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Critical Success Factors in Online Introductory Programming Courses

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ABSTRACT

The adoption of Online Distance Learning (ODL) methods brings about a couple of problems, such as the lack of timely feedback, technical incompetence, and the physical disconnect between the students and the instructor. This is where Critical Success Factors (CSFs) come in, as they help alleviate some of these issues. This paper looks at some of the CSFs that have been found to be effective in ODL, and looks at the Student-Instructor Interactions (SIIs) CSF in more detail.

We look at two ways that aim to improve asynchronous SIIs in first year computer science (CS) courses at the University of Cape Town (UCT). This was done through the development of a web application system that pairs lecture videos with forums, side-by-side, and allows instructors to ask questions and get feedback from all students, through the use of mandatory quizzes.

An experiment to test the web application was carried out, with UCT students as the participants. The results show that the application's forum system is perceived as being easier to access and navigate, compared to UCT's Vula forum system. Student participants felt that such a forum made them more likely to make posts. The results regarding the mandatory quiz component indicate that a significant percentage of the students felt that the mandatory quizzes improved their asynchronous interactions with the instructor and the course content, but would be more effective if they were optional.

1. INTRODUCTION

Learning Management Systems (LMSs) play a significant role in the administration of ODL courses, by centralizing the core course activities and allowing instructors to upload resources so that they are accessible to students. While methods of ODL do vary, this paper focusses on the asynchronous method, as it tends to accommodate a wider range of students, due to its self-paced learning qualities. CSFs are generally used to stretch some of the limitations imposed by ODL, but their literature in relation to introductory CS courses is not in abundance. Therefore, significant points found in literature addressing general online courses have also been considered.

In order to understand the significance of CSFs, we would first need to touch on some of the issues present in online courses. This includes problems such as poor student retention, high drop-out rates, poor proficiency with technology, and limited human interactions. Students tend to fall victim to many distractions, with one of them being the internet – the very tool where online learning takes place [2]. Such distractions, along with lengthy lecture videos and poor instructor characteristics, among others, contribute to poor student retention. Both students and the instructors can face problems because of their unfamiliarity with some of the software being used in ODL [28]. This leads to further problems such as the inability to upload or access course resources. ODL also lacks the physical interactions that are present in traditional classes. Communication is also limited and it can appear as an 'individual' task which makes students feel isolated from the rest of the class, and this contributes to the insufficient interactions that occur [18].

CSFs tackle some of the issues discussed, and ensure that courses are run in a way that optimizes positive learning outcomes. Some of the identified CSFs include a Supportive Learning Environment, Student Retention, Informative Assessment Feedback, SIIs, Technical Competence, and Self-Regulated Learning (SRL). These are discussed more in detail in section 2, where we carry out a theoretical analysis of the literature. Our paper directs its focus at the SIIs CSF.

SIIs refer to ways instructors and students can engage in dialogue, how questions and answers are exchanged between them, and the promptness at which feedback is provided [20, 26]. Such interactions form the basis of learning and play a key role in consolidating the students' understanding of the course material. It is generally difficult to foster interactions in online courses, due to the asynchronous nature of delivery, and students tend to perform poorly in their absence [19, 27].

Often, students have questions they would like to ask while watching lecture videos. Currently, the way to accomplish this in Vula would be to navigate to a 'forum' tab, browse through the multiple forum topics, find one that is relevant for their question, and then make the forum post. The developed web system eliminates this process by attaching a distinct forum to each

lecture video, making asking questions only a single mouse click away.

In order to gauge the overall level of the students' understanding, the web system allows instructors to setup mandatory quizzes at specific intervals within the lecture video, which prohibit the students from watching the rest of the video, until they complete the quizzes. This is the mandatory quiz component of the web application. Instructors can then see a statistical representation of the student responses, to determine how well they understand a concept.

2. THEORETICAL ANALYSIS

This section discusses some of the work that has been done in relation to incorporating CSFs in online courses.

2.1 Supportive Learning Environment

Supportive Learning Environment refers to all the aspects surrounding the LMS, that can either enhance or impede teaching and learning. Rafique et al. [17] concluded that in order for programming courses to be effective, academic institutions need to provide support to the students, by using LMSs' live conferencing to enhance engagement and address issues. Their study goes further to say that students perform better when they have secure social environments, human interactions and instructor feedback. This complements a study by Cheawjindakarn et al. [6] which found that students learn better when the learning environment is supportive, 'familiar', and comfortable. Alqahtani et al. [2] also listed learning environment as one of the CSFs. Their results were based on a survey they conducted, that proved the significance of LMSs in the learning environment, and was conducted during the current COVID-19 pandemic, when most academic institutions were 'forced' to adopt ODL without any adequate level of preparedness.

2.2 Technical Competence

This CSF has to do with the ease that students and the instructor can access and navigate the LMS. More importantly, the instructor should be able to use the LMS and other accompanying technologies to provide a smooth online experience [28]. Faculties can provide lab sessions where the instructors and students can be taught how to use the LMS. Instructors should also encourage students to improve their technical skills, by giving out projects (such as voice-over presentations) which require familiarity with new technologies [6].

2.3 Self-Regulated Learning

SRL has to do with students orienting their focus and behavior towards achieving a learning outcome [4]. There has not been much research into SLR in a computer science setting. Cheawjindakarn et al. [6] argued that SLR skills by themselves are not sufficient to have an impact on student performance, and that students also required self-motivation in order to properly channel them. We do note, that although their study addresses SLR, it was conducted in a face-to-face environment, and may not be exactly relevant.

2.4 Optimum Lecture Video Length

A huge part of asynchronous online learning includes the use of pre-recorded lecture videos. Students find watching lecture videos to be more helpful and 'practical' than reading course materials [17]. A study by Guo et al. [12] concluded that shorter and specific videos (0-3 minutes) were best received by students, videos with instructor heads felt more personal, and videos where instructors spoke with enthusiasm and with a relatively fast tone were more engaging. Research by Krasnov et al. [18] suggests that the length of the videos need not exceed 15 minutes, if they are to be effective. They measured the success of this CSF using factors such as the number of lecture video views and likes.

However, Volery et al. [28] noted that pre-recorded lecture videos are sometimes the least used feature of LMSs, especially when students attend the live conferences.

2.5 Student Retention

Most students lose interest in lectures and stop attending. Chase et al. [5] conducted a study on a first year programming course and found that student retention rates had increased from 68% to 75%, when students were offered a programming orientation course prior to the start of actual classes. This adds on to a study by Hulls et al. [14] which found that programming introductory courses spend a lot of time teaching syntax instead of actual programming techniques. This suggests that some form of coding background helps at least maintain current student retention rates. The use of gamification to improve retention rates has also been tested. Its use results in students who are motivated and spend more time than average interacting with the course, due to the 'gaming' experience offered by the LMS [17]. The structure of some assessments is altered to give a 'game' feel, and the effectiveness of this CSF is measured by the number of assessment submissions/attempts as well as the feedback from surveys [23]. Students are rewarded with badges and other forms of incentives when they complete assessments and score good marks. This keeps them focused and motivated. Piccioni et al. [23] saw a 500% increase in quiz attempts after they introduced gamification in their programming course.

2.6 Student-Instructor Interactions

Introductory programming courses require demonstration of coding techniques, and effectively student-instructor and student-student interactions [10]. This CSF can be measured by the number of question-answer pairs in forums, and surveys to gauge the student satisfactory levels of interaction within the course [22]. LMSs should allow for student-student interactions as students often find it easier to discuss problems with their peers, than with other people [24]. Live conferences should be used as a catalyst for student-teacher discussions that assist students with grasping the content of the course. Campbell et al. [4] say that computer science students in their study were very active in asynchronous media such as forums and chatrooms. Studies note that these tools are used to post/answer questions, which can also supplement the understanding of those who are not able to attend

the live conferences [10]. Krasnov et al. [18] noted that in order to be effective, answers to questions in the forums and chatrooms should be posted within 24 hours of being asked.

We now look at how forums and quizzes relate to the SIIs CSF.

2.6.1 Forums

The most common platforms used for asynchronous SIIs are forums, chatrooms, and email. Forums, when centralized, tend to get cluttered with lots of headings, questions and discontinuities, which makes them difficult to assess and navigate [3]. If students are not properly encouraged to use them, they tend to house complaints, and are no longer ideal for effective interactions [21]. However, they still remain the most common medium of communication and benefit students in that they can see how their classmates are thinking, and shy students who would rather not speak can use them freely [13, 16]. A study by Sharma et al. [25] done on Java and C++ courses found that the students who obtained distinctions spent more time browsing through the course forums, than the other students. This proves their importance in solidifying students' understanding of the course content.

2.6.1.1 Mandatory forum contributions

One of the ways used to improve SIIs as well as student-student interactions, is through mandatory forum contributions [1]. With such a method, students are required to have a minimum number of forum contributions, and are rewarded a small percentage of marks. Although it does lead to an increase in interactions, such a method contributes to the deterioration of the forum's quality, as students could end up asking basic questions – the answers to which they already know, just to make the minimum number of required contributions and get rewarded with marks [19].

2.6.1.2 E-mail

The use of e-mail, as a substitute for interpersonal interactions, is considered to have a positive impact on the students' learning outcomes [8]. This covers course announcements and assessment deadline reminders, among others. It becomes impractical, however, when emails are used for day-to-day exchanges between the instructor and the students. Large volumes of emails can burden the instructor which leads to the late provision of responses, and some of the important course-related questions being asked cannot be seen by other students.

2.6.2 Optional Quizzes

Traditionally, instructors would pose questions to the students in class, to gauge how well they understood a concept. However, it becomes difficult to get responses when learning takes place asynchronously. Optional quizzes have been used as an attempt to solve this problem, but they tend to suffer from low response rates [15].

An experiment by Z. Ding et al. [9] incorporated online quizzes in one of their undergraduate algebra courses as an attempt to improve SIIs. An online quiz, usually in multiple choice format, would be uploaded, and after its short deadline, a histogram of the class results would be displayed. They found that these quizzes enhanced interactions and student performance. However, It is worth noting that the quizzes, although optional, contributed to the course final grade. This was done to encourage student participation, which saw an increase of 1700%. B. Cook et al. [7] also adopted the same strategy, but opted not to provide feedback to the students, only their scores for each quiz question. This was so that the students would be encouraged to engage with the course material more, to determine where they could have possibly lost marks.

M. Piccioni et al. [23] in one of their studies conducted in an online "Introduction to Programming" course found that students actually liked the programming quizzes and exercises, even though they did not contribute to the final course grade. The study also revealed that a gamification component was incorporated into the quizzes, which could explain why they had such high participation rates.

This seems to point out that to some extent, students need some form of encouraging factor in order to participate in these quizzes.

2.6.3 General discussion

There is not much that is being done in terms of developing new ways of interacting. Instead, most literature seems to direct its efforts towards finding a balance between synchronous and asynchronous interaction methods, that optimizes learning outcomes [11]. The combination of the two is the ideal, as they tend to supplement one another. The common goal is thus to find ways to optimize pre-existing solutions. One way to go about this is to build reliable software.

A study by A. Sher [26] highlights the importance of a user-friendly LMS in improving interactions. It emphasizes that LMSs and other web-based programs must be designed to make it easier for students and instructors to interact efficiently. These systems should also ease the task of creating activities that encourage interactions with both the instructor and the course content.

3. REQUIREMENTS ANALYSIS & DESIGN

This section looks at the design elements of the proposed web system, and the reasoning behind them.

With all the CSFs we have identified, SIIs were chosen to be investigated in more detail. Thus, our web application attempts to address SIIs directly, by incorporating a more user-friendly forum component, and a mandatory quiz component.

3.1 Interface

Since the aim was to improve upon the current implementation of asynchronous interaction systems on Vula, the web system was developed to be a minimalistic full-stack application that houses only those components which we wish to test. Figure 3.1.1 shows a sketch of what the system is supposed to look like from a student's perspective.

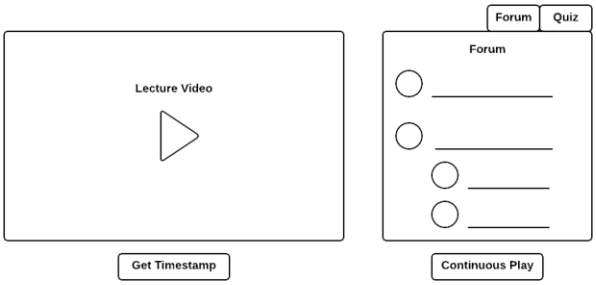

Figure 3.1.1 Landing page

This shows the landing page of the web system, providing students with immediate access to both the lecture forum, as well as the quiz tab, should that lecture have any quizzes. They will also have the 'timestamp' button at their disposal, to easily capture the lecture video's timestamp, and relate it to their forum post. This can then be used as a quick reference by the instructor, or anyone interested in the forum post.

3.2 Design

The proposed web system works with different kinds of data models, all accessible through a web server and a database. Thus, the Model-View-Controller (MVC) design pattern was adopted for the web system, because of the reduced complexity it offers through the decoupling of sets of classes. This provided each set of classes with a specific function and to some degree, independence. Independence in the sense that the pattern allowed for constant major changes to be made to the structure of the data along the way, all while the presentation remained the same. The same holds true for the presentation classes – they also went through changes, and this did not affect the Model nor the Controller. Coding complexity was reduced as each component, for the most part, could be designed without having to worry about how it would affect the others. Figure 3.2.1 shows a UML class diagram of the abstracted system (Only significant classes have been shown).

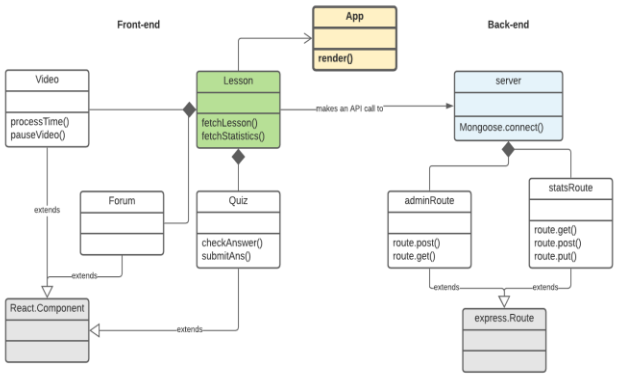

Figure 3.2.1 Class diagram for the core system

The color scheme is used to represent the MVC design pattern. The Model (blue) is the server class, which is the entry point to all the stored data. It uses two route classes to determine which data to fetch, store or modify.

The View (yellow) is the App class. This class renders the Video, Quiz and Forum components to the screen. The components in this class present the data that is queried by the Lesson (Controller) from the Server (Model).

The Controller (green) is the Lesson class. Immediately after the App class renders all the components, this class makes API calls to the server class, to fetch the lecture data, before feeding them to the rendered components in the App class. The App class then notices a change in these components, and then automatically updates only the parts of the screen where the changed components are being rendered.

The grey classes show some of the inheritance that is necessary in order to use the Javascript frameworks. They are not classes we manually developed.

3.3 Expected System Behavior

The web system has two parts – the local forum, and the mandatory quizzes. Figure 3.3.1 shows the activity diagram of the forum component. Although it is automatically visible, the forum can be brought to display by pressing the 'forum' button, which hides the quiz. The forum is an independent component and thus can be used while the lecture video is playing. The student simply types and then presses the 'post' button – there will not be a need to navigate to a different tab and search for a specific forum thread that is related to their question. The forum will then upload the student's post to the forum database, and update all instances so that other students can immediately see the question. For added convenience, the system also has a 'timestamp' button to be used optionally in conjunction with the forum. The button will extract the duration of the lecture video that the student has watched, and display a pop-up that says it has been copied to the clipboard. Students can then append the timestamp to the question in the forum to relate it to a specific time within the lecture video.

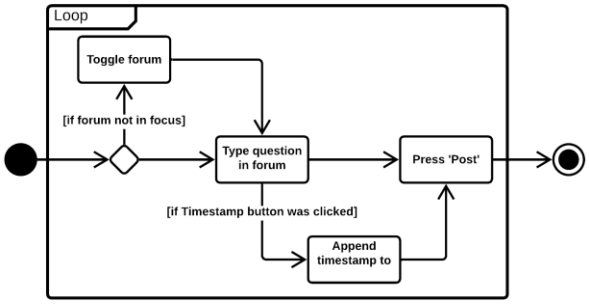

Figure 3.3.1 Activity diagram for the forum component

Figure 3.3.2 below shows the activity diagram for the mandatory quiz component. Just like the forum, the quiz can also be toggled by a press of a button, but it is automatically brought to display when it is time to take it. If a lecture contains a quiz, the quiz will not be functional until the lecture video gets to the specified quiz appearance time. This means that students would see the quiz, but would not be able to take it until it's the right time.

The lecture video constantly keeps track of its duration and comes to a halt when it reaches a time when a quiz must be taken.

Seeking past an unanswered quiz will bring the video back to the time when a quiz must be completed. A student simply chooses a single option from the four provided, and then clicks the submit button. The student's response will be uploaded to the database, and the quiz statistics will be updated.

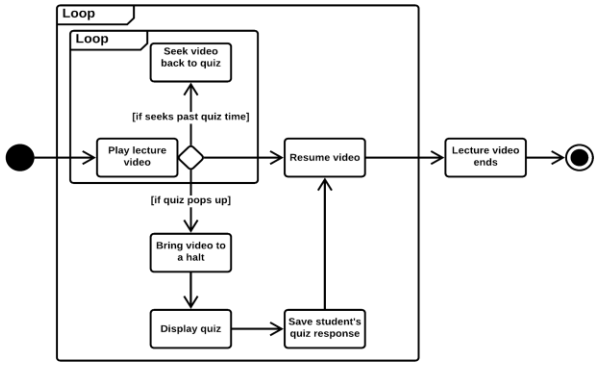

Figure 3.3.2 Activity diagram for the quiz component

4. EXPERIMENT DESIGN & EXECUTION

This section discusses the research questions the project aims to address, and the qualitative experimental methods used to collect and analyze the data.

4.1 Research Questions

As evident in most literature, improvements in SIIs tend to work with pre-existing solutions. With that in mind, this paper aims to address the following research questions:

4.1.1 What effect does the pairing of lecture videos with distinct forums, have on Student-Instructor Interactions? Does the close proximity and ease of access compel students to make posts?

4.1.2 What is the effect of incorporating mandatory quizzes on Student-Instructor Interactions? Would students like it, and would they feel as if it improves their interactions with the instructor?

4.2 Experiment Design

A qualitative design method was employed, using CS students as the primary participants. An offer to take part in the research was sent to the undergraduate CS students, and an insignificant number of students signed up. The offer was then extended to all UCT students, who had used Vula before. The research suffered from an extremely low number of participants, as only 25 students signed up.

The participants were split into two groups – one that was tasked with watching a lecture video with a mandatory quiz, and the other with an option to skip the quiz. Both groups watched the same lecture video, and were instructed to leave a post in the forum. The lecture video was changed from a CS-based one, to a 4-minute YouTube video about converting decimals to binary, to accommodate the wide variety of faculties from which the participants belonged. Tasks were completed using the developed web application.

The ideal way to measure the success of our two components, would be to incorporate them in Vula and have at least one introductory CS course use the components for a semester. We would then compare the course grades, with that of the previous year, to see if there is a positive change. But due to time constraints, we have had to come up with other ways to measure the success of these components, in the short term.

One way to do so, is to have the two groups test out the system by using it to perform tasks that they would normally do on Vula. After that, we would survey them to determine if they found our application's components better than those of Vula. If that is the case, we would then try to relate their feedback to a potential increase in SIIs by asking them if adding such components to Vula would make them more likely to make forum posts (in the case of the forum component) or answer the questions asked by the instructor (in the case of the mandatory quiz component).

4.2.1 Mandatory Quizzes

For the first group, the aim was to gather its general opinion towards the mandatory quiz, while for the second group it was to see if any of the students would opt to answer the quiz even though it was optional.

Participant feedback was collected via questionnaires. Questions posed for the first group were as follows:

- On a scale of 1 to 5, what were your feelings towards the mandatory quizzes? (1 - Not good, 5 - Great)
- Would you prefer if you had the option to skip the quizzes?
- Do you feel like the mandatory quizzes disrupt your focus and learning process?
- Do you feel like the mandatory quizzes help you interact more with the instructor?

Questions posed for the second group were as follows:

- Did you choose to skip the quizzes while watching the lecture video?
- Do you feel like the quizzes disrupt your focus and learning process?
- If you did not skip the quizzes, do you feel like they help you interact more with the instructor?

4.2.2 Lecture-Video Paired Forums

For this component, the aim was to get both groups to test out the application's forum system, and compare it to that of Vula. All participants were asked to leave a forum post about anything related to the lecture video they had just watched. Questions posed in the forum questionnaire were as follows:

- On a scale of 1 to 5, how often do you make posts on the Vula forums? (1 - Never, 5 - Always)
- Compared to Vula, did you find our forum easier to access and navigate?
- If answered Yes to the previous question, do you feel like having a forum that is easily accessible such as the one here, makes you more likely to make posts on the forum?

Both groups were also asked about the Timestamp functionality, but its relevance is overshadowed by the forum component, and will not be discussed in as much detail.

4.3 Method Discussion

As with most experiments carried out in similar literature, there needs to be a control variable that we can use to compare our results against. But due to the nature of our research, the control variables fitting were software components. Results from the forum component will be compared against students' opinions towards the Vula forums (control). As for the mandatory quizzes, since not all UCT courses have optional quizzes, results obtained from the second group (have option to watch without taking any quizzes) will be used as the control.

4.4 Ethics

The experiment did not require any physical presence from the participants. All instructions and data collection were carried out online. Participants were informed that their personal data will not be stored nor used in any form or manner. Therefore, all questionnaires remained anonymous, and participants were allowed to discontinue at any time during the experiment. Ethical clearance was granted by the Ethics Committee, to proceed with the research in a virtual setting.

5. SYSTEM DEVELOPMENT & EXECUTION

This section discusses the development process of the web system and justifies the development choices made. The developed system can be found through the link: https://onlinesuccess.herokuapp.com and the code repository at https://github.com/moses-netshitangani/video-forum.

5.1 Technology Stack

As evident in figure 5.1.1 below, MERN was chosen as the system's development stack because of its uniform language – Javascript, and its full-stack capabilities. Both the front-end and back-end were essentially written in Javascript, which made integration simple.

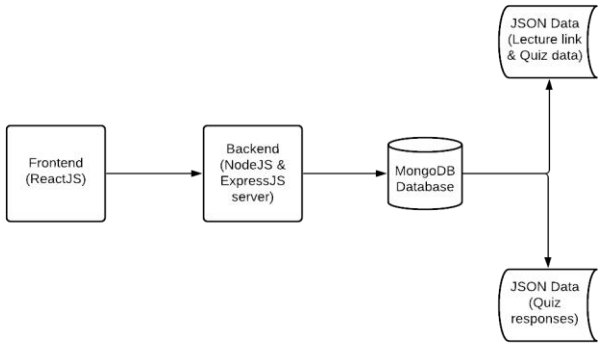

Figure 5.1.1 Mongoose, Express, React, Node (MERN) stack

React was elected as our front-end development language because of its ability in rendering dynamic single page web applications. Since each lecture video will stand side-by-side with the corresponding forum, and quiz, ReactJS makes updating parts of the page seamless and localizes these components all while still maintaining a simplistic design.

A Node and Express server was used in the back-end because of the convenient integration with the Javascript front-end. These components exchange data in the form Javascript Object Notation (JSON) objects, which eliminates the issue of having to parse objects between different data forms.

The server connects to a MongoDB database through a framework called Mongoose. MongoDB was chosen because it stores files in BSON format, which is just a binary representation of JSON. What also makes it appealing is that it is a NoSQL database, which means that the documents being stored do not have to conform to the normalization rules of SQL. It allows us to store data, the way we want to store it, without placing any strict restrictions on the structure.

5.2 Development Tools

All code was written using VS Code – the IDE of choice. Through its endless plugins, VS Code makes it easy to do different operations all in one place – such as locally hosting a server that automatically restarts when a change in code has been detected. GitHub was used for version control. Insomnia was used to test and develop the API that connects to the backend of the system. MongoDB provided the shared database where all data is currently being stored. Heroku was the cloud service used to deploy and host the web application. The rest of the software used were NodeJS packages, the names of which can be found in the package.json file in the GitHub repo.

The code is well commented and instructions to clone the repo and run it locally can be found in the README.md file, on GitHub.

5.3 Testing

The software functionality was tested on several operating systems, with no signs of major bugs. The main issue was the CSS styling that seemed to render components differently on Windows and Linux systems. The CSS code has since been optimized to cater for these operating systems as well.

6. RESULTS, FINDINGS & CONCLUSIONS

This section discusses the results from the data collected, and draws conclusions.

The results are discussed per software component, and in some cases, per group. Group 1 represents the students that had a mandatory quiz, while Group 2 represents those that had the option to skip the quiz.

6.1 Forum Component

As evident in figures 6.1.1 and 6.1.2 below, a pooled total of 92% of the students indicated that that they rarely made posts on the Vula forums. The scale ranged from 1 (Never) to 5 (Always), and 23 students chose a value below 3. Both graphs show a low frequency of Vula forum posts. This question was asked to gain a little bit of insight about the general engagement levels of the participants.

Group 1's bar graph shows a single outlier, whose posting frequency is above the median. This result was expected as a small number of the participants who chose to partake were first-years. Had it been purely first year students, then we would have seen a higher average of forum posts, due to them being new to the course and still finding their way around everything.

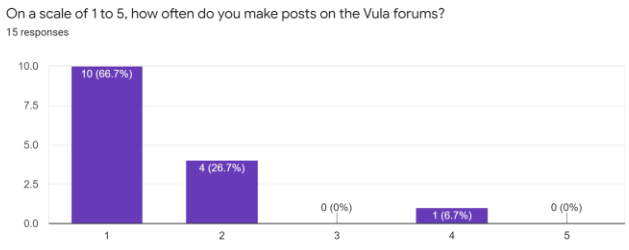

Figure 6.1.1: Vula forum posts for Group 1 (mandatory)

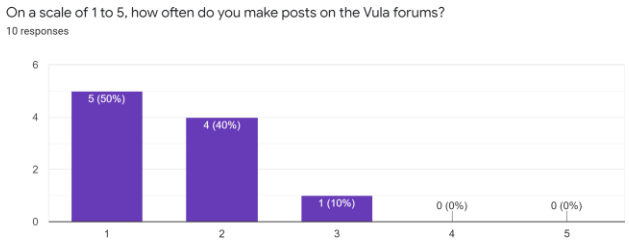

Figure 6.1.2: Vula forum posts for Group 2 (optional)

One of the project's aims was to increase SIIs through the introduction of a forum system that was less cluttered, decentralized, and quick to access and navigate. We expected all the students to take a liking to this feature. However, as figures 6.1.3 and 6.1.4 point out, only a pooled total of 95.85% of participants seemed to agree with this.

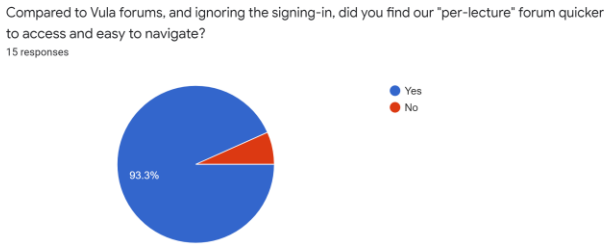

Figure 6.1.3: Group 1's feedback about the system's forum.

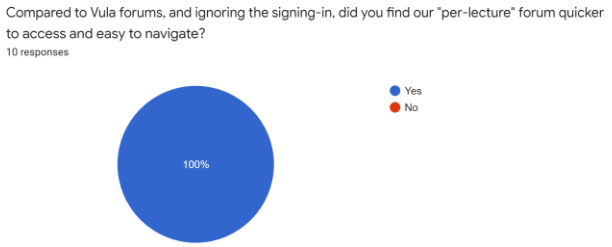

Figure 6.1.4: Group 2's feedback about the system's forum.

We notice an outlier in Group 1 once more. The student seemed to not like how the system provided access to the forum, which was an unexpected result. Since the system's forum was delivered through a Disqus API, any posts made required students to have Disqus accounts. Although all students were provided with a pre-registered account as well the login details, we feel that the signing in process may have discouraged this particular student, leading to the negative feedback that is evident in the pie chart. Nonetheless, All students but one reacted positively to the system's forum.

After gathering their opinions about the application's forum system, our goal was to relate them to the number of potential forum posts they would make if this forum system was adopted in Vula. The participants were asked if the forum system compelled them to make more posts than they currently do on Vula. Figures 6.1.5 and 6.1.6 show that a pooled total of 92% of the students indicated that the system indeed compelled them to make more posts, which is way higher than what we expected. Although it is the result that we had hoped for, it is worth noting that some students could have indicated so because the design and presentation of the forum itself appealed to them. In other words, they may have compared the two forums based off of design, and not because of access speed or navigation.

This time around, both groups had a similar pie chart – with each just having one student going against the general opinion. Based off of the high percentage of students who indicated that they

rarely made forum posts on Vula in Figures 6.1.1 and 6.1.2, we had expected more students to say that the system's forum does not compel them to make new posts. That was not the case, as students seemed to like the application's forum.

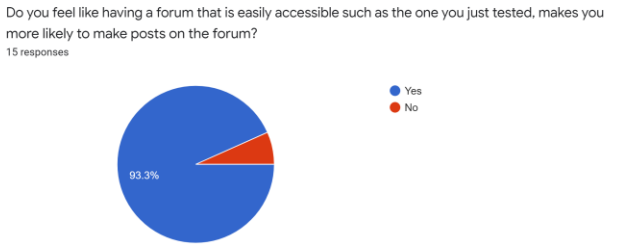

Figure 6.1.5: Group 1's opinions about making more forum posts.

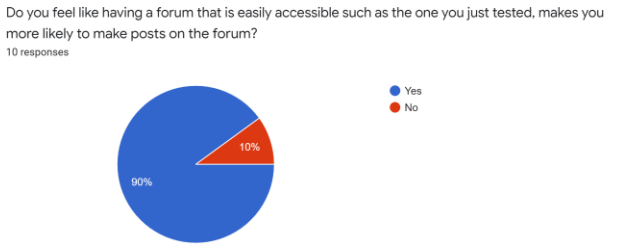

Figure 6.1.6: Group 2's opinions about making more forum posts.

The participants were encouraged to use the "Get Timestamp" button when making posts to the forum. The idea behind this was to introduce a way that makes it easier for the instructor and other students to quickly relate a forum post to a time within the lecture video. Results in figures 6.1.7 and 6.1.8 show a pooled total of 91.7% of the students that seemed to like this feature, and felt that it would make interactions between them and the instructor a bit more clearer. Similar to the previous two pie charts, both groups had a single student whose opinion seemed to stray away from the general opinion. Such a pattern makes it more likely that these are the same two students who have been outliers in our previous charts. The reason why they disliked the timestamp feature could also be related to their desktop's operating system. This feature did not work well on Linux systems, as there was an issue with pasting the timestamp to the forum. The timestamp would be pasted but only show once the post had been published.

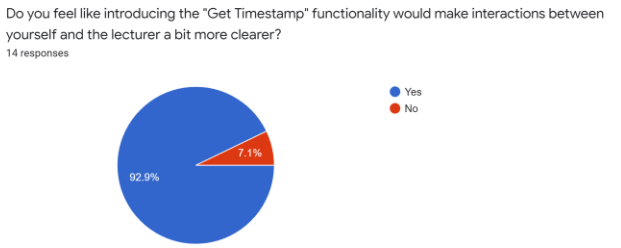

Figure 6.1.7: Group 1's opinions about the Get Timestamp button

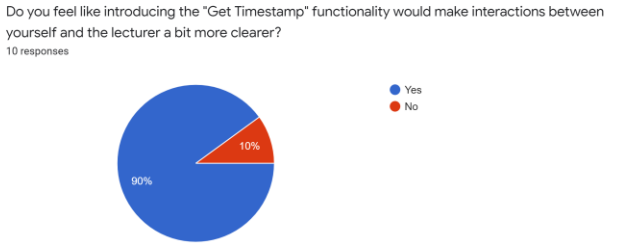

Figure 6.1.8: Group 2's opinions about the Get Timestamp button

6.2 Quiz Component

The mandatory quiz component was introduced as a way to not only increase asynchronous interactions with the instructor, but with the course content as well.

6.2.1 Group 1 (Mandatory quiz)

Figure 6.2.1.1 below shows the results for Group 1 where the scale ranged from 1 (Not good) to 5 (Great, they increase my interaction with the instructor). 80% of the students in this group gave positive feedback, and seemed to like the mandatory quiz. The topic of the quiz in the lecture video, although new to a lot of the students, was actually easy to grasp, which could explain the high percentage of students who indicated that they liked quiz. The quiz statistics also show that 83% of the students got the correct answer to the quiz.

Figure 6.2.1.1: Group 1's opinions about the mandatory quiz

In an attempt to probe more, the students were asked if they felt like the mandatory quiz disrupted their focus and learning process. Since 80% had indicated that they liked the mandatory quiz, we expected only 20% to say that they felt like the quiz was disrupting their focus. Figure 6.2.1.2 shows that 26.7% of them felt this way. This suggests that from the 80% that claimed to like the mandatory quiz, a small percentage also felt like it disrupted their learning process.

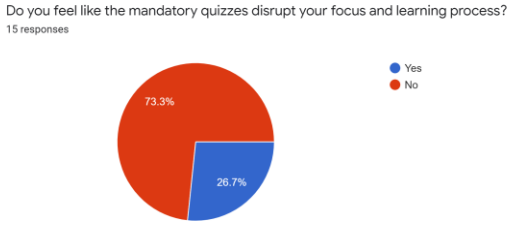

Figure 6.2.1.2 Group 1's feedback about the quiz and focus.

They were then asked if they would have preferred to have a "Skip" button that allowed them to watch the lecture video without having to take the quiz, as Figure 6.2.1.3 indicates. We expected a large number to say that they would prefer a skip button, but only 26.7% of the students were in favor of the skip button. The reason why a greater percentage were against the skip button could be because they liked how the quiz system worked. Instead of providing them with immediate feedback, it made them watch the rest of the lecture video to see how the instructor would arrive to the correct answer.

Figure 6.2.1.3 Group 1's opinion about skipping the quiz

6.2.2 Group 2 (Optional quiz)

With the second group, the same lecture video and quiz were presented, but with an option to skip the quiz. They were given instructions to watch the lecture video, and informed about the quiz and that they had the option to skip the quiz. After watching the lecture video, students were asked if they skipped the quiz. Figure 6.2.2.1 below shows the results. To our surprise, all the students chose not to skip the quiz, even though it was made clear that they could if they wanted to. Part of the reason why they chose not to skip it could be because of curiosity. They were told that unless they used the "Continuous Play" button, there would be no way for them to watch the lecture video past the quiz point. The quiz was also simple, which could also explain why none of the students chose to skip it.

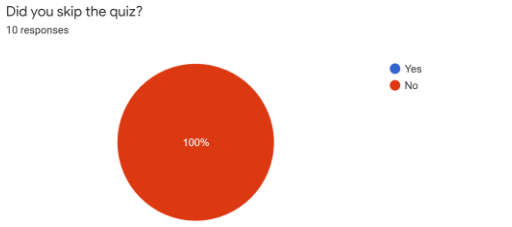

Figure 6.2.2.1 Group 2's feedback about skipping the quiz

Our final goal was to collect the opinions about the quiz, in relation to SIIs. The students were asked the same question as the students in Group 1, with a scale that ranged from 1 (Not good) to 5 (Great, they improve my interactions with the instructor). Figure 6.2.2.2 shows the results. The bar chart indicates that 100% of them gave positive feedback and felt as if the quizzes were great and increased their interaction with the instructor. The results were better than what we had expected, and had the quiz been more difficult, we feel that a significant percentage of them would have given scores below 3.

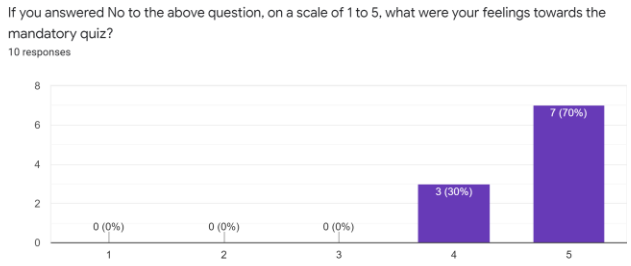

Figure 6.2.2.2 Group 2's feedback after taking the optional quiz

Lastly, we asked those students who took the optional quiz, if they felt like the quiz they took got in their way of learning and focusing. Since a 100% of them took the optional quiz, we expected a 100% to indicate that the quiz did not in any way disrupt their learning process. Figure 6.2.2.3 shows the results of this query.

Figure 6.2.2.3 Group 2's quiz query results.

6.3 Bias

6.3.1 Sample size

The largest potential bias associated with the results is the sample size. There were not enough students willing to partake in the research, which means that the results, to some degree, cannot be projected to all UCT students. However, having had students from various faculties ensured that the sample was in some sense representative of UCT students.

6.3.2 Length of lecture video

In the group that had the option to skip the quiz, we saw that a 100% of the students opted to take the quiz. We feel this result is not exactly representative of what might happen if Vula adopted the same quiz functionality. The lecture video used in the research was very short, so as to keep the students with short attention spans, engaged. With that said, It is possible that students opted to take the quiz because of how short the video was. Curiosity could also have been a factor, as the students were using a system they had never used before, and were curious about how the quiz system would work.

6.4 Conclusions

The project's aim was to improve asynchronous SIIs by coupling each lecture video with its own forum, and introducing mandatory quizzes. From the observed results, the students who took part in the research, found the new forum easier to access and navigate. The reason behind coupling each lecture video with its own forum was to see if such forum attributes would encourage students to make more posts. The feedback from the results indicated that the forum system was well received, and a significant number of student participants felt like it would make them more likely to make posts. Since this component was not tested on an actual semester course, we can only conclude that for a small percentage of UCT students, pairing lecture videos with their own forums, for quick access and navigation, makes students more likely to make forum posts. Our results are also in parallel to what A. Sher [26] said in his study of interactions in online learning about user-friendly software. The study emphasizes that LMSs and other web-based programs must be designed to make it easier for students and instructors to interact efficiently and that such systems ease the task of creating activities that encourage interactions with both the instructor and the course content. This suggests that user-friendly LMSs are a good environment for nurturing SIIs.

The ideal way of measuring the success of this component, would be to have it run in a semester course and compare the average number of forum posts, to those of the same course but from the previous year, to see if there was a positive change. Unfortunately, our research was constrained in terms of time, and the effectiveness of the new forum was validated using the feedback provided by the students who had tested the system.

The mandatory quiz component was also well received. Its purpose was to increase asynchronous SIIs by providing instructors with a way of posing questions to the students, and getting responses. The literature around quizzes hints at having some element that encourages students to take part, with that element usually being course marks. Our approach, however, was to force the students to take the quizzes by prohibiting them from watching the rest of the lecture video before completing a given quiz. Results from the experiment saw that the students that were given the option to skip the quiz, all completed the quiz and gave more positive feedback, than those for which the quiz was mandatory. A small percentage of the latter cited that the mandatory quiz disrupted their focus and learning process. From this, we can conclude that the introduction of in-lecture quizzes does contribute to an increase in asynchronous SIIs, but students should also be given the option to skip the quizzes if they want to.

The importance of these results is that asynchronous SIIs at UCT, could be improved by incorporating the two components. Higher SIIs are related to positive learning outcomes, and this could prove to provide a good boost in student performance. What was good with our participants is that they belonged to different faculties, which means that this work could also be relevant in courses other than just CS1.

6.5 Process Reflection & Execution of Project

The functionality of the "Get Timestamp" button did not work as initially planned. It was supposed to automatically append the timestamp at the beginning of a student's forum post, but because a comments API was used in place of a forum, not much could be done to achieve this. Instead, students ended up having to manually paste the timestamp, and in some operating systems, the timestamp would not be visible until the forum post was published. One of the student participants even suggested that the button should automatically append the timestamp. Apart from that, all other components worked well, and that played a major role in the success of the project.

Having more student participants would be an advantage for those trying to replicate this work. The results would be more credible compared to those that we observed. Developing a forum would also ensure that the functionality of the "Timestamp" button would be more convenient for the students, instead of using an API.

If the research had to be done again, we would put more effort into getting student participants, as well as instructors. Most of the effort was directed towards developing the software, and not actually finding a decent number of participants to gather the feedback from.

6.6 Future work

Seeing that the two components were positively received by the student participants, future work would entail improving the way these components work. The timestamp functionality could be extended to be more convenient for the instructors as well. What we mean by this is that the instructors would be able to click on the timestamp of a student's forum post, and this would automatically seek the lecture video to that point in time. This is illustrated by Figure 6.6.1 below.

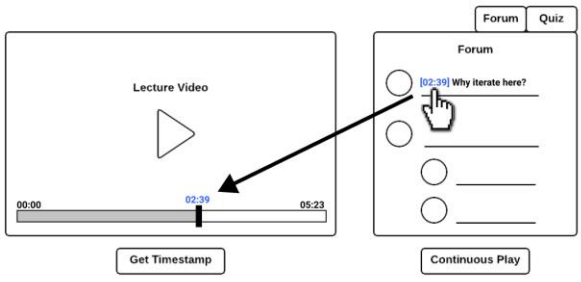

Figure 6.6.1: Improved timestamp functionality.

Although, the issue with introducing more functionality is that it adds on to the complexity of the system, which would make the system not so user-friendly anymore.

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