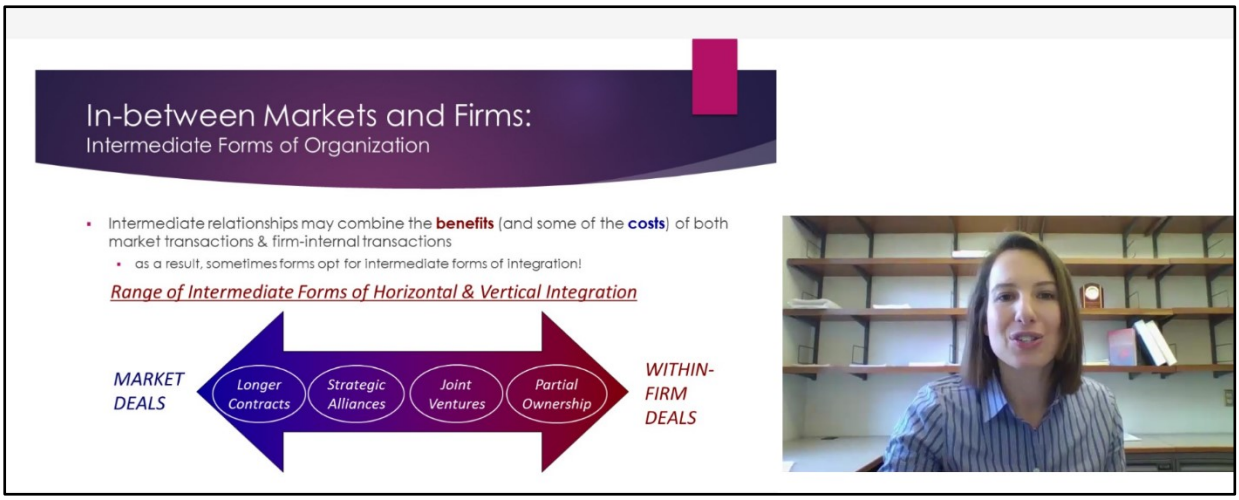

Figure 3a: Screenshot of pre-redesign video lecture on Topic C

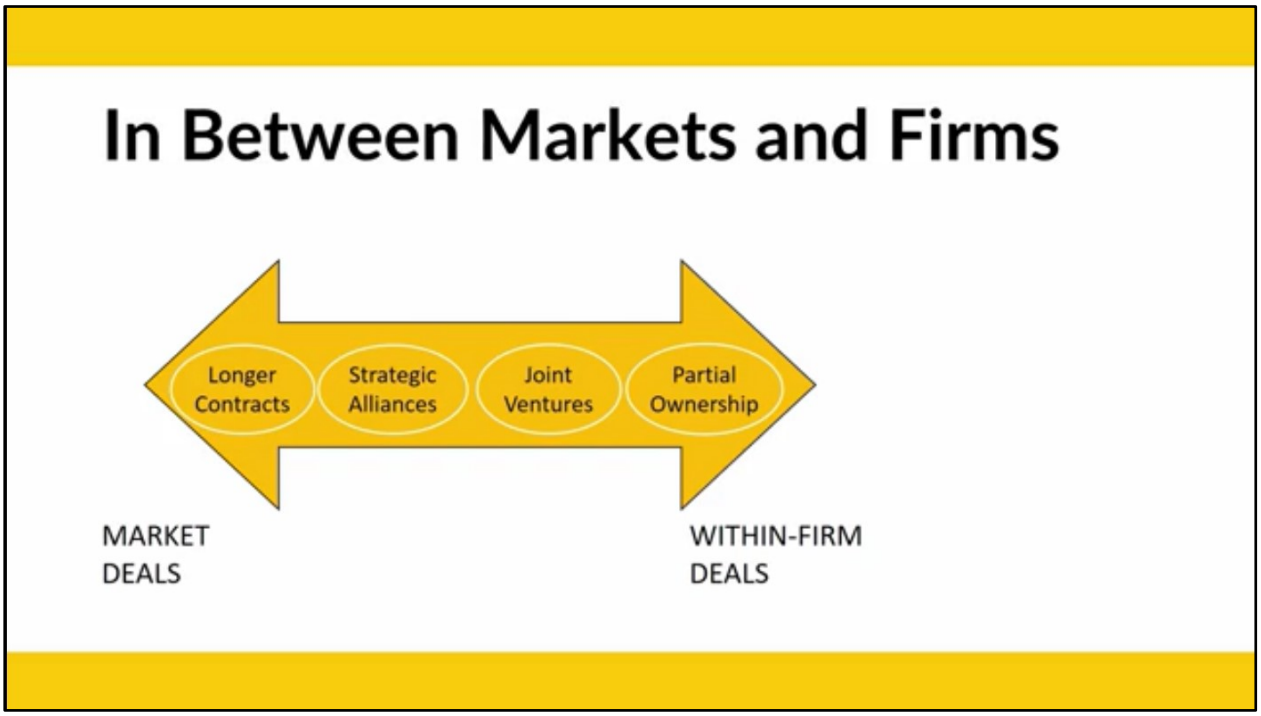

Figure 3b: Screenshot of post-redesign video lecture on Topic C

Pre-redesign, the video lectures showed the instructor's image throughout (as seen in Figures 1a, 2a, and 3a). Post-redesign, the video lectures used instructor presence to signal that students ought to focus their attention on the narration and used the instructor's absence to signal that students needed to tune into the graphics and to the text on slide (as can be seen in Figure 3b, for example). In an application of the *Signaling Principle*, which says that people learn better when cues are added to direct attention to essential material, the instructor would step off camera when the complexity of the instructional matter was high and would return to the shot when complexity declined.

Another difference pre- and post-redesign relates to the segmentation of the video lectures. Pre-redesign, video lecture length depended on the topic – with the shortest lectures being 21 minutes long and the longest extending to 60 minutes. Yet, the *Segmentation Principle* indicates that people learn better when multimedia instruction is presented or broken into learner-paced segments rather than being presented as a single, continuous unit. Therefore, during the redesign process, video lectures were broken up and restructured to be no longer than 10 minutes each. Of course, not all topics can be effectively covered in 10 minutes and therefore some topics were covered in two or even three 10-minute lectures. Overall, the total video lecture time was

shorter post-redesign than pre-redesign (222 minutes and 266 minutes, respectively), but remained comparable. The segmentation of the lectures, however, differed considerably.

The other principles were implemented through production. Comparing Figure 1a with Figure 1b (and Figure 2a with Figure 2b) illustrates how we applied the *Split-Attention Principle* (i.e., people learn better when corresponding visual and verbal content is physically proximate). The pre-version presents the instructor in a separate window while the post-version superimposes the instructor's presence over the slides. The production change doesn't eliminate gaze switching between the instructor and the content, but the instructor is physically closer and seamlessly integrated with the content post-redesign, reducing students' extraneous load when processing the multimedia. Finally, the *Personalization Principle* (which says that people learn better from multimedia instruction when the instructor's tone and style are conversational rather than formal) is embodied in the instructor's position. While the production style of the pre-version shows the instructor behind the office desk, there is no barrier between the student and the instructor in post-version and the instructor's body language is open, which is thought to increase germane load.

3. Method

3.1 Sample and Data Collection

405 students enrolled in and completed the online Strategic Management course. Each course section was capped at 45 students and was always fully subscribed, resulting in equal class sizes. Upon the culmination of the course, students were asked to evaluate course quality using standardized questions administered via an online evaluation system. Of the 405 enrolled students, 300 students completed the non-mandatory course evaluation survey at the end of the semester (corresponding to a 74 percent response rate). These students represent the study sample.

Of the 300 students in the sample, 194 students took the course in the years 2016-2018 and were exposed to video lectures developed and produced by the instructor. These students comprise the control group. The remaining 106 responses are from students who took the course in 2019 and were exposed to video lectures that were designed and developed in collaboration between the instructor and instructional designers and recorded in studio. These represent the treatment group.

This study was conducted in accordance with ethical principles for behavioral research. The Institutional Review Board (IRB) approved this study (IRB ID# 201905845) and waived informed consent by the study's student research subjects.

3.2 Measures

4.2.1 Dependent Variables

Perceived learning and student satisfaction are commonly used dependent variables in studies of online courses (Arbaugh, 2005b; Marks, Sibley and Arbaugh, 2005; Alavi, Marakas and Yoo, 2002) and video lectures (Wang and Antonenko, 2017; Kizilcec, Bailenson and Gomez, 2015; Costley and Lange, 2017). A major challenge facing online education is the comparatively high voluntary attrition rate among students (Bawa, 2016). Perceived learning and student satisfaction predict retention (Hone and El Said, 2016) and students' intentions to complete a degree online (Lorenzo, 2012; Yukselturk and Yildirim, 2008), making these constructs critical for both theory and practice (Alavi, Marakas and Yoo, 2002; Marks, Sibley and Arbaugh, 2005). Of course, comprehension and learning retention are the primary goals of education. However, online education is also a product where earned revenues through tuition depend on students' perceptions of quality. For these reasons, we examined perceived learning and student satisfaction as the outcomes of interest.

The dependent variables were derived from student responses to the course evaluation survey. The course evaluation survey consists of 11 items that address multiple instructional dimensions, each utilizing a 6-point response scale ranging from 1 = 'strongly disagree' to 6 = 'strongly agree.' To proxy for *Perceived learning*, we used students' responses to the survey item: "Concepts are presented in a manner that helps me learn." To proxy for *Student satisfaction*, we used students' responses to the survey item: "I would recommend a course taught by this instructor to other students." Because video lectures were the only feature of the course to change pre- and post-redesign and were the core of the presented material, these items capture the change in students' perceived learning and satisfaction.

4.2.2 Independent Variable

Video lecture quality is a binary variable set equal to 1 if the student was exposed to video lectures that were designed and produced in collaboration between the instructor and the instructional designer in line with multimedia learning principles. The variable was set equal to 0 if the student was exposed to video lectures that were designed and produced by the instructor.

4.2.3 Control Variables

We also controlled for variance in contextual factors that prior research indicates could affect perceived learning and student satisfaction. Between 2016-2019, the course was offered in three formats: a 12-week session, 11-week session, and 6-week session. Studies show that condensed courses can affect student course evaluations and therefore the regression analyses controlled for *Course length*, measured in weeks. Class time has also been found to be correlated with student course evaluations (Husbands and Fosh, 1993) and we controlled for the start time of the weekly, synchronous *Zoom* sessions. *Course time* is a binary variable set equal to 1 if the synchronous *Zoom* session started at 8 PM and set equal to 0 if it began at 6 PM. Finally, research indicates that a student's expected grade in the course also influences the course evaluation (Braskamp and Ory, 1994; Marsh, 1987). We controlled for student performance in the course by including the *Course grade*. Students' responses to the course evaluation survey are de-identified, so we couldn't match individuals' evaluations to their grade in the course. We instead used the section average grade (in grade point average format).

Additional class-related and instructor-related characteristics, such as class size (Arbaugh and Duray, 2002), subject matter (Arbaugh, 2005a), and instructor attributes (Arbaugh and Duray, 2002) are also known to be correlated with students' perceptions of online courses, but these remained constant in this research study.

4. Results

Table 2 presents descriptive statistics for the independent and control variables for the full sample and for the two sub-samples. Table 3 presents Pearson correlation coefficients between study variables.

Table 2: Descriptive statistics of independent and control variables

	All observations	Pre-redesign	Post-redesign
		Mean (Standard deviation)	
Perceived learning (scale 1-6)	5.38 (0.87)	5.25 (0.92)	5.61 (0.70)
Student satisfaction (scale 1-6)	5.58 (0.82)	5.49 (0.93)	5.75 (0.51)
Course length (in weeks)	10.21 (2.41)	9.77 (2.91)	11 (0.00)
Course time (6 PM = 0, 8 PM = 1)	0.32 (0.47)	0.14 (0.35)	0.65 (0.48)
Course grade (class section grade average in G.P.A. format)	3.64 (0.09)	3.65 (0.11)	3.62 (0.06)
	n = 300	n = 194	n = 106

Table 3: Pearson correlation coefficients

		1	2	3	4	5	6
1	Video lecture quality	1.00					
2	Perceived learning	0.20***	1.00				
3	Student satisfaction	0.16**	0.70***	1.00			
4	Course length	0.24***	0.16**	0.19***	1.00		
5	Course time	0.52***	0.16**	0.14*	0.31***	1.00	
6	Course grade average	-0.11	0.12*	0.02	-0.34***	0.21***	1.00

Table 4 reports differences in means in the dependent variables for the control and treatment group and gives us our first insights into the research questions. The *t*-tests show that there is a statistically significant difference

and increase in both *Perceived learning* (p<0.001) and *Student satisfaction* (p<0.01) following the video lecture redesign and rerecording. To interpret the effect size, we calculated Cohen's *d* (Cohen, 1988), which quantifies the difference in magnitude between two intervention groups in units of standard deviation. Using this approach, the video lecture redesign had a small to medium effect on both *Perceived learning* (d=0.41) and *Student satisfaction* (d=0.33), providing initial support for both hypotheses.

Table 4: Differences in dependent variable means pre- and post-redesign of video lectures

	Perceived learning	Student satisfaction	N
Pre-redesign	5.25 (0.92)	5.49 (0.93)	194
Post-redesign	5.61 (0.70)	5.75 (0.51)	106
Student t-statistic	3.45	2.72	
p	<0.001	<0.01	
Effect size (Cohen's *d)*	0.41 [0.18, 0.66]	0.33 [0.09, 0.57]	

4.1 Regression Discontinuity Results

We used a regression discontinuity design (Lee and Lemiux, 2010) to make a causal inference about the effect of video lecture design and production on student outcomes. To test our hypotheses, we performed ordinary-least squares (OLS) regressions of the control and independent variables on *Perceived learning* and *Student satisfaction*. We clustered the standard errors by course section.

Table 5 reports the results of the effect of *Video lecture quality* on *Perceived learning* and shows that, controlling for covariates, *Video lecture quality* is a positive and statistically significant predictor (β=0.36, p=0.02) of *Perceived learning*. The results provide strong support for Hypothesis 1. Table 6 shows the results of the effect of *Video lecture quality* on *Student satisfaction*. Increasing *Video lecture quality* has a positive but weakly significant effect on *Student satisfaction* (β=0.20, p=0.08), providing weak support for Hypothesis 2.

Table 5: Ordinary least-squares regression analyses of perceived learning

Dependent variable: Perceived learning		
	Model 1	Model 2
Video lecture quality		0.36*
		[0.02]
Course length	0.07	0.07*
	[0.08]	[0.03]
Course time	0.12	-0.09
	[0.41]	[0.50]
Course grade	1.57*	2.00**
	[0.01]	[0.00]
Constant	-1.09	-2.75
	[0.57]	[0.16]
Observations	300	300
R-squared	0.06	0.09
P values are shown in brackets.		
**** p<0.001, ** p<0.01, * p<0.05*		

Table 6: Ordinary least-squares regression analyses of student satisfaction

Dependent variable: Student satisfaction		
	Model 3	Model 4
Video lecture quality		0.20
		[0.08]
Course length	0.07	0.07
	[0.20]	[0.17]
Course time	0.12	0.00
	[0.33]	[0.98]
Course grade	0.62	0.87
	[0.29]	[0.19]
Constant	2.59	1.65
	[0.27]	[0.51]
Observations	300	300
R-squared	0.05	0.06
P values are shown in brackets.		
**** p<0.001, ** p<0.01, * p<0.05*		

Since both *Perceived learning* and *Student satisfaction* are measured using an ordinal scale from 1-6, we performed ordered logistic regressions for both dependent variables with the same specifications as above (not shown) as robustness checks. The results are in line with those of the reported OLS regressions.

5. Discussion

5.1 Noteworthy Findings and Implications for Theory

Our results show that designing and producing video lectures in accordance with principles of multimedia learning has a meaningful causal effect on students' perceived learning. After implementing multimedia learning principles into video lectures (and holding all else equal), instructors can expect a 0.41 standard deviation increase in perceived learning. Instructors may also experience an increase in student satisfaction; however, our analyses only uncovered a weakly significant effect of video lecture quality on student satisfaction. Previously, our knowledge of these relationships rested on small-sample laboratory studies and field studies in contexts that are dissimilar to graduate-level online programs in the U.S. (such as undergraduate courses, courses at institutions outside the U.S., MOOCs, and Amazon Mechanical Turk participants). Our study therefore contributes an important result to video lecture research and to the growing literature on online graduate education.

Our study of video lecture design and production also contributes to evidence-based research on CTML. After simultaneously implementing seven multimedia learning principles in our video lectures, it is noteworthy that our effect sizes are on the lower end of the range reported by experimental studies that examined the effect of individual multimedia principles on student outcomes: *Coherence Principle* (median *d*=0.86; 23 experiments) (Mayer and Fiorella, 2014); *Modality Principle* (median *d*=0.76, 61 experiments) (Mayer and Pilegard, 2014); *Signaling Principle* (median *d*=0.41, 28 experiments) (Mayer and Fiorella, 2014); *Redundancy Principle* (median *d*=0.86, 16 experiments) (Mayer and Fiorella, 2014); *Segmenting Principle* (median *d*=0.79, 10 experiments) (Mayer and Pilegard, 2014); and *Personalization Principle* (median *d*=0.79, 17 experiments) (Mayer, 2014c). One possible reason is that laboratory environments differ substantially from full-semester online graduate courses. In contrast to value-added laboratory studies, where participants are presented with multimedia and the studies test the effect of a singular change on learner outcomes, the success of full-semester courses depends on a multitude of factors. It depends not only on lecture quality, but also on the quality of assignments, exams, student-to-student interaction, student-to-instructor interaction, perceived fairness in grading, etc. In our case, the other course components did not change pre- and post-redesign and rerecording, but they nonetheless represented a nontrivial part of the students' overall experience. These other course components were also already satisfactory from the students' perspective (as evidenced by the relatively high student evaluations from before the video lecture redesign) and therefore our findings are likely constrained by a ceiling effect (Bakker, et al., 2019). The magnitudes of the observed effects therefore need to be interpreted within the context of an otherwise effective, full-semester online graduate course (Bakker, et al., 2019).

We also note a bigger effect of the video lecture redesign on perceived learning than on satisfaction. On the one hand, *Student satisfaction* was already quite high pre-redesign (5.49 out of 6) and *Perceived learning* was comparatively lower pre-redesign (5.26 out of 6). But the bigger increase in *Perceived learning* after the redesign and rerecording also indicates that students in this study responded not only to the higher production quality of the in-studio recording (which would be expected to increase satisfaction but not necessarily learning), but to the efforts made to increase germane load and decrease extraneous and intrinsic load through application of multimedia learning principles.

5.2 Implications for Practice

As online graduate programs consider how to best allocate limited resources, our findings offer useful empirical evidence on whether to invest into instructional designers and professional production when creating video lectures. As mentioned in the introduction, the cost of designing and developing online learning content in line with best practices is substantial. Are increases of 0.41 standard deviations in perceived learning and 0.33 standard deviations in student satisfaction worth the financial cost of implementation (not to mention the energy and opportunity cost of faculty members' time)?

From a pedagogical perspective the answer is clearly yes because student outcomes improved. From a financial perspective, however, the conclusion may depend on the nature of the video lecture content, what purpose the video lectures serve in the course, and how often the video lectures need to be changed. If video lectures are the primary means of disseminating content in the course and the lecture can be reused over multiple academic years, then investment is more likely to be worthwhile. However, if students' perceived learning and satisfaction are already high or the video lectures need to be re-developed often (to remain current given advances in the field, for instance), then the rise in students' perceptions may not be worth the added cost of professional design and production.

Finally, the disruption caused by the pandemic has made efficient online instruction a top priority for administrators and faculty members alike. It has also highlighted that educational theory for online learning matters. Our study contributes to this conversation by not only describing how online instruction can be improved through video lecture design and production, but also by quantifying the effect of applying principles of multimedia learning to video lectures on student outcomes.

5.3 Limitations and Directions for Future Research

There are certainly several limitations to this study that need to be considered when interpreting the findings. Although this is a multi-semester study with hundreds of participants, the data derive from a Strategic Management course taught by one instructor. From previous research, we know that disciplinary (Arbaugh, 2005a; Arbaugh and Rau, 2007) and instructor-specific effects induce variance in students' perceptions of online courses. Therefore, the effect of video lectures on student outcomes also needs to be studied across disciplines and instructors (Arbaugh, et al., 2009). Since dispositional, behavioral, and demographic characteristics may influence students' perceptions of video lectures, instructor-centered research would be valuable and would enhance our understanding of what works, what doesn't, and under what conditions.

Also, we examined the effect of our intervention on perceived learning. The long-term goal of instruction is, of course, comprehension and retention of the material. Therefore, it is important that future studies examine whether adoption of best practices in video lectures facilitates not only the perception of learning but also comprehension and retention.

6. Conclusion

We began this study with an interest in whether implementation of multimedia learning principles in video lectures matters for student outcomes. We pursued this analysis after finding misalignment between educational theory and practice in online learning. While research shows that implementing best practices in online course design increases learning and satisfaction, institutions are not investing sufficiently in training and support which would empower faculty to implement advances in online learning research into practice (Garrett, Legon and Fredericksen, 2019). Many faculty members also remain skeptical of online learning pedagogy and are reticent about giving up their autonomy while working with instructional designers (Garrett, Legon and Fredericksen, 2019). We used the context of video lecture design and production to measure how much adherence to best practices matters for perceived learning and student satisfaction. We exploited an exogenous

change in online course development standards in an MBA program at a large, research university, providing much needed empirical evidence for online graduate education.

Based the results of this study, the following conclusions can be made. Designing and producing video lectures in accordance with multimedia learning principles has a positive causal effect on perceived learning of 0.41 standard deviations and a weakly positive causal effect on student satisfaction of 0.33 standard deviations.

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Effects of Video Lecture Design and Production Quality on Student Outcomes: A Quasi-Experiment Exploiting Change in Online Course Development Principles

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Abstract: In seeking competitive advantage, many online graduate programs have turned to improving the quality of video lectures by investing in instructional designers and in-studio production. However, it is unclear how much video lecture design and production quality improve student outcomes. We used a regression discontinuity to evaluate how video lecture design and production practices that adhere to principles of multimedia learning affect perceived learning and student satisfaction. The study involved 300 students taking an online graduate course at a large, public research university, where 194 students were exposed to video lectures designed and produced by the instructor and 106 students were exposed to video lectures designed in collaboration between the instructor and instructional designers and produced in studio. Our findings indicate that designing and producing video lectures in accordance with principles of multimedia learning has a meaningful causal effect on students' perceived learning and a marginal effect on student satisfaction. We discuss the theoretical and practical implications of our findings for video lecture development and design in the context of online business education and the COVID-19 pandemic.

Keywords: Video lectures; Online learning; Cognitive Theory of Multimedia Learning; Instructional design; MBA program

1. Introduction

As of 2019, 46 percent of faculty members in the United States reported having taught an online course for credit (Jaschik and Lederman, 2019). In 2020, the experience became nearly universal when educational institutions transitioned to remote teaching. Yet there is a substantial disparity in how faculty members develop and design online course content (Fiorella, et al., 2017). *Inside Higher Ed*'s 2019 Survey of Faculty Attitudes on Technology indicates that 62 percent of faculty members developed and designed online courses on their own, while 17 percent of faculty members created all or most of their courses in collaboration with instructional designers (Jaschik and Lederman, 2019). *Quality Matters*' 2019 survey of Chief Online Officers at U.S. higher education institutions concluded that use of instructional design support remains low due to two factors: "Cost is an ongoing constraint, and entrenched faculty … resistant to surrendering any of their autonomy in the online or on-ground classroom persist in many institutions." (Garrett, Legon and Fredericksen, 2019, p.24)

The apparent disconnect between theory and practice of online course development, design, and production is puzzling given the substantial advances in online learning research. Unlike two decades ago when educational theory for online learning was in its infancy, today there is increasing convergence in scientific thought on best practices in online learning (e.g., Clark and Mayer (2011); Mayer (2009); Mayer (2005); Jenlink (2019), among others).

We examine how much adopting best practices matters for student outcomes in the context of designing and producing online video lectures. Video lectures are a central element in online learning. They are instructors' primary means of presenting information (de Koning, Hoogerheide and Boucheix, 2018) and students rank them as the most valuable class activity for learning and success (Magda and Aslanian, 2018). Importantly, video lectures increase instructors' teaching and social presence in the virtual classroom (Draus, Curran and Trempus, 2014; Ke, 2010). Teaching and social presence are in turn linked to key outcomes such as student participation, engagement, and satisfaction (Garrison and Arbaugh, 2007).

Best practices in video lecture design and production are informed by principles of multimedia learning (Mayer, 2014a), which were developed for the purpose of optimizing learning from visual and verbal content using theories of learning and cognition (Baddeley, 1986; Paivio, 1990; Sweller, 1988, 1994). We define professionally-produced video lectures as those created in collaboration between instructors as the subject matter experts and

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instructional designers whose primary role is to advise on pedagogical principles (Kenny, et al., 2005). They are recorded in studio by digital media production professionals. Yet instructors face few barriers to producing video lectures on their own (Kizilcec, Bailenson and Gomez, 2015; de Koning, Hoogerheide and Boucheix, 2018). Using commonly available technology, such as computers, smartphones, video or web cameras, video recording software, video-editing applications, and a high-speed internet connection, instructors can create and disseminate video lectures quite easily and cost efficiently.

Indeed, the seemingly low barriers to producing online learning content have enabled institutions of higher education to respond to the COVID-19 pandemic by asking instructors to transform courses previously taught face-to-face into an online format, virtually overnight. But, just as conducting education at a distance is not the same as delivering a quality education online, exposing students to instructors' best efforts to design and produce video lectures is not the same as exposing them to video lectures designed and produced in accordance with principles of multimedia learning. Moreover, institutions vary greatly in how they prepare and support instructors who are teaching online and instructors themselves vary in their abilities to create engaging and effective video lectures. Consequently, "the quality of faculty-created videos varies from magical to marginal." (Mosley, 2017, p.92) Given these realities, the purpose of our study is to measure the difference in student outcomes among students exposed to video lectures that are designed and produced in adherence with basic principles of multimedia learning compared to video lectures that are developed by the instructor.

This study identifies the causal effect of video lecture design and production on perceived learning and student satisfaction using a discontinuity in online course development standards at a large, public research university. A 2017 decision put into effect a requirement that all online courses in the Master of Business Administration (MBA) program be designed and developed in collaboration between instructors, instructional designers, and digital media professionals. Importantly, the requirement applied not only to new courses yet to be developed, but also to existing courses previously developed by instructors. Our research design takes advantage of this discontinuous change in development standards to assess the effect of a change in video lecture design and production quality in the context of a single online course that was taught nine times between the years 2016 and 2019. In this core MBA course, all course components remained the same over this four-year period, apart from the video lectures. This feature allows us to employ a regression discontinuity design to measure and compare student satisfaction and perceived learning pre- and post-intervention in video lecture design and production.

We make several contributions to multimedia and online learning literature. First, our research informs the current scholarly debate on video lecture efficacy by examining the combined effect of instructional design and professional production of video lectures on student outcomes. As such, it answers a call in the literature for examining how video lecture design features relate to learning outcomes (Crook and Shofield, 2017). Second, our study provides much needed empirical evidence from graduate students taking full-semester online courses. There is currently a dearth of research on the impact of video lectures in graduate education. Our understanding of how video lectures affect student outcomes rests on findings from laboratory studies of Amazon Mechanical Turk participants (e.g., Wilson, et al. (2018)), undergraduate students (often outside the United States) (e.g., van Wermeskerken, Ravensbergen and van Gog (2018); van Wermeskerken and van Gog (2017); Hong, Pi and Yang (2018); Chen and Wu (2015)), and massive open online courses (MOOCs) (Kizilcec, Bailenson and Gomez, 2015; Bhat, Chinprutthiwong and Perry, 2015). The generalizability of the available research on video lectures to online graduate education is debatable. Our field research, in contrast, is highly relevant for other graduate-level online business programs as it assesses satisfaction and learning outcomes of students taking a core course at an AACSB-accredited and nationally ranked MBA program.

This study also has important practical implications for institutions offering online courses. Given our field setting, our findings can inform future institutional decision making about resource allocation. If our findings indicate that video lecture design and production quality improve student outcomes, then institutions can better justify expenditures into instructional designers, production studios, and related staff – and these costs are far from trivial. Indeed, after accounting for key resources (such as subject matter experts, instructional designers, and technical staff) estimates suggest that designing and developing one hour of online learning content in adherence with online education best practices can range from $7,800 up to $37,400 (Movchan, et al., 2019). Of this sum, the costliest component is the time and money spent on designing, producing, and editing the video lecture (Movchan, et al., 2019).

Finally, our findings contribute much needed data and evidence to faculty members and administrators as they manage the new academic landscape created by the COVID-19 pandemic. During the forced emergency transition to online instruction this spring, faculty members self-produced entire online courses at extremely short notice. While the quality of online instruction sufficed for the moment, students' expectations are already rising ahead of the Fall 2020 semester and institutions are under pressure to increase the quality of online instruction during the summer months. This study is timely and relevant to the current global conversation about online learning as it quantifies the effect of instructional design and professional production of online course content on student outcomes.

2. Theory and Hypothesis Development

Video lectures are a central component of online education. They are the primary means of delivering instruction in online undergraduate and graduate courses (de Koning, Hoogerheide and Boucheix, 2018). The most common video lecture types can be summarized as follows: slides (slide presentation with voice-over lecture by the instructor); Khan whiteboard (full-screen video of instructor drawing or writing freehand on a digital tablet); classroom (video recording of a classroom lecture); office desk (video recording of instructor's head or torso speaking at an office desk); and studio (instructor is recorded in a studio with no audience) (Crook and Shofield, 2017; Guo, Kim and Rubin, 2014). A video lecture can include multiple styles either in sequence or simultaneously by embedding separate windows with different styles.

An important theoretical perspective that informs research on the effects of design and production in video lectures is the Cognitive Theory of Multimedia Learning (CTML, Mayer (2014a)). CTML is an evidence-based theory that joins the science of learning with the science of instruction. Its theoretical foundations are rooted in learning and cognition science, including working memory (Baddeley, 1986), dual-coding (Paivio, 1990), and cognitive load theory (CLT, Sweller (1988; 2005)).

The premise of CTML is that "people learn more deeply from words and pictures than from words alone" (Mayer, 2014b, p.43). In cognitive theories of learning, learners have limited capacity and information processing ability (Miller, 1956). They are constrained by their cognitive ability to select and organize information and integrate it into long-term memory (Paas and Sweller, 2014; Sweller, 1988). How to optimize the presentation of words and pictures to guide people's learning processes most effectively and efficiently is thus the central question that CTML scholars seek to answer (Mayer, 2014a).

Three assumptions developed in cognitive science underlie CTML. First, the *dual channels* assumption states that people process visual and auditory information through separate channels (Paivio, 1990; Baddeley, 1992). Multimedia that uses both channels can therefore increase the amount of information a learner's brain can process (Mayer, 2009; Penney, 1989), leading to quicker comprehension and richer mental representations than would be possible through verbal or pictorial presentations alone (Sweller, 2005). Second, the *active processing* assumption states that active learning is the outcome of selecting, organizing, and integrating information with other knowledge (Wittrock, 1989). In other words, learners do not interpret words, pictures, and auditory information in an independent and mutually exclusive fashion. Instead, learners select, organize, and integrate elements in relation to prior knowledge. Multimedia presentations that organize and introduce new knowledge in ways that build on existing mental schemas and logical constructs are more effective.

Finally, the *limited capacity* assumption states that people are constrained in the amount of information that visual and auditory channels can each process at once (Baddeley, 1992; Chandler and Sweller, 1991; Miller, 1956). Multimedia thus needs to be designed to not overwhelm either channel. Of course, all instructional material imposes demands on learners' ability to process information. This demand is referred to by cognitive scientists as cognitive load. Cognitive load can be divided into three categories: intrinsic, extraneous, and germane (Sweller, 1994). Intrinsic load represents the natural, unalterable difficulty of the material to be learned and it is independent of instructional design efforts (Sweller, 1994). Extraneous load is the processing strain on the learner created by sub-optimal instructional design choices, and it represents the type of load that CLT and CTML researchers strive to minimize. The third category, germane load, represents the cognitive effort required to organize and integrate information into long-term memory (Sweller, 2010). While both intrinsic and extraneous load are determined entirely or in part by the characteristics of the instructional material, germane load depends on the characteristics of the learner and on instructional design choices that enhance the learner's

ability structure and encode knowledge into memory. Instructional design of multimedia therefore aims to reduce extraneous cognitive processing and free capacity for knowledge integration.

Given CTML's emphasis on optimizing the presentation of words and pictures for learning, its principles are highly salient for video lectures. Indeed, CTML serves as the theoretical foundation for numerous empirical studies of the effects of video lectures on student outcomes (for example, Wang and Antonenko (2017); Kizilcec, Bailenson and Gomez (2015); Chen and Wu (2015); Hughes, Costley and Lange (2019), among others). Over the last three decades, CTML scholars have iterated between theory and evidence to develop basic and advanced principles of multimedia learning (e.g., Mayer (2009); Mayer and Moreno (2003; 1998); Mayer (2008); Mayer and Anderson (1992)). Although advanced principles can also be incorporated into video lectures, we applied the following seven basic principles during the video lecture redesign event that is at the center of this study: Coherence, Modality, Redundancy, Signaling, Segmenting, Split-Attention, and Personalization. A description of each principle and its underlying logic is presented in Table 1.

Table 1: Multimedia learning principles implemented in video lecture redesign and rerecording

Coherence Principle:	People learn better when extraneous narration, sounds, printed text, and visual content are excluded rather than included. Removing unneeded elements reduces extraneous load (Mayer, et al., 1996; Harp and Mayer, 1997, 1998).
Modality Principle:	People learn better from a combination of pictures and narration than from a combination of pictures and printed text because processing pictures and narration utilizes dual channels whereas processing pictures and printed text can overload the visual channel (Mayer and Moreno, 1998; Moreno and Mayer, 1999; Mousavi, Low and Sweller, 1995).
Redundancy Principle:	People learn better when the same information is presented with pictures and narration rather than with pictures, narration, as well as printed text (Mousavi, Low and Sweller, 1995) because the printed text is redundant and adds to extraneous load.
Signaling Principle:	People learn better when cues are added to direct attention toward essential material because cues limit extraneous load (Jeung, Chandler and Sweller, 1997; Harp and Mayer, 1998).
Segmenting Principle:	People learn better when multimedia instruction is presented or broken into learner-paced segments rather than when it is presented as a single, continuous unit (Mayer and Chandler, 2001).
Split-Attention Principle:	People learn better when corresponding visual content and verbal content is presented in physical and/or temporal proximity. When multimedia is designed such that corresponding text or narration and visual content are not nearby, the cognitive processing demand created by searching and integrating separate pieces of information creates extraneous load for the learner (Mayer and Anderson, 1992; Mayer and Anderson, 1991; Moreno and Mayer, 1999; Tarmizi and Sweller, 1988).
Personalization Principle:	People learn better from multimedia instruction when the instructor's tone and style are conversational rather than formal because the conversational style is more engaging and promotes germane load (Moreno and Mayer, 2000; Mayer, et al., 2004).

Using the logic of CTML, it stands to reason that designing and producing video lectures in line with the principles of multimedia learning will positively affect students' perceptions of learning and satisfaction. For instance, video lectures designed to not overload the auditory or visual channel and to take advantage of learners' dual channel processing (in line with the *Modality Principle*) will ease extraneous load and allow the learner to process information more easily. Similarly, video lectures designed in accordance with the *Coherence*, *Redundancy*, and *Signaling Principles* will lighten extraneous load by focusing learners' attention on essential material and by eliminating distracting or redundant elements. In line with the *Segmentation Principle*, partitioning material into multiple, shorter video lectures will promote cognitive processing by decreasing the material's intrinsic load. Video lectures where related visual and verbal content is presented in proximity (in line with the *Split-Attention Principle*) will reduce extraneous load by curtailing learners' need to search for and integrate separate pieces of information. In line with the *Personalization Principle*, video lectures where the instructor's body language and vocal color remain conversational and open bolster germane load and learners' ability to integrate knowledge into long-term memory. In sum, video lecture design and production decisions that limit extraneous and intrinsic load and promote germane load can be expected to reduce cognitive load and free up capacity for knowledge integration. This, in turn, will increase students' perceived learning and feelings of satisfaction. Therefore, we hypothesize:

Hypothesis 1: Perceived learning will be higher among students exposed to video lectures that are designed and produced in adherence with basic principles of multimedia learning.

Hypothesis 2: Satisfaction will be higher among students exposed to video lectures that are designed and produced in adherence with basic principles of multimedia learning.

3. Research Context

3.1 The Course

The research context of our study is an online Professional MBA course in Strategic Management at a large, public research university. Nine sections of the course were offered by the program in the years 2016-2019, and all were taught by the same instructor over seven semesters. In 2017, a program-wide decision required that all online MBA courses be designed and developed in collaboration between instructors and instructional designers in accordance with best practices in online instruction. Importantly, the requirement applied not only to new courses yet to be developed, but also to existing online courses previously developed by instructors.

During the initial meeting between the instructor and the instructional designers in 2018, it was agreed that all components of the Strategic Management course could and would remain the same *except for the video lectures*, which would be redesigned to adhere with best practices and rerecorded in studio by digital media professionals. The video lectures were redesigned and rerecorded during the summer and fall of 2018 with the first students experiencing the redesigned lectures in the Spring semester of 2019. The following course components remained unchanged pre- and post-redesign: assigned readings and cases, discussion boards, quizzes, individual written assignments, group oral presentations, and exams. All course sections also included mandatory, weekly 90-minute synchronous sessions that were oriented toward case discussion and debriefs and were conducted using *Zoom* (Zoom Video Communications Inc., n.d.). The only difference between the pre- and post-redesign version of the course was therefore the design and production of the video lectures.

3.2 The Video Lectures

Unlike existing laboratory experiments which manipulate one or perhaps two multimedia characteristics and measure their effect on learner outcomes, our field study assesses the causal effect of a more comprehensive application of multimedia learning principles in the context of a full-semester course. Given that instructional designers and instructors would also implement all relevant principles of multimedia learning (and not just one) to multimedia content, our findings are realistic and relevant for institutions as they consider adopting video lecture development standards. But, in order to reasonably interpret our findings, it is important to provide context and transparency about the state of the video lectures pre- and post-redesign, and to describe the steps that were taken to improve quality in line with principles of multimedia learning. Below, we outline the implemented changes and specify how each principle was implemented either through redesign or production.

To illustrate how the seven principles described in the Theory and Hypotheses section manifested in the redesigned and rerecorded video lectures, we offer three illustrative examples: presentation of Topic A (in Figures 1a and 1b), Topic B (in Figures 2a and 2b), and Topic C (in Figures 3a and 3b). The same information is being presented for each topic pre- and post-redesign and rerecording – but the difference is in *how* the information is presented.

For instance, the *Modality Principle*, which says that people learn better from a combination of pictures and narration than from a combination of pictures and printed text, was implemented during the design process by thoughtfully evaluating what should be presented as printed text what should instead be presented using graphics and narration. For example, the printed text that appears in Figure 1a (but does not appear in Figure 1b) was verbalized by the instructor in the post-redesign version. The printed text that appears in Figure 2a (but does not appear in Figure 2b) was presented as a graphic post-redesign.

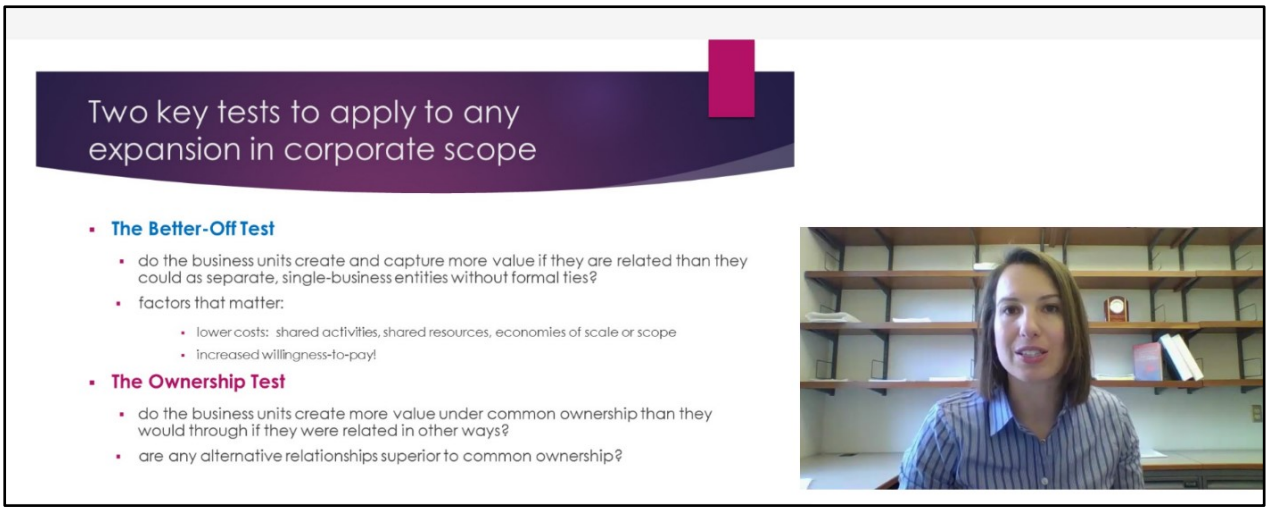

Figure 1a: Screenshot of pre-redesign video lecture on Topic A

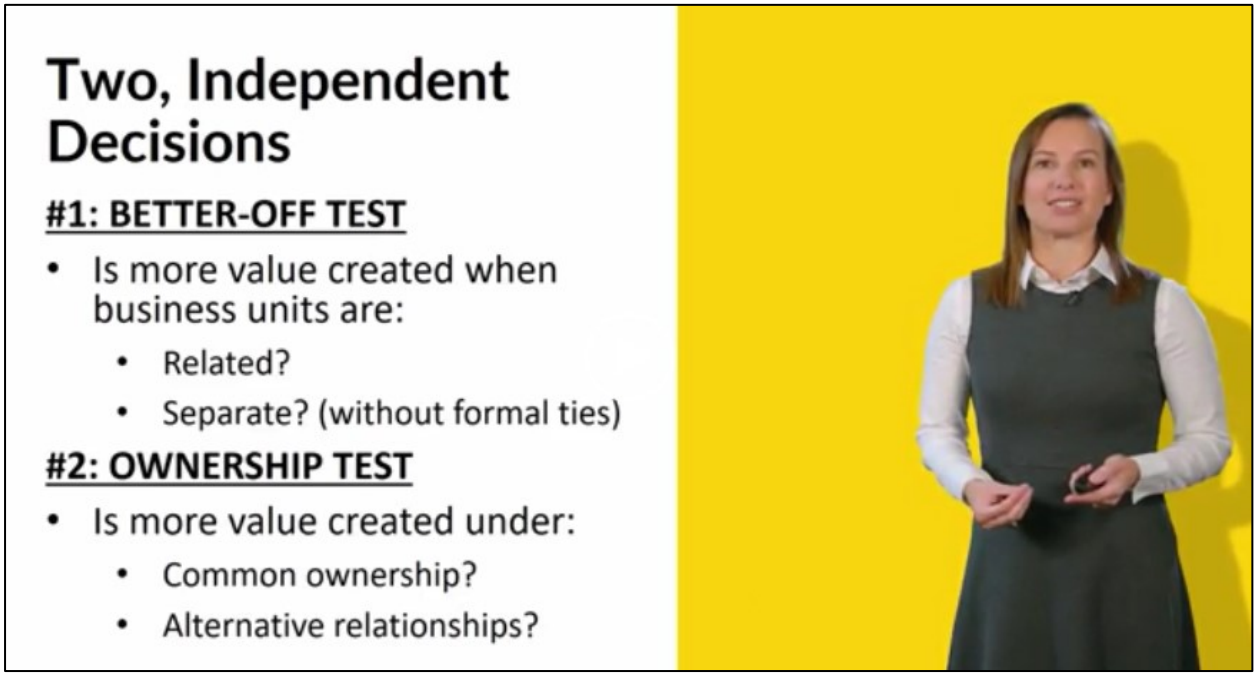

Figure 1b: Screenshot of post-redesign video lecture on Topic A

In line with the *Coherence Principle* (i.e., people learn better when extraneous narration, sounds, printed text, and visual content are excluded rather than included), extraneous words were removed from the slide title and the bullet points during the redesign (see Figure 1b, compared to Figure 1a). Another example of the *Coherence Principle* is evident when juxtaposing Figures 2a and 2b. Written text and equations that were included in the pre-redesign version (Figure 2a) were removed and replaced in the post-redesign version with a simple graphic illustrating the same concept (Figure 2b). Overall, during the redesign, the instructor and the instructional designer emphasized clarity, conservative use of bullet points, impactful graphics, and informative narration in the video lectures.

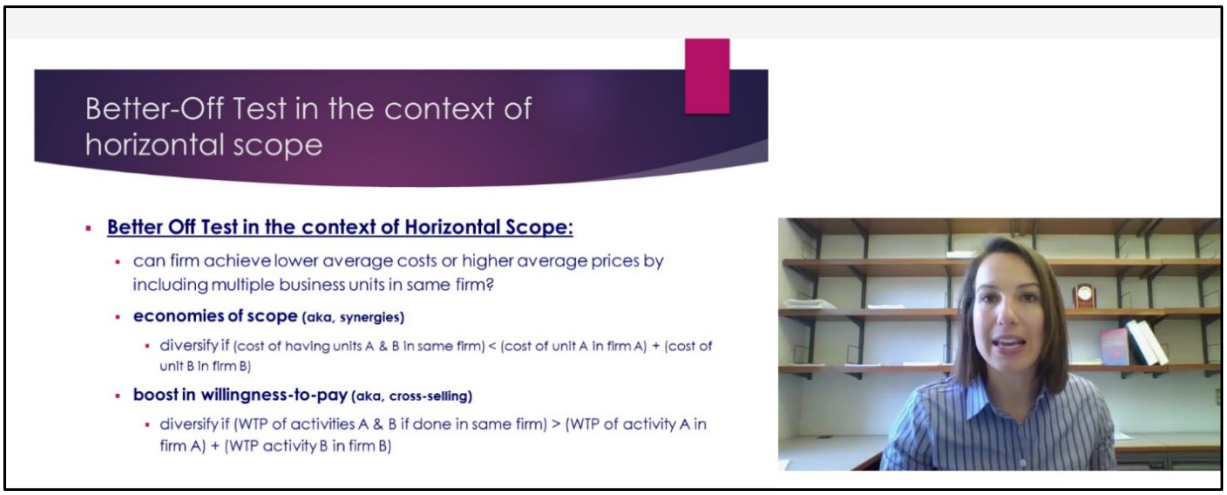

Figure 2a: Screenshot of pre-redesign video lecture on Topic B

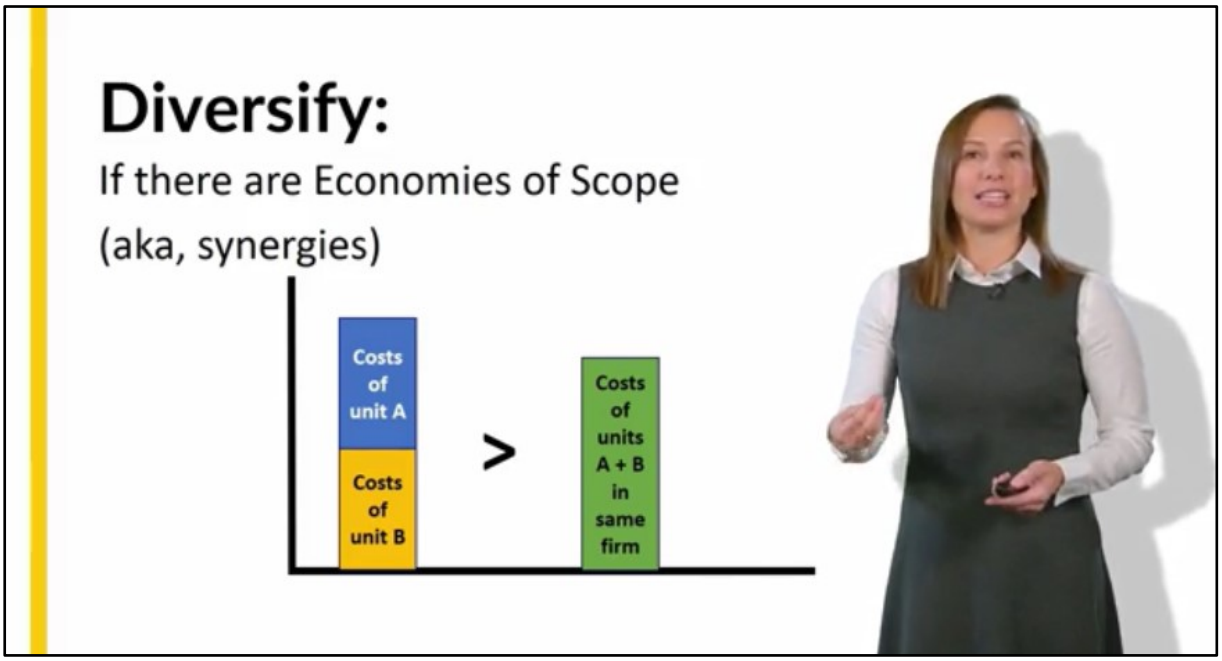

Figure 2b: Screenshot of post-redesign video lecture on Topic B

A comparison of Figures 3a and 3b illustrates how we implemented the *Redundancy Principle* (i.e., people learn better when the same information is presented with pictures and narration rather than with pictures, narration, as well as printed text). For example, pre-redesign, the video lecture on Topic C included a graphic, narration describing the graphic, and redundant printed text describing the graphic (Figure 3a). The post-redesign version eases extraneous load by removing the redundant printed text but retaining the graphic and the accompanying narration (Figure 3b).

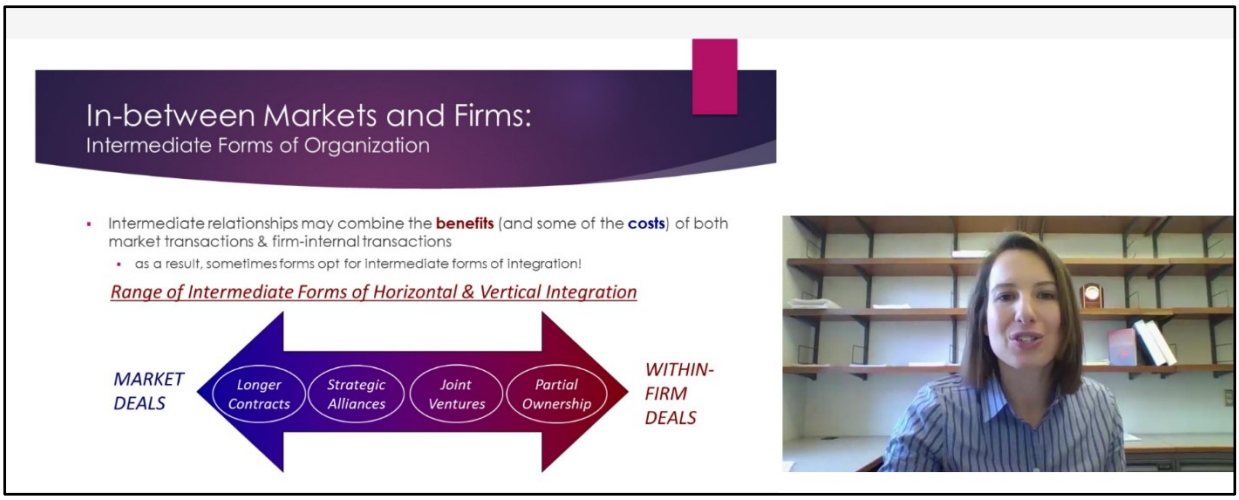

Figure 3a: Screenshot of pre-redesign video lecture on Topic C

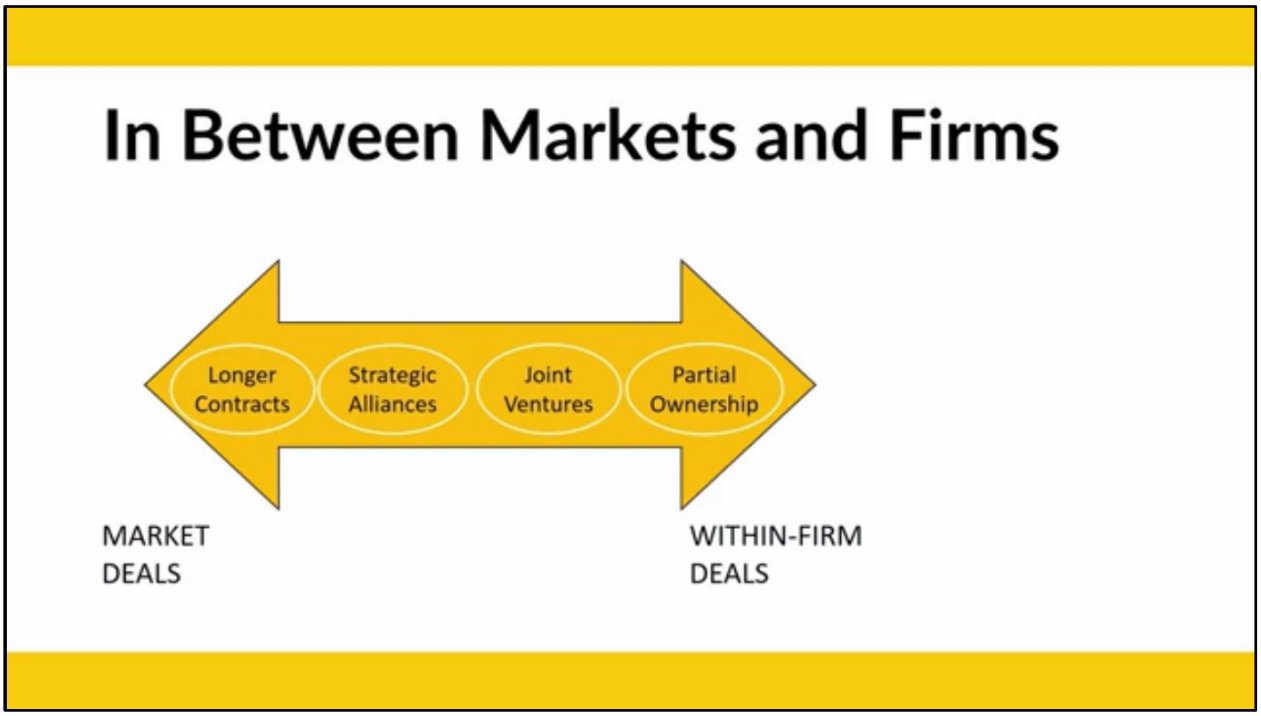

Figure 3b: Screenshot of post-redesign video lecture on Topic C

Pre-redesign, the video lectures showed the instructor's image throughout (as seen in Figures 1a, 2a, and 3a). Post-redesign, the video lectures used instructor presence to signal that students ought to focus their attention on the narration and used the instructor's absence to signal that students needed to tune into the graphics and to the text on slide (as can be seen in Figure 3b, for example). In an application of the *Signaling Principle*, which says that people learn better when cues are added to direct attention to essential material, the instructor would step off camera when the complexity of the instructional matter was high and would return to the shot when complexity declined.

Another difference pre- and post-redesign relates to the segmentation of the video lectures. Pre-redesign, video lecture length depended on the topic – with the shortest lectures being 21 minutes long and the longest extending to 60 minutes. Yet, the *Segmentation Principle* indicates that people learn better when multimedia instruction is presented or broken into learner-paced segments rather than being presented as a single, continuous unit. Therefore, during the redesign process, video lectures were broken up and restructured to be no longer than 10 minutes each. Of course, not all topics can be effectively covered in 10 minutes and therefore some topics were covered in two or even three 10-minute lectures. Overall, the total video lecture time was

shorter post-redesign than pre-redesign (222 minutes and 266 minutes, respectively), but remained comparable. The segmentation of the lectures, however, differed considerably.

The other principles were implemented through production. Comparing Figure 1a with Figure 1b (and Figure 2a with Figure 2b) illustrates how we applied the *Split-Attention Principle* (i.e., people learn better when corresponding visual and verbal content is physically proximate). The pre-version presents the instructor in a separate window while the post-version superimposes the instructor's presence over the slides. The production change doesn't eliminate gaze switching between the instructor and the content, but the instructor is physically closer and seamlessly integrated with the content post-redesign, reducing students' extraneous load when processing the multimedia. Finally, the *Personalization Principle* (which says that people learn better from multimedia instruction when the instructor's tone and style are conversational rather than formal) is embodied in the instructor's position. While the production style of the pre-version shows the instructor behind the office desk, there is no barrier between the student and the instructor in post-version and the instructor's body language is open, which is thought to increase germane load.

4. Method

4.1 Sample and Data Collection

405 students enrolled in and completed the online Strategic Management course. Each course section was capped at 45 students and was always fully subscribed, resulting in equal class sizes. Upon the culmination of the course, students were asked to evaluate course quality using standardized questions administered via an online evaluation system. Of the 405 enrolled students, 300 students completed the non-mandatory course evaluation survey at the end of the semester (corresponding to a 74 percent response rate). These students represent the study sample.

Of the 300 students in the sample, 194 students took the course in the years 2016-2018 and were exposed to video lectures developed and produced by the instructor. These students comprise the control group. The remaining 106 responses are from students who took the course in 2019 and were exposed to video lectures that were designed and developed in collaboration between the instructor and instructional designers and recorded in studio. These represent the treatment group.

This study was conducted in accordance with ethical principles for behavioral research. The Institutional Review Board (IRB) approved this study (IRB ID# 201905845) and waived informed consent by the study's student research subjects.

4.2 Measures

4.2.1 Dependent Variables

Perceived learning and student satisfaction are commonly used dependent variables in studies of online courses (Arbaugh, 2005b; Marks, Sibley and Arbaugh, 2005; Alavi, Marakas and Yoo, 2002) and video lectures (Wang and Antonenko, 2017; Kizilcec, Bailenson and Gomez, 2015; Costley and Lange, 2017). A major challenge facing online education is the comparatively high voluntary attrition rate among students (Bawa, 2016). Perceived learning and student satisfaction predict retention (Hone and El Said, 2016) and students' intentions to complete a degree online (Lorenzo, 2012; Yukselturk and Yildirim, 2008), making these constructs critical for both theory and practice (Alavi, Marakas and Yoo, 2002; Marks, Sibley and Arbaugh, 2005). Of course, comprehension and learning retention are the primary goals of education. However, online education is also a product where earned revenues through tuition depend on students' perceptions of quality. For these reasons, we examined perceived learning and student satisfaction as the outcomes of interest.

The dependent variables were derived from student responses to the course evaluation survey. The course evaluation survey consists of 11 items that address multiple instructional dimensions, each utilizing a 6-point response scale ranging from 1 = 'strongly disagree' to 6 = 'strongly agree.' To proxy for *Perceived learning*, we used students' responses to the survey item: "Concepts are presented in a manner that helps me learn." To proxy for *Student satisfaction*, we used students' responses to the survey item: "I would recommend a course taught by this instructor to other students." Because video lectures were the only feature of the course to change pre- and post-redesign and were the core of the presented material, these items capture the change in students' perceived learning and satisfaction.

4.2.2 Independent Variable

Video lecture quality is a binary variable set equal to 1 if the student was exposed to video lectures that were designed and produced in collaboration between the instructor and the instructional designer in line with multimedia learning principles. The variable was set equal to 0 if the student was exposed to video lectures that were designed and produced by the instructor.

4.2.3 Control Variables

We also controlled for variance in contextual factors that prior research indicates could affect perceived learning and student satisfaction. Between 2016-2019, the course was offered in three formats: a 12-week session, 11-week session, and 6-week session. Studies show that condensed courses can affect student course evaluations and therefore the regression analyses controlled for *Course length*, measured in weeks. Class time has also been found to be correlated with student course evaluations (Husbands and Fosh, 1993) and we controlled for the start time of the weekly, synchronous *Zoom* sessions. *Course time* is a binary variable set equal to 1 if the synchronous *Zoom* session started at 8 PM and set equal to 0 if it began at 6 PM. Finally, research indicates that a student's expected grade in the course also influences the course evaluation (Braskamp and Ory, 1994; Marsh, 1987). We controlled for student performance in the course by including the *Course grade*. Students' responses to the course evaluation survey are de-identified, so we couldn't match individuals' evaluations to their grade in the course. We instead used the section average grade (in grade point average format).

Additional class-related and instructor-related characteristics, such as class size (Arbaugh and Duray, 2002), subject matter (Arbaugh, 2005a), and instructor attributes (Arbaugh and Duray, 2002) are also known to be correlated with students' perceptions of online courses, but these remained constant in this research study.

5. Results

Table 2 presents descriptive statistics for the independent and control variables for the full sample and for the two sub-samples. Table 3 presents Pearson correlation coefficients between study variables.

Table 2: Descriptive statistics of independent and control variables

	All observations	Pre-redesign	Post-redesign
		Mean (Standard deviation)	
Perceived learning (scale 1-6)	5.38 (0.87)	5.25 (0.92)	5.61 (0.70)
Student satisfaction (scale 1-6)	5.58 (0.82)	5.49 (0.93)	5.75 (0.51)
Course length (in weeks)	10.21 (2.41)	9.77 (2.91)	11 (0.00)
Course time (6 PM = 0, 8 PM = 1)	0.32 (0.47)	0.14 (0.35)	0.65 (0.48)
Course grade (class section grade average in G.P.A. format)	3.64 (0.09)	3.65 (0.11)	3.62 (0.06)
	n = 300	n = 194	n = 106

Table 3: Pearson correlation coefficients

		1	2	3	4	5	6
1	Video lecture quality	1.00					
2	Perceived learning	0.20***	1.00				
3	Student satisfaction	0.16**	0.70***	1.00			
4	Course length	0.24***	0.16**	0.19***	1.00		
5	Course time	0.52***	0.16**	0.14*	0.31***	1.00	
6	Course grade average	-0.11	0.12*	0.02	-0.34***	0.21***	1.00

Table 4 reports differences in means in the dependent variables for the control and treatment group and gives us our first insights into the research questions. The *t*-tests show that there is a statistically significant difference

and increase in both *Perceived learning* (p<0.001) and *Student satisfaction* (p<0.01) following the video lecture redesign and rerecording. To interpret the effect size, we calculated Cohen's *d* (Cohen, 1988), which quantifies the difference in magnitude between two intervention groups in units of standard deviation. Using this approach, the video lecture redesign had a small to medium effect on both *Perceived learning* (d=0.41) and *Student satisfaction* (d=0.33), providing initial support for both hypotheses.

Table 4: Differences in dependent variable means pre- and post-redesign of video lectures

	Perceived learning	Student satisfaction	N
Pre-redesign	5.25 (0.92)	5.49 (0.93)	194
Post-redesign	5.61 (0.70)	5.75 (0.51)	106
Student t-statistic	3.45	2.72	
p	<0.001	<0.01	
Effect size (Cohen's *d)*	0.41 [0.18, 0.66]	0.33 [0.09, 0.57]	

5.1 Regression Discontinuity Results

We used a regression discontinuity design (Lee and Lemiux, 2010) to make a causal inference about the effect of video lecture design and production on student outcomes. To test our hypotheses, we performed ordinary-least squares (OLS) regressions of the control and independent variables on *Perceived learning* and *Student satisfaction*. We clustered the standard errors by course section.

Table 5 reports the results of the effect of *Video lecture quality* on *Perceived learning* and shows that, controlling for covariates, *Video lecture quality* is a positive and statistically significant predictor (β=0.36, p=0.02) of *Perceived learning*. The results provide strong support for Hypothesis 1. Table 6 shows the results of the effect of *Video lecture quality* on *Student satisfaction*. Increasing *Video lecture quality* has a positive but weakly significant effect on *Student satisfaction* (β=0.20, p=0.08), providing weak support for Hypothesis 2.

Table 5: Ordinary least-squares regression analyses of perceived learning

Dependent variable: Perceived learning		
	Model 1	Model 2
Video lecture quality		0.36*
		[0.02]
Course length	0.07	0.07*
	[0.08]	[0.03]
Course time	0.12	-0.09
	[0.41]	[0.50]
Course grade	1.57*	2.00**
	[0.01]	[0.00]
Constant	-1.09	-2.75
	[0.57]	[0.16]
Observations	300	300
R-squared	0.06	0.09
P values are shown in brackets.		
**** p<0.001, ** p<0.01, * p<0.05*		

Table 6: Ordinary least-squares regression analyses of student satisfaction

Dependent variable: Student satisfaction		
	Model 3	Model 4
Video lecture quality		0.20
		[0.08]
Course length	0.07	0.07
	[0.20]	[0.17]
Course time	0.12	0.00
	[0.33]	[0.98]
Course grade	0.62	0.87
	[0.29]	[0.19]
Constant	2.59	1.65
	[0.27]	[0.51]
Observations	300	300
R-squared	0.05	0.06
P values are shown in brackets.		
**** p<0.001, ** p<0.01, * p<0.05*		

Since both *Perceived learning* and *Student satisfaction* are measured using an ordinal scale from 1-6, we performed ordered logistic regressions for both dependent variables with the same specifications as above (not shown) as robustness checks. The results are in line with those of the reported OLS regressions.

6. Discussion

6.1 Noteworthy Findings and Implications for Theory

Our results show that designing and producing video lectures in accordance with principles of multimedia learning has a meaningful causal effect on students' perceived learning. After implementing multimedia learning principles into video lectures (and holding all else equal), instructors can expect a 0.41 standard deviation increase in perceived learning. Instructors may also experience an increase in student satisfaction; however, our analyses only uncovered a weakly significant effect of video lecture quality on student satisfaction. Previously, our knowledge of these relationships rested on small-sample laboratory studies and field studies in contexts that are dissimilar to graduate-level online programs in the U.S. (such as undergraduate courses, courses at institutions outside the U.S., MOOCs, and Amazon Mechanical Turk participants). Our study therefore contributes an important result to video lecture research and to the growing literature on online graduate education.

Our study of video lecture design and production also contributes to evidence-based research on CTML. After simultaneously implementing seven multimedia learning principles in our video lectures, it is noteworthy that our effect sizes are on the lower end of the range reported by experimental studies that examined the effect of individual multimedia principles on student outcomes: *Coherence Principle* (median *d*=0.86; 23 experiments) (Mayer and Fiorella, 2014); *Modality Principle* (median *d*=0.76, 61 experiments) (Mayer and Pilegard, 2014); *Signaling Principle* (median *d*=0.41, 28 experiments) (Mayer and Fiorella, 2014); *Redundancy Principle* (median *d*=0.86, 16 experiments) (Mayer and Fiorella, 2014); *Segmenting Principle* (median *d*=0.79, 10 experiments) (Mayer and Pilegard, 2014); and *Personalization Principle* (median *d*=0.79, 17 experiments) (Mayer, 2014c). One possible reason is that laboratory environments differ substantially from full-semester online graduate courses. In contrast to value-added laboratory studies, where participants are presented with multimedia and the studies test the effect of a singular change on learner outcomes, the success of full-semester courses depends on a multitude of factors. It depends not only on lecture quality, but also on the quality of assignments, exams, student-to-student interaction, student-to-instructor interaction, perceived fairness in grading, etc. In our case, the other course components did not change pre- and post-redesign and rerecording, but they nonetheless represented a nontrivial part of the students' overall experience. These other course components were also already satisfactory from the students' perspective (as evidenced by the relatively high student evaluations from before the video lecture redesign) and therefore our findings are likely constrained by a ceiling effect (Bakker, et al., 2019). The magnitudes of the observed effects therefore need to be interpreted within the context of an otherwise effective, full-semester online graduate course (Bakker, et al., 2019).

We also note a bigger effect of the video lecture redesign on perceived learning than on satisfaction. On the one hand, *Student satisfaction* was already quite high pre-redesign (5.49 out of 6) and *Perceived learning* was comparatively lower pre-redesign (5.26 out of 6). But the bigger increase in *Perceived learning* after the redesign and rerecording also indicates that students in this study responded not only to the higher production quality of the in-studio recording (which would be expected to increase satisfaction but not necessarily learning), but to the efforts made to increase germane load and decrease extraneous and intrinsic load through application of multimedia learning principles.

6.2 Implications for Practice

As online graduate programs consider how to best allocate limited resources, our findings offer useful empirical evidence on whether to invest into instructional designers and professional production when creating video lectures. As mentioned in the introduction, the cost of designing and developing online learning content in line with best practices is substantial. Are increases of 0.41 standard deviations in perceived learning and 0.33 standard deviations in student satisfaction worth the financial cost of implementation (not to mention the energy and opportunity cost of faculty members' time)?

From a pedagogical perspective the answer is clearly yes because student outcomes improved. From a financial perspective, however, the conclusion may depend on the nature of the video lecture content, what purpose the video lectures serve in the course, and how often the video lectures need to be changed. If video lectures are the primary means of disseminating content in the course and the lecture can be reused over multiple academic years, then investment is more likely to be worthwhile. However, if students' perceived learning and satisfaction are already high or the video lectures need to be re-developed often (to remain current given advances in the field, for instance), then the rise in students' perceptions may not be worth the added cost of professional design and production.

Finally, the disruption caused by the pandemic has made efficient online instruction a top priority for administrators and faculty members alike. It has also highlighted that educational theory for online learning matters. Our study contributes to this conversation by not only describing how online instruction can be improved through video lecture design and production, but also by quantifying the effect of applying principles of multimedia learning to video lectures on student outcomes.

6.3 Limitations and Directions for Future Research

There are certainly several limitations to this study that need to be considered when interpreting the findings. Although this is a multi-semester study with hundreds of participants, the data derive from a Strategic Management course taught by one instructor. From previous research, we know that disciplinary (Arbaugh, 2005a; Arbaugh and Rau, 2007) and instructor-specific effects induce variance in students' perceptions of online courses. Therefore, the effect of video lectures on student outcomes also needs to be studied across disciplines and instructors (Arbaugh, et al., 2009). Since dispositional, behavioral, and demographic characteristics may influence students' perceptions of video lectures, instructor-centered research would be valuable and would enhance our understanding of what works, what doesn't, and under what conditions.

Also, we examined the effect of our intervention on perceived learning. The long-term goal of instruction is, of course, comprehension and retention of the material. Therefore, it is important that future studies examine whether adoption of best practices in video lectures facilitates not only the perception of learning but also comprehension and retention.

7. Conclusion

We began this study with an interest in whether implementation of multimedia learning principles in video lectures matters for student outcomes. We pursued this analysis after finding misalignment between educational theory and practice in online learning. While research shows that implementing best practices in online course design increases learning and satisfaction, institutions are not investing sufficiently in training and support which would empower faculty to implement advances in online learning research into practice (Garrett, Legon and Fredericksen, 2019). Many faculty members also remain skeptical of online learning pedagogy and are reticent about giving up their autonomy while working with instructional designers (Garrett, Legon and Fredericksen, 2019). We used the context of video lecture design and production to measure how much adherence to best practices matters for perceived learning and student satisfaction. We exploited an exogenous

change in online course development standards in an MBA program at a large, research university, providing much needed empirical evidence for online graduate education.

Based the results of this study, the following conclusions can be made. Designing and producing video lectures in accordance with multimedia learning principles has a positive causal effect on perceived learning of 0.41 standard deviations and a weakly positive causal effect on student satisfaction of 0.33 standard deviations.

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Shaping Teachers' Perceptions of their role in the Digital age Through Participation in an Online PBL-based Course

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Abstract: Our research traced significant learning experiences of teachers enrolled in a Master's degree program in teacher education, in an attempt to understand how participation in an online course that employs the project-based learning (PBL) approach influenced their perceptions of the teachers' role in the digital age. Data was collected from 2014 to 2016 using: (a) a questionnaire gathering learners' personal and demographic details (n = 55) and (b) reflective reports on the learners' learning experiences in the course (n = 105). Content analysis of the data revealed that participants considered personal, pedagogic, and social aspects important in terms of the learning experience and this also informed their role perception as teachers in the digital age. Similarly, exposure to the PBL approach via an online framework directly influenced participants' learning experiences and role perception. The findings indicate that teachers should be given access to a learning experience combining online learning and teaching practice to allow them to form their role perception as digital-age teachers. Practical implications of the research relate to teachers' socialization in the digital age.

1. Introduction

We now live in a digital era. One of the changes that has taken place during the transition to this era which has strongly influenced education systems is the development from Information Technology (IT) computer systems to Information and Communication Technology (ICT) computer systems. This has significantly improved communication and interpersonal transferring of information and, consequently, has greatly influenced learning-teaching processes and practices. As a result of radical changes in the surrounding reality, people have begun to refer to themselves as *infors* (information organisms) acting within an *infosphere* (Floridi, 2014). Thus, one's self-perceptions as well as relationships–with self, others, and the environment-- have been fundamentally altered (Levin and Tsybulsky, 2017; Floridi, 2014; Tsybulsky and Levin, 2019).

The adaptation of teacher education and professional development programmes to the digital era should take into account the learner's worldview and its implications vis-à-vis education and society in general (Tsybulsky and Levin, 2019; Tsybulsky and Muchnik-Rozanov, 2021). Aligned with this approach, the present study developed from a conceptual framework that sees teachers' professional development as a process of socialization, which aims to prepare teachers to perform in the field of education in a manner suitable to the digital era. To attain this goal, however, the relevant programmes must provide ample opportunity for significant practice and experiences in the ICT context.

This new era calls for digital acculturation, which must include learning, teaching, and evaluation processes in which the routine use of ICT is an inseparable part of teachers' domains, rather than an external auxiliary tool. Teachers who perceive technology as a constructive and integral part of pedagogical processes and whose teaching is grounded in a digital worldview can help create the change necessary to advance the entire education system. In this sense, teachers' role perception encompasses each individual's entire set of beliefs about the role and its effects on both oneself and others (Ben-Peretz, Mendelson and Kron, 2003).

One of the experiences that allows for the assimilation of digital culture in teachers' professional development processes is learning through participation in an online course (Baldwin, Ching and Hsu, 2018; Ching, Hsu and Baldwin, 2017; Kleen and Soule, 2010). Additionally, in recent years, the project-based learning (PBL) approach has gained increased recognition as a meaningful student-centred, inquiry-based learning method, that can be conducted as a collaborative activity and hence is suitable for developing students' 21st century skills (Chu, Reynolds, Tavares, Notari and Lee, 2016; Häkkinen, et al., 2017; Tsybulsky, et al., 2020). Very few studies, to

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date, have focused on online distant learning that includes the use of the PBL approach; the majority of distance-learning courses offered online rely on traditional learning-teaching methods (Ni, 2013).

It is in this context that we decided to conduct research among practicing teachers studying for a Master's degree in a teacher-training college. The degree programme included an online course that employed the PBL approach, intended to foster participants' professional development. In order to understand whether and how the teachers' perceptions were shaped and structured by this experience, we examined their reflections on their experiences and perceptions as they evolved throughout the course. It should be noted that the participant population in this study was very unique: they were both in-service teachers working in schools, while simultaneously studying for a Master's degree in Education in an academic institution. In other words, these teachers "wore two different hats." In one role, they were acting as teachers of pupils in school, while in their other role (specifically, one day a week on their free day from school), they were graduate students in an academic institution.

1.1 Teachers' perceptions in the digital age

The study of teachers' perceptions and beliefs has recently become a priority for educational researchers (Fives and Buehl, 2008). Analysis of teachers' perceptions can clarify educational practices. Teachers' perceptions guide instructional decisions, influence classroom management, and serve as a lens for understanding classroom events,(e.g., Jones and Carter, 2007; Luft and Roehrig, 2007; Prestridge, 2017. A substantial body of research has been generated in this domain (e.g., Jones and Carter, 2007), leading to four principal conclusions regarding teachers' perceptions. Perceptions are multidimensional and complex (Hofer, 2001; Stahl and Bromme, 2007); they affect teachers' practices (Brownlee and Berthelsen, 2006, 2008; Marra, 2005); and they are context-bound (Fives and Buehl, 2008, 2010). Instruction and short-term interventions designed to promote either conceptual change, reflection, or examination of personal beliefs and perceptions have a positive effect on teachers' beliefs and classroom practices (Mason, 2010).

In the context of the digital age, a study by Tsybulsky and Levin (2019) indicated that teachers' perceptions concerning their place and role vis-à-vis the digital age can be classified according to the three types, namely, *the outside observers, the circumspect participants, and the conscientious participants*. Conscientious participants were those teachers who considered themselves an integral part of the digital society. Not only are conscientious participants aware of the existence of the digital society, they also feel that they are a vital part of it. In this sense, they can be considered "digital citizens." Accordingly, digital *citizenship* includes three components: an objective and realistic view of the surrounding environment with an awareness of the revolutionary changes taking place in contemporary digital society; a perception of interpersonal interactions as involving digital communication and sharing with others; and a subjective self-perception which includes awareness of one's role vis-à-vis one's surroundings, and an understanding that performing this role requires digital acculturation (Tsybulsky and Levin, 2019). There has been a growing interest in the professional literature in the notion of digital citizenship, with attempts to define its components, as well as its effects on teachers operating in a digital environment (Choi, Glassman and Cristol, 2017). Building on these previous findings, the research described in this article examined whether and how participation (as a Master's degree student) in an online course using the PBL approach could provide a meaningful experience, one that could help shape teachers' perceptions of their professional role from the perspective of digital citizens in the digital age.

1.2 Learning in an online course

An online course constitutes a unique learning environment that contains relevant and varied informative contents, activities, and assignments that require a degree of initiative and creativity (Khan, et al., 2017). The format requires learners to participate in forums, communicate via email, and use links to knowledge banks and other relevant sites (Baldwin, Ching and Hsu, 2018). The premise of an online course is that higher-order learning is best supported in a community of learners engaged in critical reflection and discourse (Garrison and Cleveland-Innes, 2005; Hill, Song, and West, 2009; Garrison, Anderson, and Archer, 1999; Sung and Mayer, 2012). Garrison, Anderson, and Archer (2001) proposed a community-of-inquiry model of online learning. This conceptual framework was based on the idea that the success of a community of learners depends on interactions between the instructor and the content, among the students, and between students and the instructor. The manifestation of these interactions requires cognitive presence, social presence, teaching presence, as well as emotional presence (Majeski, Stover, and Valais, 2018).

Hussein-Faraj, Barak and Dori (2012) found that students studying online enjoyed more positive learning experiences than did students studying in traditional frameworks using traditional methods. Students noted the importance of convenient and easily accessible communication, and the numerous possible ways to illustrate and demonstrate abstract concepts in online learning. Other contemporary studies have stressed the contribution of the online lecturer to students' sense of satisfaction regarding the learning. A positive correlation was found between the students' perception of the lecturer's commitment and high quality of teaching, the level of students' achievements, and participants' general satisfaction from the online learning experience (Xiao and Wilkins, 2015). A study by Naresha, Reddyb and Pricildac (2016) listed several levels of learners' awareness in an online course, examining the extent of the students' acceptance and adoption of the digital learning environment. It was clear that the digital learning courses provided global exposure and helped learners enjoy the experience of distance learning in real time. Parkes, Stein and Reading (2015) discussed the issue of the students' readiness to operate in an environment of academic institutions that is characterised by digital learning. The current generation of learners has been called *digital natives* (Prensky, 2009), in reference to their comfort and familiarity with digital technology. Nevertheless, the question remains relevant: To what extent are the students prepared for functioning and utilising the online environment in their academic studies? One way to address this issue is by offering online distance-learning courses that implement the PBL approach.

1.2.1 The PBL approach

Research has shown that online learning combined with a PBL approach significantly advances academic learning, both from the perspective of the learner and also with regard to the process (Barak and Watted, 2017; Taradi, et al., 2005). Learning of this kind provides the learner, the lecturer, the academic institute and the society as a whole with a significant contribution: they receive high-quality learning products that are effective and more appropriate for their needs. Nevertheless, online learning combined with PBL involves addressing various requirements pertaining to pedagogical and technological content, which need to be predefined and necessitate the compliance all those involved in the process: the instructor, the learner and the academic institute (Taradi, et al., 2005). Participation in an online course combined with practice according to the PBL approach has the potential to provide learners with meaningful experiences that will shape and develop their self-perception as digital citizens and informed teachers.

1.3 Experiences and their importance in the learning process

The theory of experiential learning, proposed by Kolb (1983), sees learning as a process in which knowledge is constructed through active experience. The cycle of experiential learning constitutes a key component in Kolb's theory (Kolb, 1983; Kolb and Kolb, 2005) and it includes four interrelated stages: concrete experience, reflective observation, abstract conceptualization, and active examination of the use of the new concepts in new situations. Experiential learning in teachers' professional development has focused on the teachers' experiences as they develop their skills in the classroom: experimenting, reflecting, and adapting new theories, practices, and content, to which they were introduced in a professional context (Girvan, Conneely and Tangney, 2016). In the current study, we applied Kolb's theory of experiential learning and the concept of the circle of experiential learning to explore teachers' experience of learning in an online course using the PBL approach. In our comprehensive process of observation, we first considered participants' concrete experiences while participating in the online course, and then focused on their reflections, their construction of new educational views and perceptions, and concluded with an examination of their active implementation and use of the new concepts in new situations, namely the designing of their educational projects.

Research conducted very recently by Tsybulsky, et al. (2020) examined the content and quality of developing experiences of student-teachers, when studying pedagogic courses according to the PBL approach. This research indicated, among other things, that the trial experience with the PBL approach provided a positive (introspective, social and cognitive) learning experience that produced significant learning and the professional development of student-teachers. Another study by Tsybulsky and Oz (2019) indicated that the significant experiences of student-teachers when leading PBL in elementary-school classes shaped their educational attitudes and practices. On the basis of these studies, the assumption underlying the current study is that implementing the PBL approach to the distance-learning platform and format would similarly render significant experiences that shape teachers' educational views, including their perception of their role as teachers in the digital age.

The present study aimed to trace significant learning experiences of teachers, studying for a Master's degree in a teacher-training college, in order to understand how the experience of learning in an online course using the PBL approach shaped their role-perceptions as teachers in the digital era. This distinct combination of distance

learning with the PBL approach affords a unique opportunity for students and instructors alike; moreover, it constitutes a promising framework for examining teachers' role perception in the digital age.

With this goal in mind, the following research questions were formulated:
What were the main experiences of teachers while participating in an online course using the PBL approach?
Did the teachers' learning experiences in the online course using the PBL approach enable them to form a perception of teachers' role in the digital era, and if so, how?

2. Methodology

2.1 The method

The research followed a hermeneutic phenomenological approach (van Manen, 1990, 2014). An underlying assumption of this approach is that the information that the study seeks to reveal can be found in the meanings that participants attribute to their experiences (van Manen, 1990). A phenomenological study focuses on the common meaning that several individuals attribute to their experience of a phenomenon, in other words, the common denominator of participants' perceptions regarding their experience of a phenomenon (Creswell and Poth, 2016). The phenomenological approach is a valuable method for examining participants' learning experiences as it provides the researcher insight into the participants' perspectives regarding the phenomenon under study (Tsybulsky, et al., 2020).

2.2 The context and the research population

The research population comprised 55 practicing teachers who between 2014–2016 had enrolled and participated in an annual course that was offered as part of a Master's degree programme in education (with a focus on management of educational systems). In this context, it is again important to remember that the participants were both in-service teachers working in schools, while simultaneously studying for a Master's degree in Education in an academic institution. In the context of this study, we refer to the participants as students in an academic institution, as there is no mention of their work as teachers. Although, in their reflective journals the participants occasionally referred to their work as teachers, their status in the context of this research remains that of graduate students.

The course was delivered as an online course using a Modular Object-Oriented Dynamic Learning environment (referred to as the MOODLE platform). This is an online, asynchronous platform, which course participants could use to complete their assignments, to maintain contact with the lecturer and with fellow students in the course, and to access the information that the lecturer sought to convey to students. The platform also displays the individual student's progress in the course. As it is an asynchronous platform, students could advance through the course at their own individual case, while maintaining a dialogue with the lecturer, and interacting with fellow students. Furthermore, on the MOODLE site, a forum was established for posting questions and responses, both between the students and the lecturer, as well as among the students in the course. No other social network platform, such as Facebook or WhatsApp, was used; all communication took place within the course's domain on the MOODLE platform.

The subject of the course was *organisational learning*. Course assignments varied and alternately required individual and group work. At the end of the period of online learning, three face-to-face meetings were held, during which students presented the products of their project. The goal of the course as defined in the syllabus was 'to help students understand the significance of processes of organisational learning and the ways to transform an organisation into a *learning organisation*. The course is delivered within a framework for distance learning and calls for individual and group study. The course encourages active learning so as to create a learning experience that encompasses practical and applicable aspects.

The students were assigned a group project as part of the course, namely, to construct a programme for promoting an organisational learning culture in the school; their proposal should specify the processes, means and the manner in which the proposed change would be assimilated among the school's teachers. The students worked on this assignment in groups of 3–5 students. The intermediate products included an interview with a staff member who held a leading role in the organisation, a joint presentation to introducing the main concept and its realisation, and presentation of the project before their peers, who also participated in evaluating the product and provided verbal feedback online.

During the period of the study, 2014–2016, the course was offered three times: In the 2014 course, 19 students participated; in 2015 there were 17 participants; and in 2016, 19 students. Among all 55 participants, the majority were women (90%), most were elementary-school teachers (70%) and the remainder taught in secondary schools. Most of the participants (86%) reported that they had medium-high mastery of computer skills and only a few (14%) reported low mastery; however, it should be noted that none of them reported high mastery of computer skills. Participants' ages ranged between 30 and 50 years, with a mean age of 39. All of the participants lived within a 40 km radius from the academic institution in which they were studying; nevertheless, this factor was not important to the learning, as all of the course was held in an online asynchronous environment. Participants' teaching experience ranged between 5 and 18 years, with a mean of 12 years of experience. A relatively small proportion of the students had previous experience in online learning, whereas for the others, this was their first time studying in this format.

The participants were informed about the research goals and procedure and indicated their willingness to participate, by completing a written informed consent form. The study was approved by the University's Ethical Committee.

2.3 The research instruments

The two main research instruments employed were a questionnaire and reflective reports. The questionnaire served to collect the data regarding participants' background variables, i.e., their gender, age, years of teaching experience, the class levels that they taught (elementary or secondary), prior computer skills, and past participation (or lack thereof) in an online course. All of the students (n = 55) completed the questionnaire. In the reflective reports, the participants recorded their reflections about their experiences in the course. They were asked to consider their learning experience throughout the course, in a free manner, without any particular instructions to guide them. Students were asked to record their reflections twice during the course, in the middle of the course and at its conclusion. In total, 105 reflective reports were reviewed. Five students completed this assignment only once. It should be noted that the reflective reports constitute a common manner for collecting data in phenomenological studies, as they afford participants to reflect retrospectively on their experiences (van Manen, 1990, 2014).

2.4 Data analysis

The data were analyzed using the phenomenological data analysis method, which provides an understanding of how participants experienced the phenomenon (Moustakas, 1994). The unit of analysis that was employed was that of teachers' expressions, defined as a clause or clause complexes (a number of clauses). Using the definition of clause as put forth by Halliday and Matthiessen (2013), clause is a unit of language that contains at least one subject and one predicate. The analysis procedure included several stages. The first stage involved coding of the data, whereby text transcripts were scanned for recurring "significant statements" (Moustakas, 1994) and expressions regarding the learning process that the participants experienced. Descriptions of experiences, i.e., participants' thoughts, feelings, and emotions, were identified by the appearance of clauses such as "I felt," "I experienced," and "I thought." An examination of the expressions used in such clauses enabled us to cluster them into "core themes" (Moustakas, 1994). In the final stage of the analysis, the significant statements and themes were incorporated into a narrative expression of the results, that is, a 'textual description' of what the participants had experienced, based on their descriptions (Moustakas, 1994).

The validity of the study was ascertained by conducting a thorough examination of data at the different analytic stages, so that at each stage the researchers were able to reconfirm that the findings of the previous stage were grounded in the data. Each of the researchers analysed the data individually and according to their best understanding and knowledge of the studied field. Next, a brainstorming session between the two researchers was held, which included a discussion of each researcher's findings and their correspondence to the research questions. In cases of initial disagreement, additional discussion ensued until a joint decision could be reached regarding the assignment of the narrative texts to particular categories.

3. Findings

The findings are presented in two sections in line with our research questions.

3.1 The experiences of teachers participating in an online course using the PBL approach

In general, most of the teachers learning in the online course reported that they enjoyed a positive, interesting, and challenging experience that enriched and deepened their understanding of the studied contents and reinforced the creative aspect in the learning process. The combination between independent work and team work strengthened the learners' sense of individual and group responsibility and increased their sense of cohesion as a group. The teachers used several principal expressions to describe their learning in the course including: 'a challenging experience', 'practical contents', 'varied teaching methods', 'comfortable distance learning' and 'peer learning'. Nevertheless, a few of them reported negative learning experiences and even mentioned several difficulties involved in the course framework such as a heavy load, difficulty in managing the learning from a distance without regular face-to-face meetings, and difficulty working with the staff from a distance.

A more focused analysis of the findings revealed that the learners' addressed three main aspects (a) the personal aspect, i.e., their individual learning experience in the course; (b) the social aspect, i.e., relationships that were formed between peers and with the lecturer; (c) the pedagogic aspect, i.e., teaching methods and the learning process of the course. In each of these aspects, it was possible to discern both positive experiences of the learners which were viewed as the advantages of online learning, and negative experiences which were associated with the difficulties involved in online learning. A detailed description of the three aspects follows.

3.1.1 The personal aspect of experiences of teachers learning in the online course

As noted, this aspect included the learners' observations regarding their learning experience. The participants related especially to their pleasure during the learning, the speed, and quality of feedback during the course, the study load, the options within the course, the manner in which they presented assignments, and their general satisfaction with the course. The positive experiences were mainly associated with a rich variety of content knowledge, the comfort and ease of the timetable for performance of assignments, the sense of enjoyment increasing their motivation, the ability to choose methods and tools, the availability of subject materials, and the speedy response of the lecturer. Thus, for example one of the teachers noted:

> *I experienced learning that did not involve a blackboard and chalk. It was a different kind of experience, including active learning that requires higher-order thinking in all areas – from joining a work group that motivated me to learn, through the integration of technological tools. Also reading articles in English, gaining insights, the experience of personal learning achieved together through team work.*

Negative experiences were mainly associated with the study load imposed by course assignments, not all the assignments were seen as relevant to the course subject, and there was a sense of deficient interpersonal communication with members of the group in order to perform the assignments. Thus, for example, one of the participants remarked: 'The course was very intensive; there was a lot of material covered in a short period of time. The integration of technology did not always address the need'.

According to the teachers' reports, they found these experiences mainly help with self-discipline and [in providing] exposure to a variety of sources of information. It is important for us to internalise these insights as central leading figures in the organisational systems in the digital era.

3.1.2 The social aspect of the experience of teachers studying in the online course

As noted, the social aspect of the experiences reported by the participants pertained to the relationships they developed with their peers.

The participants emphasised the unique experience of working as a team with peers, but from a distance. They noted that while this connection offered a different type of interaction, particularly because the experience was new to them, it was also so foreign to them that they often found that they needed to communicate by telephone in order to "bridge" the physical distance between them. They also reported a strengthening of their sense of responsibility for completing the assignments, due to the collective nature of the group course work. The collaboration created a positive and challenging learning experience. Thus, for example some of them noted:

'independent work alongside work in a team reinforced personal and group responsibility', 'the performance of personal assignments led to the performance of group assignments', 'I have responsibility for others as well'.

Some of the participants also testified that the work relationships that were forged and developed during the course extended beyond the framework of the course. Thus, for example, one of the participants remarked:

> *Forging relationships with my peers in order to complete assignments created a challenge, but also provided an opportunity for us to get to know each other; we also began to help by each other complete tasks that we were given in the school. We became colleagues in the teaching profession.*

The difficulties noted were related mainly to the assignment to one team rather than another. For example, one of the course participants said:

> *As with anything new and different, there were fears concerning the structure of the course and its performance. Already at the first meeting, I did not find myself assigned to the group I wanted, but fairly quickly I understood that I had to alter my thinking and accept that I was not the one to choose.*

Other difficulties mentioned were related to the framework of distance learning and its effect on interpersonal and group interactions. One of the participants remarked: 'The need to fit into a learning group when you don't know any of the participants or your abilities makes things very difficult'.

3.1.3 The pedagogic aspect of the experiences of the teachers studying the online course

As mentioned above, this aspect was identified when the participants' reports referred to the learning experience, emphasising the processes, methods, and tools the lecturer employed to bring the learners to optimal achievements. Additional components of the pedagogic aspect were related to the instructor's performance, specifically, providing reflective feedback on the learners' progress and evaluating their achievements in the knowledge domain. participants also noted the combination of varied teaching methods, the attractive and challenging presentation of materials and the perception of the course lecturer as a model for imitation on the subject of integration of technological tools in teaching.

Positive experiences were associated mainly with the ability to learn and apply new teaching aids, personally experiencing the construction of a learning unit using technological means, self-enrichment by learning various materials on the course subject, and working together within a collaborative group. For example, one of the teachers noted,

> *There was a sense of openness and an intellectual experience when constructing a learning unit with the help of technological means. [I] understood that organisational learning [the subject of the course] is useful not only for the school but also in daily life.*

The negative experiences were mainly associated with the difficulty of learning online without regular meetings, the lack of face-to-face feedback, lack of explanation by the lecturer concerning materials presented in graphs and tables. Some of the participants thought that it was not always possible to express themselves. Working in groups made performance difficult, especially in the context of a lack of mastery of technological tools and the sense that not everything was relevant for their teaching. This was expressed by one of the teachers thus:

> *Interaction at a distance makes things difficult. There was a lack of visibility; the presentations were full of graphs and tables with no face-to-face explanations. This makes learning very difficult and reduces the pleasant experience of the course. Also, I don't always understand what I can do with it [what is learned] as a teacher in the classroom.*

3.2 The way the online course experience using the PBL approach shaped participants' perception of their role as teachers in the digital age

This section of the findings relates to the role perception of the teachers participating in the online course and the relevancy of the learning and materials in the course to their current and future role as teachers in the digital era.

A more focused analysis of the reflections reported by the teachers at the end of the course identified three aspects of their role perception as teachers in the digital era: (1) the personal aspect – the teacher's self-perceptions regarding their own professional functioning and their role when working both in the virtual realm and face-to-face with others; (2) the social aspect –participants' perceptions of a teacher's role when engaging

in team work and professional collaboration; and (3) the pedagogic aspect –participants' views regarding a teacher's educational practices when working in the online environment and collaborating according to the PBL.

3.2.1 The personal aspect of the teachers' role perception as shaped by the online course experience

The online course experience shaped teacher's personal self-perception regarding their own professional functioning and role in the following ways. First, the experience of improving their own methods of online learning helped them hone their teaching methods in the virtual space. Likewise, as their fears concerning the use of technology tools were alleviated, they came to perceive the ICT tools as more user-friendly. Second, they came to perceive professional development as a continuous, multidimensional process, a perspective that is in line with contemporary approaches. Finally, having gained valuable experience in online learning not only helped shape and reinforce their motivation, but also expanded the range of their professional skills. Overall, the online course experience improved their professional self-image and enhanced their confidence in their ability to function in cyberspace, which they considered especially important in relation to their role as teachers in the digital age.

3.2.2 The social aspect of the teachers' role perception as shaped by the online course experience

In social terms, the teachers referred to their perception of the teacher's role in relation to their collaboration and team work experiences and the significance of the social domain in the teacher's work in the digital era. The teachers especially spoke about the nature of team work and its implementation in their work at school. Participants considered three levels when addressing the social aspect of role perception: the pupils, the teachers, and the school.

The following quotes demonstrate the meanings that teachers attributed to their experience of team work and collaboration during the course and the implications of this work for their professional role.

Teachers' role perception vis-à-vis the pupils:

- 'Team work among pupils offers a variety of different teaching methods and encourages the integration of computers'
- 'Employing collaboration between pupils as a teaching method necessitates the presentation of challenges and demands higher-order thinking'

Teacher's role perception vis-à-vis their colleagues:

- 'Working online with other teachers, as a team, reduces fears, and allows mutual learning'
- 'Collaboration facilitated by ICT is a worthwhile activity that should be practiced regularly among colleagues'

Teacher's role perception vis-à-vis the school:

- 'Collaboration can be used as a tool to motivate change processes in the school'
- 'Team work enables the achievement of better results'
- 'Collaboration can be achieved by working with digital tools'

Thus, for example, one of the teachers noted:

> *The professional changes that we undergo are created as a result of our experiences and the feedback we are given on the way; sometimes the change is an impetus to become a leading figure in the system. It's important that we internalise these insights and see them as a way of life in the organisation in the professional and administrative roles that we fill as teachers in the school.*

3.2.3 The pedagogic aspect of the teachers' role perception as shaped by the online course experience

The pedagogic aspect was seen mainly in the teachers' descriptions of how they experienced and experimented with ICT, the ICT pedagogic tools and methods they were exposed to through the online course, and their thoughts about implementing these in their own teaching at school.

The main tools that the teachers acquired and that they reported having used previously in their teaching were: recording and editing films, processing pictures, advanced searches on the Internet, use of Google Drive. They also noted that the course enabled them to develop skills and capabilities to better incorporate these technological tools in their pedagogy and to find and provide learning contents.

Thus, for example one of the teachers noted: 'I was exposed to tools, contents, technological tools, and pedagogic tools and I was able to integrate these components in my teaching in an informed, balanced, and correct manner'.

The teachers also noted having learned about some of the tools for the first time, namely, the tools for peer evaluation and the PBL approach. For example, one of them remarked: 'The tools for peer evaluation were new and fascinating, relevant to my role as a teacher', while another teacher described the experience thus: 'PBL is a tool that I really believe in. I am happy that I had the opportunity to try this out and so I can apply it in my classroom teaching'.

The research findings revealed that through the course, participants learned to discover what were their personal weaknesses in the field of teaching with technology, which tools they had mastered, and which tools they had yet to master, either partially or fully. Moreover, they became aware of the extent to which they felt confident integrating these tools in their daily work in the classroom.

To recap, three distinct aspects were prominent in participants' descriptions of both their experiences during the course and of the meanings they attributed to experiences that helped shape their perception of their role as teachers in the digital era. Table 1 below summarises the expressions of these aspects in the teachers' testimony.

Table 1: Findngs summary

Aspect	The Teachers' Experiences in an Online PBL Course.	The Impact of These Experiences on Teachers' Role Perception in the Digital Age.
Personal	Participants reported a sense of enrichment and pleasure derived from the learning experience.	Participants emphasised the acquisition of abilities and the honing of skills for working in both the virtual and physical worlds.
Social	Participants forged professional interpersonal relationships and collaborations with colleagues.	Participants gained an understanding of the significance of the social domain in the teacher's work and related to the impact of collaboration on their role vis-à-vis the pupils, their colleagues, and the school.
Pedagogical	Participants emphasised methods and tools that helped them as learners to increase their knowledge and understanding of ICT-related pedagogic tools and methods.	Participants reported a new awareness of their strengths and weaknesses in the realm of ICT pedagogy and their degree of confidence regarding the integration of said tools in the classroom.

In general, the findings indicate that learning in the online format allowed the participating teachers to form insights concerning what constitutes meaningful learning that increases motivation. It also enabled the participants to understand the implications of being a teacher in the digital era and how to adapt teaching to the culture of this era. One of the teachers explained it thus:

> *This type of learning helped me to gain insights that influenced and will influence my professional development. It is important to continue to learn over your professional career, but it is also important that this should be meaningful, in order to leave its mark … professional changes that enhance our professional lives occur because of enlightening experiences that we have on the way, and often the very fact of the change is what affords us the insight… as leading figures in the education system and in the school organisation we should internalise these insights and see them as a way of life for the organisation, forming a culture founded on values and perceptions.*

The course subject and the way in which it was taught led the participants to insights regarding their future professional development, and regarding observations pertaining to their teaching methods, so that they could improve the existing class and school processes and introduce new teaching processes appropriate for the digital world.

It also emerged that learning about the PBL in an online course helped the teachers develop skills for teaching and learning using collaborative team work alongside personal work. They felt they had been, exposed to a different kind of learning. Thus, studying in this course constituted a model for meaningful learning, while introducing participants to ways to integrate technological means into their routine teaching. It also helped

develop their teaching skills and acquainted them with the computerised environment. This was explained by one of the teachers.

> *This type of learning influenced my professional development, since it gave me tools and ideas to integrate within my teaching methods as a teacher. It also allowed me to broaden my horizons concerning computerised learning and technology use in the future.*

The research findings indicate that learning in the online course using the PBL approach positively influenced the learning-teaching skills that the participating teachers acquired, creating a positive learning experience. In turn, this experience provided the motivational impetus to face challenges and develop new skills. They gained a fresh perception of learning as a continuous process that stimulates their professional growth and pedagogic development as teachers in the schools.

4. Discussion and conclusions

The phenomenon of online learning has been gaining popularity at all levels of the learning sphere, from the school education system to higher education institutions (Khan et al., 2017). Stakeholders involved in the system see this phenomenon as one of the expressions of human development affecting economic, technological, social and cultural aspects of human life (Ching, Hsu and Baldwin, 2017).

The assimilation of technological innovation in the education system constitutes an essential foundation for future advancement and progress in the digital era (Tsybulsky and Levin, 2019). Despite a comprehensive understanding of the importance of assimilating technological innovation in the education system, the assimilation process differs from institution to institution in terms of the path, stages, pace, and even content. The differences stem from a large number of factors that influence the process (Avidov-Ungar and Eshet-Alkalai, 2011a, Avidov-Ungar and Eshet-Alkalai, 2011b, Avidov-Ungar, O and Magen-Nagar, 2014). The purpose of the research described here was to trace the significant learning experiences of practicing teachers enrolled in a Master's degree programme in Education. The aim was to learn how the experience of participating in an online course using the PBL approach influenced the learners' perceptions of their role as teachers in the digital era.

The main finding was that the teachers who participated in the online course took into account personal, pedagogic, and social aspects when describing both their experiences and the significance they attributed to said experiences, in terms of their perceptions of their role as teachers in the digital era. Moreover, the research findings indicate that after studying the online course using the PBL approach, not only were the participants able to hone their perception of the teacher's role in the digital age, but also were able to accommodate this new knowledge within the trajectory of their professional development.

The main contribution of the current study is in shedding light on participants' perceptions of their role as teachers in the digital age. Participation in an online course that featured the PBL approach provided experiences that helped shape their role perception in this regard. The underlying assumption was that the course, its contents, framework, and approach provided unique and novel experiences, which in turn set the stage for a re-examination of their role as teachers in the digital age.

It seems, in this context, that the course that constituted the arena for the present research constitutes an example of a unique platform that could be used to train practicing teachers in the digital era. Relying on the study by Tsybulsky and Levin (2019), it seems that the teachers who participated in the online course were able to learn from their experiences during the course and understood the implications of these experiences for their role as teachers. Thus, they were able to contemplate the subjective, interpersonal, and objective components of becoming "digital citizens" in their professional life.

The research findings regarding the learning experiences that shaped the teachers' perception of their role in the digital age allowed us to track the manner in which personal experiences shape these role-perceptions. A clear picture emerged, indicating that teachers' participation in an experiential learning (Kolb, 1983) process (in this case an online course using the PBL approach) had an impact on teachers' role perception. The teachers' positive impressions of this learning experience included the acquisition of tools and skills as well as positive implications for their professional, pedagogic, and managerial growth.

On the one hand, this finding supports previous studies in this field, e.g., Tsybulsky, et al., 2020; Tsybulsky and Muchnik-Rozanov, 2019; Tsybulsky and Oz, 2019. However, on the other hand, the present findings are innovative, as they demonstrate the way in which a cycle of experiences is created: experiential learning–shaping of role-perceptions–meanings of educational-managerial practice among learners who were practicing teachers and also held managerial roles in their schools.

It should be noted that the research findings are based on a small sample that was recruited and studied between the years 2014 and 2016. The number of students who participated in this online course each year was relatively small (between 17–19 students). It is recommended that future studies should examine the three aspects of learners' experiences that emerged in the research described herein and continue to explore and identify components of the learning process that can help teachers adapt their role-perceptions to the demands of the digital age.

In conclusion: the personal, pedagogic, and social aspects of the experiential learning were evident in the participants' descriptions and in the meanings they attributed to this experience, which I turn led them to re-evaluate their role as teachers in the digital age. Together these aspects constitute a system, one that is influenced by the format of teaching and simultaneously influences the learning experience. Hence, as a process that addresses all three aspects, this experience has also long-term implications for the evolution of participants' personal and professional development and affects their perception of their role as teachers.

4.1 Practical implications

The practical implications of the present findings are related to the process of preparing teachers to adapt their role perception to the advantages and demands of the digital era. It seems that in this era, it is necessary to provide the right combination of online learning and experiential learning, such as the online course using the PBL approach described in this article. We suggest that it was more than the course's *online* format and more than its use of the PBL approach that led to the finding pertaining to adaptation of teachers' role perception. Rather it was this particular combination, which allowed the learners to try out digital experiences while they created significant pedagogic or organisational products for their professional and administrative roles as teachers and members of the school organisation. Clearly teachers need to be presented with opportunities to learn and gain significant experiences in the target context and framework. Through their experiences they can construct their worldview and role perception of what it means to be a teacher in the digital era while experimenting with meaningful learning, including the use of digital tools.

It bears repeating that the research participants were students in a graduate-degree program who were also teaching in schools. The requirement to take an online course as part of the Master's program enabled them to partake in a learning experience that differs from the type of learning experience with which they typically provide their pupils at school. The findings of the current study suggest that the teaching strategies to which the participants were exposed should be adopted as an integral part of teachers' professional development process, throughout the course of their career.

It is recommended that teachers' professional development processes should include learning experiences involving features of digital-era learning, such as team work and collaboration in both virtual and real environments. It is also recommended that lecturers teaching online courses should define them not as external and temporary projects, but rather as an inseparable part of the teaching culture of the digital era. The findings of the current study make it evident that encouraging learners to develop their skills and abilities as digital citizens will be advantageous for the professional and personal development of all parties involved.

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Building an e-Learning Application Using Multi-agents and Fuzzy Rules

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Abstract: One of the biggest challenges in education is teaching mathematics, especially to children. It has been proven that difficulties students face when learning basic mathematics are often the result of previously acquired misconceptions. These misconceptions prevent the student from understanding new concepts and will eventually create a psychological barrier that prevents the student from learning more advanced mathematics. The conventional classroom environment does not provide the teacher with the most efficient means to detect and correct such misconceptions. The goal of our research is to develop an e-learning system for basic mathematics that is capable of providing each student with personalized content to overcome these misconceptions. The system uses a multi-agent architecture to monitor the activity of the student while simultaneously observing and modeling the student's knowledge and misconceptions. Lessons and exam questions are chosen dynamically by the multi-agent system to cover the prerequisites of new lessons depending on the profile of the user.

Keywords: Multi-agents, e-learning and Fuzzy rules

1. Introduction

Teaching mathematics to primary students is one of the biggest challenges in the modern education system. The high inter-dependency of the mathematical concepts makes any misunderstanding in the basic concepts hard to overcome in later years. The modern education system and the typical classroom environment provide material in a way that is convenient for the majority of students. However, the classroom environment does not provide the teacher with the ability to take into consideration the specific misunderstandings of a student and the differences in cognitive learning ability between students. The current education system does not provide students facing difficulties with customized content suitable to the students' abilities and weaknesses. The result is a high rate of students facing difficulties with mathematics in an education system that is not capable of addressing and improving. It has been proven that children who are facing difficulties in mathematics do not lack a 'math gene' (Devlin, 2001), meaning that there is no special mental disability that they have which prevents them from excelling in mathematics. Instead, it was found that difficulties in mathematics are often due to pre-acquired misconceptions that can prevent them from understanding advanced mathematical concepts.

Teachers in a typical classroom environment do not possess the means and the time to detect the misconceptions of each student and to correct them. As a result, the teacher will overlook the mathematical shortcomings of a large number of students. This results in a significant number of students who are held back from learning advanced mathematical concepts, as the psychological barrier and rapid pace of newer concepts being introduced leaves them behind their peers.

This problem manifests itself even more for children with Dyscalculia (Kucian et al., 2014, Kucian et al., 2011), which is a mathematics learning disability. Recent studies have demonstrated that the rate of dyscalculia ranges between 3% and 6% among the general population (Kucian et al., 2011), although it is often undiagnosed (Berch, 2017, Karoll, 2008). It has been proven that the brain of a student with dyscalculia is capable of forming connections that compensate to a great degree the effect of dyscalculia if the student is provided with the proper educational tools (Kucian et al., 2011).

The goal of this paper is to describe an e-learning system for teaching basic mathematics. The system monitors the progress of each student to build the student's profile, which includes the student's knowledge and misconceptions. Based on the student's profile, the system will dynamically select content suitable to the needs and abilities of the student. This is done through the use of multi-agents system (Wooldridge, 2002,

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Franklin and Graesser, 1997) and the use of fuzzy logic to build the user profile and to arbitrate between conflicting agents.

In the next section, a summary of the state of the art will be provided. An overview of the system will be provided next, followed by the details about the multi-agent architecture that was used to build the system. The conclusion will be presented in the final section.

2. Current Research in Learning and e-learning

Delvin (2001) refutes the idea that mathematics is associated with special abilities or genes that is only available to an elite subset of the population. On the contrary, the author demonstrates that mathematical ability is similar to language ability but at a higher abstract level.

Russell et al. stated that most mathematical tests do not provide enough information on the student's level in each sub-domain and do not identify why the student has performed poorly within these sub-domains (Russell et al., 2009). These limitations can be overcome when using computer-based assessments. This motivated the authors to develop an online assessment system designed to measure students' comprehension of specific algebraic concepts, which are variables, equality, and graphing, and to identify misconceptions related to them. The system also provides teachers with lesson plans and accompanying materials for each misconception that has been diagnosed in their classroom. The authors used this online assessment test on four groups of students, each group with varying access level to the ability report, the misconception report and to the related materials for each misconception. Statistical results showed that groups having more access to results and material performed higher than the others.

Goguadze et al. (2011) used a Bayesian model to represent students' misconceptions related to decimal number concepts. In order to achieve that, each test question was associated with a list of false answers and each false answer was linked to a misconception with a certain probability. In the learning phase, test results are used to build the learning profile of the average student, including both knowledge and misconceptions. The actual student results are applied to the standard model to produce a personalized model for each student. McLaren et al. (2012) extended the work to build a computer-based e-learning system for decimal concepts using erroneous examples. The authors recognize that the idea of learning using erroneous examples is controversial, due to the behavioral theory that claims that presenting errors to students will make them more inclined to make those errors. Nevertheless, the authors conducted an experiment in teaching 6th grade students decimal concepts using a computer-based course. The students were divided into two groups, one using erroneous examples while the others used the standard problem-solving approach. The teaching was conducted in a computer room over a week. A post-test exam was conducted at the end of the week, and then another delayed post-test exam was conducted a week later, during which no material related to decimal number was taught. The experiment showed no significant difference in the performance between the two groups on the immediate post-test. On the other hand, in the delayed post-test, there was a significant difference in favor of the group that learned through erroneous examples. The authors interpreted these results as proof that erroneous examples provide a deeper understanding over time and help long-term retention.

Shute et al. (2012) proposed four process adaptive cycles to connect the students with appropriate educational material. Intelligent tutoring systems assess the learning capability of the learner in the interactive environment and develop the model of knowledge, skills and expertise. Hypermedia systems can be made adaptable to the learner's model. Adaptive intelligent tutoring systems (Phobun and Vicheanpanya, 2010) combined intelligent tutoring systems with adaptive hypermedia to store the knowledge and use appropriate concepts for the learner. In the intelligent tutoring system, adaptive testing of the students is also very important in assessing the knowledge and deficiencies of the student. Diagnosis model based on computerized adaptive testing along with domain model of competency, curriculum domain model and student model is essential for performance improvement (Badaracco and Martinez, 2011). Badaracco and Martinez (2013) emphasized that importance of item selection in computerized adaptive testing and proposed fuzzy linguistic information to model the expert knowledge to enhance the accuracy of diagnosis of competency of the student. Intelligent tutoring systems may produce good learning abilities for the students but most of the research is focused on technologically advanced countries. The tutoring scenario changes for less developed countries which do not have the luxury of advanced technology. A good review on intelligent tutoring systems

for the developing world is presented in Nye, (2015). As the internet access in the household of developing countries increases every day and children in those countries have less access to adequate educational institutions, e-learning is also becoming more and more important and can play the pivotal role in supporting educational needs.

It is observed in the studies that computer technology provided a positive effect on learning mathematics in children (Li and Ma, 2010, Moeller et al., 2015). Computer technology can also be used successfully to improve the basic numerical competencies in children with mathematics learning disabilities (Geary et al., 2012, Bartelet et al., 2014). Serious computer-based games can also enhance the cognitive learning of difficult mathematical concepts and can provide different levels of learning difficulty (Echeverria et al., 2012). A good systematic literature review about the positive impact of serious games on learning can be found in Boyle et al. (2016). The use of erroneous examples was proposed to improve the learning of mathematical concepts for a web based tutoring system (Adams et al., 2014). The idea is based on motivating students to process the material more deeply when they are articulating on the incorrect examples done by others.

Computer assisted collaborative learning (Solimeno et al., 2008), can help students to have low anxiety and high problem-solving efficacy by providing them with different educational opportunities. Computer supported collaborative learning is an interesting research direction in the futuristic e-learning classrooms where debates can help students learn complex concepts. Many approaches including instructor led methods, scripted methods or autonomous creative environment for the students can help build collaborate e-learning framework (Fischer et al., 2013, Goodyear P. and Jones C., 2014). In addition, virtual communities like wikis, forums and virtual worlds can provide successful learning experiences (Zhang et al., 2012, Zhang et al., 2014).

Sullivan, et al. proposed implementation of a particular lesson structure based on posing a challenging task to the students to activate their cognitive thinking (Sullivan et al., 2016). This top-down approach can also be incorporated in the e-learning framework.

Al Duhayyim and Newbury (2018) have built an adaptive e-learning system using fuzzy logic. The teacher deconstructs the learning material into concepts. Each concept is further simplified into sub-concepts that are associated with the parent concept using a fuzzy variable concept weight (CW). The CW reflects the importance of the sub-concept in understanding the concept of the parent concept. The teacher also creates a question bank. Each question is associated with a sub-concept and the teacher enters a Concept Error Value (CEV) to reflect the amount of impact this question should have on the student knowledge assessment of the sub-concept. The student knowledge level is evaluated after each test using a set of fuzzy rules taking into account the CW and the CEV. Future studies will be conducted to evaluate the results of using this application in a classroom.

Eryilmaz and Adabashi (2020) have created an Intelligent Tutoring System for teaching Excel in higher education using Bayesian Networks and Fuzzy Logic. The knowledge model of the course is divided into topics. A question bank is created, in which every question is associated with a topic. Based on the pre-test scores and post test scores, the performance of the student in a specific topic is evaluated using fuzzy rules. The pre-requisite dependency between the topics is modeled using a tree of topics. Depending on the Bayesian Networks model result for each student, the system determines the topics with satisfied pre-requisites. This model uses the performance level of the student in each topic, in addition to parameters such as the time spent on questions, sequences of reading pages and reading times to enhance the student's assessment. The system provides the student with a navigation system using drop-down menu that informs the student about which topics are ready to be learned and which are not based on the result of the Bayesian Networks model. Students using this system had a higher mean value on academic performance than the students who studied using the traditional e-learning system (Eryılmaz and Adabashi, 2020). However, this system does not detect misconceptions thus is not suitable to be applied for complex topics such as teaching Math. Furthermore, the question bank does not take into account the difficulty of a question; hence it is not reflected in the assessment of the student level.

Lai and colleagues have studied both the constructive learning methodology, where the learning is performed though an instructor that presents the material to the students, and the collaborative learning methodology, where learning is carried out by group learning as the result of learners working together (Lai et al., 2006). They modeled both learning methodologies as an agent negotiation problem where the learners and the

instructor negotiate using fuzzy agents to agree on the difficulty of the course content and the level of comprehension that this material provided. A high level of difficulty and a low level of comprehension would allow the learners to choose an alternative course content provided by the instructor. Although this research is interesting, the newly proposed course content is chosen by the learners, not the system, thus there is no guarantee that this alternative content will actually achieve better results. Lai and Lan proposed a conceptual framework for adaptive learning where the negotiation mechanism is used to realign learning sequences dynamically according to the knowledge and responses of the learners (Lai and Lan, 2012). The conceptual framework was implemented in Lai et al. (2012). In this implementation, the system chooses a sequence for teaching a specific learning objective. After each unit, the student is required to answer some questions. The student is also required to enter the knowledge level that he/she believes that they have achieved. If this level is far from the assessment of the system, a negotiation phase occurs where the system may increase its assessment, or the student may decrease his/her assessment. If no agreement is reached, the system will re-evaluate the student through another set of questions. If the level of knowledge of the student is satisfactory, the system will proceed with the next element in the sequence. Otherwise, the system will repeat the same learning objective again.

3. System Overview

The goal of this system is to monitor the activities of the students and to model the knowledge and misconceptions of each student. When the student requests to start the next lesson, the system examines the prerequisites of the next lesson in the course the student is taking. If the student suffers from misconceptions or missing information in these prerequisites, the system uses a multi-agent approach to determine whether the system will present the student with the lesson in question or present him or her with a lesson chosen to cover these missing information and misconceptions.

At the end of each lesson, an exam will be presented. The distribution of the questions will also be done using a multi-agent approach to test both the concepts of the lesson the student has just taken as well as the areas in which the student has potential misconceptions and missing information.

The diagram shown in Figure 1 provides an overview of the system.

The first step in building the system is to use the help of subject matter expects to decompose the mathematical concepts into a set of Knowledge Elements (KEs). Each KE may be further decomposed into sub knowledge. The sub-knowledge element will be given a weight that reflects the importance of this sub-knowledge towards understanding the concepts of the parent's knowledge. For example, in Figure 2, the subtraction is decomposed into single digit subtraction, double digits subtractions and multiple digits subtraction, with respective weights of 30%, 30% and 40%. The sum of all weights from one level of KE to its sub-KE should be equal to 100%. This decomposition is repeated if needed, which produces a tree of Kes.

The subject matter experts also indicate the prerequisites of each KE, if any. The importance of this prerequisite towards the understanding of the dependent KE is expressed using a fuzzy variable ***dependency.*** The ***dependency*** fuzzy variable has 3 labels: low, medium and high dependency. The application uses the JFuzzyLogic (Cingolani and Alcala-Fdez, 2012) library to implement the fuzzy rule system. Figure 3 shows the definition of the ***dependency*** fuzzy variable and Figure 4 shows the membership function of the variable.

After the KEs tree has been built, the system allows the different content providers to enter the content of the courses they teach. The content providers may represent a governmental entity, usually the ministry of education, or any other private institute that has developed a teaching material of a course. The system allows having multiple versions of the same course and these different versions may be entered by different content providers or by the same content provider using different teaching styles for each version.

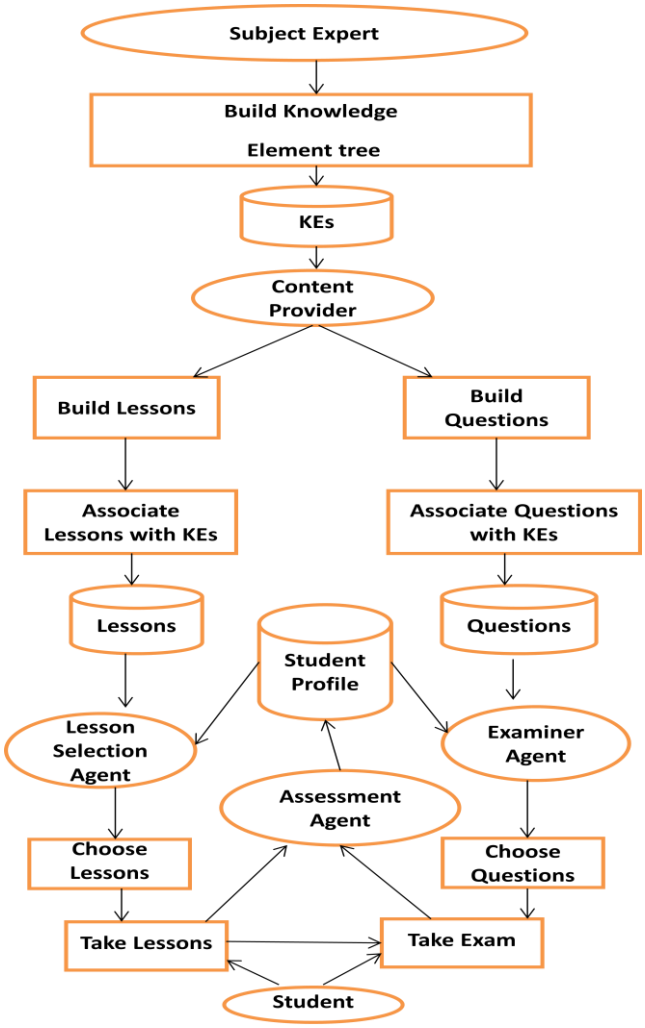

Figure 1: System Overview

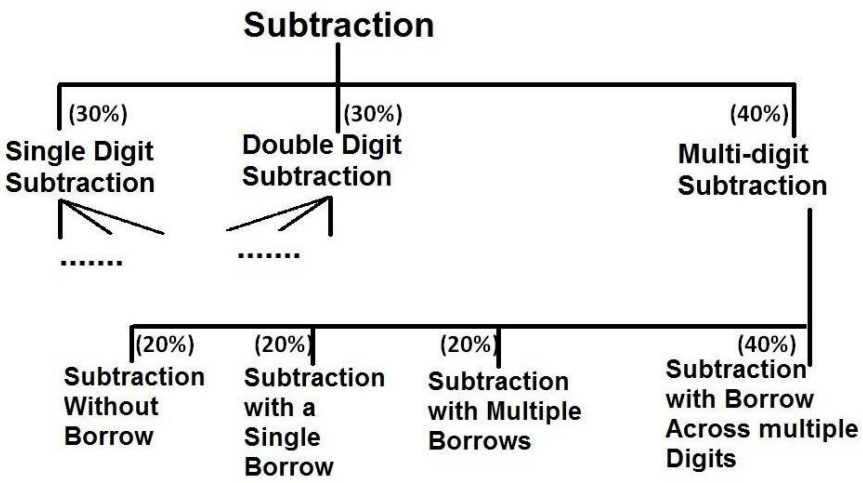

Figure 2: Decomposition of a topic into a tree of Knowledge Elements

```
// Fuzzify input variable 'Dependency': {'low', 'medium' , 'high'}
FUZZIFY Dependency
        TERM low := (0, 1) (30, 0) ;
        TERM medium := (0, 0) (30,1) (50,1) (70,0);
        TERM high := (60, 0) (70, 1) (100, 1);
END_FUZZIFY
```

Figure 3: The definition of the fuzzy variable *Dependency*

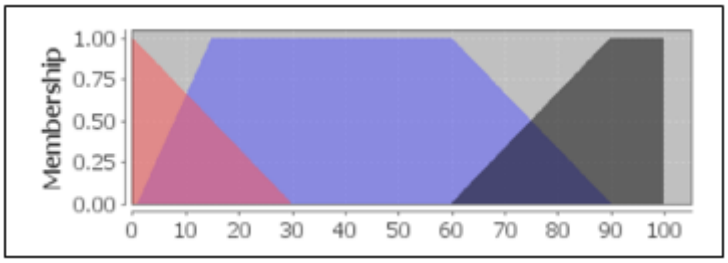

Figure 4: The membership functions of the fuzzy variable *Dependency*

The content provider enters the course teaching material as a set of ordered lessons. Each lesson is connected with the set of KEs it covers. The link between a lesson and a KE is associated with the fuzzy variable coverage, representing how well the lesson covers the KE. The content provider builds their own units and lessons, reflecting his/her teaching preference and best practices.

After each lesson, the system creates an exam to cover the course the student has just taken and to test for misconceptions and missing knowledge from the student's profile. Content providers provide questions, but the system may decide to include questions provided by other content providers, although a higher priority will always be given to the questions submitted by the course provider. Each question in the system is associated with a set of KEs; this association has a fuzzy variable importance that represents the importance of the understanding of this KE for the student to be able to solve the question. The difficulty of the question is described through the use of the fuzzy-variable difficulty.

The student registers with the system to choose the course he/she will take. Before starting the course, the system will create an assessment exam generated dynamically from a set of questions that cover the pre-requisites of this course. To select questions, the system starts with simple, direct questions related to root KEs. If the student answers these questions correctly, the system will then present the student with more difficult questions related to these KEs and some basic questions covering new KEs that are dependent on the KEs that have been tested. If the student was not able to answer some questions successfully, the other dependent KEs are not tested to prevent creating a negative experience for the student. This test will be used to create the models for the knowledge and the misconceptions of each student.

The student's level of knowledge will be represented by a knowledge tree with an assigned fuzzy variable knowledge to each element of the KE tree, representing the knowledge of a student in this KE. Similarly, the student's misconceptions are described through the misconception tree, which assigns a fuzzy variable misconception to each element of the KE tree. When a student starts to take a course, the student's progress is monitored in the system through the student's knowledge profile and the student's misconception profile.

When a student requests a new lesson within a course, the lesson provided is not necessarily the lesson defined in the sequence chosen by the content provider. In fact, each lesson is associated with a set of KE prerequisites that should be satisfied for the student to be able to understand the lesson. For each KE, the value of the student's misconceptions and the student's knowledge will be inspected. If the misconceptions of a given prerequisite's KE exceed a pre-defined threshold, an intelligent agent, named the Lesson Selection Agents (LSA), will be created. Similarly, an LSA will be created for each prerequisite's KE whose lack of knowledge value is bigger than the threshold. The lack of knowledge represents the knowledge that the student does not have and is equal to 1 minus the knowledge of the student in a KE.

To choose the next lesson, the set of agents will go into a negotiation phase to determine whether the next lesson will be the one defined in the content provider's sequence or another lesson that covers a lack of knowledge or misconception from which the student suffers. This negotiation is conducted using fuzzy rules and will be discussed in more details in the next section.

After each lesson, the student will be subject to an exam. The exam questions may be related to the lesson that the student has just taken or to the KEs that have a misconception value or a lack of knowledge value that exceed a predefine threshold. In fact, the system will create an intelligent agent, named the Examiner Agent (EA), for the current lesson and for each misconception and lack of knowledge exceeding this threshold. The agents will go into a negotiation phase, conducted using fuzzy rules, to distribute the available questions between the agents. The details of the question distribution will be provided in the next section.

When a question is presented to a student in a test, this information is stored in the database with the correctness of the student's answer. A question's probability of being included in a test depends on parameters such as the relevance of the question, the profile of the student, the last date this question was presented to the student (if ever) and the previous correctness of the answer. In fact, a question that has been presented to a student will have a period of restriction time during which the question cannot be presented again to the same student in another quiz. After this restriction period, a question that has been previously answered in a wrong way will be more likely to be presented again to the student. A question that was entered by the content provider of the course that the student is taking will also have higher priority to be chosen over questions that have been entered by other content providers.

When lessons are presented to a student and when questions are correctly answered by a student, the value of the misconception and knowledge of the related KEs will improve through the Assessment Agent (AA). KEs that have a higher weight in a question or a lesson will improve better than KEs with lower rates, and vice versa. Similarly, false answers will increase the misconceptions and decrease the knowledge of the related KEs. The amount by which the misconceptions and knowledge are increased or decreased is not constants. Instead, they are a function of the number of misconceptions that the student has about the related KE. In fact, when a student is presented with new mathematical concepts and when the student answers related questions correctly, the system use a higher rate of increase in the knowledge of the student. When the student is presented with lessons and questions to a misconception of the student, the values related to the KE should not increase with a high rate as this correct answer may be the result of a lucky guess or the result of elimination of other possible answers to the question. A KE with a high misconception will result in a higher number of questions related to that KE to be chosen in the exam and we do not want to risk stopping the examination of a misconception prematurely. To achieve this effect, the rate of increase or decrease of a misconception and knowledge depends on the value of the misconception.

4. Managing the e-learning system through multi-agents' interaction

The main goal of this research is to model the knowledge and misconceptions of the student and to provide the student with the material that would help him or her overcome these misconceptions and missing information before starting a lesson. The system is implemented using a multi-agent architecture, where the material presented to the student is chosen based on the interaction between the agents.

The lesson presented to the user is chosen by the Lesson Selection Agent (LSA). Before presenting a lesson to the student from the course the student is taking, the prerequisites of this lesson are compared to the student's profile. If the student's level of knowledge or misconceptions is unsatisfactory, the LSA creates a Teaching Agent (TA) for each detected misconception or missing knowledge related to these prerequisites. The LSA will also create a Curriculum Agent (CA), which will always propose the next lesson from the current course that the student is taking. Conflict will occur between the CA and the TAs, as each agent will try to push different lessons. Each TA will use the values of the dependency of the prerequisite the agent is representing, which reflects the importance of this prerequisite towards the understanding of the lesson, and the level of misconceptions of the student or missing knowledge in this prerequisite to determine the ***demand*** of the TA. The ***demand*** is another fuzzy variable expressing how crucial the need is to present teaching material to the student to explain this prerequisite before giving him or her the lesson of the course. On the other hand, the demand of the CA is a function of the progress of the student in the unit being taught, starting from a system constant and increasing with the progress of the student in the course. It is implemented this way to express

the need not to interrupt the current unit being taught when the student is near the end of this unit unless really needed. The LSA will compare the demands of the TAs and that of the CA and will choose to offer the lesson proposed by the agent with the highest demand.

The system uses 3 fuzzy variables: the misconceptions, the lack-of-knowledge and the dependency between the subjects. Each fuzzy variable has 3 labels: high, intermediate and small. Figure 5 shows the set of fuzzy rules that determine the demand of the TA representing the misconception of the student in a prerequisite. The system uses the center-of-gravity technique to determine the crisp value of the demand level of a TA. The fuzzy rules were implemented using jFuzzyLogic (Cingolani and Alcala-Fdez, 2012).

```
RULE 1 : IF misconception IS low THEN demand IS low;
RULE 2 : IF misconception IS medium THEN demand IS medium;
RULE 3 : IF misconception IS medium AND dependency IS medium THEN demand IS high;
RULE 4 : IF misconception IS medium AND dependency IS high THEN demand IS very_high;
RULE 5 : IF misconception IS high THEN demand IS high;
RULE 6 : IF misconception IS high AND dependency IS high THEN demand IS very_high;
```

Figure 5: Fuzzy Rules Determining the Demand Level of a Training Agent

The Examiner Agent (EA) is responsible for choosing the set of questions to be presented to the student in an exam. The EA will contain multiple sub-agents that compete for the available question slots. The EA will create a Course Exam Agent (CEA) that is responsible for proposing questions related to the course's lessons that the student has recently taken. For each misconception exceeding a predefined level and for each knowledge element below a predefined level, a Quiz Agent (QA) will be created. The QA is responsible for proposing questions to further test the knowledge of the students in the KEs related to the misconceptions or missing knowledge of the student. This problem can be represented as a resource distribution problem where a fixed number of resources, which are the number of questions that will be presented in the exam, will be distributed between the agents that are proposing questions. Similarly to the LSA, QA demand will be a function of the misconception and knowledge variables and will increase if these misconceptions and missing knowledge are related to prerequisites of the current course. The EA will arbitrate between the conflicting agents using fuzzy rules to evaluate the demand level of each agent. The EA will assign a percentage of questions to each agent based on the agent's demand.

To evaluate the effect of the system, it is planned to use a test group with problems in mathematics. The group will be tested at the beginning of the course to deduce the lack of knowledge and misconceptions of each student. The group will be divided into two sub-groups. The first will only use the classroom environment to teach the new course. The second group will use the electronic system with the help of teaching assistants instead of the classroom. At the end of the course, each sub-group will be evaluated to determine the effect of using the proposed system on improving the student levels.

5. Conclusion

In this paper, we presented an innovative architecture for building an e-learning system using a multi-agent architecture.

The system is capable of tracking the progress of the student through the tracking of knowledge and misconceptions. Based on the progress of each student, the system provides the student with the learning material that is needed for the student to be able to progress in the course. Based on the prerequisites of each section and the weaknesses of the students, the system may provide the student with material that covers the knowledge areas in which the student lacks the required knowledge or has misconceptions in. When the system suspects that the student has a weakness in a knowledge area, the system increases the number of questions related to this area to help evaluate the level of the student and eventually provide the student with the needed teaching material.

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Quantifying and Incentivizing Exploration of Reputable Sources for Argument Formation in an Online Discussion Forum

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Abstract: Nuclear power forms part of the first-year physics undergraduate course work in the extended curriculum program at the University of the Western Cape. This investigation intends to assist students in mastering their understanding of how nuclear power works through the development of critical thinking skills around the topic and to create awareness among students of the implications of expanding a nuclear power footprint. Through debate, students in this course investigate the impact of South Africa increasing its nuclear footprint within a global context. In this work, students were encouraged to explore publications and reputable websites surrounding this topic and based on their findings formulate arguments. The authors conceptualized and developed a Sakai tool (based on Learning Tools Interoperability), called Reference Register (RR) to compliment the work. RR stores the reference uploaded by each student, shares uploaded literature resources to the group members, and quantifies the number of times a student uses a reference when presenting their argument. The incorporation of the RR was intended to encourage students to formulate arguments based on well-founded literature. Authors sort to investigate in which ways and to what extent does an online discussion forum facilitate students becoming ethically, environmentally, and socially aware in the area of nuclear energy and to assist students in becoming better in their professional communication skills. The outcome of this student engagement included students becoming familiar with what constitutes a well-formulated scientific argument based on a literature review, group engagement, becoming aware of South African current affairs regarding nuclear power, and its social and economic impact.

Keywords: online debate; undergraduate physics; reference register; Sakai; e-learning

1. Introduction

The University of the Western Cape (UWC) is one of 26 public universities in South Africa. At the University of the Western Cape (UWC) strategic plans in learning and teaching have led to the outcome of the Charter of Graduate Attributes (UWC, 2009). The Charter intends to ensure that graduates from UWC are more employable and possess desirable graduate attributes on the completion of their studies. Part of the Charter includes a set of overarching skills and abilities.

The skills embedded in this class activity for first-year physics undergraduate students' address critical thinking and allowing students to become relevantly literate. It intends to expose them to an application of physics, nuclear power generation and in doing so, for a student to become ethically, environmentally, and socially aware within this context. The activity uses the online debate platform to assist students in becoming skilled communicators. At the time of this study using online activities are relatively new at UWC. The difficulty in the rapid transition stems from either or both off campus internet connectivity and or the lack of a suitable device among a vast number of students. The Sakai tool, Reference Register (RR), conceptualized and developed by the authors was created to encourage students to explore published texts and then to incentivize well based literature-reviewed arguments.

This group activity is envisaged to enhance the students' learning in the form of understanding of content and to build transferable skills. The discussion forum allows for cooperative learning where it is hoped to maximize the students' own and each other's learning as described by (Johnson, et al., 2008). In a later paper Johnson (Johnson, et al., 2014) states that cooperative learning is defined by and allows for positive interdependence, where students consider that if one performs better then all students engaged will.

Debates in more technical subjects can effectively facilitate critical thinking (Kennedy, 2007). When this takes place in an online forum, the discussion can take place at any time and in any place, thus students have the opportunity to ponder the discussion and to produce detailed and considered reflections. Some of the advantages discussed in papers by Andresen (Andresen, 2009), Fleming (Fleming, 2008), and Hazari (Hazari, 2004) are that students can reflect on the evolving discussion as often as they like. When this is held online the hesitation for exploring debates in a classroom, because it may alienate some students is removed and therefore

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a discussion board can feel more inclusive, students have time to read and review the exchanges of views. Therefore, with this insight, the authors envisaged that this activity would promote accountability and inclusivity which is particularly difficult in larger classrooms. In the University of New South Wales Teachers Assessment Toolkit: Assessing by Discussion Board the following added advantages are;

> *Students can see and evaluate their peers' posts, and this helps develop a community of inquiry and a more democratic assessment process. When assessed, students are more inclined to contribute actively and productively to the discussion. This leads to comprehensive class discussions, as well as increased opportunities for students to demonstrate the depth of their learning.*

In the work by Scott (Scott, 2008) and Paul et al (Paul, 2019), critical thinking involves solving complex problems by raising pivotal questions, gathering appropriate information, disseminating the findings, and communicating the outcomes. Maiorana (Maiorana, 1992) in Scott (Scott, 2008) states: 'the purpose of critical thinking is to use questioning techniques to achieve understanding, evaluate viewpoints, and solve problems', all of which are valuable skills to acquire for any scientist in training. Scott (Scott, 2008) found that the debate process also helps students' master content. Cheese et al (Cheese, 2015) convey in their work that debates stimulate critical thinking and can be a highly effective way to actively engage students in the classroom. At many tertiary institutions classes sizes greater than one hundred students is not unusual and this could be an effective way to get more students to engage with the course work. Shaw (Shaw, 2012) and Zare et al (Zare, 2013) too are convinced that debates stimulate critical thinking and can be a highly effective way to actively engage students in research in the online classroom, mastering the course content and aid in improving the students' communication skills. Zare et al (Zare, 2013) findings included claims that additional benefits of the debates included, boosting the students' confidence, overcoming stage fright, and improving teamwork skills. In the work by Tessier (Tessier, 2009), students value debates for developing their arguing skills, where the Internet was used as a primary source. Later it was discovered that students concluded a source was trustworthy most often by considering the authority of the author. McGreevy et al (McGreevy, 2017) used a virtual online debating platform and the majority of the students in their study found that it to be a non-threatening environment for discussing emotive and difficult issues. Students communicated that it allowed them to see how their peers formed ideas and in turn reflect on how best to express their ideas and formulate an argument. In the book by Davis et al (Davis, 2016) the reasons for incorporating a debate in a teaching platform can be summarised by the following;

- The participants in the debate learn to listen and to engage meaningfully in conversation with those with whom they disagree.
- Debaters learn to identify and confront inconsistencies while exploring the same introspection of their own beliefs and preconceptions.
- Participants in a debate appreciate well thought through arguments, stances and are willing to tackle complex ideas.
- Learners understand the significance of effective communication.
- Debaters learn to assess the objectives and then formulate the processes necessary to achieve them.

This investigation intends to explore the benefits of debates and the benefits of the online forum to enhance the critical thinking skills of first-year physics students and for them to master the course content in the area of nuclear power. The motivation for the development of RR was to create a tool that would guide students to develop structured arguments. The RR allows the course presenter to quantify the number of sources a student used and therefore this can be used, as in this instance, as an assessment criterion.

2. Research Methodology

Students in the physics ECP (Extended Curriculum Program) contributed to the nuclear power debate towards the end of the first semester. Physics 151 (2018) consisted of 119 students, where 85% (101) of the students have agreed to the authors' reporting of the outcome of this study. In class the topics radioactivity, fission, and fusion are explored; these topics served as an introduction to the mechanisms of nuclear power generation and a launchpad for the discussion of whether our country should go ahead and expand the number of nuclear power plants (NPP) it already had.

In class, students are ordinarily divided into groups of three. For this exercise, two groups are put together for the debate and told, which team is for and which team argues against the expansion of nuclear power in South Africa. The first part of the activity is for students to find literature that would assist with their argument.

Students were then given a week to find suitable literature, upload their references onto the RR and view and familiarise themselves with what the other participants have uploaded. For the debate, a student would only be awarded for using the literature the group submitted to the RR. This would then imply that in each debate group, of six students, each student should have read six papers. Students were given a rubric and the following criteria were emphasised as part of the evaluation of their performance in the debate i.e. The number of times a student's posts a comment is considered (this prevents a student from only posting one long argument), the period over which they post (this prevents a student from logging in the night before and then only spending one day to engage in the activity), how they engage with the other participants in the forum. The students received a rubric that was created by Nandi et al. (Nandi, 2009). A students' final grade then constituted of an assessment using the rubric and the outcome from the RR.

2.1 Educational Technologies used for Online Debate Forum

Within Higher Education (HE) learning-and-teaching environments, eLearning is defined as the use of time and space-dependent and independent application(s) intended to effectively distribute a range of multimedia content, such as; lecture material, assessments, communications, and discussions to both academics and students. For this study, the institutional Learning Management System (LMS), branded, iKamva (based on Sakai - https://sakaiproject.org) will support the eLearning concept, as well as the integrated eTool, termed, Reference Register (RR).

2.1.1 Discussion Forum

The eTool, Discussion Forum (DF) located within iKamva can be used by the academics (and teaching assistants) to create, moderate, manage several online forums/topics and groups within a course. For this research study, the students are split into two main groups (i.e. groups one and two), with further sub-groups for the topic, "nuclear power for the sustainable future in South Africa?". A depiction of the online setup can be viewed in figure one, which displays the main and sub-groups with the number of messages (unread as well). Additionally, the site can also send private messages to group participants, provide feedback, set word counts, permissions, and grade the discussions. DF was used for this study to facilitate and enable communication amongst the ECP students (within their groups) regarding the debatable issue, the use of nuclear power within South Africa. A depiction of the latter can be seen in Figure 2.

The DF serves as a contributing, communication, reading, and writing eTool within iKamva for both the academics and ECP students. It allows for non-real-time (asynchronous) communication, meaning fewer chances for students to control the interaction within a forum and thus higher probability for fair opportunities and easy engagement than in a face-to-face discussion.

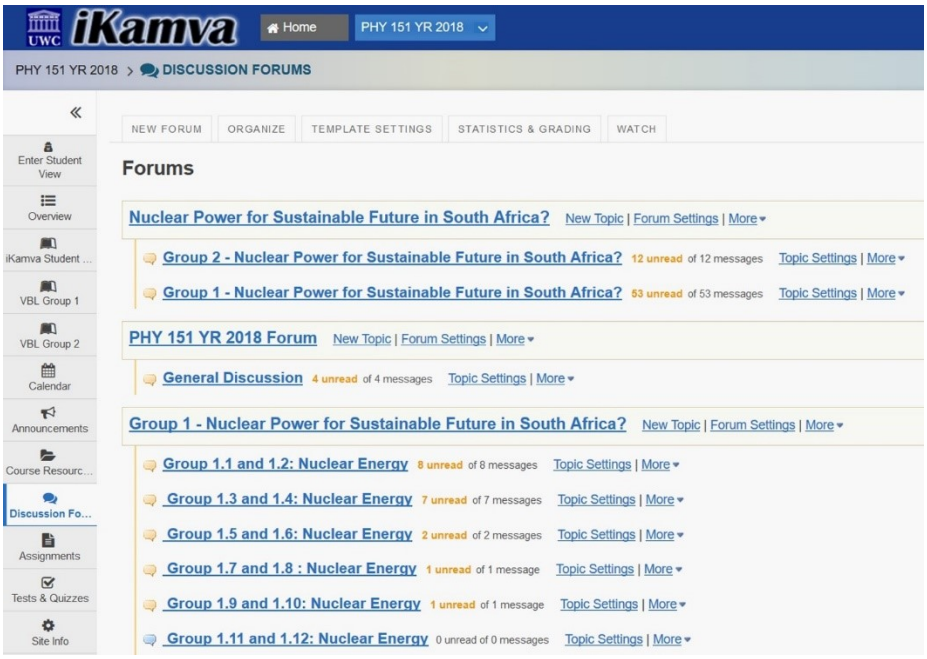

Figure 1: Depiction of Discussion Forum structure which displays two main groups (Group 1 and 2), with related sub-groups

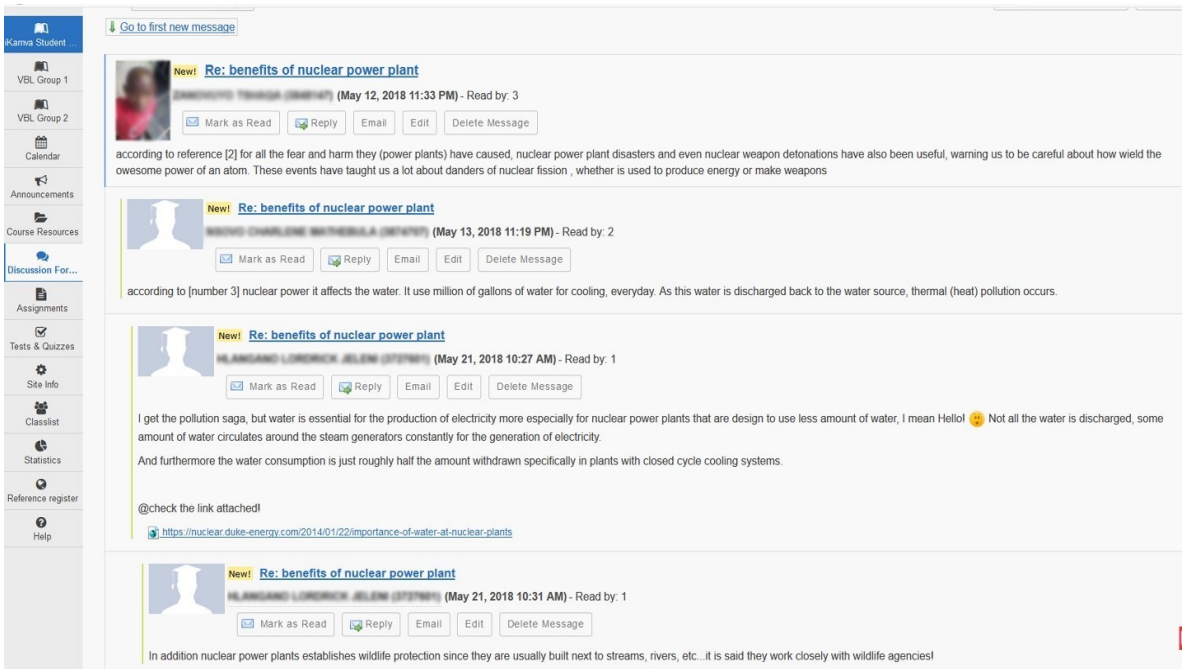

Figure 2: Asynchronous Communication between ECP students engaging with one another on the debatable topic, "Nuclear Power for Sustainable Future in South Africa"

2.1.2 External Tool: Reference Register

The RR is a custom-built external tool, used to complement the DF. The R Rallows students to collate their arguments (see Figure 3) and upload their references (see Figure 4) before the start of the debate. Students may also view the references provided by fellow members of their group, thereby familiarising themselves with multiple sources to support their assertions. Given that the debate requires students tospend a considerable amount of time online, the emphasis had been placed on providing a streamlined interface to students to facilitate the collection - and the validation - of their references. Furthermore, the RR serves the teaching staff as well in terms of,

- real-time information on the state of debates is provided via dashboards (see Figure 5),
- it mitigates some of the administrative burdens by analyzing and collating results, and
- allows for the download of all responses contained within the DF, or those responses that are determined to be properly referenced.

As the RR is a custom-built tool, additional functionalities not provided by the LMS can be developed. These include validation of references, automation of processes, sentiment analysis, and custom workflows such as email reminders via integration with third-party services such as Google Apps (Giannakos, 2010; Miranda, 2017; Rubens, 2012).

The efficacy of this work was assessed using the following three measurands:

1. Students experience feedback forms.
2. The online discussion forum analysis and the outcomes from the RR data
3. Assessment of the quality of the debates using the rubric.

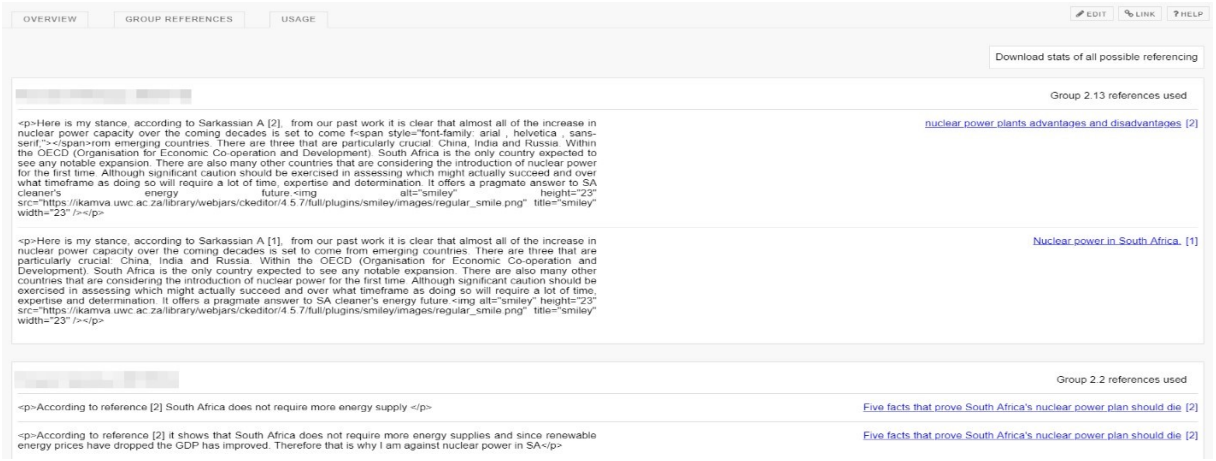

Figure 3: (Administrator interface) Collation of arguments that have been properly referenced. Instead of interrogating each post in the discussion forum, administrators have a single location to view or download all referenced posts

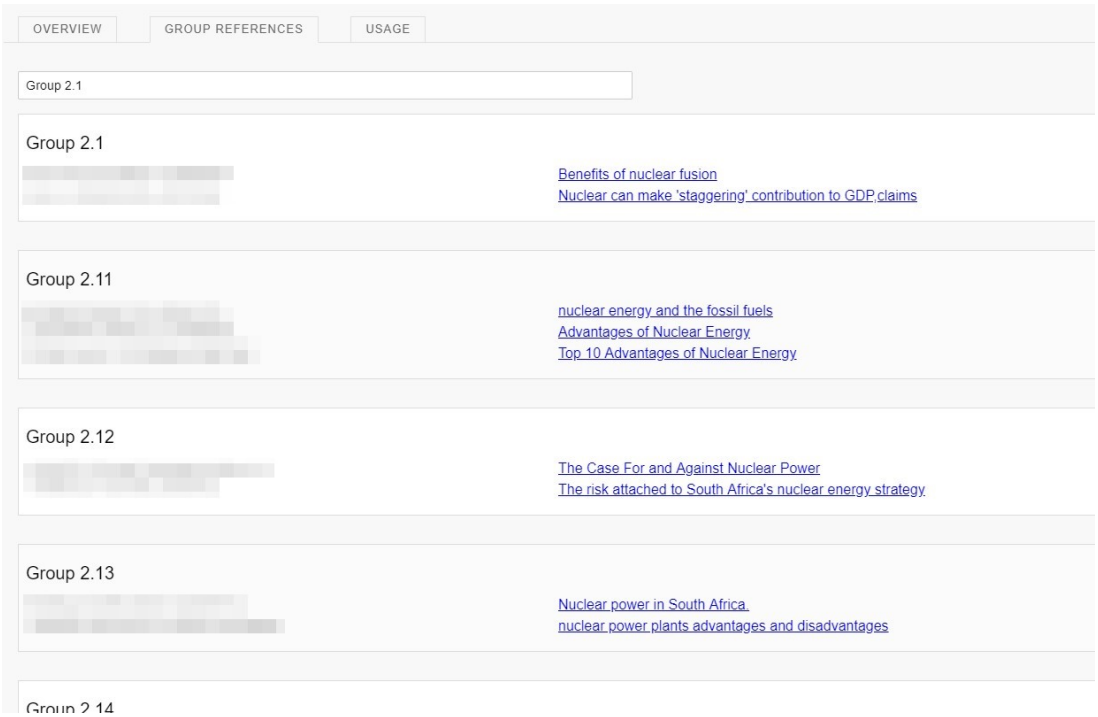

Figure 4: (Administrator interface) Real-time view of group references and reference submitters, filtered by group title. Administrators can interrogate references supplied by specific students or groups

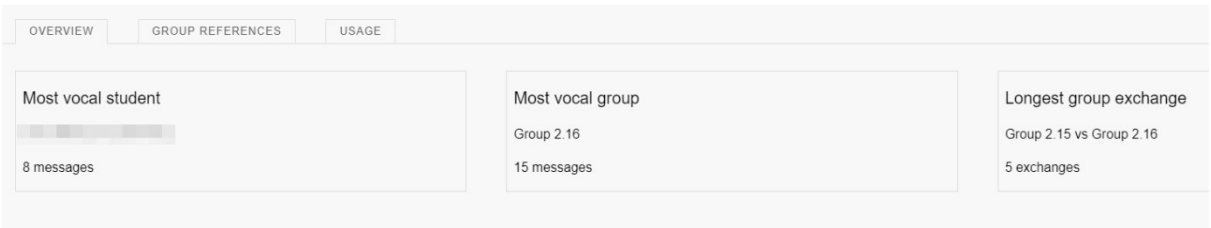

Figure 5: Simple real-time dashboard displaying useful information on the state of debates. Administrators may use the dashboard for quick indications on the health of the debates, whereas for students, the dashboard acts as a rudimentary gamification interface

3. Results

Physics 151 (2018) consisted of 119 students, where 85% (101) of the students have agreed to the authors' reporting of the outcome of this study. Of the 101 students, 65 students completed the feedback forms and 53 students participated in the debate.

3.1 Student Feedback Forms

This section will present the measurement of the research activity using paper-based student feedback forms. In class when introducing the activity the students were asked if they had ever participated in a debate and only a handful of students could say yes. This prompted a further discussion on debates. In the questionnaire given to the students' the first question the students were asked, and was used to gauge their previous knowledge on the topic, "Before learning about how Nuclear Power works in Physics 151, what were thoughts about the Republic of South Africa (RSA) exploring this as an opportunity for our future energy mix? Did you know that RSA is considering building more NPP?". The results indicated that the majority of students did not know that RSA was exploring the possibility of building more NPP and therefore their only knowledge before the debate was the material discussed in class. In class, the focus was on the mechanics of a nuclear power plant and radioactivity. An hour-long lecture was used to watch a documentary on the Fukushima nuclear power plant failure, we discussed the differences between the Chernobyl incident and Fukushima. Further short discussions included South Africa's current energy mix within the global context and the socio-economic structure surrounding South Africa's natural resources and employment.

The second question,"Did the rubric assist you in preparing a good debate? Explain.". The majority of students found the rubric very helpful as it focused on key aspects of the debate. Furthermore, the students mentioned it assisted them to include references for their claims. However, references are not considered a requirement in the rubric but the incorporation of the RR makes it a requirement. The students were then asked about their experience i.e. "What were the good and not so good experiences using an online forum for discussing the subject matter?". Most students enjoyed the online debate forum, i.e. they felt at ease not having to talk in front of their peers. A small group found the online forum a new and interesting experience. Additionally, a few students complained that the groups they were debating against did not respond in time or not at all. An option going forward would be to allow these students to join an additional group in the event the rest of their group members does not participate.

Despite having provided training, a few students did not understand the layout of the online forum or how to upload their references correctly. A smaller group of students felt disadvantaged because they did not have access to the internet at home and had to stay on campus to regularly engage in the forum. Given the intermittent Wi-Fi and the limited number of computer laboratories on campus, this is something to brainstorm in the future. The feedback form then included a Likert chart indicated in table 1.

The final question asked in the feedback form was "Do you have any other feedback for the team?". The responses that came back were that some students would prefer the traditional manner of debating instead of the online version, due to internet access. Students would like a way to monitor or to be notified that other group members posted or responded to their posts. A great recommendation given by the students was that groups should be monitored to ensure that they contribute to the debate and give their arguments.

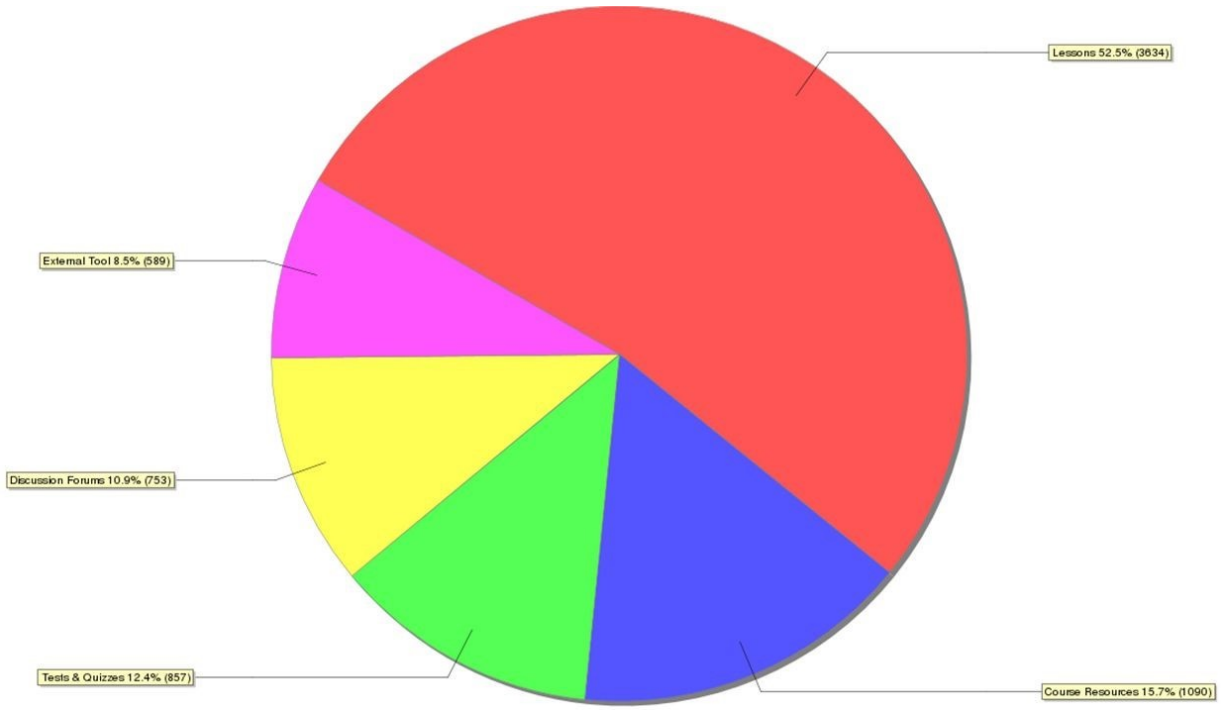

Figure 6: Pie chart displaying the total activity (753) for utilization of Discussion Forum on Learning Management System by the ECP students.

3.2 Debate online analysis and the outcomes from the RR data

The graphical representations alongside the statistical information concerning course activity, engagement, and participation for this study were derived from the LMS system.

Figures 6 – 9 displays, and support the DF responses. These illustrate the total activities for utilization of DF and Reference Register (RR) by the students and the total site visits – and unique visits for the duration of the project (Term 2, 2018). Overall, this stand-alone secondary quantitative data will highlight the visibility (logins) and engagement (within DF) of the students. Figure six displays the total activities by the ECP students (and the most active students) for the utilization of the DF in terms of accessing, reading, -and replying to posts within their groups. A total number of 753 activities were done during the duration of the project, averaging six activities per student. Figure seven reflects visible and engaged students during the first semester, but most importantly note the spike in visits for May 2018 (compared to Feb, Mar, and Apr 2018), as this was the time frame for the project. Note that the visits are defined as more than one visit per day per student, whereas unique visitors is just one login for the day per student. As seen from the bar chart, there is an increase in terms of visits for each month, whereas the number of unique visitors is roughly the same each month. Figure 8 displays the total activities by the ECP students (and the most active students) for the utilization of the external LTI tool, termed, Reference Register. A total number of 589 activities were done during the duration of the project, averaging 5 activities per student.

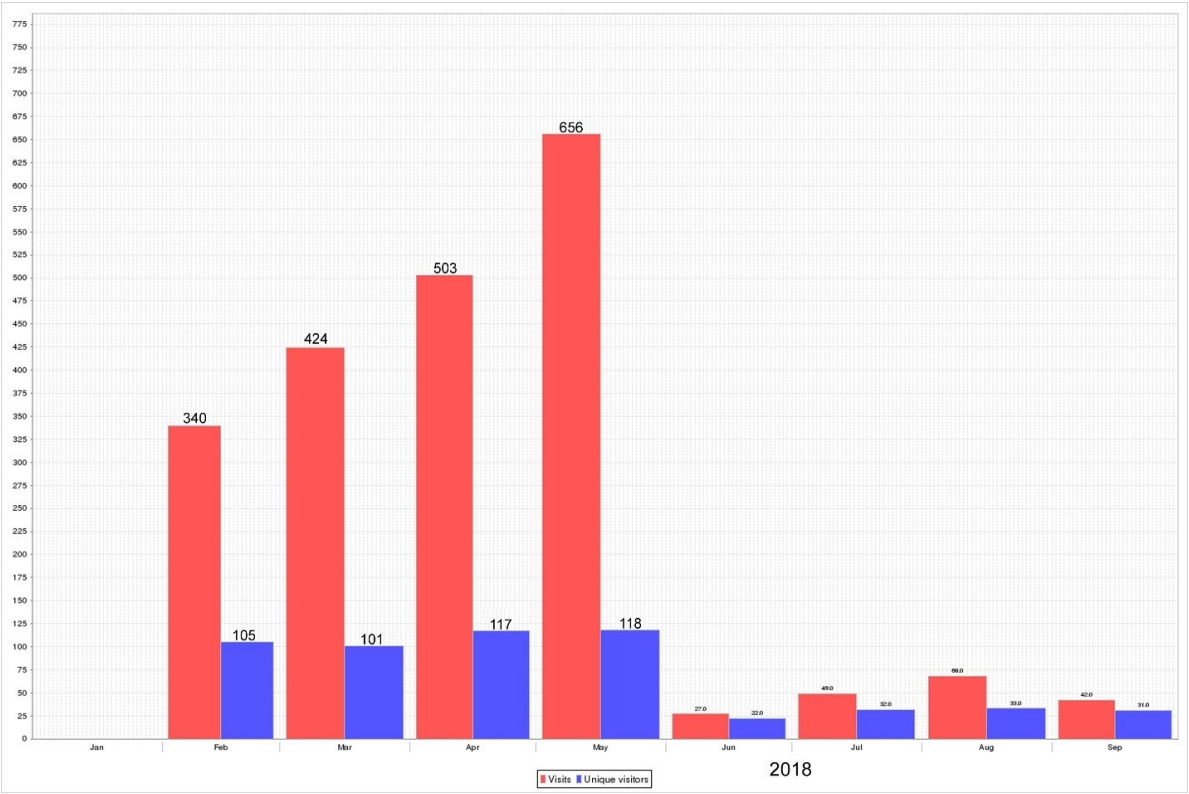

Figure 7: Bar chart displaying the number of visits and unique visitors by ECP students during the time frame, Feb – June 2018.

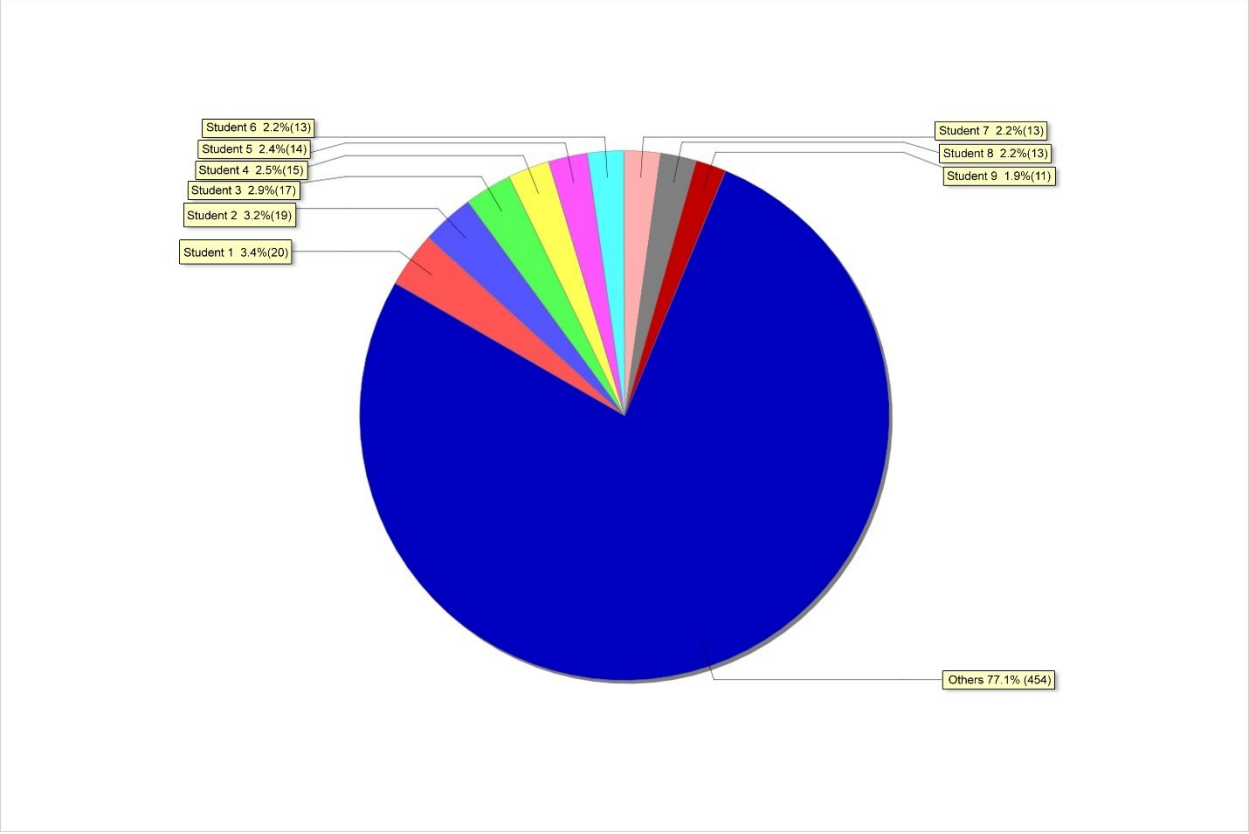

Figure 8: Pie chart displaying the total activity (589) for utilization of the external LTI tool, Reference Register on the LMS by the ECP students

Furthermore, Figure nine is a pie chart displaying the numerous eTools used on the LMS for the first semester of the academic year and can be seen that the DF and External Tool (RR) eTools comprised of 10.9% (753) and 8.5% (589) of the total usage of eTools, respectively, which coincides with the totals in Figure six and eight, respectively.

For the debate, 53 people participated. Of the 53, 2 people just entered one line to say hello. 30 of the 50 people then managed to use some form of in-text referencing either the "[]" or "()" brackets. However, when going through the data manually an extra 10 students used some other forms of referencing. The confusion could be a result of different formats used across disciplines. When comparing the results of the students who managed to use a form of in-text referencing and their performance as an outcome from the assessment using the rubric there is a 70% correlation. Where a student is considered to have done well in the referencing (RR) component when they use most/ or all the literature provided by their group. One student managed to score well using the rubric, however, it did not include any citations in their argument. On further investigation when reading the debate posts it becomes very clear that their views are an accumulation of reading reviews from many sources.

3.3 Assessment of the quality of the debates using the rubric.

The rubric created by Nandi et al (Nandi, 2009), helped students and assessors clarify the criterion for a good debate discussion. Students would refer to one another in text and when reviewing their work it becomes clear how this helps with the flow of the debate. The rubric, because of the many criteria ensured the longevity of the debate specifically considering the objective measures, i.e. participation rates and consistency of participation.

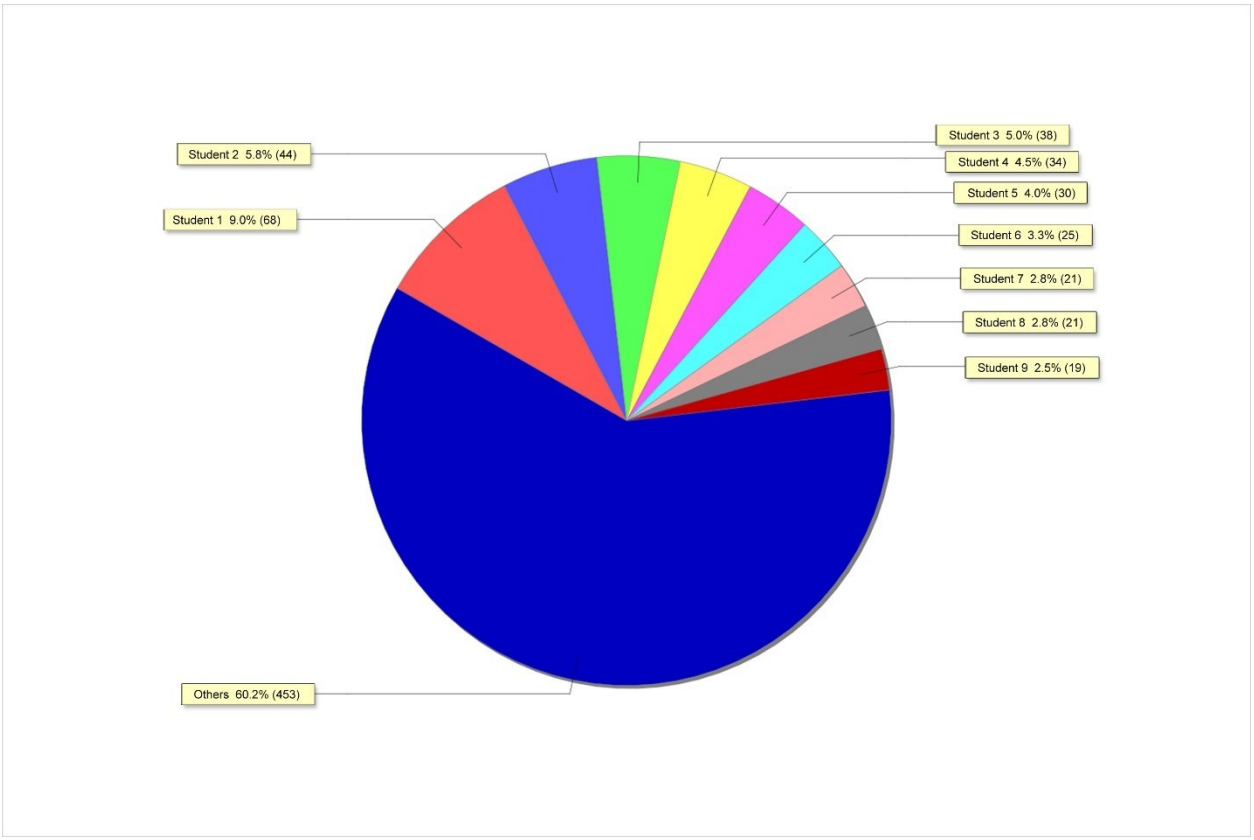

Figure 9: A pie chart displaying the numerous eTools used on the platform for the duration of the project, and can be seen that the DF and External Tool (RR) eTools comprised of 753 and 589, respectively of the total usage of eTools

4. Discussion

The DF was used with the intention of providing the students in this study with a platform where learning technologies could be explored. The utilization of DF permits the academic teaching-and-learning participants to work as a group or on an individual basis to participate in online discussions, which in this case focused on

nuclear energy plants. Their findings (or contributions) were visible to the group members within the group and the other group, i.e. Group 1.1 and Group 1.2 as seen in Figure 1.

An added benefit to the utilization of DF is that the student contributions can be done from any geographical location, with numerous electronic devices with a stable reliable internet connection. Students were asked to contribute and participate in the online discussion, to prompt further discussion about the topic amongst their peers, which is listed in the topic under the forum, entitled, nuclear power for sustainable future in South Africa (see Figure 2). The group size was limited to six students max for ease of online invigilation and to allow for more engaging group involvement.

Furthermore, regular online engagement within a DF regarding any given topic at hand iterates that students should not only be involved in the online space but should also grasp the theory content. If the students do the latter, they should create understanding via communal feedback, which in turn will increase their understanding of the theory section. This productive learning-and-teaching initiative using a communication qualitative assessment educational technology tool, called, DF, allowed the students to construct knowledge and to support their arguments by uploading sources to their counterclaims. The findings would support the work by Jonassen (Jonassen, 1994) in that it shows that the use of DF is not only seen as a communication tool within an LMS but it could also be considered to be a cognitive tool that enables 'cognitive learning strategies and critical thinking' amongst online participants and therefore allows for learning beyond the classroom.

In agreement with Markel (Markel, 2001), the constant interaction amongst the students in the form of posting comments, replying to posts, reading their peers' post, and uploading of sources involves numerous educational processes from 'reflection and the construction and re-construction of domains of knowledge' which allows for deeper learning and affords the student an opportunity to refine their thinking and let their voices' to be heard.

5. Conclusion

The first-year ECP physics students at the UWC discussed the debatable topic of whether South Africa should extend its nuclear footprint. An external LTI educational tool, named RR was designed, developed, implemented, and ultimately embedded onto the university's LMS to assist the students to move away from an argument-based opinion to an opinion that is based on peer-reviewed sources (references). RR can quantify the number of times a student uses a reference and the number of different references used in their online debate. To ensure the longevity and maximum engagement in the discussion students were provided with a rubric.

Analyzing the discussion threads, it is encouraging to see how the students engaged with the educational tool, their peers, and the debatable topic nuclear power for sustainable future in South Africa. The results from the feedback form, the discussion threads, and the LMS statistics strongly suggest that the RR tool improves the communication skills of students for scientific research discussion purposes. The DF allowed the students to participate effectively in their own time and free to express their views with their peers. An event, which will not easily happen, if this class activity was to be done face-to-face.

Some of the improvements to the online debate using RR will include allowing students who are in groups where the engagement is very low the option to participate in another group, allowing students to upload more than one reference at a time, incorporate an online rubric (making use of Google Apps), have a way of displaying who the winning group of the debate is, and then finally to poll the before and after debate answering the question, "should South Africa increase their nuclear footprint?".

Acknowledgement(s), Funding, Author contribution and Ethics

The authors wish to acknowledge the assistance and encouragement from colleagues in the physics extended curriculum programme and special efforts by the administrative assistant Justin Klaas. The authors wish to express their gratitude for the support from the Department of Physics and Astronomy and University of the Western Cape's Directorate of teaching and learning. Dr. Lynndle Square taught Physics 151 during the time of this investigation, came up with the idea of using an online debate to discuss the topic, and came up with the Reference Register concept. Mr. Valentino van de Heyde set up and monitored the eTool, Discussion Forum (DF) located within iKamva and Mr. Duncan Smith developed the Reference Register tool. All three authors contributed to the development of this paper and the collection and analysis of the data. The principal investigator and applicant for ethics

clearance from the University of the Western Cape ethics committee was Dr. Lynndle Square, Ethics Reference Number: HS18/7/31. The authors declare that no competing interest exists.

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Editorial for EJEL Volume 19 Issue 3

Dear readers of the EJEL,

The previous issue of the EJEL highlighted the impact of the COVID19 pandemic on development and relevance of e-learning. However, e-learning continues to evolve independently of the pandemic at a very fast pace, as is reflected in this issue, which includes ten articles covering a range of topics such as collaborative e-learning, digital literacies, problem-based e-learning and e-learning design, to mention a few.

In the first article, Sultan Alyahya and Asma Aldausari from the Department of Information Systems, King Saud University, Saudi Arabia, describe the development of a digital collaborative learning environment for preparing standardised tests. They recount the entire development process starting with a review of the available technologies and including the evaluation of the platform created. The evaluation demonstrates the supportive effect of the learning environment in many dimensions of the learning process, be it the participative, the cognitive, the interactive, or the social dimension.

Alaa Zuhir Al Rawashdeh and his colleagues from Ajman University, Ajman, UAE, from Al Balqaa Applied University, Jordan, Ain-Shams University, Egypt, and from Clemson University, USA, describe the advantages and disadvantages of e-learning from the perspective of higher education students in the United Arab Emirates in the second article. Their findings based on a survey of a random sample of 100 students suggests that learners' understanding of the advantages and disadvantages of the e-learning environment is important for the effectiveness of their learning.

In the third article Yehuda Peled and her colleagues Gila Kurtz, and Orit Avidov-Ungar from Western Galilee College, Holon Institute of Technology, and Achva Academic College, Israel developed and validated an inventory of digital literacy skills required in the learning process. Seven subscales are determined using 54 items and validated using structural equation modelling and factor analysis techniques. The inventory might be suitable for assessing teachers' competencies with the use of e-learning tools.

Rikke Ørngreen—who is a former chief editor of the EJEL and whom we would like to greet cordially on this occasion—, Sara Paasch Knudsen, Ditte Kolbæk, and Rune Hagel Skaarup Jensen from Aalborg University Denmark, investigate to what extent Moodle supports problem-based learning (PBL) scenarios. For this purpose, a literature based qualitative analysis of the features of Moodle and the requirements of PBL scenarios is conducted. This is followed by a survey distributed to 345 students, asking them to identify their favourite Moodle course. The resulting courses have then been evaluated qualitatively. The findings indicate that Moodle is mostly used as a distribution platform of learning materials. As this is at odds with the university's overarching PBL approach the authors recommends several ways to mitigate this misalignment.

In the fifth article, Daniel Bumblauskas of the University of Northern Iowa, USA, and Nick Vyas of the University of Southern California, USA, revisit the PBL approach. The authors argue that e-learning and PBL have emerged as a viable and complementary combination during the COVID pandemic. Using the PBL principles, the authors substantiate this approach by examining a Statistical Process Control module delivered online. The online learning scenario is found to be interactive, conducive to learning, especially to learning of critical thinking skills, and enhancing the learning experience overall. Furthermore, the article suggests that online-supported PBL is a powerful means of advancing the quality of teaching.

The PBL approach is also the topic of the eighth article by Orit Avidov-Ungar (also one of the authors of the third article), and by Dina Tsybulsky from Achva Academic College, Israel. Both authors examine the extent to which participation in an online course using PBL as part of a Master's degree in a teacher education programme shapes participants' roles as future "digital age teachers". The analysis of quantitative and qualitative data collected over a three-year period shows that this form of experiential learning is very helpful in developing learners' understanding of their future teaching roles.

While purposive design of learning scenarios is important for the success of e-learning, attention must also be devoted to more fundamental characteristics of e-learning, such as participants' listening comprehension, which

Reference this paper: Söbke, H., and Cubric, M., 2021. Editorial for EJEL Volume 19 Issue 3. *The Electronic Journal of e-Learning,* 19(3), pp. 220-221, available online at www.ejel.org

is a topic examined in the sixth article. The team of authors, led by Nikesh Bajaj, from Queen Mary University of London, UK and the University of Genova, Italy describes how semanticity, sentence length and noise level influence the auditory attention of non-native speakers in e-learning environments. The results indicate that the effects of semanticity disappear in noisy environments, while increasing sentence length has a negative impact on listener's attention. Overall, the results emphasise the importance of linguistic and auditory factors for effective e-learning design, especially in the institutions aiming to attract more international students.

Design characteristics of e-learning media are also the subject of the seventh article in this issue. Marketa Rickley of the University of North Carolina, USA and Pavlina Kemp of the University of Iowa USA examine the impact of professional production of video lectures on learning outcomes and student perceptions. Video lectures produced by the lecturer are compared with video lectures produced in a studio in collaboration with instructional designers. The latter are found to have a positive influence on students' perceived learning and have led to a very slight improvement in their satisfaction. The results confirm again the importance of the careful design of e-learning media for successful learning.

In the ninth article, Magdi Amer (Cognizant Digital Engineering) and Hossam Aldesoky (The Higher Institute of Social Work, Cairo, Egypt) introduce software for personalised learning of mathematics. The tool records the activity of the student, and deduces their level of knowledge and their misconceptions in order to make recommendations for the next tasks to be solved. The software aims to prevent creation of psychological barriers based on acquired misconceptions that may prevent the students from understanding more complex mathematical concepts.

The use of nuclear power is often the subject of intense society-wide debate. The tenth and final article by Lynndle Square, Valentino Van der Heyde, and D. Smith (University of the Western Cape, Bellville, and North-West University, Potchefstroom, South-Africa) draws on this topic in a national context to examine the educational use of online discussion forums as a venue for evidence-based discourse. A Reference Register is used to monitor the frequency and quality of evidence sources used for argumentation. In addition to the domain-specific learning objectives on nuclear power and its social and economic implications, cross-disciplinary learning objectives such as a structured fact-based scientific discussion are achieved.

We believe that these ten articles will contribute to a continuation of a fruitful global discussion on the shaping of e-learning in the years to come. We hope that the article will provide the readers with some inspiration for their own work, and we are eagerly awaiting your new submissions, especially those which are critically reflecting on the current e-learning implementations.

Journal Editors,
Heinrich Söbke and Marija Cubric