Student-Summarized Videos in an Adaptive and Collaborative E-learning Environment (ACES)

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Declaration

I hereby declare that this thesis has not been and will not be, submitted in whole or in part to another University for the award of any other degree.

Signature:

University of Sussex

Thesis submitted by Nouf Alzahrani for the Degree of Doctor of Philosophy

Abstract

The purpose of this research was to develop a collaborative e-Learning framework using summarised videos as learning media to provide a more efficient learning experience where participants' engagement and motivations are enhanced. The research aims to increase participants' overall learning level, understanding level; motivation and communication skills.

For this research, a collaborative environment has been built where students participate in a video sharing system allowing them to create their own summarized videos from existing course video material. Students can then share these videos with other system participants with the ability to view, rate and comment on videos. Instructors upload the core video footage, which the students are able to edit and summarize.

Two experiments were run with live modules within the Department of Informatics; a pilot study and full experiment. Feedback from the pilot study was used to develop the framework for the full study. The experiments involved pre and post participation surveys to measure satisfaction and awareness effects. Also, system participation data was used for analysis of engagement and other factors defining the outcomes of this experiment.

The findings showed a considerable increase in student satisfaction regarding their understanding and motivation with video summarization tool used in the experiments. The results of collaboration aspect of the experiment showed a slight increase in their satisfaction on their learning level, however, it had minimal effect on students' motivation and engagement as no significant difference was noted after using the system.

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"and say: 'My Lord', Increase me in knowledge"

[The Quran 20:114]

I thank Allah the Almighty for the completion of my PhD

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Publications

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List of Codes:

List of acronyms

ACES	Adaptive Collaborative E-learning Summarization
CBM	Computing for Business and Management
CDM	Computing with Digital Media
CLT	Cognitive Load Theory
CS	Computer Science
DIVER	Digital Interactive Video Exploration and Reflection
EVA	Educational Video with Collaborative Annotations
FF	Fast Forward
GME	Games and Multimedia Environment
KVSUM	Keywords-based Video Summarization
LAB	Learning By Asking
LDAP	Lightweight Directory Access Protocol
LVP	Learning Video Portfolio
MAI	Metacognition Awareness Inventory
MKO	More Knowledgeable Other
MVC	Model View Controller
OLV	Online Lecture Video
PCK	Pedagogical Content Knowledge
PLEBOX	Personal Learning Environment Box
TAM	Technology Acceptance Module
Tcl	Traditional Classroom Learning
TPCK	Technological Pedagogical Content Knowledge
TUT	Tampere University of Technology
Tvl	Traditional Internet Video Learning
UCD	University College Dublin
UOC	Open University of Catalonia
VAK	Visual, Auditory and Kinaesthetic Learning Style
Vel	Video FRAM e-learning
Video FARM	Video Framework with Associated Information
ZPD	Zone of Proximal Development

Chapter 1: Introduction

1.1 Introduction

The rapid evolution of technology in the 21st century has had an impact in almost every field, and society in general has changed its behaviours with regard to sharing information and knowledge within the context of this technological evolution.

Technology has played a significant role in the major scientific discoveries of recent times too. The genetic, astronomical and medical advances in recent years would not have been possible without tools such as simulators and computer-aided systems. All this new information is passed on via education, and learners of this age can experience the benefits of these powerful new tools that help their understanding of a subject. Technological improvements in the education and learning process can act as a catalyst in improving the effectiveness and benefits of education.

The term 'electronic learning', or the more widely used term 'e-learning', refers to learning with the use of computer technology. According to Hall et al. (2007), e-learning is 'the use of technology to support, enhance or deliver learning'. All educational activities carried out by individuals or groups working online or offline, via a network, or standalone computers and other electronic devices can be broadly defined as e-learning. Alternatively, e-learning can also be generally defined as audible, visual and interactive synchronous or asynchronous educational activities (Akkoyunlu and Soylu, 2008).

E-learning currently plays an important role in the education sector worldwide, particularly in higher education, as universities and colleges have started offering online courses. Further, the use of e-learning in companies and organizations has also been found to be beneficial. Companies use e-learning to deliver training to a group of people simultaneously; this can be done within a short time frame and at a low cost with the use of cutting-edge technologies that are asynchronously accessible at any time (DelVecchio and Loughney, 2011).

The e-learning format allows for more flexibility and content depth, as e-learning classes are not constrained by instructors, timetables, or classroom capacity. Since students can access the required material and information whenever they wish to, they are able to better organize their schedule. Further, they also have the opportunity to review the material as many times as they wish, if they need to improve their understanding of a topic. Another advantage is that students do not need to be physically present in the classroom and may access the materials from any place and at any time (Arkorful, 2014). This eliminates the cost of travelling and accessing a facility, which is beneficial to both teachers and students. Yet another advantage of e-learning is that it utilizes different types of learning styles and materials, so students can learn at their own pace and take advantage of learning materials that meet their own level of knowledge and interest (Arkorful, 2014). Thus, e-learning as a pedagogical tool provides an improved educational framework that helps learners to effectively learn and enhance their knowledge (Salter et al., 2014).

In this research, a framework incorporating two important tools to enhance the effectiveness of e-learning will be discussed: video-summarizing tools and a collaborative environment. These two tools in combination have the potential to increase learners' motivation and their level of coherent understanding that is explained in (Alzahrani, 2015).

1.1.1 Social media and learning

There is no doubt that current education and learning go beyond textbooks and the physical space of classrooms. Social media, which can be defined as 'a set of internet-based technologies designed to be used by people' (Bingham, 2011), has made a considerable contribution to enhancing the learning process. In this computer era, social media can be solely utilized using web 2.0, where rich media content can be shared among Internet users. Social media in its current form is used to meet both formal and informal learning needs. For example, many universities and educational institutes use blogs, video postings, and messaging in social networks to update students and teachers (Davis et al., 2012). However, social media has potential for use as the core media for teaching and learning. The high usage of social media for knowledge exchange on Internet sites reflects the trend in education toward the increasing use of social media technology and provision of audio-visual content and material over web 2.0. (Redecker et. al., 2010).

There are many advantages of utilizing social media in education, the most obvious of which is the ability to improve teamwork and collaboration. Students can share information, discuss assignments, work in teams online and be linked to a vast number of experts in a short time. Teachers can also introduce new content and share it instantly over social media. This can be received and used by students immediately. Social media education provides opportunities for developing and practicing new skills as it encourages participants to work together and learn from each other in parallel with traditional lectures.

However, there are challenges to education in social media as well. The large amount of content can confuse learners and make it difficult for them to find the relevant information (Louvigne et al., 2012). Moreover, the content on online media needs to be controlled and monitored carefully and directed toward achieving the learning objective. Some of the other issues are lack of support, careless maintenance, lack of knowledge, and lack of order, which can discourage participants in finding motivation and hinder their improvement in learning.

1.1.2 Motivation, engagement and understanding

Students need to be motivated to be able to understand the content in depth, and understanding the content in depth can help students engage with the problem-solving process. The three terms *motivation*, *engagement* and *understanding* will be used extensively in this research. Therefore, it is important for the reader to clearly understand what each of these terms mean in this context.

- *Motivation:* Student motivation is defined as the student's desire to participate in and learn in the learning process. The motivation level indicates the level of desire that the student shows in the learning process:

a low level of motivation indicates a less desirable attitude toward the academic material, and a high level of motivation indicates a more desirable attitude toward the academic material (Mendezabal, 2013).

- *Engagement:* This term refers to the level of involvement in the academic activity. This is a measure of the frequency of participation shown by the student. A higher level of engagement implies a higher frequency of involvement in the academic activity (Trowler, 2010), also, a higher level of engagement indicates a higher level of commitment to the subject and learning.
- *Understanding:* It is defined as a deep understanding of the related subject and the logical connections that the student perceives in the written, oral or visual piece of information, along with the quality of forming a unified view of the subject. In this thesis, the term 'coherence' is used interchangeably with 'understanding' and 'level of knowledge'.

1.1.3 The use of videos in e-learning

The hypothesis that learning using videos can enhance coherence and understanding in the learner has played a major role in the development of video-based learning material (Greenberg & Zantetis, 2012). According to Greenberg and Zantetis (2012), based on more than 100 studies on the utilization of videos in education, its educational impact can be summarized by three key concepts:

1- *Interactivity with content:* the learner can interact with the visual content.
2- *Engagement*: the learner connects to the visual content and gets drawn in by the video.
3- *Knowledge transfer and memory*: Video learning improves memory.

Interactivity and *engagement* are important factors that motivate students to learn effectively. However, it should be noted that for *interactivity* and *engagement* to take place, the quality of the video experience should be high. Greenberg's et. al experiments and the studies demonstrate the importance of interactivity and engagement in video learning. With regard to the question of how these factors promote learning, it is answered by the constructivist theory explained in section 2.1.4.

The Forrester Consulting (2011) study shows that in addition to learning from video content, students can also benefit from video literacy and utilize it as a skill. Video viewing helps in the development of creativity, sociability, self-esteem, and cultural understanding. It also familiarizes students with the act of being in the spotlight, conveying messages appropriately, and presenting in front of and addressing audiences. Another advantage of videos is that they present information in an attractive and consistent manner that is likable and can be processed more easily and quickly by learners (Zhang et al., 2006).

1.1.4 Collaboration in e-learning

Discussion-based learning in a collaborative environment has significant benefits for students, as it improves communication skills, knowledge sharing and transfer of ideas among group members. Collaborative learning works as a training tool in which several people gain skills by studying together. In this setting, skills can be acquired more quickly than with the self-studying technique (Kokcharov et al., 2013).

The advantages of collaborative learning include its efficiency, higher retention and participation rate, and increased learner motivation. These benefits have been established by socially oriented learning theories including the constructivist theory, which will be discussed later in Chapter 2 (Caballe, Xhafa & Abraham, 2008). Considering these benefits, more modern educational institutes have started increasing the use of collaborative learning in their online courses (Chiong & Jovanovic, 2012). However, collaborative learning should be monitored in the context of e-learning to ensure that it does not stray from the e-learning context. Therefore, it is essential for e-learning systems to drive collaboration tools toward theirs pedagogical purpose.

1.2 Organization of the Thesis

In this section, a detailed outline of this thesis is provided. Table 1.1 shows how the thesis is organized.

Chapter	Title	Description
Chapter 1	Introduction	Introduction to the thesis and the framework for the theories
Chapter 2	Literature Review	In-depth analysis of the related literature reviewed
Chapter 3	Methodology	Research methodology for both the pilot study and full study
Chapter 4	System Development	System framework for both the pilot study and full study
Chapter 5	Pilot Study	Pilot study details and analysis of the results
Chapter 6	Full Study	Full study details, analysis of the results
Chapter 7	Discussion	General discussion of the study findings
Chapter 8	Conclusion and Future work	Conclusion from the research and Future work
References	References	References
Appendixes	Appendixes	All appendixes attached to the thesis

Table 1.1: Organization of the Thesis

As can be seen in the above table, in addition to this chapter, there are five more chapters that contribute to this thesis. A more detailed explanation of each chapter follows:

1.2.1 Chapter 2

This chapter contains a literature review of the past work that supports the presented hypothesis and provides a theoretical basis for the research in this thesis. The literature review is divided into four main sections: the theoretical framework, the use of video in e-learning, video summarization and collaborative e-learning. Each section reviews and discusses key previous studies that are relevant to the work in this thesis.

1.2.2 Chapter 3

Chapter 3 discusses the proposed research methodology and solution for both the pilot study and full study. Moreover, this chapter discusses the method used for collecting data and analysing it.

1.2.3 Chapter 4

Chapter 4 discusses the system structure: the design and development of the system are described in more detail, with a focus on the key development issues.

1.2.4 Chapter 5

Chapter 5 explains the actual methodology that was implemented in the pilot study, which took place in March 2015 at the University of Sussex. This includes details about the system, participants, questionnaires, data collection and other study features. The data are analysed and discussed.

1.2.5 Chapter 6

This chapter is divided into two sections. In the first section, the findings of the pilot study are analysed to identify the modifications needed to conduct a full study. The resulting modifications made to the methodology and to the system are explained in detail. The second section provides the full study details, including the system, the participants, questionnaires, data collection and other study features. The data are then analysed.

1.2.6 Chapter 7

This chapter provides a discussion of the general findings of the studies.

1.2.7 Chapter 8

In chapter 6, a general conclusion of the thesis is provided, which reflects the relationship between the findings and the research questions and hypothesis. In addition, areas for future work in this domain will be discussed.

1.3 Motivation

1. The widespread use of short videos in social environments and the easy process for sharing them on multiple platforms such as Facebook, Instagram and Snapchat have proven to be very successful and have grabbed the attention of users. People enjoy watching short videos more than they enjoy long videos because of their busy lives in this technological era. Educational videos are relatively longer than social media videos, as they contain more comprehensible information. However, they might contain unnecessary information that can cause learners to lose their attention. Therefore, short clips might be preferable and more understandable in particular topics.

2. The use of videos in education is a hot topic at the moment, but there is not a lot of research about what they can do in terms of teaching. The usefulness of simply recording lectures is limited; if learners could edit the recorded videos and share it with others, it would make the process more engaging and interactive.

1.4 Problem Statement

Although video learning improves learning experiences and is a good medium for presenting information, it is still limited in terms of its impact on learning. Simple video learning lacks in-depth interaction, which is provided when a student has the ability to not only stop, play, and rewind videos, but also edit, comment and share.

The main focus of this research is to improve learning by applying the constructivist theory, by investigating the benefits of e-learning, collaborative learning and video learning. The aim is to create an e-learning environment based on the constructivist approach by using videos as a learning medium and supplementing them with editing and summarizing tools, as well as creating a collaborative environment to increase knowledge sharing and motivation.

1.5 Research Aim

The aim of this research is to provide a tool to enhance motivation and coherence in learners and to provide evidence for its effects.

1.6 Research Hypothesis and Questions

The hypothesis of this research is that an e-learning system based on student-summarized videos in an adaptive collaborative e-learning environment enhances motivation, understanding, and engagement. Thus, the aim of the experiment is to determine whether an e-learning system based on student-summarized videos and collaborative learning affects student motivation, understanding and engagement.

The proposed system is based on theories about how motivation and understanding in learners can be improved. The following research questions will be addressed:

- Will an e-learning system based on student-summarized videos in an adaptive and collaborative e-learning environment improve motivation, understanding and knowledge?

This question is divided into two main components:

1- Will summarizing videos using the tool improve motivation, understanding and knowledge?

2- Will the collaborative e-learning environment improve motivation, understanding and engagement?

1.7 Contributions

This investigation studied the potential of a video summarization tool in a collaborative e-learning environment for increasing the level of understanding and improving motivation and coherence in academic students. The proposed system in Chapter 3 consists of two separate correlated tools: the video summarization and virtual collaboration tool. In brief, the contributions of this thesis include:

A. Establishment of an e-learning system—ACES—that effectively combines video summarization and collaboration (Alzahrani, 2015).

B. Creation of a video summarization and collaboration tool that has detectable effects in improving student motivation, understanding, and engagement by reducing the transfer of unnecessary information from the core components (which is in line with the cognitive load theory [CLT] and cognitive theory of multimedia learning [CTML]), by increasing knowledge sharing through sharing of summary material, and by providing students with a deeper understanding of the subject through the creation of their own learning material and summary (in line with the Shulman formulation and the technological pedagogical content knowledge [TPCK] formulation.

Minor contributions:

C. The student-summarizing tool created engages students in a more active learning process that requires them to partake in actions rather than simply watch or listen to content. This is backed by the visual, auditory and kinaesthetic (VAK) learning style, according to which engaging in action has a closer association with constructivist learning and increases learning motivation and engagement.

D. The easy-to-use web-based interface of the system provides students with a better learning experience in the learning environment, which may increase their motivation, understanding and engagement. Students can benefit from the interactive learning environment provided by the proposed system, as it transforms the typical learning method into a more active and interactive one.

1.8 Summary

The main concept of this research is to improve the learning of knowledge by applying the constructivist theory to create a system that incorporates the benefits of e-learning, collaborative learning and the use of videos in learning.

The hypothesis this research is based on is that combining video learning with a collaboration system will enhance motivation, understanding and engagement in a way that is better than the practices of traditional learning.

Chapter 2: Literature Review

In this chapter, studies that support the work in this thesis are reviewed and discussed. There are four main sections in this literature review: the theoretical framework, the use of videos in e-learning, video summarization, and the effects of collaborative e-learning on learning experience. In each section, the key relevant studies are explored and analysed in light of this research. At the end of the chapter, interrelated research questions are developed based on these studies.

The theoretical framework section highlights the following theories related to learning motivation, engagement and understanding:

- The visual, auditory and kinaesthetic (VAK) learning style theory
- The cognitive theory of multimedia learning (Mayer theory) (CTML)
- The cognitive load theory (CLT)
- The constructivist theory
- The technological pedagogical content knowledge (TPCK) formulation

The following section describes the different adaptive learning materials in the e-learning context and explains the concept underlying this thesis.

The next section (the use of videos in e-learning) explores how videos are utilized and incorporated in e-learning systems and how they have added value to the learning process. It covers the following topics:

- Use of videos in e-learning systems
- Interactive videos in e-learning
- Short videos in e-learning
- Summary of this section

This is followed by a section on video summarization trends and how they have been utilized in modern e-learning systems in different studies, and this section is divided into:

- Automatic summarization techniques
- Non-automatic summarization techniques
- Summary

Finally, the chapter discusses studies on collaborative e-learning environments and peer learning, which are covered under the following topics:

- Sharing material in collaborative e-learning
- Personal learning environment
- Vialogues in e-learning
- Educational videos with collaborative annotations
- Interaction-based grouping of students into study groups
- Summary.

2.1 Theoretical Framework

Scholars such as (Jung, 1971; Kolb, 1981 and Tennant, 1997), have tried to explain learning styles by using psychological and personality approaches, while other scholars such as (Sarasin, 2006) have focused on learning based on the teaching material used. The psychological interpretations of learning behaviour by Jung and Kolb provide an understanding of individual techniques and abilities related to understanding and learning. However, although these interpretations can explain the difference between individuals' behaviour in learning, they remain highly subjective and difficult to measure in practice.

Motivation and understanding are two important factors related to how a learner absorbs information in both traditional learning and e-learning environments. There are many theories on how learners' motivation and understanding in learning can be improved, but few studies have provided empirical evidence of the benefits of different learning tools with regard to improving coherence and motivation. Therefore, the aim of this research is to provide a tool to enhance motivation and coherence in learners and to provide evidence for its effects. An important observation of this literature review was the need for experimental studies to lean more toward objective methods of assessing improvements in learning in the e-learning environment. In this section, a set of theories on learning style that focus on the types of learning material will be discussed.

2.1.1 The VAK Style of Learning

Sarasin (2006) has focused more on material-based categorizations and divided learning styles into the visual, auditory and kinaesthetic (VAK) styles, which are the main learning styles when students engage with activities and build their own content. In the visual learning style, materials are associated with images and graphical representations such as text and graphs. In the auditory style, learners absorb information through listening and speaking. In the kinaesthetic style, in this thesis, learning occurs through activities as students are expected to create their own summary rather than act as passive learners and use already available learning material.

According to Edison (2008), kinaesthetic learning, which is a subset of active learning based on Glass (2003) definition of kinaesthetic learning, is one of the basic educational tools of modern and current learning practices and educational trends. This type of learning is based on the premise that learners absorb information more fully when they are actively (physically and/or intellectually) engaged in the learning activity.

The kinaesthetic learning style is preferred for learning related to experience and practice. In other words, in this style, the learner prefers reality-based learning. According to Baxter (2010), realistic movies and videos are more connected to the kinaesthetic learning style than the visual learning style, as videos of real events and people draws a connection between learning and a simulated real experience.

The VAK model can be implemented in e-learning systems to drive improvements in learning. For example, an e-learning system that utilizes lecture videos is representative of the VAK model of e-learning. Videos are believed to be a powerful learning media, as explained by several theories and experiments, which will be discussed in later sections. Further, in keeping with the VAK model, the ACES tool helps students move from a simple visual learning style to an active/constructivist one based on Piaget's theory of constructivism, which will be discussed in section 2.1.6.

According to Fleming (2012), there is no evidence to indicate that the VAK learning style is beneficial for learning. However, the absence of empirical evidence does not necessarily mean that this learning system does not have any benefits. The

VAK learning style is popular among learners and teachers, as it helps learners recognize their own learning style and learning preferences, which can be between visual and auditory, visual and kinaesthetic, or auditory and kinaesthetic learning styles (Cherry, 2015).

2.1.2 The Mayer Cognitive Theory of Multimedia Learning

Mayer (2005) states that the use of words and pictures in contrast to words alone improves the learning process. The theory proposes that there are three main assumptions in multimedia learning:

1. Information processing has two separate channels: auditory and visual. This means that most of what the human mind learns comes from either what we hear (words) or what we see (images).
2. Each channel has limited capacity.
3. Learning processes involve filtering, selecting, organizing and integrating information based on prior knowledge.

The cognitive theory of multimedia learning proposes that the human brain does not interpret multimedia presentation of words, pictures and auditory information in a manually exclusive fashion. Instead, it is the process of constructive experience that the learner is engaged in. Therefore, according to the theory, the assumption that increasing the channels of information gives the learner a better opportunity to learn is wrong, and information delivery should be designed according to how the human brain processes information (illustrated in Figure 2.1 below).

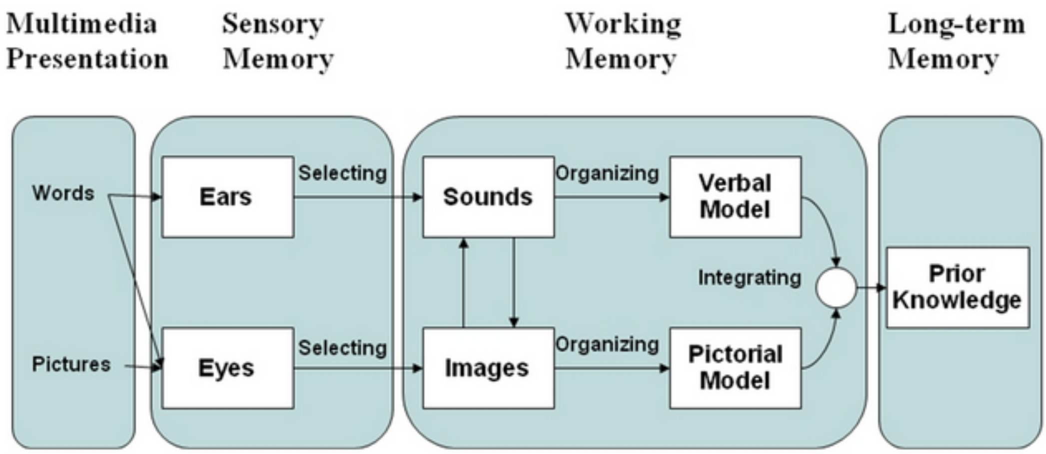


Figure 2.1: Cognitive Theory of Multimedia Learning (Mayer, 2005)

The most important principles of Mayer's theory that support multimedia learning are (Mayer, 2005):

1. *The Redundancy Principle:* People learn better from images and spoken words than images, spoken words and text.
2. *The Multimedia Principle:* People learn better from images and spoken words than spoken words alone.
3. *The Modality Principle:* People learn better from images and spoken words than images and text.
4. *The Special Contiguity Principle:* People learn better from corresponding pictures and text when they are near each other or on the same screen than when they are far from each other or on different screens.

Although the cognitive theory of multimedia sets the foundation for multimedia learning, it does not cover the use of videos in learning (Gall, 2004). In addition, Astleitner and Wiesner (2004) have highlighted the fact that Mayer's research ignores the motivation factor and does not consider it as an element that affects the learning process and memory resources.

2.1.3 The Cognitive Load Theory

The cognitive load theory provides a model of how the human brain processes multimedia information. According to Sweller (1999), there are three types of cognitive loads that help the brain process complex visual and verbal information:

1. *Intrinsic Load* (Manage): This represents the materials inherent to learning. The intrinsic load is increased as the material gets more complex.
2. *Extraneous Load* (Minimize): This represents the mental effort invoked in response to instructional activities and the way they are designed and presented. The extraneous load does not make a direct contribution to understanding the material.
3. *Germane Load* (Maximize): This represents the mental effort exerted into integrating new information with existing knowledge.

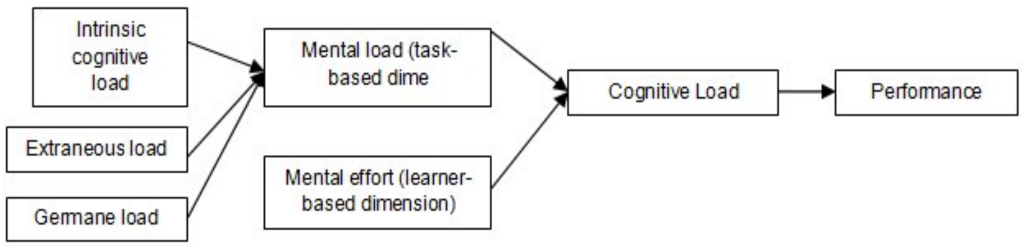


Figure 2.2: Cognitive load theory

The theory suggests that in order to allow the greatest amount of mental resources to be dedicated to the germane load, the learning materials should have less extraneous load.

There is considerable evidence to indicate that the human mind processes two separate working memory channels: one for processing visual information and the other for processing auditory or verbal information (Baddeley, 1999; Miyake et. al. 1999; Paivio, 1986). The limitation on each channel indicates that a channel can be overloaded when lots of new information is being processed concurrently (e.g. Baddeley, 1999; Sweller, 2008). These findings form the basis of Mayer's theory of multimedia learning discussed above.

Based on the cognitive load theory and Mayer's theory, providing redundant or irrelevant information through visual and verbal channels will hinder the learning process as it increases the extraneous load. Therefore, in order to maximize learning, the multimedia learning environment should be designed in such a way that irrelevant sounds or videos are eliminated.

According to Gunawardena (1995), there are other factors that play a role in increasing coherence in the context of video lectures, such as the social presence learners experience when watching a real person in the video. Empirical studies in the literature review, which are presented in later sections, study the effect of video learning on learning coherence and the effects of shorter and redundancy-removed video clips when extraneous load is reduced.

2.1.4 The Constructivist Learning Theory

The constructivist learning theory is a popular and widely accepted theory according to which learning is more meaningful when the learner can interact with the problem or concept (Xu et al., 2008). According to Piaget (1950), who presented the constructivism theory, learners are more motivated and engaged in the learning process when they are actively engaged in the problem and play a more active role in understanding it, as this eases the absorption of information for the learner. Therefore, according to this theory, teaching strategies should involve more interaction with the problem to create a meaningful context that helps students gain knowledge and construct it based on their own experience. The theory describes how learning takes place through proactive interactions and reinforcements. That is, the learning process is believed to be an active process that takes place in a self-directed fashion. A real-world example of learning based on this theory is the way children learn a language. Young children learn their first language by simulating others. That is, children in the first stage of learning their first language do not study grammar, vocabulary or sentence structure in a structured or formal way. Some common examples of constructivist learning methods include role simulation, learning by debate, collaborative learning in groups, and engaging in real-world activities such as internships.

E-learning environments are in keeping with the constructivist learning theory, as the e-learning content can be student-centred, resource-rich as well as highly interactive (Zhang, 2004). Further, the constructivist theory suggests that learners learn best when they are actively engaged, and this explains why students learn from videos more than other learning styles such as reading, as the level of engagement and activity are higher with videos, as was discussed earlier by Greenberg and Zantetis (2012). Constructivism is also the basis of collaborative learning, as knowledge is constructed and transformed among students (Vygotsky, 1978). Collaborative learning groups improve learning motivation by making learners actively engage in problem solving. Thus, constructivism is an important theory in the context of this research, as it supports the self-directed learning that occurs in e-learning systems utilizing videos and collaborative learning as drivers of engagement, activity, and motivation. Another important feature of the constructivist learning theory is that it explains how learning occurs and how coherence is enhanced by increasing motivation and encouraging students to actively engage in problem solving.

According to Piaget's theory (Piaget, 1950), the construction of information by students based on their knowledge, by summarization of the context and addition of more information from different sources based on their understanding, helps learners to be more motivated and increases their level of understanding. A limitation of Piaget's constructivist theory is that it focuses on self-directed learning, so learners need to search for the knowledge and information required to solve the problem without support from peers. Moreover, this type of learning requires a high level of egocentrism in the learners (UKEssay, 2015).

2.1.5 The Social Constructivist Learning Theory

Vygotsky's (Vygotsky, 1978; McLeod, 2007) social constructivist learning theory is similar to Piaget's constructivist theory with regard to how a learner learns. However, while Piaget has emphasized on self-initiated discovery, Vygotsky places more emphasis on the social context of learning. He rejected the assumption made by Piaget that it was possible to separate learning from its social context. In his theory, he suggested that experienced learners around the learner play a major role in the learning process. This includes teachers as well as other learners. The important features of Vygotsky's work are listed here:

1. The More Knowledgeable Other (MKO): This refers to a co-learner, someone who has a better understanding of the information than the learner himself. Peer learners or learners with more experience and understanding of the information qualify as MKO. The key feature of an MKO is that he/she must have a better understanding and more knowledge about the topic than the learner. According to Falchnikoy (2001), 'the more knowledgeable individual can act as a tutor to the less knowledgeable'.
2. The Zone of Proximal Development (ZPD): This refers to the zone that differentiates the learner's current development from his/her potential development when taught by an MKO (Eddy, 2010). Instructions or guidance should be given based on the learner's needs, so that the learner can develop the required skills. Interaction with peers is an effective way of

developing skills. In other words, the ZPD is the zone where learners engage with their more skilful peers (MKO) to develop skills.

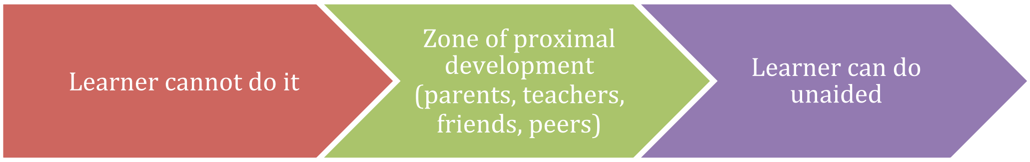


Figure 2.3: Zone of the proximal development process

3. Every function in the learner's cultural development appears twice: first, at the social level, and later, at the individual level. This means that a function is first apparent between people and then within the learner.

Thus, the constructivist learning theory supports peer work and collaboration in learning, as evidenced from the concepts of MKO and ZPD proposed in Vygotsky's theory. According to this theory, learners can improve their knowledge by supporting each other: learners with a high level of understanding can benefit from helping others, while those with a lower level of understanding can benefit from the support of learners with a higher level of understanding. This is one of theories that formed the basis of the collaborative video tool developed in the present study.

2.1.6 Other Studies on the Constructivist Learning Theory

In 1960, Bruner (University College Dublin UCD), who was influenced by Vygotsky's works on the constructivist learning theory, suggested that the different processes used by learners in problem solving vary from person to person and that social interaction lay at the root of good learning. Burner believed that it is possible to structure knowledge in a way that enables the learner to easily grasp the information. This is a relative feature as there are many ways to structure a body of knowledge and many preferences among learners. Here, understanding the fundamental structure of a subject would make it more comprehensible.

All three researchers, Piaget, Vygotsky and Bruner, share the belief that learners learn from doing and taking on active roles rather than just observing, which is in keeping with constructivism. Thus, according to their theories, understanding and knowledge are re-evaluated when the learner is engaged in active learning.

According to Smith (Smith 1981 cited in Ord 2012), there are three assumptions that support active learning:

1- Students learn best when they are involved in an activity.
2- Learners need to discover knowledge by self-directed learning to make the content more logical to them and for the content to have significant meaning.
3- The freedom of setting their own learning objectives and the ability to actively track them within a given framework will help learners to increase their knowledge.

2.1.7 The Technological Pedagogical Content Knowledge Formulation

In 1987, Shulman (1987) presented the pedagogical content knowledge theory, which focuses on understanding a subject matter in depth and in a flexible manner, thus allowing teachers to help students create their own knowledge framework to draw associations between ideas and solve problems. In order to make connections across fields, teachers need to have an in-depth and coherent understanding of the subject matter. This understanding of the subject provides the foundation for content knowledge and ideas that can be accessible to others. In other words, teachers are not likely to be able to help students to learn content if they do not have deep knowledge about the subject (Ball, 2008).

According to the Shulman formulation, teachers need to use different methods to make the subject easy and understandable. This means that teachers should be able to visually present ideas with examples and illustrations, and deliver knowledge in a way that is easily comprehensible (Loughran, Berry and Mulhall, 2012; Craig and Orland-Barak, 2014).

The pedagogical content knowledge theory was expanded by Koehler and Mishra in 2009 to the technological pedagogical content knowledge theory, according to which technology can help solve problems and make a subject more understandable for learners. Technological pedagogical content knowledge requires an understanding of the concept of representation using techno-pedagogical techniques that utilize technology in a constructive way to teach content. The most important feature of this theory is the relationship between using technology in a specific content domain and having an in-depth understanding of the content. Having a good understanding of this relationship will help learners gain deep knowledge so that they are better able to produce effective content that can help other learners as well. The learners will therefore not only depend on teachers, but also depend on technologists who have a good understanding of the required technology.

This theory is related with the constructivist learning theory in that it demonstrates the effects of giving students the opportunity to transcend the passive learner role and take control of their learning. This can help them manage their learning by engaging in something rather than just observing it. Moreover, learners learn better by designing their content based on their preferences; thus, they can improve their understanding by having in-depth knowledge about the subject matter through self-directed learning.

Based on the technological pedagogical content knowledge theory and Vygotsky's theory of constructivism, it seems that the ideal learning environment would be a technology-driven one where knowledge is gained from peers and friends, and learners with a high level of understanding of the subject can transfer their knowledge to their less knowledgeable friends. Thus, all the previous studies mentioned so far support the idea of an e-learning system where students can edit the teaching material to create other teaching material and share these in a collaborative environment.

2.2 Adaptive e-learning

The trend in modern e-learning has moved from standard and static computerized and modern tools of learning to tools that can serve students according to their individual needs. This type of learning is called 'adaptive e-learning'. This idea is built on modern learning style theories, which suggest that students need different learning materials, as they do not share the same learning style and experience. In other words, people learn in different ways and have a tendency to adapt to certain learning strategies better than they adapt to others (Akkoyunlu and Soylu, 2008). In the literature review in the next chapter, research in this area is reviewed. Studies in this field mostly focus on the effectiveness of the learning environment in improving learners' involvement and increasing their factual knowledge.

Adaptive e-learning has been defined by many academic scholars. For instance, Stoyanov and Kirschner (2004) have defined adaptive e-learning as 'an interactive system that customizes and adapts content in e-learning pedagogical models and interactions between participants and the environment to meet the individual needs and preferences of users'. According to this definition, the adaptive e-learning system has the ability to provide course material and content based on students' behaviours and styles. In recent years, adaptive e-learning systems have emerged from the idea that hypermedia systems and intelligent tutoring systems must be developed such that they can adapt to the needs of individual students to achieve a better and improved educational experience (Surjono, 2011).

Standard and traditional e-learning systems that are not classified as adaptive according to Stoyanov and Kirschner's definition are suitable for homogenous groups of students who are highly prepared and highly motivated. In a more diverse environment where students come from different backgrounds with different knowledge, learning objectives, learning styles and different perspectives of learning, this type of standard system can present problems and may not have the answers to this diverse environment. The adaptive e-learning system provides a solution to this in the form of delivery methods that are fit individually to the needs of each student instead of a unified delivery method for all of the students. In other words, the system assesses students' abilities and provides learning material based on their level of understanding and knowledge. For example, the system may be able to gauge that a specific student lacks knowledge in geometry, but has a good background in algebra. In this case, the system will alter its content to fit the student's needs by presenting more learning material on geometry and less material on algebra. This will improve the student's ability in the area that he/she lacks knowledge. However, this definition of adaptive e-learning is restrictive as it relies on the application to make simple choices between learning materials based on a learner's achievements in tests.

Another less restrictive definition of adaptive e-learning is proposed by Burgos (2006): '… A method to create learning experiences [not only] for students, but also for the teachers, based on the configuration of a set of elements in a specific period aiming to increase performance of predefined criteria'. According to this definition, the adaptive e-learning experience is beneficial for teachers and students alike. Teachers benefit from adaptive e-learning systems as they provide teachers with a better understanding of students' abilities and weaknesses and their progress. In the traditional e-learning system, the teacher may face a scenario where he/she presents material already covered by students very well and skips material that the students did not cover, which makes the learning experience less efficient.

The most common definition of adaptive e-learning focuses on automatic summarization, for example, a system that automatically changes learning content based on user profile. The definition of adaptive e-learning in this research is different, but it still fits that of general adaptive learning. In addition, the definition of adaptive e-learning by Burgos is more suitable for the research in this thesis, as the system used in this study is adaptive in the sense that it allows for the creation of new learning material based on summarized videos and collaborative social interaction. Learners can make changes to the provided material based on their preferences and based on their collaboration, adapting to the learning material as they do.

2.3 Videos in E-Learning

Incorporating digital videos into hypermedia environments is a powerful educational tool in many educational settings, including teacher training (Zottmann et al., 2013). As was discussed in Chapter 1, the introduction of videos in e-learning adds a powerful dimension to the learning process. It adds interactivity, interest and tangible learning benefits, as will be shown in this section.

In this section, a number of studies on the use of video lectures in the learning process are critically reviewed, and how they have affected motivation and understanding in students is discussed. Each section has several subsections that discuss these studies in detail. For example, the following section (use of videos in e-learning systems) contains a number of subsections, each of which is about a specific study on the use of videos in e-learning.

2.3.1 Use of Videos in E-Learning Systems

This section explores the key relevant studies on the utilization of video lectures in e-learning systems and its effectiveness with regard to students' learning experience. Five studies are reviewed: Wells, Barry and Spence (2012); Pedrotti and Nistor (2014); Chtouki, et al. (2012); Wieling and Hofman (2010); and Gilardi et al. (2015).

2.3.1.1 Using Video Tutorials in the Learning Process

Wells, Barry and Spence (2012) have demonstrated the use of video tutorials in the learning process. After a 3-year study, they integrated their assessment criteria into videos, which subsequently improved student satisfaction and led to a noticeable improvement in their outcomes.

Wells and his research team studied a pool of 84 students and found that traditional learning, such as that adopted in the classroom setting, resulted in minimal improvement in student skills, when these methods were compared to methods incorporating video lectures in a programming course. The reason for the high failure rate was that students were not aware of what topics to focus on, because the traditional lectures were very sporadic and irrelevant to the main context. Students also found difficulties with regard to the motivational aspect of studying and understanding in traditional learning, and they also found it difficult to find other resources to help them develop their knowledge. The high failure rate was initially the result of low motivation to learn, as the students had worked extra hours to find extra resources on their own.

The limitations of traditional lecture delivery methods, apart from time limitations and accessibility, can be overcome by using multimedia technology for lecture delivery. With multimedia technology, the instructor can record a narration to accompany the video, with which the general concept can be explained and tips can be provided. The student can replay, stop, rewind and forward the video as many times as they want, which has the potential to optimize their learning.

When recording, creating or using video tutorials, the research team stated that three important issues need to be focused on:

- A clear definition of the association between the resource and the study topic should be provided.
- The resource needs to be effective and well received by the students.
- The extra cost and training associated with creating and maintaining the resources should be taken into account.

The videos lectures were provided for each unit by an e-learning portal in 2008. Each video had duration of 10 to 15 min and covered a particular concept to avoid confusion and to focus on answering the associated questions. The videos contained an explanation of the programming problem and how to solve it. Moreover, students were taught how to solve and code the solution step-by-step, debug, program, and test. Video lectures are useful because they answer many questions related to coding and explain each concept separately.

With regard to the structure of the lesson, the researchers suggested that the students needed to study programming units in the second year and use the first year for learning about pre-programming preparation. The decision to study programming units in the second year, after they had obtained enough information about the course in the first year was backed by the idea of minimizing the challenges and complexities of the programming subject and helping students to become more computer literate before learning programming. They believed that this would help student acquire skill sets such as problem solving and basic mathematics in the first year, which they could then use in programming in the second year.

The feedback from the students was positive, and the outcome improved from 2008 to 2010, which confirmed that the use of the video tutorials was a major contributing factor in the improvement of the results. Student satisfaction had increased dramatically as well. A survey about the video tutorial was conducted in the final week of lectures. The responses were positive, as more than 87% of the students found the video lectures really helpful for their weekly assignments and for their revision before the exam. Table 2.1 shows the student outcomes after the exam, from 2008 to 2010.

How do you rate the video tutorials provided?		
	2009 %	2010 %
Very unhelpful	0	2
Unhelpful	0	0
Average	9	0
Helpful	26	11
Very helpful	65	88

How do you rate the content of the video tutorials?		
	2009 %	2010 %
Very poor	0	0
Poor	0	0
Average	13	2
Good	39	27
Very good	48	71

How did you use the video tutorials?		
	2009 %	2010 %
Learn C programming	70	54
Learn the weekly material	48	34
How to complete the assignments	87	95
Study for the exam	57	38
I did not watch them	4	0

Did the video tutorials help you learn the unit material?		
	2009 %	2010 %
Not at all	0	0
Sometimes	13	9
Often	48	45
Always	39	46

Did the video tutorials encourage you to complete the assignments?		
	2009 %	2010 %
Never	0	4
Sometimes	13	9
Often	48	29
Always	39	59

How often did you use the video tutorials to help you complete the assignments?		
	2009 %	2010 %
Not at all	4	0
Sometimes	26	14
Often	30	21
Always	39	64

Which of the following resources did you find most helpful?		
	2009 %	2010 %
Lectures	30	27
Lecture slides	78	63
Video tutorials	65	84
Assignments	52	39
iLecture	30	2
Student News	4	5

Which of the following is the most valuable resource provided for this subject?		
	2009 %	2010 %
Lectures	9	2
Lecture slides	0	0
Practicals	44	37.5
Video tutorials	35	59
iLecture	13	0

Table 2.1: Survey Results (Wells et al., 2012)

Enriching the current educational material with rich multimedia content, such as online lecture slides, quizzes and videos, has been shown to have a positive effect in increasing learner motivation and their level of understanding overall. This was what fuelled attempts to create e-learning systems that are highly dependent on video content in the past decade. The survey results of Wells' team indicated that introducing video content can be effective and increase student satisfaction and grades, as 87% of the study population (84 students, including 25% off-campus students) found that it was a helpful addition to their learning resources. The students' performance improved impressively, as the failure rate decreased from 30% to 13% for the on-campus students and from 38% to 6% for the off-campus students.

The researchers also unexpectedly found that introducing video lectures to the course material led to devaluation of the traditional lectures, as students preferred video tutorials over face-to-face lectures. This was evident from the low attendance rate for face-to-face lectures after the inclusion of video lectures in the course material. However, there may be a bias in the finding, as the attendance rate could also be related to the ease of the particular course or a general dislike for the lecturer. The researchers did not clarify whether this rate was compared to that for other face-to-face lectures attended by the same students or to the attendance rate for the same course in the past years by different students. Further, the researchers only compared the results with those of previous years and not with the students' results in other non-video modules or traditional learning, and therefore, they could not definitively prove that the video tutorials achieved better results than traditional tutorials (attending lectures).

2.3.1.2 Online Lecture Video System

The research conducted by Pedrotti and Nistor (2014) describes the effectiveness of an online lecture video system (OLV) that was implemented as part of a study at a large German university on learners' motivation and acceptance of the online system as a source of learning. The system provides online lecture videos with synchronized presentation slides that students can collaboratively annotate and comment on.

The OLV offers three templates to present the materials, with the first template being the basic template that consists of three parts:

- A video stream of the recorded session

- Synchronized lecture slides on the right side of the video
- Navigation links at the bottom of the video, which allow for quick navigation via chapter and slide change markers.

The second template is a mobile template, which delivers only an audio stream of the recording with synchronized slides in full frame. This is due to unavailability of flash players on devices such as the iPhone.

The third template is an advanced one that consists of a flash-based web application. In addition to the features of the basic template, this template allows learners to add time- and location-sensitive annotations to the video lectures. Students can interact with the annotations of other students who are registered for the same lectures.

After using the system, the students participated in a survey that was conducted through a web form integrated with the system to connect user behaviour recorded with the survey results. The acceptance of the OLV system was assessed using Venkatesh's technology acceptance model (TAM), based on which login frequency (2.55 logins per week) and average login time (3.79 h) were determined. According to the researcher, these values indicate acceptance of the technology. However, this is not considered in the system, and these values are not compared to other data. In addition, TAM has been critiqued by many researchers, including Legris, Ingham and Collerette (2003), with regard to its usefulness. The frequency of login and the average login time do not necessarily indicate acceptance of the technology, as frequency and usage time may vary at different stages. For example, students may spend most of their time on the system during the initial phase when they explore the system, and the usage time and frequency may decrease in the later phases. These limitations were not mentioned by the researcher.

The other findings in the paper were quantitative data from the survey that were not detailed enough or analysed sufficiently. Although the researcher states that the system had a high acceptance rate among participants, limited analysis and data were provided to support the claim. In addition, the lack of comparison with traditional methods is also a limitation of this study.

2.3.1.3 Use of YouTube for Video Lectures

In another study, Chtouki et al. (2012) investigated the effect of videos as an education resource with regard to enhancing student learning and engagement, and evaluated the impact of YouTube videos on student performance. The empirical study included two groups of learners: the first group was provided videos from YouTube as learning material, and the other group was provided with traditional classroom material, including textbooks and lectures. The experiment involved uploading videos related to each concept of the subject, including database, software, hardware, networking and programming. The course was divided into two parts: the first part explained the concepts of the course, and the second part was dedicated to computer programming. At the end of the term, a survey was conducted.

The learners reported that they found the traditional methods difficult to follow: 50% of the students found the first chapter difficult to understand in the traditional way. Moreover, 80% of those who watched the YouTube videos found it helpful. The group of students who used the YouTube videos showed a 15% higher success rate compared to the previous year. The results of the experiment demonstrated that the YouTube videos did indeed increase student interest in the subject. This was reflected in their understanding of complex concepts and their grades, which were both better in the first group in which learners used YouTube videos. Thus, in this research, it was shown that video learning can improve student understanding and provide a higher level of learning motivation than traditional in-class learning.

It must be understood that the video itself was not the only reason for the increase in motivation and improvement of understanding, as YouTube is also a social network that can be used as a social learning environment. Therefore, the better results may also be related to the social environment, and comments from other students may have played a role in improving students' level of understanding. However, this aspect of using YouTube in learning was not discussed in the paper.

2.3.1.4 Video Learning VS Traditional Face-To-Face Learning

Wieling and Hofman (2010) studied the effectiveness of using videos in education and compared it to the effectiveness of traditional face-to-face learning. The primary goal of this research was to assess the effect of online on-demand video lectures on student performance while also taking into account the number of lectures the students attended in person.

For this experiment, the researchers randomly grouped students studying a course on European law, international relations, and international organizations into three groups: (1) traditional face-to-face course, (2) online video lectures only, and (3) online video lectures with online quizzes with appropriate feedback. A total of 474 students participated in the study (161 male students and 313 female students). The study assessed the groups based on lecture attendance, number of lectures viewed online, feedback, and grades. Prior achievement, learning style and attitudes, and time invested in the course were also considered.

The results showed that the number of online lectures viewed by the students and attended in person were positively associated with their overall performance. The performance of those who attended online lectures frequently was higher than that of those who viewed them to a lesser extent. However, there was no significant difference between the group of students who used online video lectures only and the group who used online videos with online quizzes and feedback. Figure 2.4 shows the results of the experiment.

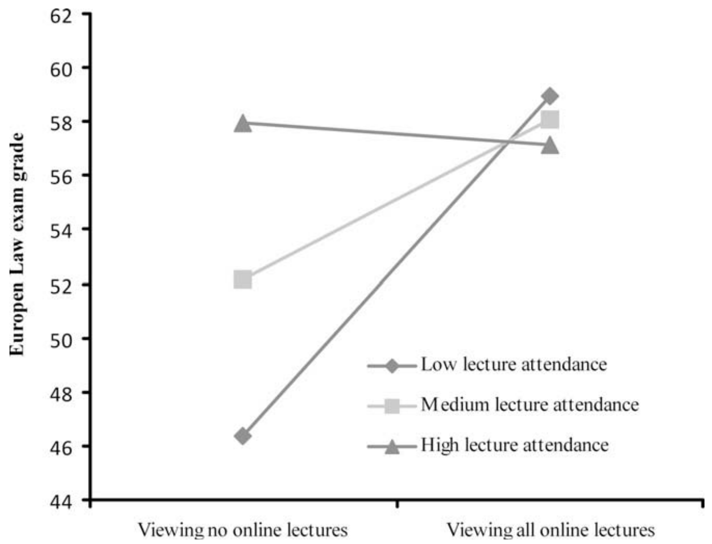


Figure 2.4: Exam Grade According to the Number of Online Lectures Viewed (Wieling and Hofman, 2010)

From the findings, the researchers concluded that the online videos help students who miss face-to-face lectures, as they can later view the online video lectures and therefore improve their grade. However, the researchers did not investigate whether the effectiveness of online video lectures is the same as that of face-to-face courses.

2.3.1.5 Different Video Delivery Formats

In 2015, Gilardi et al. examined the link between the delivery format of video lectures and the engagement of the learners with the video content. The researchers studied five different lecture delivery formats:

- *Screencast*: Screen captures of the lecture presentation with audio commentary
- *Enhanced Screencast*: Screencast with additional footage of the presenter filmed using a video-recording device
- *Lecture theatre recording*: A formal recording of the lecture in a lecture theatre in which, unlike in the enhanced screencast, the lecturer faces the audience instead of the camera
- *SussexDL*: A new video lecture delivery format developed for the research in which an image of the presenter is superimposed on the slide along with the recording (there is no post-production work involved, as the slides and presenter appear together on the screen as a single unit) (Figure 2.5)

Figure 2.5: SussexDL Video Format (Gilardi et al., 2015)

- *In-person Lecture*: a one-on-one tutoring session in which lectures are given live to the student.

The experiment involved 50 participants (43 students and 7 staff members), who were exposed to all five delivery formats. The participants were only told that it was a Japanese learning study, and the real purpose of the study was not revealed in order to reduce the risk of bias. The research question was related to whether the video lecture delivery format influences how engaged students feel.

The results showed a significant difference in the median level of engagement perceived between SussexDL and the other video delivery formats, with the exception of the in-person lecture format. The SussexDL format and in-person lecture format were quite similar with regard to the level of engagement perceived. However, in-person lectures have significant drawbacks, as they are rather impractical in learning environments with a high number of learners. As the difference between the SussexDL and in-person lecture format was small, the researchers felt that a larger scale study should be conducted to understand the differences. Nonetheless, based on the findings of this study, the SussexDL format seems suitable for this thesis as it is associated with a high level of engagement.

2.3.2 Interactive Videos in E-Learning

A broad definition of interactive videos would be videos that are capable of processing user input to perform relative actions. There are different forms of interactive videos, such as videos with links to external websites and videos with more complex actions such as processing control actions (playing, cutting, stopping and linking to other material) (Rouse, 2013).

'Interactivity in video-based models can be used as an instructional method to engage learners in relevant cognitive activities' (Wouters et al., 2007). Many different studies have been conducted on the utilization of interactive video lectures in e-learning. The main studies are those by Zhang et al. (2006); Yin, Lin and Chen (2013); Delen, Liwe and Willson (2014); Merkt et al. (2011); Franzoni, Ceballos and Rubio (2013); Huang et al. (2012); and Seeliger and Arbanowski (2014). These seven studies are discussed in the following sections.

2.3.2.1 Effectiveness of Interactive Videos in E-Learning

To examine the influence of interactive videos on learning outcomes and learning satisfaction in e-learning environments, Zhang et al. (2006) conducted four different empirical studies on four different groups of participants: (1) Group 1 was provided with interactive videos (35 participants); (2) Group 2 was provided with non-interactive videos (35 participants); (3) Group 3 was provided with electronic learning material without videos (34 participants); and (4) Group 4 was provided with traditional learning material in a classroom (34 participants). The research aimed to determine the effectiveness and impact of interactive videos on e-learning.

The 'Learning by Asking' (LBA) system was used for this experiment, as shown in Figure 2.4. The system promotes high levels of interaction by providing learners with direct access to individual video segments. The objective of the LBA system is to provide an interactive and personalized online learning environment that makes self-paced learning possible. In the LBA system, students can watch lectures on integrated instructional videos, as well as access the associated lecture notes and lecture slides for each video. Additionally, the control panel provided allows learners to skip or replay any video clips, lecture slides, or notes at any time.

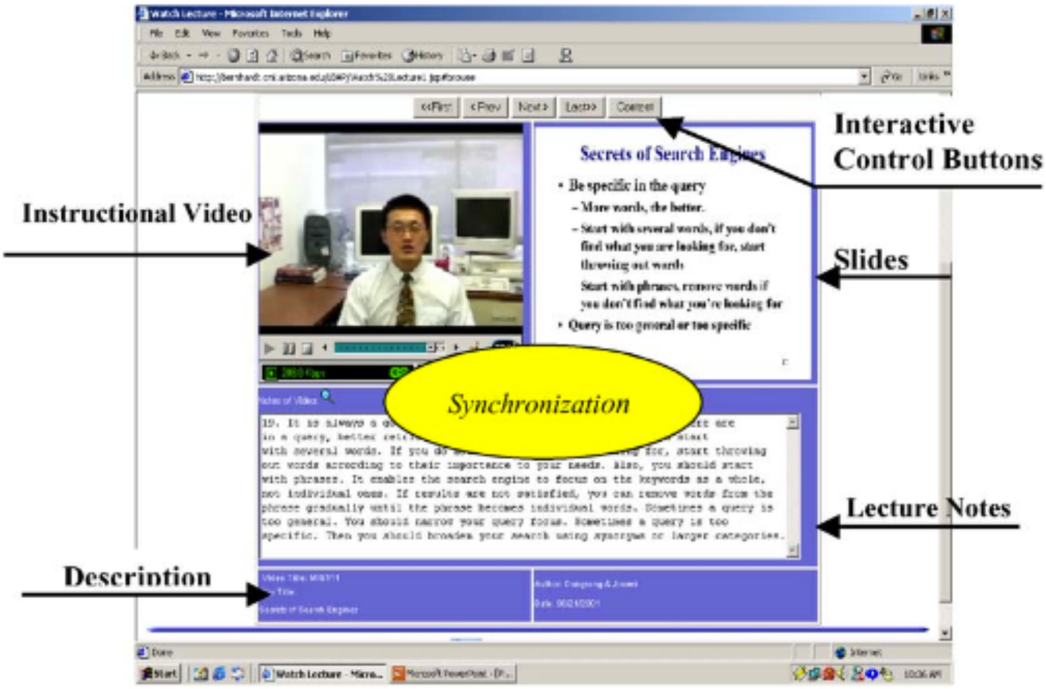


Figure 2.6: The Interactive E-Classroom of the LBA System (Zhang et al., 2006)

In Group 1, the learners could interact with the video through the control buttons provided on the control panel. The interface provided for Group 2 had no control panel, so the videos were not interactive. However, the learners were able to stop and replay the video or parts of it as they needed. The LBA interface for Group 3 did not contain videos, but only slides and lecture notes. The LBA system was not provided for Group 4, as they followed the traditional learning method in the classroom setting. Participants were given hard copies of lectures slides at the beginning of each session, and the learning outcomes were assessed by measuring the difference between the pre- and post-test scores.

Significantly better learning outcomes were observed in Group 1 than in the other groups, as shown in Table 2.2. These findings suggest that interactive videos are a stronger and more effective delivery medium. An interesting finding was that the outcomes of e-learning with non-interactive videos were not significantly different from those of e-learning without videos. This seems to indicate that using non-interactive linear videos has little effect on the average outcome.

Satisfaction was measured using a post-test survey, which showed a significantly higher level of satisfaction in Group 1 than in the other groups. However, the difference between Group 2 and Group 3 was small, which suggests that the use of linear videos has little effect on satisfaction, as shown in Table 2.2.

Groups	Means	Standard deviations	*N*
E-learning group with interactive video (1)	6.46	0.56	35
E-learning group with non-interactive video (2)	5.94	0.84	35
E-learning group without instructional video (3)	5.74	0.75	34
Traditional classroom group (4)	5.03	0.67	34

Table 2.2: Descriptive Data for Learner Satisfaction (Zhang et al., 2006)

The findings of this research indicate that utilizing videos in education improves understanding. It also shows that interactive videos tend to provide an even higher level of motivation than is achieved with non-interactive videos, as shown in the results in Table 2.3. This is probably because the user is able to control the video by using control buttons such as rewind, pause, and fast forward, which result in increased motivation and focus levels.

Wells et al.'s study in section 2.3.1.1 shows that video learning did indeed increase the learning and coherence level of students. However, Wells, Barry and Spence did not compare online video learning with e-learning without the use of videos. In addition, this study by Zhang et al. has shown that there is little or no gain in coherence and motivation levels when linear videos are used for content delivery; that is, it is only interactive videos that are capable of causing a major increase in the level of understanding and motivation.

2.3.2.2 Case-Based Learning with Multimedia Teaching Materials

Similar to Zhang et al.'s study (2006), other studies have been conducted on the utilization of interactive video lectures in e-learning. Yin, Lin and Chen (2013), for instance, proposed a new interactive video e-learning system for medical students that allowed them to interact with multimedia teaching materials in addition to case-based multimedia teaching materials, so that they could obtain detailed background information about each patient. The students were required to answer questions while watching documentary videos (Figure 2.7). The system also included simulated animations of surgical procedures in a virtual environment, which could be recorded and saved by the students in their individual accounts (Figure 2.8).

Figure 2.7: Questions Asked During the Documentary Video Procedure (Yin et al., 2013)

Figure 2.8: Virtual Demonstration of the Surgical (Yin et al., 2013)

Although this seemed to be a promising e-learning system that was more effective than other types of learning media (based on their background research), there are no experimental studies or statistical data to support this system. Therefore, the effect of this e-learning system on student learning behaviour cannot be confirmed.

2.3.2.3 Interactive Learning VS Traditional Learning

Delen, Liew and Willson (2014) conducted a study to compare the effectiveness of interactive video e-learning systems to that of traditional video learning systems with regard to student learning performance.

The study included two groups the contained a total of 80 undergraduate and graduate students from a university in southern Texas in the United States. Every fifth student was assigned to the control group, which therefore comprised 16 students. The control group was provided with the standard video learning material, and the second group (experimental group: 64 students) was provided with an interactive learning system. The participants in the control group were provided with video content with which micro-level interaction, such as play, pause, rewind and forward, was possible. The participants in the experimental group were provided a higher level of interactivity with the video content. The experimental group participants also had access to macro-level interaction, including note taking, supplemental resources and practice questions (Figure 2.9).

The videos for this project needed to be rich in facts, so as to enable the students to learn many facts in a relatively short time. For this purpose, six videos related to renewable energy sources were selected, including hydropower, wind energy, geothermal energy, biomass energy, biofuel energy, and solar power. These six videos added up to a playing time of 16 min.

Figure 2.9: The Enhanced Video with Embedded Functions (Delen et al., 2014)

The results showed that the experimental group had a notably higher success rate in the recall test (M = 16.50 and SD = 2.06 vs. M = 14.81 and SD = 2.88 in the control group). Although the experimental group spent 50% more time with the learning material than the control group, this did not seem to have a significant effect on the recall test scores.

Means and standard deviations of major variables.

	Mean	SD	95% CI around the mean	
			Lower	Upper
Self-regulation[a]				
Manage	3.60	0.57	3.47	3.72
Seek info	3.77	0.57	3.64	3.90
Adaptive	3.88	0.43	3.78	3.97
Recall test[a]				
Total score	16.16	2.33	15.64	16.68
Time[a]				
Total time (minutes)	22.20	6.27	20.80	23.60
Self-regulatory behaviors[b]				
Supplemental resources	5.42	1.62	5.02	5.83
Practice questions	3.78	0.90	3.56	4.01
Interactive notes	11.64	10.86	8.93	14.35

[a] $n = 80$.
[b] $n = 64$.

Table 2.2: Mean and Standard Deviation Values of Major Variables (Delen et al., 2014)

According to the results, the enhanced interaction provided with video learning led to a better improvement in students' learning than the minimal interaction tool. Students spent more time learning in the experimental group than in the control group, based on which it could be concluded that the higher level of interaction resulted in a higher level of engagement, which in turn led to a higher level of understanding.

In conclusion, the findings of this study imply that the higher level of interaction in video learning results in higher learning quality in terms of engagement and understanding. Therefore, it is important for modern online e-learning systems to utilize interactive video learning tools rather than traditional lecture viewing tools.

It should be noted that there are several limitations to this study, such as the small sample size, which reduces the statistical power of the data. In addition, the participants did not have any incentive to take the learning activities seriously, as the study was not part of the required course. Moreover, student motivation and behaviours in online learning environments were not examined. They assessed students' self-regulation strategies quantitatively but not qualitatively, which is a limitation because the quality of students' self-regulation may be associated with their learning performance.

2.3.2.4 Interactive Vs. Non-Interactive Vs. Print Learning

Merkt, Weigand, Heier and Chwan (2011) studied the effectiveness of interactive videos and compared them to print material and non-interactive videos. Two types of videos with different degrees of interactivity and content-equivalent illustrated textbooks were provided to German secondary school students in order to measure the effectiveness of interactive videos. The experiment was conducted on 12th and 13th grade students, who had an average age of 18.20 years, from certain secondary schools in Germany. The included students were divided into three groups, each of which was assigned a different content delivery medium: Group 1 was assigned illustrated textbooks; Group 2 was assigned videos with common video player features such as start, stop, rewind, forward and pause; and Group 3 was assigned an enhanced video learning tool with additional features such as an interactive table of content, an interactive index and a timeline that allowed for navigation via a slider. Figure 2.10 shows the three different media used in the groups.

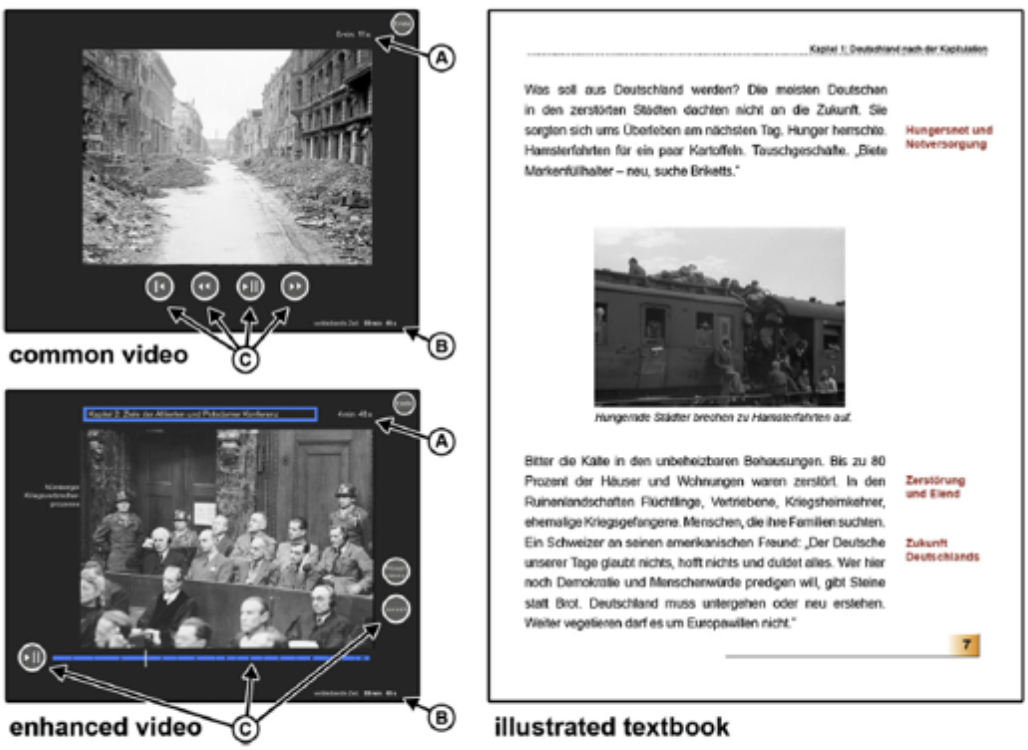


Figure 2.10: Three Different Media used in the Groups (Merkt et al., 2011)

The content domain for the experiment was a documentary about the history of Germany from 1945 to1950 (the period after the Second World War). Students were asked to write three short essays after watching the video or reading the text. A total of 60 students participated in the first study (31 female students and 29 male students; age, 18.20 ± 0.78). The students were randomly divided into three groups of 20 students each. The second study was conducted in twelve Germany history classrooms and comprised of two history lessons (45 min each).

In the second study, assessment of knowledge acquisition after the experiment showed that the students who viewed the traditional videos had higher scores (M = 54.18, SD = 5.65) than those who viewed the enhanced videos (M = 49.74, SD = 5.92) and those who read the illustrated textbook (M = 51.65, SD = 6.35). The number of facts mentioned in each essay was also higher in the group of students who viewed the traditional video (M = 18.98, SD = 8.16) than in the group provided with the illustrated textbook (M = 15.65, SD = 7.05) and the group provided with the enhanced video (M = 15.47, SD = 8.83). Additional measurements also favoured the traditional video over the enhanced video and illustrated textbook, although the effect was not as large as that for the number of facts and knowledge acquisition.

The results of both studies confirmed that video learning has better outcomes in terms of knowledge acquisition than textbook learning. However, both studies failed to demonstrate whether the video with enhanced features was better than the traditional video.

It is surprising to note that the additional video features, such as the table of contents, seemed to have a negative effect on learning. It is possible that because the additional features allow student to freely navigate the video and watch different parts of it in no particular order, they missed out on important information. Because the students did not have such a tool in the traditional video tool, they had to go through the chapters in order and therefore watch the video from the beginning to the end, without skipping any sections. This allowed for optimal flow of information, in the way intended for the course. In other words, skipping sections may decrease the learner's ability to link gradual and continuous information and cause them to miss out facts. It is therefore important for an e-learning tool to consider the natural flow of information in the video and not allow students to skip over content easily so that they miss out important information.

2.3.2.5 Interactive Learning in Correlated Courses

Franzoni, Ceballos and Rubio (2013) have defined and developed an online video system with an interactive platform to increase interactivity in instructional video learning. They found that browsing through non-interactive videos is a time-consuming process that involves listening and watching videos sequentially in a linear process. Their system features proactive and random access to video content based on questions or search targets, use of an interactive word glossary, and extra information for the teachers and comments for students in real time. The research aimed to increase interactivity and motivation in order to improve learning effectiveness.

As part of the study, their model-view-controller (MVC) system was introduced at some universities in Mexico. The system aimed to develop correlations between courses, for example, by linking math courses with physics, economy and chemistry courses. This would help students access different types of information. The system presents extra related notes on the screen while the video is playing, to help students understand the topic better.

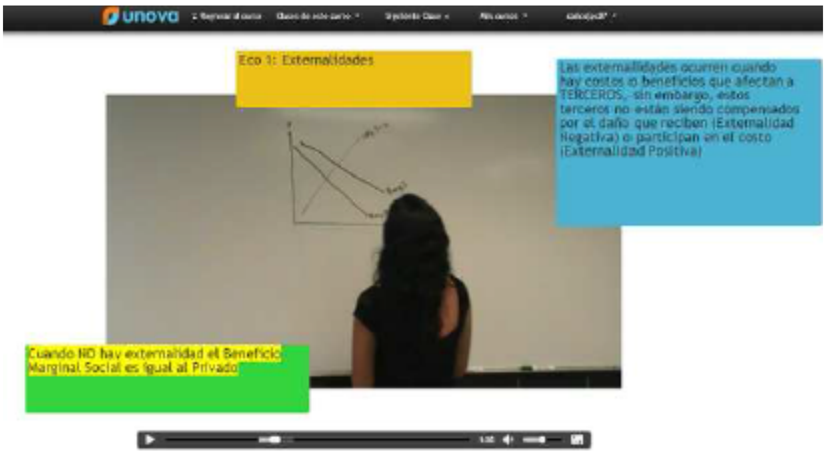


Figure 2.11: A Screenshot of How Students View a Class (Franzoni et al., 2013)

The system seems interesting and may have the potential to contribute to the learning process, but the paper did not provide any information about the experiment or post-experimental data. Therefore, the effectiveness of the system is unclear.

2.3.2.6 Learning with Video Portfolio Metacognition

Another study by Huang, Huang, Wu, Chen, and Chiang (2012) used the learning video portfolio (LVP) system to improve students' metacognition, which is defined as the ability to self-monitor and reflect on the mental process. The LVP provides the learner with the following features: learning through imitation, self-monitoring, teacher assessment, expert reference system, and upgrading and enhancing metacognition in the student.

The objective of this research was to improve students' metacognitive abilities so that they could use it in the learning process. Having knowledge of metacognition allows learners to be aware of the objectives, as a result of which they are better able to find the important information needed to solve problems by analysing and interacting with the learning resources. It also involves knowledge of using the right strategies at different times to increase learning effectiveness. Another advantage of having knowledge about metacognition is that it increases the level of motivation by making students aware of what knowledge they lack, and it offers them the opportunity to identify areas in which they need to improve. The LVP provided a self-monitoring framework that allowed students to be aware of their metacognitive abilities. The LVP platform contains a screen with interactive touch tables, using which the student can engage in role playing with the help of the teacher. It was also designed to suit the classroom environment, where both teachers and students can use the platform for interactive activities.

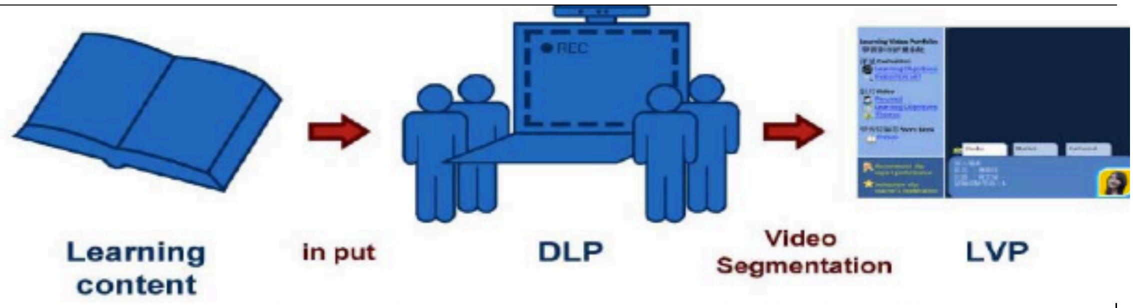
Figure 2.12: A Student using the LVP System (Huang et al., 2012)

The videos in the LVP system were broken down into six parts:

- *Evaluation*: the objective of the learning material

- *Imitation and Learning*: access to other people's videos and the ability to use their strategies
- *Self-monitoring*: recorded videos of student performance that can be reviewed
- *Expert references*: recommended videos by teachers or experts
- *Evaluation by Teachers*: teachers' advice on student performance based on the recorded videos of a particular student
- *Integration*: the activity as a whole, including the concepts and performance of a student.

The table below shows the structure of the LVP experiment



Users	Teacher, textbook publisher, course designer	Students, teacher	Main: students (individual) Sub: teacher and parents
Learning state	Providing learning objects, Themes (e.g. unit...), Assessment and evaluation forms	Authentic learning activities, team Discussion, articulation	Students: evaluate, reconsider their performance Teacher: gives advice to the student Parents: acquaint themselves with the students' learning status
Equipment and tool support	Digital files	DLP: a screen, a PC, two projectors, a tracking system and a touch table Kinect: receives students' gestures and transfers them to the screen Screen recorder: records the whole view of the screen, including students' action videos	File editing software: web-based application with a media player, connected with the database

Table 2.3: A Self-Explanatory Presentation of the LVP System (Huang et al., 2012)

The researcher believed that the LVP system would help students improve their comprehension and monitor and evaluate their metacognitive ability through more realistic self-inspection. The National Central University of Taiwan was the host institute for this experiment, which included 37 participating students. To assess study behaviour and metacognitive awareness in the subjects, a 35-question metacognition awareness inventory (MAI) questionnaire was prepared for the students to answer. After they filled in the MAI questionnaire, the students were asked to take part in a 50-min situational learning activity. After three days, the students were asked to perform specific tasks for 30 min on the LVP by themselves, after a brief instructional tutorial session. The same MAI questionnaire was given to students again after the experiment, in order to understand the effectiveness of this learning system. In addition, a random number of participants were selected for a 15-min interview about their previous learning experience.

		Mean	SD	p
Planning	Pre	3.266	15.95231	0.03*
	Post	3.757	15.88500	
Information Management Strategies	Pre	3.551	13.77760	0.12
	Post	3.813	17.71032	
Comprehension Monitoring	Pre	3.181	12.14790	0.003*
	Post	3.923	6.41427	
Debugging Strategies	Pre	3.978	9.85901	0.588
	Post	4.027	8.68907	
Evaluation	Pre	3.288	6.91857	0.001*
	Post	3.986	9.02774	

*stand for significant different

Table 2.4: Pre- and Post-Experiment MAI Questionnaire Results (Huang et al., 2012)

The survey results, as seen in Table 2.4, showed a significant difference in comprehension monitoring, which suggested that students were able to adopt an effective learning strategy after using the LVP system. The findings also indicate that students' performance and ability to strategize were improved after they used LVP.

With videos, students can learn about the topic in more detail. Usually, students are not aware of the details that are lacking when they study a subject. The LVP findings showed that the use of videos makes students aware of these details and motivates them.

However, this research did not evaluate how videos help learners improve their understanding, and it does not compare the LVP method with traditional methods with regard to the ease of understanding the content. Thus, although this system has clear benefits, it is limited by the lack of supporting data.

2.3.2.7 Direct Interaction with Video Content

Seeliger and Arbanowski (2014) presented an approach for utilizing interactive video content to create an interactive e-learning experience by providing students with a comprehensive tool to interact directly with video content items and access to supplemental information. The approach was based on a web system that links videos with related information on a time-independent navigation tool. This allows learners to navigate video manuals, documentaries and TV programs throughout the video. Once the learner clicks on the object that interests them, the supplementary information is displayed. The system comprised three main components: the back-end solution, the video editor, and the interactive video player.

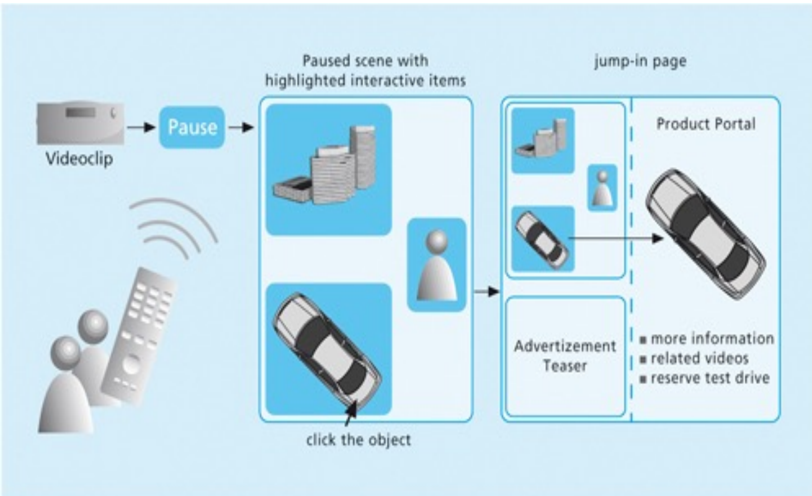


Figure 2.13: Non-linear Video Content Interaction (Seeliger et al., 2014)

The supplementary information (objects) linked to the video content includes the title describing the object, a subtitle that provides further information, a detailed general description of the object, a link to the external website, links to external images, links to external PDF documents, social media services for publishing object information on social media networks such as Facebook and Twitter, links to contact information about the person, and links to related videos.

Figure 2.14 shows how the video is displayed after objects are added, and Figure 2.15 shows how objects can be added to a video in the system.

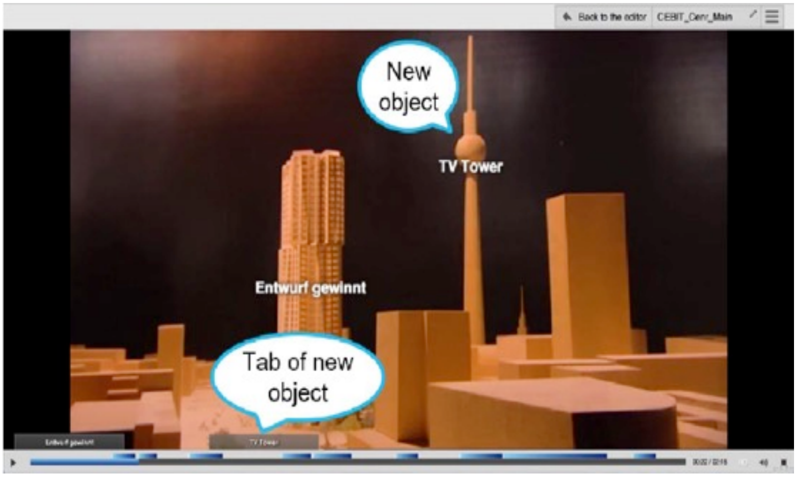


Figure 2.14: Example of a Visualization of Interactive Video Content for Video Manuals (Seeliger et al., 2014)

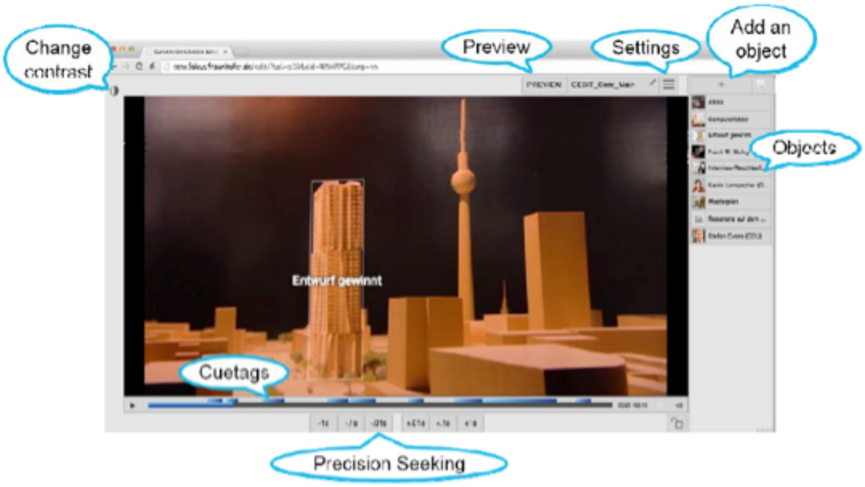


Figure 2.15: Interactive Video Editor (Seeliger et al., 2014)

Like many of the other studies presented in this review, this paper lacked experimental data to support the effectiveness of the learning tool. However, it can lay the foundation for the development of a new tool for educational improvement using video summarization and its functionalities, such as portability (being a web system that can be run in all web browsers), and the editing tool can be implemented in a pedagogical system.

2.3.2.8 Video Framework with Associated Information

The use of video with associated information in learning was investigated by Fu, Pao and Xu (2010). These researchers introduced the concept of Video FARM in e-learning. Video FARM is a platform that, in addition to just playing videos, also plays associated information, such as comments, discussion, outline, Q & A, and pictures that explain the video, simultaneously with the video. Video FARM was introduced after video sharing services started coming into practice in 2009, when researchers found that the presentation of Video FARM is suitable for educational applications such as e-learning.

The following features were introduced by researchers as Video FARM features: video uploads in a hierarchical manner; suggesting and outlining interesting sections of the video while watching or recording; querying about synchronized associated information with each segment of the video; sharing, commenting on, and evaluating the video as a whole, or a segment of the video; and assigning online exercises and homework to the students.

The researchers investigated the effectiveness of Video FARM in two different courses—general physics and introduction to multimedia. The experiment included three methods of teaching in each course: traditional classroom learning (Tcl), traditional Internet video learning (Tvl), and Video FARM e-learning (Vel). Students with similar educational backgrounds and grades were included in the investigation.

The results of the experiment showed that the mean scores of the FARM group were higher than those of the other two groups in both subjects, with the lowest standard deviation (Table 2.5).

Exams / Classes	Quiz I	Midterm	Quiz II	Final
Phy-Tcl	79±16	77±15	77±15	76±14
Phy-Tvl	80±14	79±13	79±13	76±12
Phy-Vel	81±12	80±11	79±10	77±10
MM-Tcl	82±16	80±15	80±15	78±14
MM-Tvl	84±14	82±13	82±13	78±12
MM-Vel	84±12	83±11	82±10	79±10

Table 2.5 : Mean and Standard Deviation Scores for Physics and Mathematics with the Three Different Teaching Methods (Fu et al., 2010)

Thus, it seems that the best testing result among the three groups was achieved by students who used Video FARM. The other two groups that were taught in traditional classroom and the group that used traditional Internet video learning had lower average grades.

2.3.3 Short Videos in E-Learning

A key issue in video learning is the length of the videos. Long videos may decrease student motivation and focus and eventually demotivate students from using the system regularly in the long term, as they may find it difficult to spend long hours watching lengthy videos. Therefore, scholars have investigated the results of using shorter videos. The general conclusion is that short video clips can help student improve their knowledge and learning, so short video clips may be more useful than long videos with regard to helping the learner stay focused and motivated. This will also have an effect on the general understanding level and absorption of information in the students.

This section discusses studies on the effectiveness of short videos in e-learning in which short videos are compared to relatively longer versions of the lecture videos. The studies reviewed are Marques, Quintela, Restivo and Trigo (2012); Hsin and Cigas (2013); Wen-Chi (2012); and Fu, Pao and Xu (2010).

2.3.3.1 *Exploring Videos in the Form of Small Clips*

Marques, et al. (2012) conducted an on-field empirical study on the effect of short video clips on coherence in the learner. The lesson was about the applications of groundwater flow, which were illustrated with the help of video clips; students found it difficult to understand the basic concepts of this topic in the traditional classroom setting. The study aimed to show how videos in the form of small clips can drive attention and arouse interest in the context of engineering education.

The investigators designed an IP camera that could provide a video link between the laboratory and the lecture theatre in order to help students improve their knowledge and understand the concepts clearly. The experiments conducted in the laboratory included the visualization of flow lines and the construction of flow nets. Videos were recorded during the entire duration of the experiment, with a focus on the complex parts of the topic, and the students had direct access to video clips with a whole range of configurations. A video clip titled 'Earth Dam Disasters' was prepared and included in an online survey using the Qualtrics software (Qualtrics software, n.d). The objective of the survey was to evaluate four different aspects of the use of video clips as an educational tool. The participant pool included 4th year students in an integrated Master's in Civil Engineering course and a group of academics in this field.

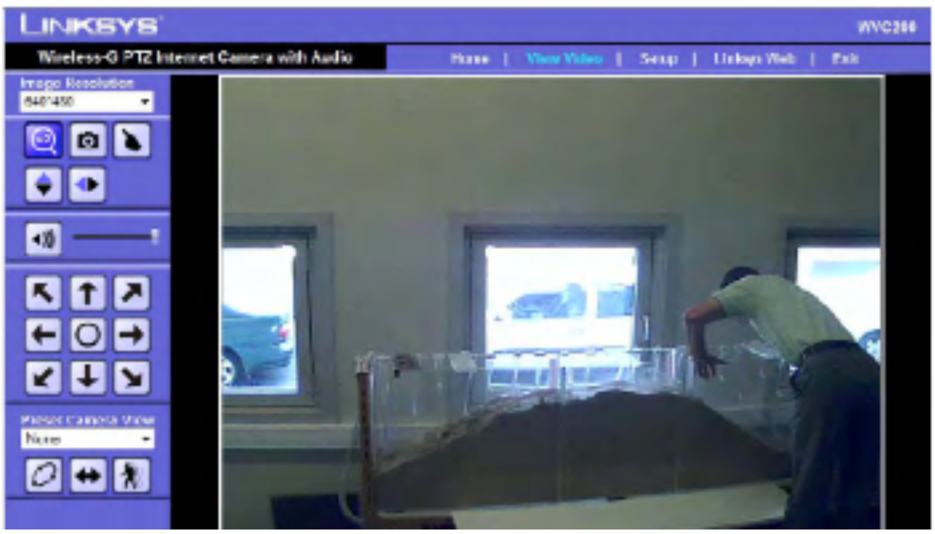


Figure 2.16: Lecturing Through the Ethernet (Marques et al., 2012)

The questionnaire comprised the following questions:

- How do you rate the small-scale study equipment used in the video clip in terms of its potential as a teaching tool?
- How do you rank the value of the video clip with regard to exploring the features of groundwater flow (e.g. flow lines)?
- How do you grade the effectiveness of the video clip as a vehicle for dissemination of information on the topic 'Earth dam disasters'?
- How do you rate the impact of the contrast established between the model-simulated disaster and the real catastrophic event documented in the video clip?

The results showed that 70% of the students believed that the small-scale study equipment had a positive impact, and almost all the students stated that it was useful. Further, 62% of the students indicated that the video clip with exploration features was *very useful*, and the rest of the students indicated that it was *useful*; none of the students felt that it was not useful. With regard to the third question, 96.6% of the students replied that the vehicle was *useful* for the dissemination of information about the topic. Finally, 97% of the students stated that they found the contrast between the model simulation and actual disaster video to be *useful* or *very useful.*

The survey results showed that the students felt inclined to use the video clips because of the ease and convenience of using it. Overall, the experiment had a very positive impact on the student group who participated. The video clips were proven to be an excellent medium for the transmission of messages in the academic context, as they can illustrate the correlation between the theoretical and practical application in the best way possible.

Although the results were in support of the use of video clips in the context of education, some fundamental information, such as the background of the participants, was not provided. The only information given about the participants was their age and gender, and there was no information on whether the participants had any previous knowledge of or were familiar with the video lectures. Moreover, there was no comparison between the video clips and other methods of content delivery, or comparison between the use of short and long video clips.

2.3.3.2 Effect of Short Video Lectures

In another study, Hsin and Cigas (2013) described the effects of using short video lectures for teaching computer science and mathematics. The videos created were less than five minutes in length and focused on a specific course topic. This design was based on the hypothesis that long videos often fail to maintain students' attention and focus, and that short videos can improve student outcome and decrease their withdrawal and failure rate (Fang, 2009).

Student performance in six online terms, from 2005 to 2012, was assessed in an introductory course in discrete mathematics. The online course videos were designed to be asynchronous: there was no provision for live streaming, and interactive lectures were regularly scheduled. Over the 8-week online course, different means of interaction between the instructor and students were provided, such as phone conversation, email, chatting, and pre-recorded videos. This experiment was distributed over four different years: one experiment in 2005, one experiment in 2009, three experiments in 2011, and one experiment in 2012.

In the first experiment, which was held in 2005, the instructor used phone and email communication and Q&A discussion forums as part of the online course to answer students' questions. This was helpful for the students and motivated them to participate more. However, the students found it difficult to discuss their questions in mathematics over the phone, which was not considered as an ideal medium to solve mathematical problems.

The second experiment was held four years later, in 2009. In this experiment, the instructors used chat rooms and virtual whiteboard sessions with visual and audio components to provide an interactive environment for instructors and students, where students could address and share their concerns. However, as the number of participants increased, the instructors found it difficult to be present at all the chat sessions at the scheduled time.

In the third experiment, which was conducted in 2011, the instructors tried to eliminate the time-scheduling problems related to chatting and the Q&A forums, which were noted in the 2009 experiment. To tackle this problem, the instructors started to record short video clips to answer students' questions and uploaded them to the server, where students could watch the videos online. The Q&A forums and chat room sessions were still included, but the extremely high response of the students to the videos caused the participation in the chat rooms and forums to drop to 0.

The other three field studies took place in 2011 and 2012. In these studies, the instructors used the same facilities as before, and the same videos were available for the full term. However, the interactive chat sessions were only used when requested by the students. Moreover, in addition to the existing videos, the instructors continued to produce new videos when necessary to improve student learning.

The results showed a dramatic drop in the rate of failure and withdrawal in 2012, which corresponded to the introduction of the video clips. The students' response to the videos was positive, and their satisfaction was notably increased. The average grades scored in the course increased slightly after the introduction of the videos, and students' interaction with the instructors showed a notable decrease. Figure 2.17 shows the results of all six experiments.

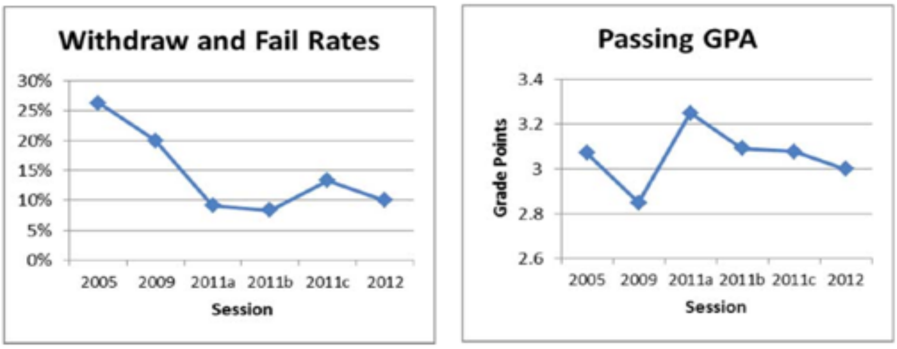


Figure 2.17: Withdrawal and Failure Rate and the Passing GPA Average of the Six Experiments (Hsin et al., 2013)

The findings suggest that direct interaction with instructors via the online Q & A sessions could have benefits. However, if there are a large number of students, the instructors may find it difficult to find the time to answer all the questions and, eventually, a lot of questions will remain unanswered or answered late. In addition, the high pressure on teachers can play a major role in demotivating teachers to use the online system efficiently and effectively.

The assumption of the researchers that the introduction of short video clips improved achievement and reduced the withdrawal and failure rates is arguable to some extent, as different students attend the course every year. The background of the students may have been different, and other influential factors may have not been considered. A comparative analysis is required to support the argument that the introduction of short video clips was the reason for the reduction in the withdrawal and failure rates.

An important finding of the study is that the superiority of short videos over lengthy videos was demonstrated in the post-experiment survey. This finding is very critical, as short video clips will be a key feature of the learning solution proposed in this thesis. The next study also highlights this point, and more details about the learning solution are provided in the next chapter.

2.3.3.3 Short Videos VS Long Videos in E-Learning

Wen-Chi (2012) also reported that short video clips provide better understanding and motivation than lengthy videos. This study aimed to identify the advantages and challenges of using short video clips in education, particularly in social science subjects.

The experiment was conducted over two consecutive academic years, and a survey was conducted at the end of each semester. As part of the experiment, the instructors provided short videos in each lecture during the term. These videos were obtained from online social networks such as YouTube. The videos were chosen based on their relevance to the lecture topic and typically covered theories, policies, examples of problems, and examples of solutions to the problem. At the end of the first semester, the participants were asked to answer a survey on the course, and the response rate was 30% (60 out of 167 students in the course responded to the survey). As seen in Table 2.6, the survey results showed that the introduction of videos had satisfactory outcomes.

	Summary statistics		
	Sample	Mean	Var.
Q1: The videos were relevant to the subject.	AY08/09	3.98	0.73
	AY09/10	4.40	0.31
Q2: The videos were overall objective and unbiased.	AY08/09	3.75	0.67
	AY09/10	4.02	0.61
Q3: The videos increased my interest in the subject.	AY08/09	3.86	0.74
	AY09/10	4.23	0.62
Q4: The videos were effective in making connections between theory and real world.	AY08/09	4.12	0.44
	AY09/10	4.31	0.31
Q5: The use of videos did not disrupt my concentration.	AY08/09	3.47	1.03
	AY09/10	3.85	0.76
Q6: Overall, the use of videos was effective.	AY08/09	3.75	0.80
	AY09/10	4.15	0.44
Q7: Recommend the continued use of video sources in classroom teaching.	AY08/09	3.90	0.87
	AY09/10	4.31	0.50

Table 2.6: Mean and Variation Scores for Seven Questions Asked in the Survey Conducted in Academic Years 08/09 and 09/10 (Wen-Chi, 2012)

However, as was observed by the researcher, the students found it difficult to focus on the important aspects of the topic because of the large number of video clips provided in a single lecture. In addition, Win-Chi also observed that during the lecture video in the economics class, students lost interest and did not pay attention when the focus of the lecture shifted from the economic to the political aspect. The researcher therefore decided to make a shorter version of the lecture video with the politic aspect trimmed off, thus allowing the students to focus more on the economic contents without being distracted by the related political content.

Over the next academic year, the experiment was repeated with a number of video clips and with video clips of a shorter length, as the researcher had also observed in the first experiment that students found it difficult to concentrate on some parts of the videos. These parts that the students seemed uninterested in were trimmed off for the second experiment. Of the 148 students enrolled in the course, 65 (44%) participated in the experiment. The survey results at the end of the second experiment showed even greater satisfaction with the study material, as the mean score for all of the 7 survey aspects increased (Figure 2.18).

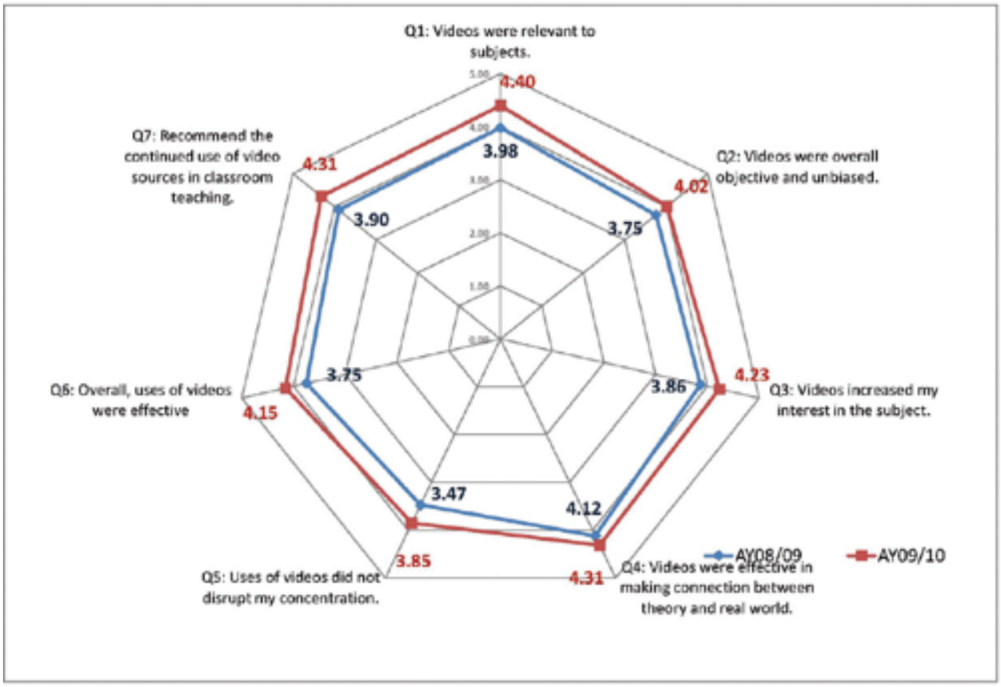


Figure 2.18: Survey Data over Academic Years 08/09 (in blue) and 09/10 (in red) (Wen-Chi, 2012)

Wen-Chi concluded that long videos can be distracting, and that students often find it difficult to maintain the same focus level throughout the video; therefore, shortening the videos can improve their quality from an education perspective. However, it may not always be possible to shorten videos, especially if trimming it may lead to loss of important information. Therefore, shortening or trimming of videos should be undertaken with caution, as excessive trimming may leave out important connecting information and leave students confused. Another important point to note is that students view and evaluate videos differently according to their learning behaviour and personality, and it is possible that some students may actually prefer longer explanations and off-topic interruptions.

According to the cognitive learning theory and Mayer's learning theory, long videos contain lots of redundant information that can distract the learner and increase the extraneous load on the brain. Therefore, it is implied that shorter and subject-aimed video clips can enhance learning coherence further by reducing extraneous load. However, from an alternative perspective, long videos provide students with a wider picture of the discussed topic and improve their understanding. Trimming might increase the focus of the students for a particular video, but important information may be left out in the process. It would be interesting to study the effects of allowing students to make the trimming decision individually, instead of unifying the process.

2.3.4 Summary of Video Learning

In summary, the studies reviewed in this section are generally in agreement about the benefits of video learning and its positive impact on learning outcome. Wen-Chi tried to optimize the utilization of videos in learning by showing that shorter video clips have higher quality than lengthy lectures from the education perspective. However, shortening videos may lead to the deletion of important content. Further, according to their personality and learning style, some students may prefer longer videos that cover all the details of the topic, and these students may not benefit from shorter videos. Another development in video learning was the addition of supportive interactive material to videos, such as the comment option, and insertion of associated information and pictures that explain the video, which can increase the understanding level of learners, as was demonstrated by Chtouki et al. (2012) and Delen, Liew and Willson (2014), among others. However, a similar experiment conducted by Merkt, et al. (2011) revealed contrasting results, as traditional linear videos were reported to be more beneficial than the interactive videos. This is probably because the interactive video used in their study let students skip over sections, as a result of which they may have missed out on important information. Seeliger and Arbanowski (2014) went a step further and introduced a tool that allows direct interaction with lecture videos by adding objects such as links and texts to the lecture video timeline.

Thus, based on the studies reviewed, there seems to be general consensus about the benefits of video learning, but there is still a lack of empirical evidence to support the new additions and advancements introduced in the form of interactive videos.

2.4 Video Summarization

As discussed in the previous section, long videos may be distracting and contain a lot of information that the students do not need. Therefore, summarization of the video may have the potential to help students to create videos that suit their needs and increase their performance. Video summarization also adds interactivity to the learning process, in the form of the video editing process, which can increase the motivation and engagement level of learners. The benefits and limitations of video summarization will be explained in more detail in the following studies.

In this section, seven studies are reviewed: Fujimura, Honda and Uehara (2002); Chang, Yang and Wu (2011); Ren and Zhu (2008); Yoshitaka and Sawada (2012); Zahn et al. (2010); Mertens, Ketterl and Vornberger (2009); Bartherl, Ainsworth, and Sharples (2013); and Kannan, Ghinea and Swaminathan (2013).

2.4.1 Automatic Summarization Techniques

2.4.1.1 Fully Automated Summarization

The time required for shortening long videos is a major concern, as manual summarization of videos is time consuming, especially when there are a high number of videos. Fujimura, Honda and Uehara (2002) proposed a fully automated summarization system in which videos are summarized based on a colour and utterance algorithm. Utterance is defined as a piece of speech that is preceded and followed by a clear pause (silence). The technique involves using a decoder to extract captions with utterances and effective sound in videos. After the captions are extracted, the algorithm analyses how the utterances are connected to each other and then detects intervals with coherence.

The experiment included 16 students, and coherence and preservation of important information were examined. According to the authors, a limitation of this technique is that it is difficult to maintain the balance between compression of videos and coherence. The more the video is compressed, the less coherence is observed; this finding implies that fully automatic summarization does not provide higher coherence. The effectiveness of this algorithm is therefore questionable, as fully system-dependent summarization may result in random compression of information and impede coherence. This limitation points to the need for some level of human interaction; that is, the summarized video should be checked by an instructor to ensure that no important content or coherence is lost. If the users were allowed to determine the compression rate, it may help them better understand the contents (Fujimure et al., 2002).

2.4.1.2 Image Processing, Text Summarization and Keyword Extraction

Chang, Yang and Wu (2011) presented an automated summarization system that integrates image processing, text summarization and keyword extraction techniques. Their aim was to create a learning platform to produce online learning material automatically from input videos without human annotations. For this purpose, the researchers introduced a keyword-based video summarization (KVSUM) technique that can provide both visual and verbal surrogates and has the following functionalities: keyword extraction, subtitle detection, a summarization module, thumbnail generation, and keyword cloud generation.

Sixty undergraduate students were provided with two different video surrogates. The first was based on the KVSUM technique, and the other was based on the fast forward (FF) technique. The FF technique allows students to watch the video at a faster speed and no audio is provided. Learner performance and their understanding of the video content were evaluated. The researchers examined the effect of the KVSUM technique on learner performance and learners' preference for the video surrogates. The main purpose of this study was to examine how two different types of surrogates affect learners' comprehension of video content. Two 50-min videos were selected. Each fragment was set at 19-s intervals in the summarization module of KVSUM. In addition, the time limit of the final summaries was set as 5 min. With the FF technique, a summarized video that was approximately 5 min long was produced by speeding up the original video content with post-processing actions on the captions. To evaluate whether the learners had any prior knowledge about the topic of the video content, pre- and post-video tests were performed for each video surrogate. In the post-video test, students were allowed to answer the test while watching the video by pausing it when required;

they were not allowed to rewind it. Additionally, a questionnaire was provided to the participants with a variety of questions before and after they watched the summarized videos.

The results showed that students who used the KVSUM technique had a higher level of understanding than those who used the FF technique. The survey results showed that some students who used KVSUM stated that they were able to understand the main points from the summarized video and did not need to watch the entire video.

According to the results, it seems that the higher level of detail that KVSUM provided enhanced the students' coherence level. In the FF technique, students may miss out on important information as a result of the fast forwarding and lack of an explanatory audio. Thus, the FF technique creates a random learning environment where learning is dependent on the rate of forwarding, and the level of coherence may be affected by how frequently the student forwards the video.

From the findings of this study, it is not clear whether KVSUM can really enhance coherence. It is possible that because FF was not a good content delivery method, the KVSUM technique seemed to improve understanding in comparison to it. It would be useful to compare KVSUM with other video summarization techniques.

2.4.1.3 Video Summarization without Temporal Redundancy

Ren and Zhu (2008) tried to remove temporal redundancy and add new video objects to a shorter version of the video, defined as a summary of the video. These researchers developed a summarizing algorithm with which a video can be segmented into multiple shots and the key frames can be selected. The algorithm works at three levels: pixel likelihood ratio, which depicts how similar two images are in energy; edge change ratio, which depicts the change in the ratio of the strong energy edges; correlation coefficient histogram, which depicts the correlation between the histograms for two frames. These ratios indicate when a scene is over and create the segment. The algorithm was not satisfactory, as negative classification exceeded 34% when it was applied. This is a relatively high percentage, which indicates that this algorithm is not reliable.

Segmenting videos based on observation of image processing changes does not necessarily lead to correct summarization of the video. When a video lecture is delivered without any illustrating images, with a single person presenting the information, no segments are detected as there are no strong energy changes in the video and almost all the frames are similar in energy. Further, such systems are not capable of detecting the importance of the video content itself. For example, if the video contains too much extra information that is not important but contains high energy changes, the system will treat it as important content. Finally, as discussed before, this study also shows that automatic summarization of videos without any human interaction yields inaccurate results. Thus, it can be concluded that it is difficult to achieve high levels of coherence in a summarized video without human interaction.

2.4.1.4 Summarization Based on User Watching Behaviour

Yoshitaka and Sawada (2012) proposed a new framework for video summarization that detects the behaviour of the viewer while they are watching the video content. This system captures the eye movements of the viewer and evaluates how the viewer operates the remote controller while watching a video (Figure 2.19).

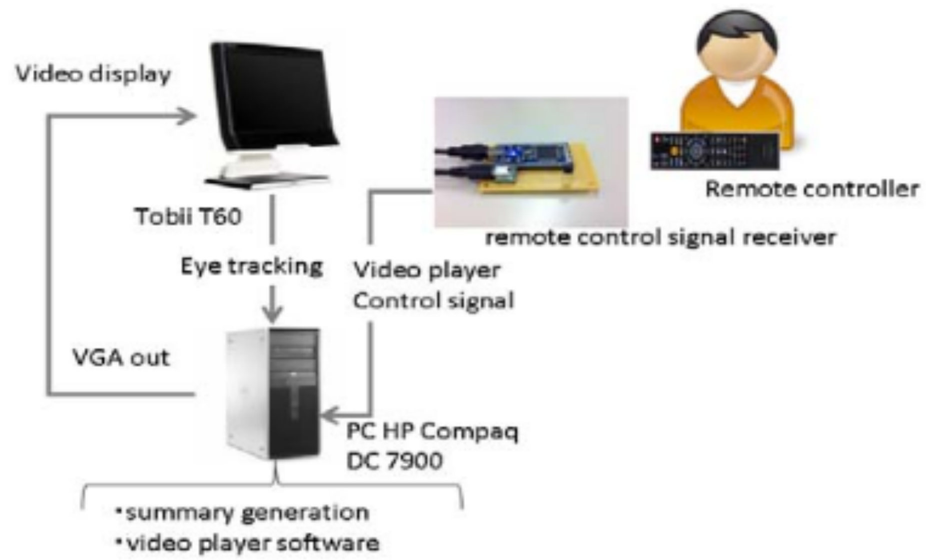


Figure 2.19: System Organization (Yoshitaka et al., 2012)

This system focuses on the video playback operations and eye movements of the viewer to draw a picture of user performance and interest. For example, fast-forwarding the video indicates a lack of interest in the content. Similarly, if the viewer rewinds the video, it may indicate that a particular scene is considered to be important. Eye movement can reflect the objects on the screen to which the viewer is paying attention to and when the viewer is paying full attention. The system identifies temporal alterations in saccade and fixation. Saccade is defined as rapid eye movement where the viewpoint jumps from one point to another, while fixation is defined as a state in which the eyes do not move but stay focused on a certain point. Evaluation of saccade and fixation reflects how interested the user is in the video. For example, continuous fixation between 300 ms and 3000 ms indicates that a static object is being watched, with full attention on the content. On the contrary, saccade reflects lack of interest, and no specific attention to the content.

Nine participants were selected to test this system. The participants were tested separately, and after the experiment, they were asked to fill up a questionnaire where they were asked about the reason they did or did not invoke controller commands. The participants were required to watch a video program of a football game. Specific attention and the duration of fixation were observed while the subject was watching the video. Along with eye movement history, the system also evaluates the remote controller operations to create the summary video.

The detailed procedures for this experiment are as follows:

- The video subject was explained to the viewer, including the duration of the video, conditions for termination of the experiment, controller operations, and whether or not the video was played more than once.
- The viewers were given time to practice different operations, such as fast forward, rewind, and pause.
- Eye tracking for each subject was performed.
- A post-video evaluation was conducted wherein participants were asked to fill out a questionnaire about the importance they assigned to different

parts of the video, by asking them to rate their degree of attention as low, medium or high.

The results showed that the performance of the system was not satisfactory. The findings from evaluation of fixation and saccade were not satisfactory, as eye movements also depend to some extent on the personality of the viewer. However, the results of the controller evaluation were more accurate than the results of the eye movement evaluation.

The results suggest that personality differences affect the evaluation of fixation, as eye movement is highly subjective and dependent on the personality of the user. The viewer may have high focus during saccade, but the system will not evaluate the corresponding video segment as important. Similarly, the viewer may concentrate on a part of video during fixation, but at the end, the viewer may find that it was not important. In this case, the system will regard that part as important while the viewer will not regard it as important. Thus, the findings of this study are questionable to a certain degree.

Based on the studies reviewed so far, it seems that automatic summarization is not a favourable technique, as the results are often highly subjective or lack accuracy. The following section will focus on tools that support summarization instead of automated and system-generated video summarization systems.

2.4.2 Non-automatic Summarization Techniques

2.4.2.1 Digital Video Tools in E-Learning

Pea et al. (2004) introduced an educational tool called digital interactive video exploration and reflection (DIVER), which was expanded further in 2006 (Pea et al., 2006). The first version of DIVER enabled users to create virtual pathways through existing video content by using a virtual camera and annotation window for commentary. The videos created were called Dives, which were posted onto the WebDiver server for active collaboration, further repurposing, and discussion.

The DIVER tool requires that students and teachers use a digital video camera to record videos. The tool has been expanded over the years, and multiple functionalities have been added. In its current form, it not only enables video recording but also enables users to upload external videos other than the recorded videos.

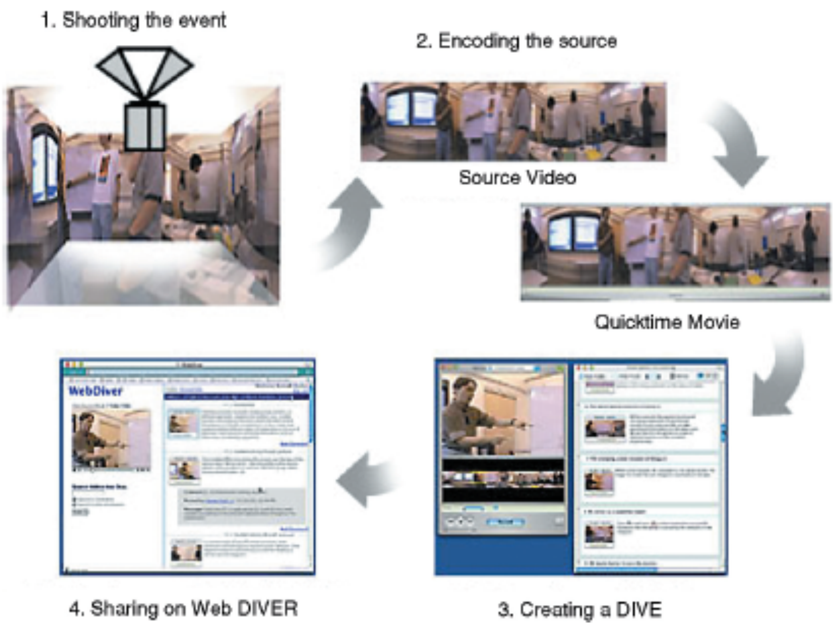


Figure 2.20: Overview of the DIVER Tool (Pea et al., 2004)

Zahn et al. (2010) also used the DIVER tool to study the benefits of integrating digital video tools in education, which they found to support both cognitive processes and social learning. Their empirical study examined the cognitive, action-related and social-cognitive learning effects of videos on the learning process.

They proposed the following two hypotheses:

1- Constructive tools that allow annotating, editing and re-sequencing of videos have opened up new vistas for making videos accessible to constructive learning in formal education.

2- These video tools are effective from the constructivist perspective too, as they support both the cognitive process and collaborative learning (Zahn et al., 2010; Pea et al., 2004).

The researchers designed approaches to investigate both the challenges of and opportunities for using digital videos in learning, which allowed students to individually create content that was authentic, meaningful and consequential for them. This gives learners the opportunity to experience the learning process as competent and motivated learners. From a cognitive perspective, to understand this complex topic, the empirical study required learners to act as designers and rework the video by using different sources, but they were asked to preserve the concept of the original video. This required them to select, compare and reflect on content they wished to present and on how to present it. The researchers believed that this process would improve their knowledge acquisition with regard to complex topics that are difficult to absorb. From the constructionist perspective, this empirical study proposed a tentative model of visual design that involved a collaborative problem-solving process with intensive interactions between video content and form.

The study included 234 students from eight 11th grade classes in four different German secondary schools. The students were asked to rework a video source showing a historical documentary on the 1948 Berlin Blockade. The students participated in two subsequent 45-min sessions using portable notebooks. Students were assigned the task of watching videos and discussing them. In each school, the students were grouped into dyads (a group of two students) and were given one of the two different tools available for this experiment. The first tool, DIVER, enabled students to record clips based on students' preferences point of view, rearrange them, and add annotations on the panels for the path clips that were recorded and then uploaded on WebDiver, where they could be shared among other participants. Students could also select a specific view of the video by zooming in on the screen. The second tool was a simple video player with a simple text editor.

The clips that the students recorded with DIVER appeared in a separate column next to the source video. Students could also add annotations on the panel of the path clips. This tool is useful for studying documentary videos, since they contain a big frame of visual images and each user can record the images from different angles and view the video based on their understanding. This means that students who use DIVER create videos based on their visual skills. The researchers focused on assessing the visual aspect of the video rather than the information presented, as students can record clips. This means that the students do not miss out on important information, but they also do not need to view the entire image for receiving information. This tool improves the visual analytic skills of learners instead of enhancing their to be more active.

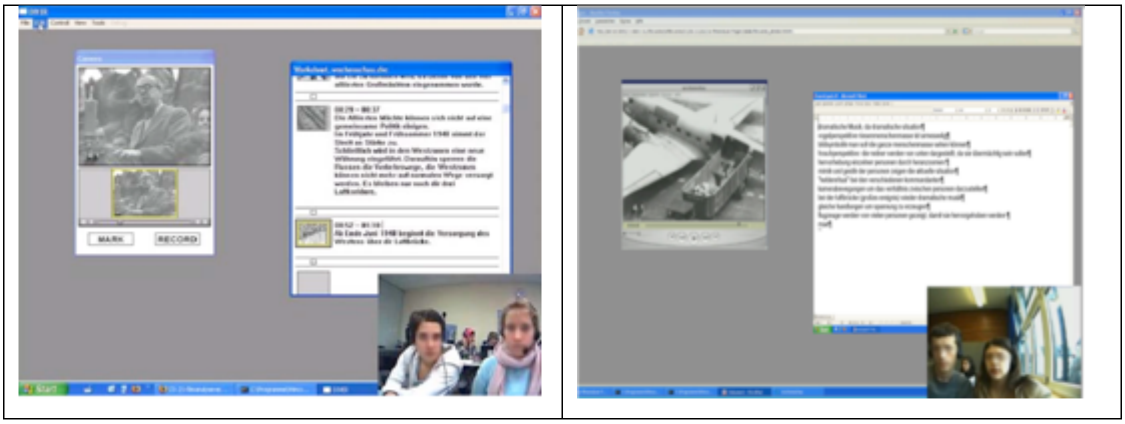


Figure 2.21: DIVER Tool (left) and the Simple Video Tool (Zahn et al., 2010)

The factual knowledge of the students was assessed using pre- and post-experiment multiple-question tests. The mean percentage of correct answers increased from 45% to 65%, and the standard deviation decreased from 15.5 to 8.2. The results indicated that this technique could be effective, as the students' factual knowledge did increase after they worked with this tool. Moreover, students who used the DIVER tool asked for help less frequently than those who used the simple video tool with the text editor. The percentage of students in the DIVER group who asked for help was 1.63%, as opposed to 5.32% in the simple tool group.

This technology is important to the present research, which will also use a similar but improved version of this tool. Although Zahn et al. proved the effectiveness of editing videos in delivering content, they did not assess the level of understanding and motivation in their participants or compare their method to other methods of content delivery such as traditional classrooms or e-learning without videos. Only the level of understanding before and after using the tools was measured.

Moreover, factual knowledge gain was not compared between the two tools used (DIVER and simple video with text editor). In addition, they did not measure the effectiveness of extracting the information itself, but they only measured the effectiveness of the visual aspects of recording the video.

2.4.2.2 Multi-Path Videos

Barthel, Ainsworth, and Sharples (2013) tried to improve on the DIVER tool by exploring the potential use of online videos in knowledge-building activities and the available conceptual tools that enable useful collaborative activities based on sharing video representations. They designed a new tool called Video Pathways; this tool was different from DIVER because it provided an environment to create video artefacts in a collaborative environment. The purpose of the discussion around the video is to create new refined conceptual artefacts, whereas in the case of DIVER, the source video material was analysed with the help of a number of tools. This study by Barthel Ainsworth, and Sharples explored the interaction between learners as they attempted to create video resources in a collaborative learning environment. The idea was to let students utilize the multipath video system (Video Pathways) to create different versions of a single video with different clips that have different perspectives, as explained in Figure 2.22.

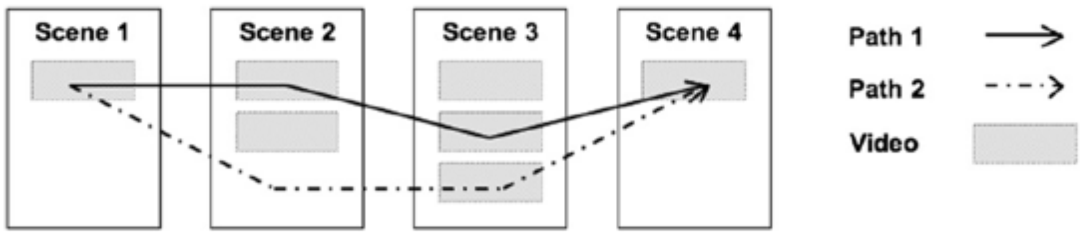


Figure 2.22: Schematic Diagram of a Multi-Path Video (Barthel et al,. 2013)

Video Pathways allowed students to create a movie project and add scenes to the project. Scenes could be retrieved from YouTube by copying and pasting the YouTube URL for the video or by copying YouTube scenes from other previously created movie projects. All the students in the group associated with the movie project could add or remove scenes as they wished. Each movie contained a path library that included different video paths, which allowed users to watch the same video from different perspectives. The study investigated whether students could effectively use Video Pathways to create multi-path videos.

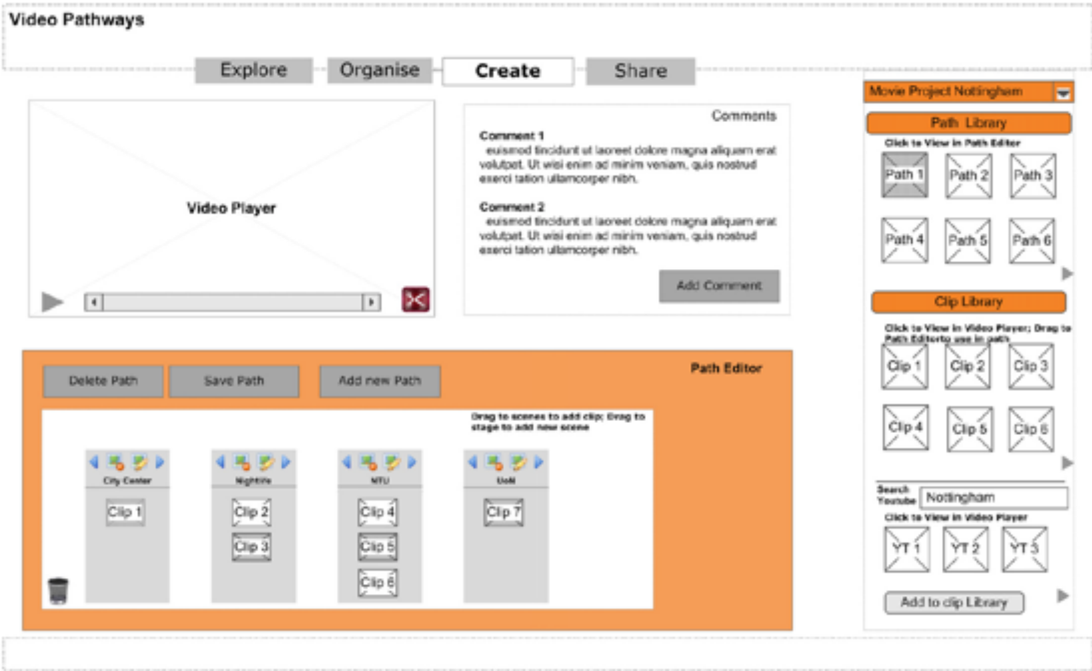


Figure 2.23: Wireframe of the Video Pathways Interface (Barthel et al., 2013)

The first experiment included 13 postgraduate students, and the second experiment included 18 participants. The participants in both experiments collaborated remotely to create multi-path video resources. The participants chosen were individuals with no prior video-editing experience, who were presented with a PDF tutorial file along with a 45-min training session on how to use the system. The participants were given five days to complete their tasks. Three of the four groups chose to work together in the lab where the researchers were present, which gave the researchers the opportunity to observe the activities of the group. After the task was accomplished, the participants were asked to answer a survey on system usability, the collaboration process and their previous experience. A post-experiment reaction instrument and a post-experiment group interview were also used. A second similar study was conducted with industry professionals and academics. A comparison of the evaluation between the two studies is summarized in Table 2.7.

Items	Study 1	Study 2
Task	Create an introduction to Nottingham for different	Create an analysis of the reasons for the global financial

	audiences	crisis of 2008
Participants	13 students	18 industry professional and academic
Group	Three groups of 3 and one group of 4	One group of 4, four groups of 3 and one group of 2
Location	Co-present	Distance
System introduction	54 min training and online documentation.	Online documentation
Study period	5 days	14 days
Research instrument	Questionnaire, product reaction and group interview.	Log file analysis and interviews.

Table 2.7: A Comparison of Evaluation Between the Two Studies (Barthel et al., 2013)

With regard to the effectiveness of creating multi-path videos, the results showed that participants from both studies frequently used the most relevant functions of the system, as shown in Table 2.8.

	Study 1	Study 2
Groups	4	6
Video clips	94	86
Scenes	51	36
Paths	9	23
Shortest path (min:s)	0:41	0:26
Longest path (min:s)	10:52	19:43

Table 2.8: Overview of the participants' study activities (Barthel et al., 2013)

The aim of this experiment was to examine how people work together and share their understanding of a topic by creating multi-path videos, and to assess the usability of the Video Pathways prototype in collaborative knowledge-building activities. Moreover, the study aimed to determine whether the system could enable people to create multiple perspectives on topics through videos; however, usability problems and lack of support for close real-time collaboration made it difficult to coordinate the work.

This research examined:

- The effectiveness of using Video Pathways to create multi-path videos from participants' point of view,
- The outcome of participants' efforts in representing their perspective,
- The benefits and limitations of task designs that have influenced these results.

The findings focused on how users were motivated and how the outcome represented the views of participants. However, the study did not show how valid the created results were. Moreover, the created videos were not evaluated with regard to how they could add value to the education process, and the motivation and coherence level in the students after they used the system were also not assessed. The researchers did not examine whether this tool improved participants' understanding and knowledge. Instead, they used the system to explore how people interact to create representations in a social video environment. The Video Pathway system lacked important functions to support grounding and discourse management of collaborative activities, and its usefulness in distributed settings is therefore limited. Finally, although Video Pathways allowed users to edit video clips in a specific order, it only allowed them to create their videos in an ordered sequence. For example, in a video containing scenes 1–5, users could not re-arrange the scenes in a reverse or random order, for example, as 4-3-2-1-5. This is also a limitation to the system, as students do not have full control of the summarized video clip.

2.4.2.3 VirtPresenter Video Editing Tool

In another study, Mertens, Ketterl and Vornberger (2009) produced a framework using VirtPresenter, which allows end users to create adaptive videos by merging parts of different video sources. The VirtPresenter was developed as part of the Opencast Project, which involved 250 institutions that aimed to collectively use web lectures and podcasts. This project offered the opportunity for creating adaptive video documents from multimedia sources from all the involved institutions, along with discussion forums. The VirtPresenter features are inclusive of:

- Clips of video lectures and appended labels and annotations,
- Easy access to original sources on a specific topic,

- Categorization of video objects and their classification according to the corresponding collections,
- Appending personalized information such as comments and title to the created clips.

There are two important developments in recent educational trends that function as drivers for the VirtPresenter approach: the development of bookmarks in multimedia content, and the idea of exchangeable and reusable learning objects in e-learning. Website bookmarking allows users to easily retrieve the subjects they require at any time. Therefore, applying this concept to video lectures facilitates easy retrieval of information. However, the benefits and limitations of this approach in real-life situations are not clear yet.

VirtPresenter resembles the DIVER tool in many aspects, as they both share the same purpose: making video content more understandable to learners. However, the technology used is different with each tool. The DIVER tool provides summarization tools to individual learners to help them create their own video summaries, and it has a collaborative environment where learners can comment on and share the summary videos. However, the VirtPresenter tool provides editing tools for the original video with which learners can link the original segment to alternative segments, provided the content of the original and alternative segments is the same. The segments in the original video can be linked to alternative segments with different difficulty levels. While learners watch the original video, they can switch to advanced or basic segments that have been linked. This type of system requires a huge content repository of alternative segments for a given video.

The advantage that VirtPresenter has over the DIVER tool is that students have more flexibility in creating clips, as it allows them to add alternative clips from different videos and not from a single video as in the DIVER tool.

However, there are no studies in support of VirtPresenter, as is the case with the DIVER tool. In addition, the DIVER tool focuses on the visual aspects of the video and how different points of view of the same video can affect student understanding, while VirtPresenter focuses on the addition of alternative clips in the original video to make the content more comprehensible instead of summarizing the video. Moreover, the DIVER tool does not focus on the information itself, but on how the combination of different types of information based on students' preference affects students' understanding and learning.

2.4.3 Summary of Video Summarization

As seen in the previous sections, several attempts have been made by researchers to enhance learner motivation and understanding with the use of video summarization tools. As discussed previously, introducing videos, specifically short and summarized videos, in learning can enhance motivation and understanding. However, although these tools received positive responses from the learners, they were not compared with other traditional teaching tools (such as textbooks and classroom lectures) to study their effect on understanding and motivation; thus, there is no empirical evidence of their advantages.

Automatic summarization of video clips could help reduce the effort required for creating summary videos. However, as was shown in the previous studies mentioned in Chapter 2, particularly in Ren and Zhu (2008) and Chang, Yang and Wu (2011), the automatic summarization of videos with the help of computer algorithms and without human interaction is chaotic and is not an accurate process. It is difficult to automatically identify the important parts of the video content based on an algorithm alone, without human interaction. Further, another advantage of summarization involving human interaction is that it allows for more interaction with the video, which can have a positive impact on learner motivation and engagement (Agarwala et al. 2012). The promotion of engagement by user interaction with the system in the creation of summary videos is supported by the constructivist theory, according to which learning occurs more efficiently when the learner is actively engaged in problem solving.

Summarization of video lectures is an engaging activity for users as it requires them to identify important parts of the video and combine them into a short video clip that summarizes the entire video. Simply watching a long detailed video may affect a learner's concentration, due to the redundant information and unrelated discussions that are a part of the long video. On the other hand, engaging in summarization will drive the learner to listen and watch carefully for the important parts and cut out the unimportant parts. Thus, the learner is more actively engaged in the learning activity and has better concentration. In addition, the created short video clip can be reused later while revising, as the learner has essentially created revision material for himself/herself.

The benefits of collaborative and social learning with regard to enhancing learner motivation have also been demonstrated with tools such as DIVER and Video Pathway. However, there is no empirical evidence to show that collaborative and social learning tools can enhance coherence.

When students create their own videos from different sources and link each video to one another, they are engaged in an inventive, constructive and active experience where imagination, creativity and knowledge-building experience come into play. Therefore, these e-learning systems are in keeping with the constructivist theory, as the ACES tool helps students construct their own knowledge, which motivates them to engage with the content.

Although there is a very limited pool of research in this area, the idea of combining summarized video learning with collaborative learning to create a single e-learning system seems appealing. In the present study, such a system will be explored and evaluated with regard to its effects on understanding and learning motivation. In the next section, studies on collaborative e-learning environments are reviewed.

2.5 Collaboration in E-Learning and Peer Learning

Collaborative learning is a learning process where two or more people work together to create meaning, explore a topic or improve skills (Resta and Laferriere, 2007). Participants in collaborative learning gain the benefits of working together to build knowledge and skills, sharing information from the source material, and commenting on the works of others. Laister and Kober (2002) discussed the features of collaborative learning in a virtual environment. According to them, collaborative learning is a well-organized training system for students who prefer to learn together, and it can be viewed as an outcome of daily organizational practice. In their study, they discuss how collaborative learning can aid students in achieving goals as they share their knowledge and experience with each other. In theory, models of collaborative learning are very effective as means of learning. In practice, collaborative learning can build personality traits that can help participants in their future learning, cooperative learning and work.

Bingham (2011) defined social collaborative learning as a process that involves learning with and from others. It has been around for long time and is witnessed at conferences when participants work in groups. This process, coupled with current internet-based technology, can occur online among colleagues who work in the same group but never meet in person.

Online collaborative learning is a form of collaborative learning that occurs online where the Internet is used as a tool for collaboration. In this context, the scope of social media can be extended to information and knowledge sharing. Online communication can offer a lot of opportunities to students, as the cost of face-to-face meetings is reduced or eliminated. The cost of such meeting increases as the number of group members increases.

2.5.1 Sharing Materials in Collaborative E-Learning

Tervakari et al. (2012) believe that web-based learning environments provide the student community with improved opportunities for communication and collaboration, and they tried to prove this in a field study. They argued that students often seek the help of other students rather than teachers. Therefore, they provided a social media service with the purpose of enhancing student collaboration, communication and networking skills, and promoting peer learning in small groups.

The experiment was held at Tampere University of Technology (TUT) in Finland. A designated system called the TUT Circle was used as the learning environment. The main feature of the TUT Circle is that students can form groups where all the content is shared among group members. The content is created by students and shared with selected groups. The content can be in many forms including Wiki pages, blog posts, news items and events. Other important aspects of the TUT Circle include instant messaging, commenting and contributing to contents. In the experiment, an online course called Usefulness of Web-based Services was organized by 35 students. The TUT Circle was used as a learning environment for this course to promote student networking, collaboration and communication in small groups. Students were required to contribute to weekly assignments by writing at least one relevant message on a discussion forum. Students were motivated by extra points to write additional messages in five of nine weekly assignments. This was to promote information sharing and active participation. In addition, students were given other tasks, including group-work projects, where they were divided into nine groups. The log data were collected to evaluate interaction, and a survey was conducted after the experiment to assess student experience after they used the TUT Circle for learning. The survey aimed to evaluate students' peer learning activity by asking them to respond to 14 statements by assigning a score on a 5-point Likert-type scale, in addition to other open-ended questions.

The log data showed that students read other student's messages intensively, but few students commented on the content created by other students. The interaction was slow, and most of the activity occurred close to the assignment deadline. Group interaction was moderate because students strictly controlled the visibility of the content of their groups, and most of the contents were private to students within the group. This indicates that over-securing collaboration data minimizes interaction in collaborative e-learning environments. There should therefore be an open space for information sharing, as the purpose of the collaborative environment is to improve communication, information sharing and learning overall.

According to the results of the survey, only 34% of the students thought that sharing, presenting and producing information were easy. Further, 40% of the students found it difficult to present their ideas and questions, and half of them found it difficult to comment on the messages. Another major finding was that only one-third of the participants found the resources in the system useful to their learning, and only a quarter of them thought that presenting their own ideas, opinions and questions was useful to their learning. The survey results also showed that half of the students thought that the TUT Circle did not support interaction in group work.

Overall, the results were largely affected by how the TUT Circle was designed. The other major factor was lack of motivation in the students to use the system, as revealed by the increase in interaction at the time of submission. This suggests that students were not motivated to use the system for collaboration, and they tended to do most of the work off the system, using the system only for the purpose of submission.

2.5.2 Personal Learning Environment

In another effort to explore the benefits of collaborative e-learning, Rodrigues, Zhou and Sabino (2011) studied how e-learning can improve learning experience using social networking. For this purpose, an e-learning platform called Personal Learning Environment Box (PLEBOX) was used. The collaborative features offered by PLEBOX were wall posting, real-time chatting, groups, links, and RSS. These modules created a knowledge- and data-sharing environment among platform users. The study was conducted on a group of 187 students over a period of four months before a survey was administered to the users to evaluate their experience with PLEBOX.

The survey contained six questions:

- Is the design attractive?
- Are the modules easy to use?
- Are the modules useful?
- Were you satisfied after using the created modules?
- Are the modules helpful to share information?
- Are the features easy to use and do they work correctly?

The survey results showed that 70% of teachers and 95% of students found the modules easy to use. Moreover, 90% of teachers and all the students agreed that the modules were helpful for information sharing.

A limitation of this study is that there is no evidence in support of improvement of learning and factual knowledge. Thus, although the users were satisfied with the features and functionality of the system, its effects on learning are not clear.

2.5.3 Vialogues in E-Learning

In an empirical study on the effectiveness of vialogues in e-learning, Agarwala et al. (2012) combined the features of dialogues and videos to create a new asynchronous video discussion tool called the Vialogue. The Vialogue is a discussion tool based on videos that purposively targets reflective adaptive collaborative learning. The Vialogue system developed for this research included the following features:

- *Video-annotated Discussion for Interactive and Meaningful Conversation:* Vialogues allow students to share time-coded comments on the video at any specific time or portion. Other students can view and click on the time-coded comment, and the system will take them to that portion and time of the video.
- *Pedagogical Tools:* Learning activities can be designed and monitored effectively by teachers using the pedagogical tools and features provided by Vialogue. These tools include embedding at different points of the video, giving and receiving feedback, and interacting with students.
- *Moderate Participation*: Students can control the privacy of their own comments so that they have full control over whether their comments should stay private or be visible to other students.
- *Portability:* The discussions can be embedded along with the video using HTML code blocks for use in other external systems.

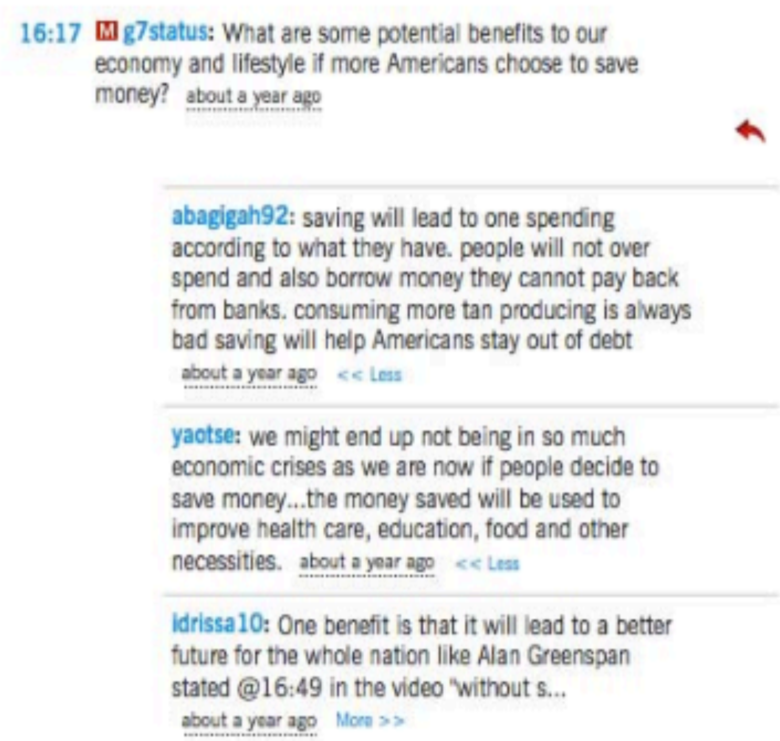


Figure 2.24: : Example of a Comment on Specific Portions of the Video in the Vialogue System (Agarwala et al., 2012)

For this study, the researchers collected data from the Vialogue system over a six-month period in many diverse settings, including educational classes, professional development, understanding fiscal responsibilities and also in film production. Data from a total of 272 users were collected, 177 of whom were active users who accessed the system more than once. There were 2460 distinct comments on a total of 311 videos. The activeness of the system (ratio of active users to the total number of users) was determined to be 65 on average, and participation (ratio of the average number of comments per active user) was determined to be 15.21. The data usage showed that the Vialogue user base had grown and was retained. Moreover, Vialogue users learnt to become moderators over time. According to the researchers, this information along with the relatively high amount of time the users spent on watching videos indicated that the system creates learning opportunities for users.

This empirical study showed that Vialogue can enhance motivation and create a social learning environment. However, although this had a positive effect on learner motivation, its effect on coherence was not assessed. Moreover, the learning opportunities provided and its contribution to learning are debatable. There were no data on individual learning behaviour and how it was affected by the Vialogue system. In addition, the system was not solely used in the educational domain, and many videos were related to other unrelated areas such as film production scenes where users used the system to comment and review the film scenes. Therefore, it cannot be assumed that the system contributed to learning and understanding, and such an argument is questionable.

As was implied by previous studies, a system that enhances the motivation level of a student will probably enhance student coherence, as motivation is known to increase learning efforts. Yet, in the absence of empirical studies, this claim cannot be verified.

2.5.4 Educational Videos with Collaborative Annotations

Wai Yat Wong and Reimann (2009) tested another form of video collaborative learning with the Educational Video with collaborative Annotation (EVA). EVA is a web-based interactive asynchronous video teaching and learning platform with the following features:

- Real-time collaborative temporal video bookmarking and HTML annotation,
- Synchronized video and annotation delivery for smooth presentation and viewing,
- Auto-indexation of the contents of video bookmarks,
- Associated annotation for easy searching and navigation.

The EVA interface contains two main parts: the first part is dedicated to video streaming, while the other part is dedicated to displaying video bookmarks and associated lists of annotations made by users.

The aim of EVA was to introduce a platform that supports interactive, collaboration and reflective learning. EVA was adopted by many courses offered at the University of Sydney, including sport coaching, child developmental psychology, teacher professional learning and social works. Here is an example of how EVA is used in sport coaching: a short clip of the students’ performance and live sessions is recorded and uploaded to the system so that it is available for other students and teachers to comment on. According to the researchers, the outcome of this implementation was positive and students interacted with the system.

EVA was developed to enhance micro-learning. The research findings suggested that EVA has indeed motivated students to participate, and they were excited about using EVA. Although the idea of using collaborative learning videos seems promising and suggests that motivation and coherence can be enhanced, the research lacked numerical data and survey results to support it.

2.5.5 Effects of Online Collaboration on Learning Material

Mukti et al. (2005) have studied how online collaborative learning can improve learners' understanding of the study material. Two groups of students were given identical projects and lectures in an animal diversity course. One group was randomly assigned to use traditional face-to-face collaborative learning, while the other group was assigned to use online collaborative learning communication tools such as e-mail, Yahoo messenger, activity bulletins and forums. To ensure proper collaboration between group members, careful planning and preparation was undertaken. Objectives, relevant materials, content knowledge and application, and process skills were clearly defined by the research team at the University of Kebangsaan, Malaysia. Groups of six students each were heterogeneously formed so that they contained a balanced mix of individual abilities, learning styles, backgrounds, ages and genders. The total number of individuals in the traditional collaborative learning group was 85, while the online collaborative learning group consisted of 101 students. The researchers did not cite any specific reason for the difference in the number of students between the two groups. In the introductory phase, the students were asked to introduce themselves to each other, and also were given clear explanations about the skills required to accomplish the tasks. In addition, the grading criteria and assessment system were discussed in detail. At the end of the semester, both groups were given an identical post-experiment test to measure their level of understanding.

The results showed a significant difference in the post-test scores between the groups. The online collaborative learning group had higher scores than the traditional collaborative learning group. These findings indicate that online collaboration fosters the development of higher order thinking skills and critical thinking via discussion, clarification of ideas, and evaluation of others' ideas. There was no significant difference in factual knowledge gain between the groups. Figure 2.25 shows a comparison of the scores and grades between the two groups.

A limitation of this study was that it did not determine whether the level of learning increased as a result of knowledge sharing.

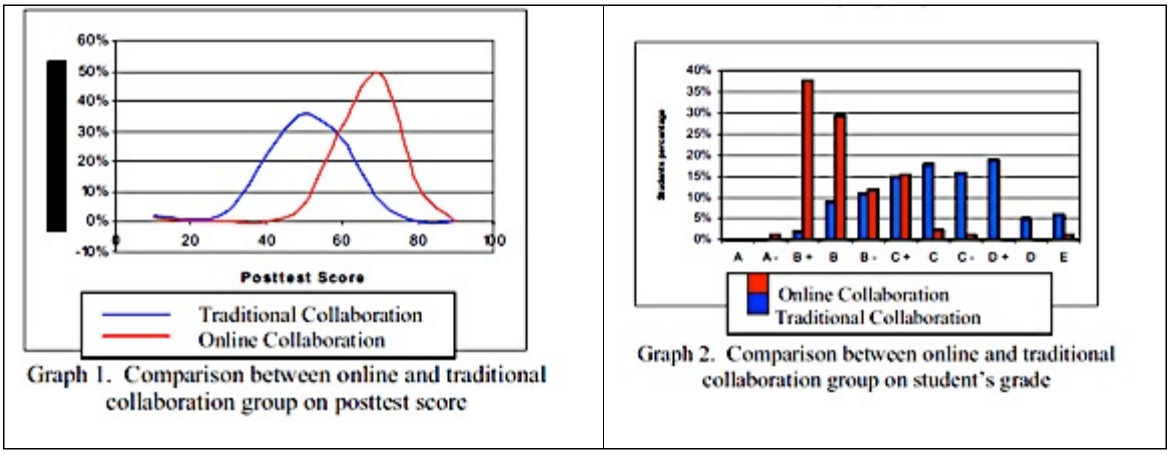


Figure 2.25: Comparison of Scores (left) and Grades (right) Between the Online and Traditional Collaborative Learning Groups (Mukti et al., 2005)

2.5.6 Interaction-Based Grouping of Students into Study Groups

The study by Jagadish (2014) aimed to maximize the benefits to users in an online collaborative learning environment by grouping learners based on the K-NN clustering algorithm. Jagadish believed that group structure plays a major role in maximizing the learning benefits of individuals in the group. He therefore proposed a grouping method based on the K-NN clustering algorithm to maximize learning abilities. The knowledge level of students in each class is calculated using questionnaires in order to assign students to groups closest to their knowledge level based on the K-NN clustering algorithm. After completion of the classification, students are allowed to enter chat rooms and interact with other students. An overview of the process is shown in Figure 2.26 (Jagadish, 2014).

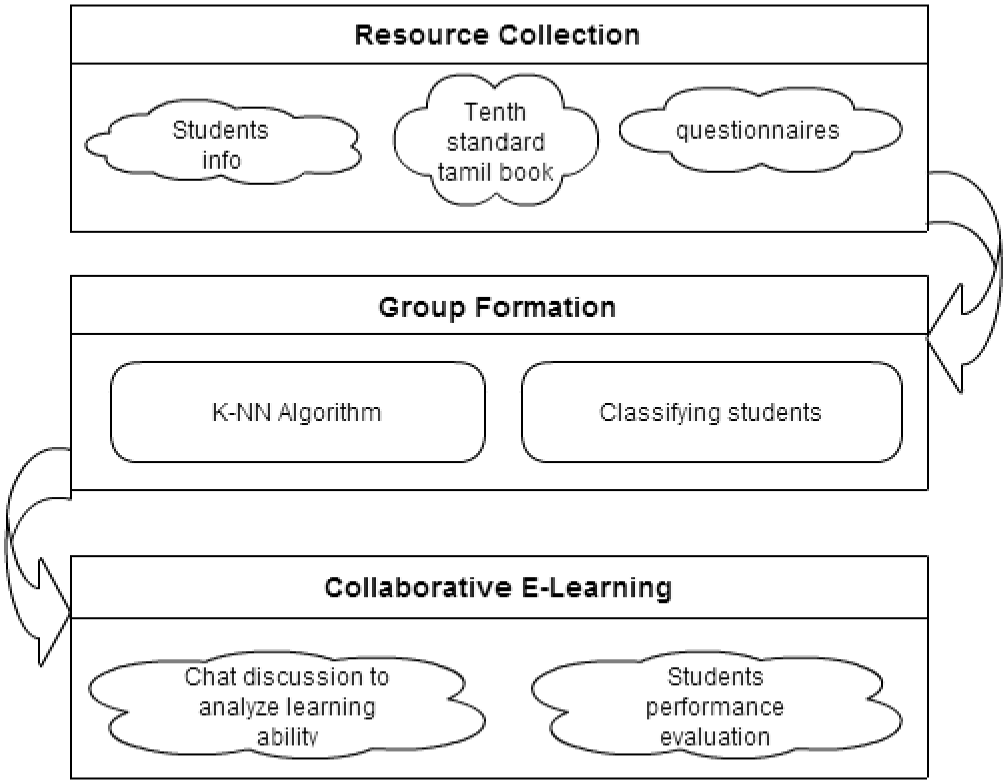


Figure 2.26: System Architecture (Jagadish, 2014)

The logic of the K-NN algorithm is shown in the following pseudo-code:

1- Procedure initial grouping (group list)
2- Updating the knowledge level of all students in the group list
3- Assigning each knowledge grid to student groups
4- Labelling all the other student groups as No Class
5- Repeat
6- For each student (S)
7- For each outside student group (G) of students (S)
8- For each neighbouring student group (H) of the outside student group (G)
9- If H belongs to cluster S2
10- If S > S2, label all groups in S as in S2
11- Else
12- Label all students grouped in S as S2
13- Else if H is transitional
14- Label H as in S
15- Until no change in the student cluster labels can be made
16- End of process

The algorithm retrieves a set of students and classifies them into three groups. These three groups of students are required to learn the text book content, after which they enter the chat rooms. The purpose of the algorithm is to create a balanced group with an even distribution of high-quality, fair and poor learners. According to the author, the availability of high-quality learners in each group will increase the knowledge level of other students by the sharing of valuable information in the group chat rooms.

Figure 2.27 shows a comparison of different grouping algorithms, which depicts that the knowledge level is maximized with the K-NN algorithm.

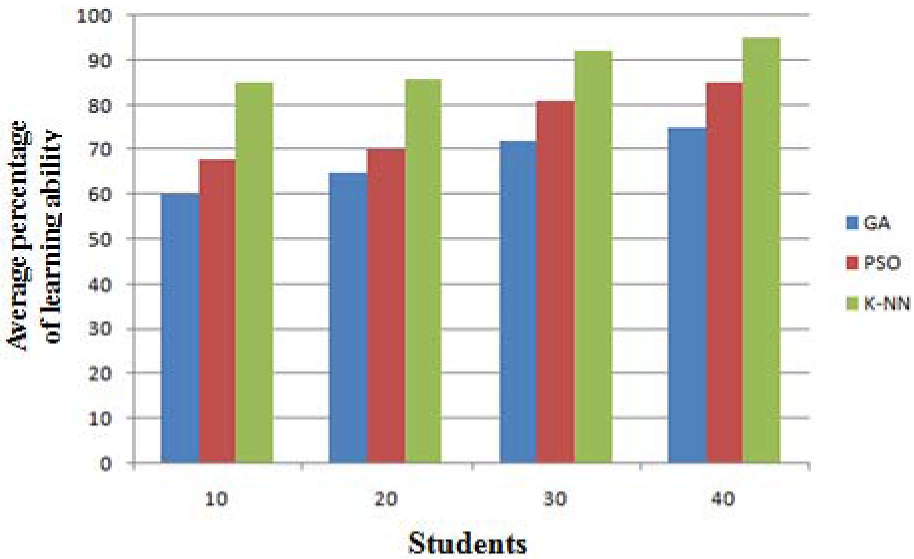


Figure 2.27: Comparison Between Various Grouping Algorithms (Jagadish, 2014)

The experiment included 10^{th} standard students in a Tamil learning course. The students were assigned to read the Tamil book and were tested before and after they interacted in the chat rooms. The results showed a significant increase in the test scores after they entered the chatrooms and collaborated with other students, as shown in Figure 2.28 and Figure 2.29.

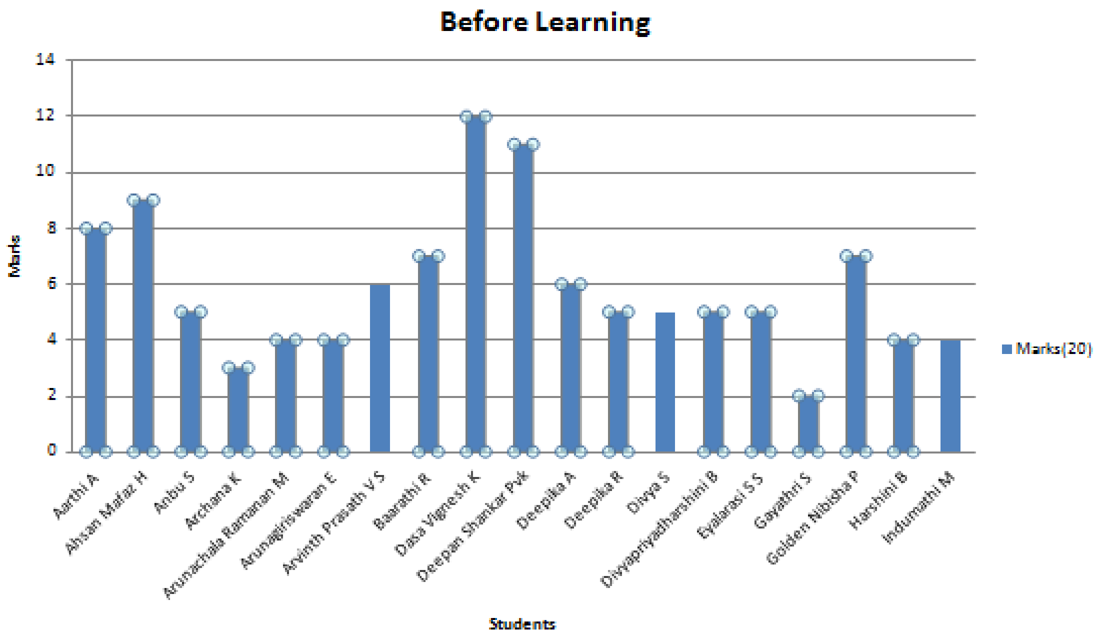


Figure 2.28: Pre-learning Scores (Jagadish, 2014)

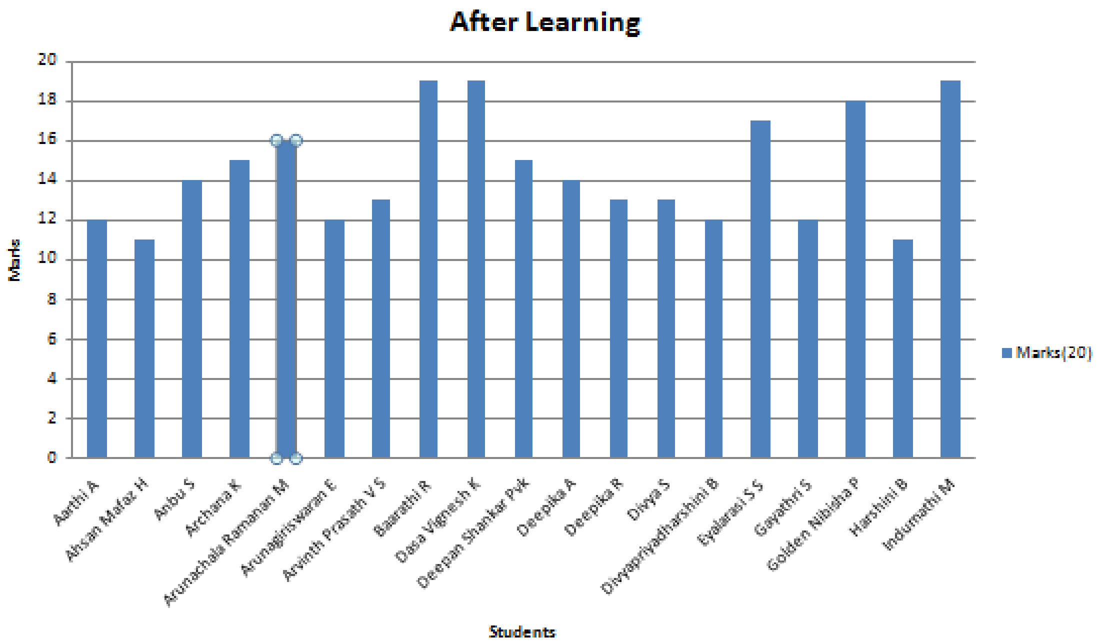


Figure 2.29: Post-learning Scores (Jagadish, 2014)

The research showed that collaborative learning improves the learning process, as evidenced by their pre- and post-chatroom scores. However, it cannot be definitively stated that this grouping technique increased the knowledge level of students, as the researcher does not clarify whether the same test was administered before and after the chatroom sessions. If the same test was administered, then it can be assumed that the students entered the chatroom with prior knowledge of the questions they would be asked in the next test and may have looked for answers to the questions they were unable to answer correctly in the previous test. In this case, the chat rooms may have been used only to seek answers to questions that students were previously unable to answer. Further, the researcher assumes that the presence of a high-quality learner among other lower quality learners will improve learning, as the high-quality learners will transmit their knowledge in the chat rooms. However, this cannot be guaranteed, as the personality of individuals play a role in their learning behaviours too, and individual personalities are neglected in grouping techniques. For example, high-quality introverted learners may not communicate effectively with other students in the chat rooms, so knowledge sharing may not be as effective in such scenarios.

2.5.7 Automatic Real-Time Assessment of Online Discussions in Peer Learning

The process and design of discussion flow in computer-aided collaborative learning are important aspects of a well-designed collaborative learning platform. The discussion feature is widely used in collaborative learning and learning in general, and a growing number of studies in this area suggest that many pedagogical organizations have moved on to apply and enable discussion features in their education systems. However, with the growing number of participants in the online discussion system, the monitoring and assessment of discussion content remain a challenge. To ensure valid content delivery by participants to build a knowledge base, a firm real-time assessment of the online discussion system is required.

Caballe, Xhafa and Abraham (2008) have proposed a multidimensional model based on data from analysis of online collaborative discussion interactions. This model represents the first step toward automatic real-time assessment of online discussions in collaborative learning. The research team has provided a framework that integrates various models and methods, including a negotiating linguistic exchange model, discourse contributions and machine-learning approach, in order to assess the discussion content provided by the participants. The discussion initiator can put in requests and tag initiations and therefore influence how their posts perform. Moreover, the posts are assessed through other participants' reactions to the post. Negative reactions can disqualify posts, while positive reactions make the posts more likely to be accepted and verified. The initiator has control only after the automatic tagging process. However, this step can be refined by tutors later on to ensure that incorrect tagging is minimized.

The experiment included graduate students enrolled for the Methodology and Management of Computer Science Projects at the Open University of Catalonia (UOC). They were required to use the system outside the campus for a duration of two weeks. The participant-generated evaluation proposed by the system was validated against the tutor evaluation.

According to the researchers, 75% of the evaluations were found to be valid, which suggests that this online collaborative system was able to successfully utilize participants' evaluation and validation of posts and minimize validation efforts by supervisors. In other words, the researchers believe that online discussion materials can be validated automatically by analysing the data generated from interaction between all the participants with no or little supervisor verification required. However, this is an arguable finding, as 25% of the student evaluations were not valid or did not match those of the supervisors. Therefore, this system clearly has room for improvement.

2.5.8 Benefits of Peer Learning

According to Boud, Cohen and Sampson (2014), peers are people in a similar situation who do not play the role of a teacher or expert practitioner. They explained that Students learn better by explaining their ideas to others and by participating in activities to learn from their peers. Also, students "develop skills in organizing and planning learning activities, working collaboratively with others, giving and receiving feedback and evaluating their own learning" (Boud, cohen and Sampson, 2014). Researchers added that "peer learning is becoming an important part of many courses, and it is being used in a variety of contexts and disciplines in many countries". In addition, as the advantage of peer learning, students can learn successfully, as students have the opportunity to learn from each other. "It gives them considerably more practice than traditional teaching and learning methods in taking responsibility for their own learning and more generally, learning how to learn”.

‘Peer learning encourages different types of learning outcomes. Some of the outcomes involve:

- Collaborative learning (Working with others): “peer learning can create a sense of responsibility and increase confidence and self-esteem through engagement in a community of learning and learners. Much learning takes place from sharing others’ experiences, existing knowledge and skills. Students learn about the backgrounds and contributions of the people they are working with. Peer learning necessarily involves students working together to develop collaborative skills” (Boud et al, 2014).
- “Critical enquiry and reflection: Challenges to the existing ways of thinking arise from more detailed interchanges between students in which points of view are argued and positions justified” (Boud et. al, 2014).
- “Communication and articulation of knowledge, understanding and skills: Concept development often occurs through the testing of ideas on others and the rehearsing of positions that enable learners to express their understanding of ideas and concepts” Boud et al, 2014).
- How to learn and mange learning: “Peer learning activities require students to improve self-management skills and require them to achieve with others. Learning to cooperate with others to reach mutual goals is a prerequisite for operating in a complex society. Peer learning prompts the acquisition of knowledge about ways of working with others in groups and one-to-one, and the implications of one’s own learning choices on others. Seeing the different approaches that others use can broaden students’ understanding about variations in learning” (Boud et al, 2014).
- Self and peer assessment. There are seldom enough opportunities for formative assessment and feedback from staff in order to develop skills and concepts significantly. Peer learning settings provide opportunities for additional self and peer assessment of a formative kind’.

While students share knowledge and learn from each other as peer learners, they also explain concepts to each other as peers. In video summarization, students need to understand the subject in depth in order to be able to summarize the video and deliver the information in a way that their friends can understand easily. Falchnikov (2001) mentioned that the more knowledgeable individual can act as tutor to the less knowledgeable ones. Students can explain specific ideas that other students do not understand by discussing the video, adding scene comments and adding notes or images to make the created video content more clear and easy to understand.

According to Falchnikov (2001), the benefit of peer learning is the free communication style, which allows students to freely discuss any points that they do not understand without any fear: 'That the tutee may respond without fear of ridicule or reprisal and may be less reticent about asking "stupid" questions of a peer tutor than they would of a teacher'.

2.5.9 Summary of Collaboration in E-Learning

In summary, the studies on collaborative learning reviewed here indicate that the usability and ease of tasks are very important issues in collaborative learning. Moreover, Tervakari et al.'s study showed that over-securing collaborative content was counter-effective for collaboration. Another important finding was that collaborative features in video learning are motivating and create a social learning environment for students. Further, Mukti (2005) also reported that online collaborative tools enhance critical thinking ability and thinking skills.

2.6 Literature Review Conclusion

Overall, This research utilizes three main learning features for increasing motivation, understanding and engagement: video learning, video summarization, and collaboration. Video learning is backed by the Piaget theory of constructivist, as it suggests that students can construct their knowledge and search for the information they need to solve the problem and engage with the subject matter. Adding activities in learning by using videos could help increase motivation and transform the passive learning role into a more active one and thus increase student engagement. As videos arguably provide a simulated real-life experience rather than a basic visual representation, they indeed represent active learning. Summarization as a tool is backed by the cognitive load theory, as it helps to reduce extraneous load by removing redundant information from a long video and introducing relative important issues. The constructivist theory backs the concept of summarization and collaboration, as both are required to increase the engagement level of the user.

In this chapter, these concepts have been supported by some key studies that have been reviewed. The two important tools developed (as discussed in section 2.4.2.1) are the DIVER tool (Zahn et. al., 2010) and VirtPresenter (in section 2.4.2.3) (Mertens, Ketterl and Vornberger, 2009). The DIVER tool can be used to edit a single video and share it with other students. However, Zahn's study did not provide evidence of the effectiveness of this tool in improving understanding and motivation or compare it to other tools. VirtPresenter allows students to edit a video using alternative clips from different sources instead of from a single source, which is an improvement over DIVER (videos can be summarized only from a single source). However, again, there are no empirical studies to support the effectiveness of such a tool, and the video streams are limited to set pathways. Thus, although the general effectiveness of these tools is evident, their application is educational settings is questionable in the absence of empirical evidence. The present research will build on the key findings presented in this chapter to develop a bespoke learning framework and conduct a live study with volunteers assigned participants to demonstrate the effectiveness of summarization and collaboration tools in education.

Chapter 3: Methodology and System Framework

3.1 Introduction

The literature review in the previous chapter demonstrated the potential of an e-learning tool that uses collaborative videos and video summarization. Based on the findings from the review, a pedagogical tool will be developed for summarization of video clips and collaboration in the learning environment.

This chapter provides a detailed overview of the approach used in this research. This includes an overview of the research methodology and how data are acquired, and detailed coverage of the pedagogical system developed and used for the experiments. The follow figure 3.1 depicts the stages of the research and the time period of each stage.

Figure 3.1: Overview of the research stages

The main factors that affect the motivation, understanding and management level of learners are used in the developed system. After the system was developed, an experimental pilot study was conducted with the participants where the system was a part of a live module during the academic term. After the pilot study results were analyzed, the system was modified based on the findings for use in the full study. The experiment was performed in the following term after the pilot study, which was the first term of the year. The experimental protocol was similar to that of the pilot study, but the modified system and approach were used, the details of which will be provided in the following chapters.

3.2 Research Approach

This study relies on (1) a quantitative approach that uses quantitative data from the survey and the pedagogical system developed, and (2) a qualitative approach that uses the findings of a post-experiment survey. This mixed-methods approach was used, as a single methodological approach based on either quantitative or qualitative data can make the findings ambiguous. The limitations of using only the quantitative or only the qualitative approach are discussed:

Quantitative approach: Solely relying on the quantitative approach by using questionnaires and user data generated from the system (this will henceforth be referred to as 'user data' for the sake of simplicity) may limit the participants' responses to rigid pre-defined responses set by the research designer. Thus, the use of questionnaires can limit users' responses to specific findings and leave no room for thoughts or opinions that are not already included in the survey. This rigid nature of the quantitative research approach may result in a relevant variable being missed entirely (Creswell, 2013). According to Matveev (2002), the quantitative method offers the possibility of 'achieving high levels of reliability of gathered data due to controlled observations, laboratory experiments or other forms'. Moreover, Matveev (2002) says that the quantitative method 'states the research problem in very specific and set terms and arrives at more objective conclusions'.

Qualitative approach: One of the qualitative methods used was the semi-structured interview, with which new ideas can be brought up while students answer the questions. The other qualitative method used was case studies. However, the validity of qualitative findings may be compromised when the findings are generalized to large populations due to their subjective nature and the relatively small samples used. In other words, the subjective nature of qualitative data makes it difficult to generalize the findings to the population at large (Creswell, 2013).

In order to ensure the validity of the data, a sequential integrated method of research design is recommended where quantitative, qualitative and user data are analysed in parallel to minimize ambiguity. This is also called the triangulation method (Mertens and Hesse-Biber, 2012).

3.3 Research Phases

This research consists of five phases:

1. Development of the learning framework: In this phase, a system that utilizes functionalities evaluated in previous studies will be developed. The main factors that affect the coherence, motivation and understanding level of learners are utilized in the developed system.

2. Pilot study: After the system is developed, an experimental pilot study will be conducted with participants where the system is a part of a live module during the academic term. Participants are encouraged to interact with the system in a way that ensures all functionalities of the system are used, and user statistics will be recorded.

3. Analysis of the results and system modifications: Pre- and post-experiment surveys will be conducted. A qualitative approach is used in the survey, along with a quantitative approach, to evaluate user experience with the system. After the pilot study results are analysed, the system will be modified based on the findings for use in the full study.

4. Full study: In the full study, participants use the system during the following academic term. The experiment will be similar to the pilot study but with a modified system and approach and a larger sample, based on the analysis and feedback from the pilot study.

5. Analysis of the results: The user data generated from the system will be evaluated using quantitative and qualitative approaches (1) to assess the effectiveness of the system in motivating and encouraging users to effectively utilize the system to summarize lecture videos and (2) to assess their level of understanding and engagement.

Students have extended access to the system over the module's duration, and they will complete a post-experiment survey at the end of the term. The pilot study is used to validate the system and the research decisions before the main study is undertaken.

3.4 Data Acquisition

There are five sources of data, which are briefly outlined below, but explained in more detail in chapters 5 and 6:

Pre-experiment questionnaire: The purpose of this survey is to evaluate users' experience with video learning and previous video summarization tools (appendix 2.1 and 3.1).

Post-experiment questionnaire: The purpose of this questionnaire is to qualitatively evaluate the usability and effectiveness of the system from the perspective of the participants by using a quantitative approach. To evaluate the results, the QUIS questionnaire was used. The QUIS questionnaire was designed to assess users' satisfaction and judgement of a specific statement to measure their attitude towards different interface factors. In addition, the USE questionnaire was administered to evaluate the usefulness and ease of use of the system (appendix 2.2 and 3.2).

Post-experiment interview: Open-answer questions are asked in the post-experiment questionnaire so that participants can talk about their experience. The purpose of the interview is to qualitatively evaluate how the system has supported the learning process by using the qualitative approach.

User-generated data*:* User-generated data are data extracted from the database such as the number of summarized lectures created by the students, number of comments added, and number of scene comments added to the summarized video clips.

Researcher observation: This refers to the observations made by the researcher during the experiment.

3.5 Overview of the Experiment

The pilot study was designed to test the technology and system interface, and the full study was designed to determine how the use of videos in education enhances motivation, provides a better understanding of the learning material, and improves the learning of knowledge based on the constructivist theory and the technological pedagogical content knowledge (TPCK) formulation, as well as the reported benefits of e-learning, collaborative learning and videos in learning.

3.5.1 Experimental Design

Both the pilot and full studies will use a within-subjects experimental design. According to Charness et al. (2012) and Keren and Lewis (2014), in a within-subjects design, one group of participants is tested more than once and their results are compared at the end of the study. That is, the same group of students are tested under different conditions and the results are compared to determine whether they prove the hypothesis proposed. In the actual experimental setting, "the subject is exposed to different experimental conditions that differ substantially with regard to the stimuli employed and the subject is never exposed to the same stimulus more than once" (Keren and Lewis, 2014). According to Keren and Lewis (2014), the differences observed between conditions in an experiment with a within-subjects design are not confounded by individual differences, as the subjects act as their own controls. The exclusion of individual differences results in a higher degree of sensitivity to treatment effects or, in other words, improves the statistical power of the findings.

Using a within-subject design is efficient in terms of subjects and time, as it can be completed in less time: in this research, the actual study was conducted over a period of three months with the same group of participants. The within-subject design is statistically efficient and makes it easier to detect differences across different levels of the dependent variable, which measures the level of motivation, understanding and management. Moreover, to avoid the carryover effects of this experimental design, an interval was included between each condition and different tasks to prevent fatigue and practice as the one condition was tested at the beginning of the term and the second one was tested after 7 weeks. In addition, the different tasks and measurements were beneficial for solving the carryover effect of assimilation and the contrast effect, which will be explained in more detail in Chapter 6. Finally, to avoid the catching-on effect, the aim of the study was explained as follows: the aim of the new system is to help improve motivation, understanding and management, either via self-directed learning without knowledge sharing or self-directed learning with knowledge sharing.

Permission to divide the students into two groups (one with access to the tool and one without access to the tool) was not provided by the department and course coordinator, as it was not in keeping with the rules of the academic institution (students need to given equal access to all study resources). The experiments will be therefore conducted on all students at the same time, and the results for each condition will be compared based on the following questions:

1- Do summarization and sharing with friends help students improve their coherence, motivation, understanding, knowledge and engagement?
2- Are students satisfied with the new learning tool with regard to the engagement it provides with a more active learning process?
3- Does the system meet students' learning needs in the learning environment without the need for additional tools?

The ACES tool provides the same learning material (video lectures) that the students would have received as part of the course, which would have otherwise been delivered without the new system proposed here. The questionnaire was handed out to the students before and after they used the summarizing video and collaborative tools.

3.6 Sampling and Study Media

The pilot study was an experimental study performed in a new learning environment before the full study is performed. The target populations for the pilot study were undergraduate and postgraduate students enrolled for the *Multimedia Design and Application* module. This module was selected based on the modules available at the school that provide lecture videos, which made it easier to upload existing video lectures into the system.

To collect the sample, a self-selected sampling approach was used, which involved gathering data from a target population available during term time, studying the module and being willing to take part in the experiment. Students were asked to sign a consent form if they wished to take part (appendix 1.2). Therefore, the participants were selected on a random voluntary basis; more details are presented in the following section.

Similar to the pilot study, the target population of the full study, which commences after completion of the pilot study, will be students from the same school. The selection process will also be similar to that of the pilot study. The full-study experiment will take place in the beginning of the autumn term, from September 2015 to the end of the term. The full study will be conducted 6 months after the start of the pilot study, so that there is enough time to analyse the results and modify the system.

In both studies, the students will use all the features of the system available during the study, including generating videos, participating in collaborative environments, and using annotations and comments. The students must have a good understanding of how to use the system, as this goes beyond standard interaction with a video that is usually a part of online learning. Therefore, a tutorial section is provided to students to help them understand how the system functions. Any additional features and changes introduced in the modification phase after the pilot study will be explained in detail in Chapter 5.

Only students who enrol for the modules have access to the system. As the original videos are video lectures from the *Multimedia Design and Application* module, the participants are those enrolled for this module only. This is because summarizing a video requires an in-depth understanding of the subject rather than just a general view of it. Based on the Shulman theory of pedagogical content knowledge, which is explained in detail in Chapter 2 (section 2.1.7), students need to understand the subject in depth to make the content comprehensible to others. In addition, creating summary videos only from the provided lectures reduces the possibility of the students introducing incorrect and irrelevant material in the summary videos, which is likely when students look for material from different online sources.

The video format is used in this system is SussexDL, as mentioned in Chapter 2. The Gilardi et al. (2015) research showed that the level of engagement is greater with SussexDL than with other delivery formats; however, the results also show that the engagement level with SussexDL is quite similar to that with in-person lectures.

3.6.1 Pilot Study

The main purpose of the pilot study is to make sure that the system functions and to obtain feedback about the system in general before the actual study is undertaken in September. Therefore, a sample audience of at least 20 students is required to obtain statistically significant data. This number is derived based on past academic research discussed in the literature review. For example, as described in section 2.3.2.2, the researchers who introduced the Video Pathway system had 13 participants in their first experiment and 18 participants in the second experiment. It was not important to obtain a higher number of participants in the pilot study, as the pilot study was performed only to test the technology. Therefore, a sample of 20 students, similar to those in studies conducted in the same area (as shown in Chapter 2), is justified. Additionally, due to technical problems with the IT service (chapter 5, section 5.6.4), the experiment took place at the end of the term and the number of participants was low because it was during the time of course submission. The sample audience was recruited on a voluntary basis from among male and female students in informatics. The breakdown of the user group for the pilot and the full study will be discussed in Chapter 6 and 7.

The module has a 12-week duration, but the system was only available during 8 weeks of the module due to problems in deploying the system. This will be discussed later in Chapter 5.

3.6.2 Full Study

Based on the results of the pilot study and students' feedback in the post-study questionnaire, the system will be modified.

The module, which covers 12 weeks, started in September 2015 and ended in December 2015. The participants in this study were enrolled in five different courses, but all of them had enrolled for the 'Introduction to Multimedia' module. In the first week, the students were asked to try out all the functionalities in the system. In week 7, the students were divided into three groups based on their lab session time as decided by the module leader. Each student was assigned a task, which they needed to complete by watching the videos. The following tasks were assigned:

1. Use lectures 2 and 3 to create a summarised video, which answers the following question: Commonly, compression is applied to images to reduce the file size. Explain how this is done based on how humans see light and the make-up of sensors in the eye, and follow this with a description of the first two stages of the JPEG compression format and any other clips you feel appropriate.

2. Use lectures 2 and 3 to create a summarised video which answers the following question: Explain how the GIF image format works with an initial description of the difference between True and Palette colour followed by a description of the GIF format and any other clips you feel appropriate.

3. Use lectures 6 and 7 to create a summarised video which answers the following question: Explain how web pages are served by providing a description of how HTTP works followed by how HTML works and add any other clips you feel appropriate.

They were required to gain an in-depth understanding of the content and then create a video to answer the question assigned to them. Following this, the students needed to share the created video summary with other students. This will be discussed later in Chapter 6.

Three different conditions were set for using ACES in the full study, as listed below:

- Using ACES for watching videos (WV, condition 1)
- Using ACES for watching videos, summarizing videos, adding notes and comments and uploading images (WVS, condition 2)
- Using ACES for watching and summarizing videos, adding notes and comments, uploading images, sharing the videos with friends, and discussing the created videos (WVSC, condition 3).

In each condition, different tasks were assigned. Under condition one, the students were only expected to watch the video. In condition two, the students were asked to create a general summarization of the video lectures, and in condition three, the students were assigned the different tasks. In the first week, students watched the video and summarized it, and in week 7, the students answered the task questions and shared it with others.

3.7 Ethical Considerations

Before the experiment was commenced, an ethical review was required to ensure that user data were handled in the correct way and also to obtain permission for launching the trial system and collecting the data from postgraduate and undergraduate students. The information sheet about the study, the consent form, the details of the experiment, the recruitment email, and the pre- and post-questionnaires (provided in Appendix 1, 2 and 3) were subjected to an ethical review.

- <u>*Information Sheet:*</u> This sheet explains the purpose of this study, which is to evaluate participants' learning experience with using the system and their satisfaction level during participation in the summarized video-generating system. This sheet also indicates the criterion for inclusion, which is access to the online lectures in this module; that is, only students enrolled in the *Multimedia Design and Application* module were included. Moreover, the information sheet covers all the information that the participants need before they participate in the experiment (See Appendix 1-1).
- <u>*Consent Form:*</u> The participants are required to sign the consent form before they can take part in this video summarization and adaptive collaborative e-

learning environment project at the University of Sussex. The participants will be informed that all the provided information is confidential, and that participation is voluntary (See appendix 1-2).

- *Recruitment Email:* The recruitment email explains the aim of the research, provides all the information related to the experiment, and specifies the schedule of the experiment. Further, contact information is provided so that the participants can ask any questions related to the experiment. The recruitment email is sent to all participants (see Appendix 1-3).
- *Pre- and Post-Test Questionnaires:* A copy of the pre- and post-test questionnaires is sent to the ethical review team, as required in the ethical review process (see Appendix 2 and 3 respectively). The questionnaires are provided in detail in sections 5.6.1 and 5.6.2.

The ethical review described here is the one proposed for the pilot study, and a similar ethical review will be used in the full study, which commenced in September 2015 (Chapter 6).

3.8 Summary

This chapter has illustrated the research methodology used for this study and how it has guided data collection. The first section described the research phases along with the data acquisition techniques. The research phases included a brief description of the pilot and the full study that will be presented in the following chapters. This was followed by an ethical review of the study.

These methodologies described will be put into practice in the following chapters, which describe the pilot study and the full study.

Chapter 4: Design and Development of the E-learning System

4.1 System design

As discussed in Chapter 2, this e-learning system will be based on theories related to motivation and coherence in learners. The system features are mainly derived from previous research that attempted to create a learning environment than was more effective than the traditional learning environment. This is discussed in the summary section of Chapter 2.

This section presents an overview of the system developed for the first experimental study. This includes technical implementation of the system and a description of the system models. In addition, key design decisions and their origins in the theory framework discussed in Chapter 1 and 2 are discussed.

4.1.1 System Framework

This system is a web-based one that does not require any special applications at the client end apart from a browser. This provides easy access from any device, including mobile devices and tablets. The system was developed using the PHP framework at the server end and HTML 5 and JavaScript at the client end, along with the FFMPEG library for summarization (FFMPEG software, 2013). The database utilized is MySQL (MYSQL, 2008).

4.1.2 System Architecture

The system is hosted on a single web server that is physically located at the University of Sussex and hosts the database, video directories and the video editing tool (FFMPEG). All client requests are handled by this server. The conceptual model of the system can be summarized as shown in Figure 4.1. Summarization of the video is divided into two main processes: first, the student creates a holder that contains multiple clips from the same or multiple videos; then, the student creates a video from the created holder by selecting the clips that need to be merged into a single video. Once the student confirms the selected clips and the video information (video title and description), FFMPEG is used to create and combine the clips into a temporary video file. This information is entered into the database and the video is entered in the directory. After this process is completed successfully, all the temporary files and selected clips are deleted and the student is notified that the video was successfully created.

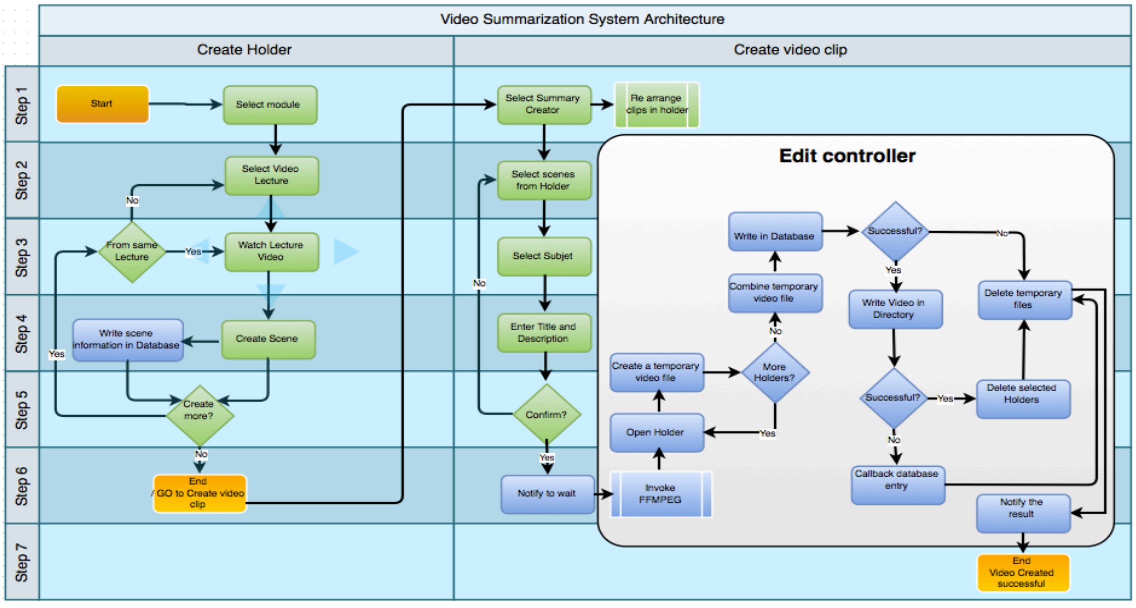


Figure 4.1: Conceptual Model of the System Architecture

4.1.3 System Users

The system is designed for four types of users. Each type of user has pre-defined functionalities:

- *Admin*: The admin is responsible for adding information about the university, coordinators, and subjects. As different universities may use the tool, the coordinator for each university needs to be added.
- *Coordinator*: The coordinator of each university is responsible for adding teachers and students at his/her university and linking them to their corresponding subjects, which are added by the admin.
- *Module Leader*: The teacher is considered as the module leader, who uploads their own video lectures for the subjects. The students watch the lecture videos and summarize them.
- *Student*: The students are the main users of the system, as the system and the study are built with the student's perspective in mind. The students are

able to use the summarization and collaborative functionalities of the system.

4.2 System Modules

In this section, the functionality of the system and its tools are discussed in detail, along with the key design decisions and their relationships with the theory framework discussed in Chapter 1. The system consists of two separate correlated tools: video summarization and virtual collaboration.

4.2.1 Video Summarization Tool (ACES)

This tool provides students with the functionalities they need to create a shorter version of lectures from different related sources. The functions of the video summarizing tool are shown in Figure 4.2.

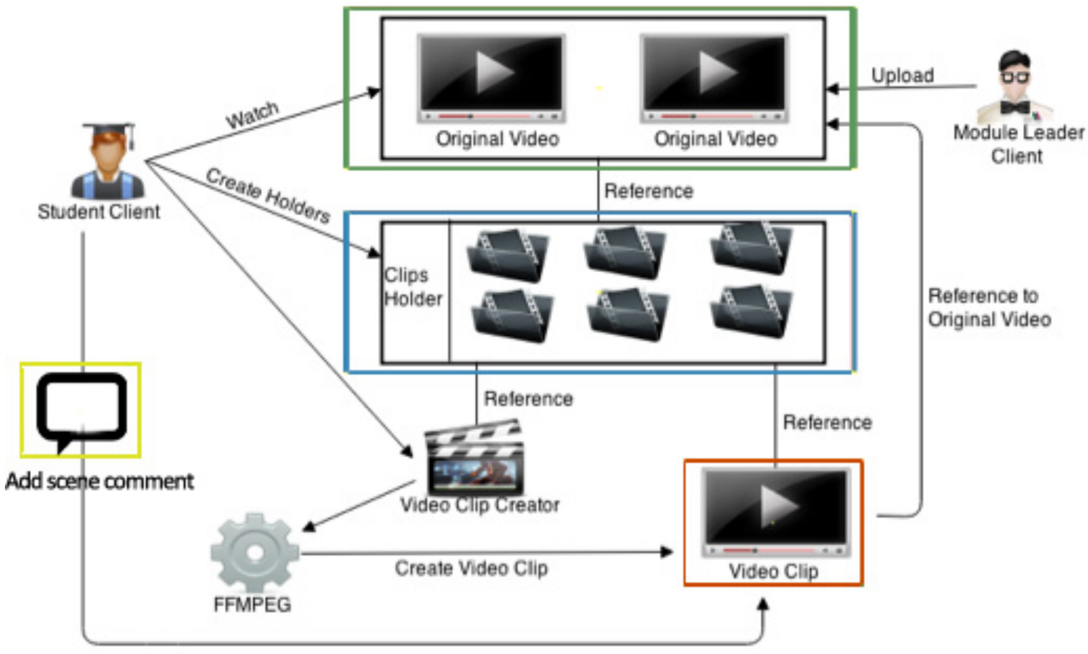


Figure 4.2: Conceptual Design of the Video Summarizing Tool (ACES)

The video summarizing tool will consist of the following four elements, as shown in Figure 4.2:

- Original video: The system is initially populated with a set of original video lectures. The original video lectures are lectures that have not been edited or summarized and are relatively long. In the case of the module being used, the original videos are 50 minutes long. These videos act as the basis for all summarized videos that students interact with. It is important to control the content of original videos to ensure that the system stays true to its educational purpose and to avoid incorrect or inappropriate flow of information in the system. Although a future system that includes a tutor review of external videos could be envisioned, the additional time and effort required on the part of the tutors prevents the inclusion of this feature in the present experimental study. Therefore, original videos are only provided by teachers, and students can only create summarized videos from the original videos provided (Figure 4.3). More information about adding videos is provided in section 4.4.

Figure 4.3: Original Video Display for the Multimedia Design and Application Module

- Clip Holder: Students can capture parts of the original videos and save them as scenes for later use. All the captured scenes are saved in the student's scene holder. Each created scene will have the following information saved: start capture time, end capture time, user-entered label, and original video reference, which are explained in more detail in section 4.6 (see figure 4.4).

Clip Holder List

ID	Label	Video ID	Subject	Start Time	Duration
25	re	12	Flash	5.13	4.1
26	test1	1	3d modeling	4.7	10.3

Figure 4.4: Screenshot of the Clip Holder Table

- Summarized video clips: Figure 4.5 shows how students can create summarized videos from saved scenes by choosing and re-ordering them in the holder to form a new summary video. The summary tool utilized here is FFMPEG (see section 4.7 for more information).

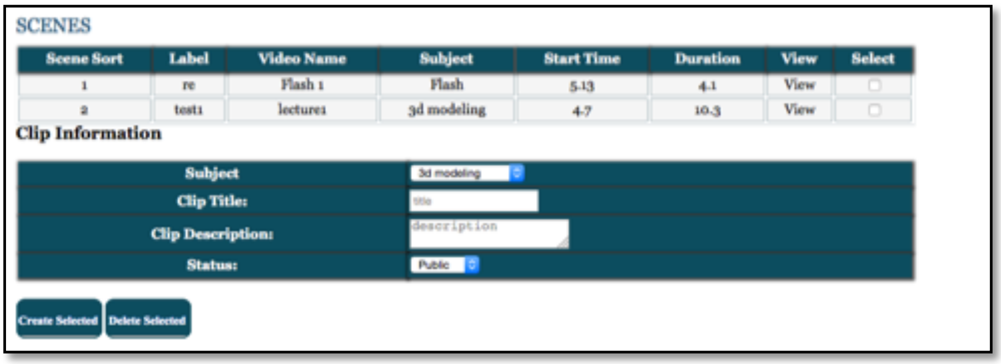


Figure 4.5: Summary Video Creation (Table Screenshot). The scene holders are used to select and reorder the screen in the new video clip.

<u>Scene comments:</u> As shown in Figure 4.6, after the summary videos are created, students can add comments to specific parts of the scenes from a field box in the video page. The comment time can be viewed on the video timeline. These comments will appear when the corresponding parts are being played in the video (more details are provided in section 4.10).

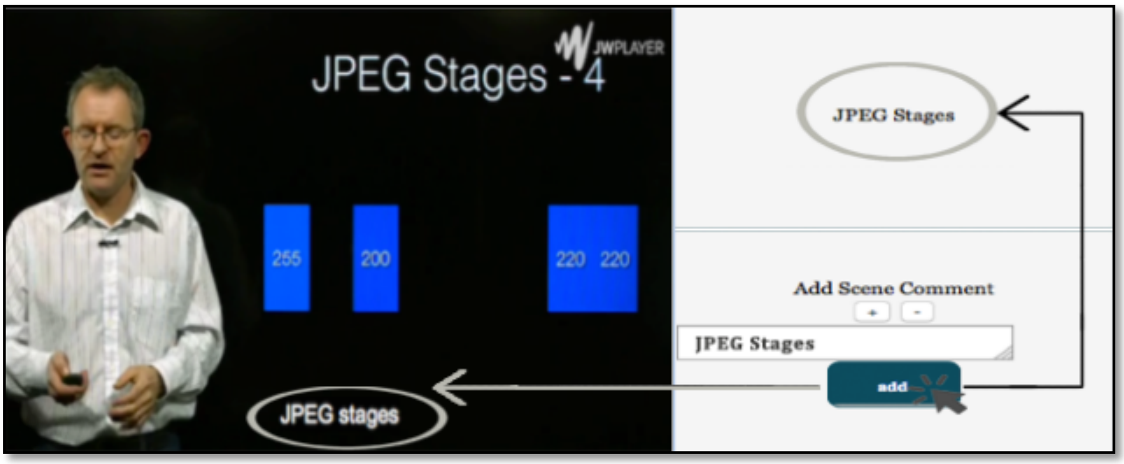


Figure 4.6: Scene Comment Box Where Students Can Add Scene Comments to the Summary Video Clip

4.2.2 Video Collaboration Tool

Collaboration is a feature of most e-learning systems. This feature, when implemented correctly, helps student share knowledge and information actively in a way that also increases motivation and engagement, as was found in previous studies (mentioned in Chapter 2), particularly in Agarwala et al. (2012) and Mukti (2005). It can be argued that the constructivist theory also backs collaborative learning as being motivating and engaging.

There are many forms of collaboration in video learning that could be applied to the current system. For example, Agarwala et al.'s (2012) study showed that commenting on and sharing video clips with other students are effective means of motivating students in the learning process.

A virtual collaborative tool provides collaborative functionalities that increase the engagement level of students. Figure 4.7 shows how the collaboration tool functions in the system.

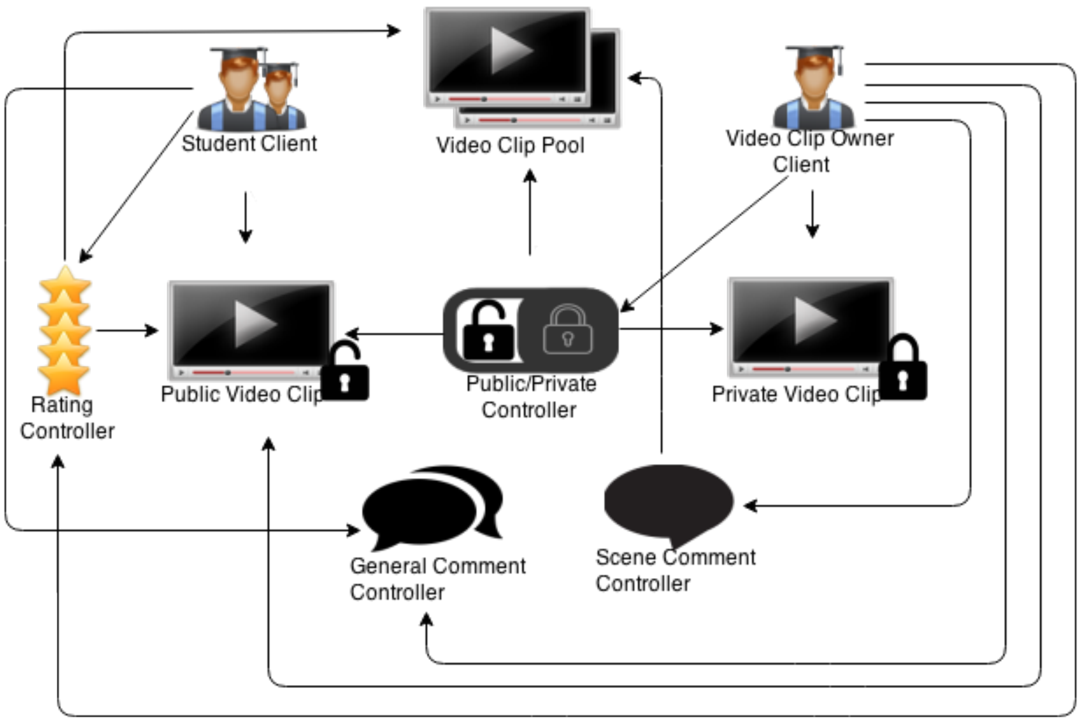
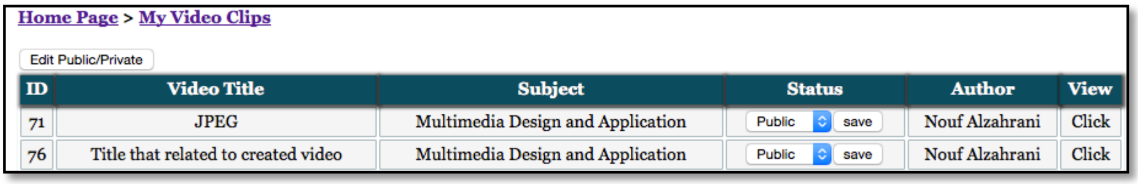


Figure 4.7: Conceptual Diagram of the Video Collaboration Tool

The video collaboration tool comprises of the following three elements (shown in Figure 4.7):

- Sharing the summarized video: The sharing of videos is an automated process wherein students can view a list of the latest summarized videos from their friends and subscriptions on their homepage as video feeds. However, the owner of the summarized video must make sure that the privacy setting of the video is public for it to be available for sharing (Figure 4.8). Students can change the setting from private to public and vice versa whenever they wish to. The process of adding friends with whom the video is shared is explained in more detail in section 4.14.


Home Page > My Video Clips

Edit Public/Private

ID	Video Title	Subject	Status	Author	View
71	JPEG	Multimedia Design and Application	Public save	Nouf Alzahrani	Click
76	Title that related to created video	Multimedia Design and Application	Public save	Nouf Alzahrani	Click

Figure 4.8: Screenshot of the List of Summary Video Clips with their Privacy Option

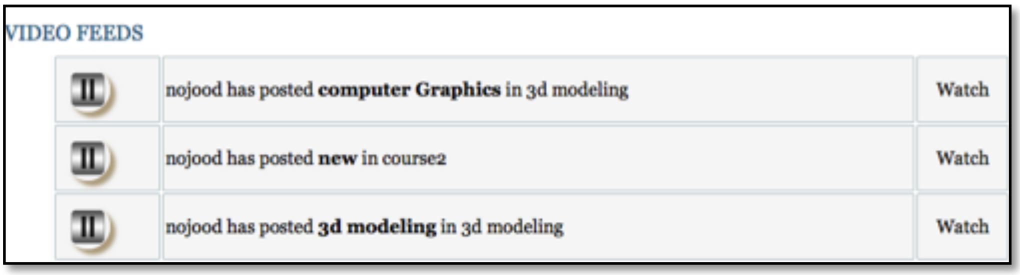


Figure 4.9: Screenshot of the List of Public Summary Video Clip Feeds Available to Subscribers and Friends

- <u>Rating the summarized video</u>: Evaluation of the summarized video is a subject that is often overlooked by researchers due to the lack of standard measures for assessing the quality of the summary (Hammond, 2010). The quality of a summary depends on its intended purpose as well as the application domain. Therefore, a rating tool has been introduced to the system that lets students rate the summarized videos. Students can evaluate the video and provide a rating based on its usefulness with regard to improving their understanding. The average score of the video will be an indicator of the quality of the summary, as shown in Figure 4.10. This explained in more detail in section 4.12

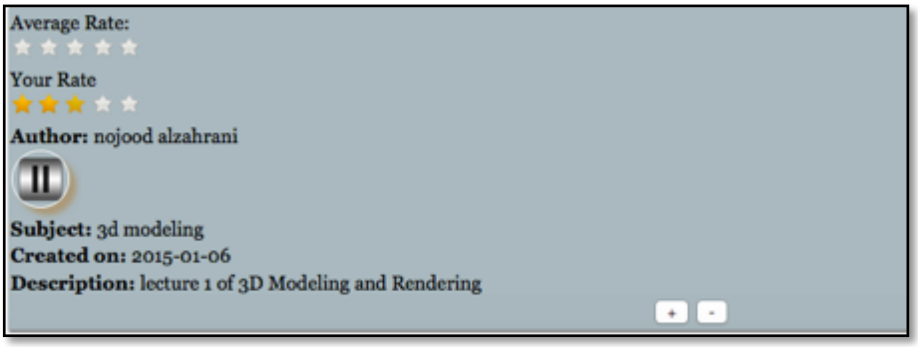


Figure 4.10: Screenshot of How the Rating is Presented for Summary Video Clips

- <u>Commenting on the summarized video (discussion section)</u>: To enhance the collaboration functionality of the system, students are allowed to comment on each other's videos in the discussion board. The comment box is present on the summary page and is loaded automatically with the video. The comment owner can delete the comment if needed (see Figure 4.11) (see section 4.13 for more information on this feature).

Figure 4.11: Screenshot of the Discussion Board under the Summary Video Clip

4.3 Authentication Model

As mentioned earlier, the application is hosted on a University of Sussex server, and clients can access the system through any browser by using the link to the server. Authentication based on identity is needed for the system to present objects to the user. The system needs to be secure, as it will be accessible off campus too. Students will use their University of Sussex login information to log in, so an SSL certificate needs to be installed for login security.

The authentication model in this system will use the Lightweight Directory Access Protocol (LDAP); that is, users will be allowed to use their own university login information that will be evaluated at the university's central repository, based on which they can successfully log in or are denied access. Figure 4.12 below represents the authentication model of the system.

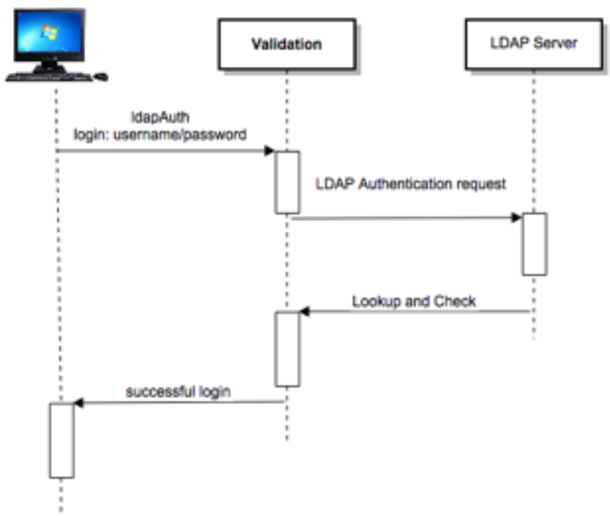


Figure 4.12: Login Authentication Model

The LDAP allows the client access if the username exists and the password is correct, but if otherwise, the client is denied access. Communication with the LDAP server can only be established if the system is hosted on the university server.

4.4 Addition of Data

This section explains how various types of data are added and manipulated into the system, including text and multimedia data.

4.4.1 Adding Students and Teachers

Administrators are added to the system manually, and after login, the admin user is redirected to the admin page according to the admin role set in the database. The administrators will need to register universities, coordinators and subjects to the system database to allow other functionalities, and coordinators are responsible for adding teachers and students to the system. This is needed in order to categorize the data and have more control over data entry.

4.4.2 Adding Videos

Original video lectures will be uploaded to the system by teachers, as shown in Figure 4.13. Teachers can categorize their uploaded video lectures under different subjects. Uploading a video involves two steps:

- Video information is entered into the database, including type, date, teacher and subject, in addition to an auto-generated ID.
- The uploaded video is moved to the *upload* directory and is renamed with its auto-generated ID to ensure that it has a unique name in the upload directory.

As the files are multimedia files, they are expected to be relatively large in size. Therefore, the chunking functionality is used to downsize the files uploaded to the server in order to avoid upload timeout. The video file is recreated after all the chunks are uploaded and placed in the specified directory.

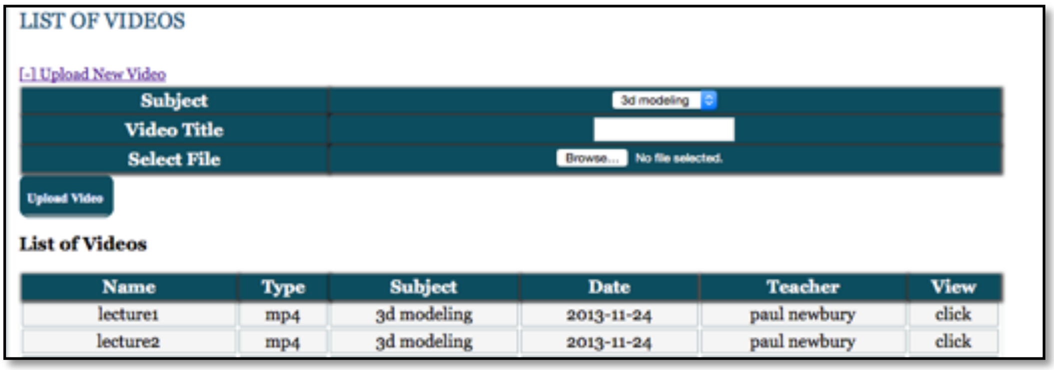


Figure 4.13: Original Video Uploads using the Chunking Technique

4.5 Lecture Video Display

Students can view the lecture videos for the subjects they are enrolled in by navigating to the video page. The JW Player JavaScript library (JW Player) is used to display the videos in the system. JW Player was chosen for this project because of various factors including its popularity, functionalities, easy implementation and large community support. The video will be dynamically served at the client end via the PHP code from the server end. To serve the video, a PHP file is created and named *video.php.* This file is assigned a parameter, which is a unique identifier (an id) for the video file to be retrieved from the database, so that it is displayed in the upload directory and served at the client end, where it can be streamed by the user.

Pseudo streaming is used to stream the video file to the client in order to avoid moving the whole video into the header. Only parts of the video are streamed, with the later parts streamed only once one part is downloaded to the client. Thus, the entire video is not moved to the memory and the memory is preserved.

4.6 Clipping Videos

In order to create a summary video clip, students need to select parts of the original video lectures. To do so, students can visit the video lecture page where the video is displayed and create a scene by selecting the start and end times of the clip before saving the clip in the scene holder (Figure 4.14). The scene holder will hold the start and end times along with the lecture video ID for later reference. This process can be used to create multiple scene holders for the same or different video lectures, as the summarized videos can be created from multiple video sources.

Figure 4.14: Original Lecture Video and the Scene Holder Creation Tool

<u>Sequence diagram of the process:</u>

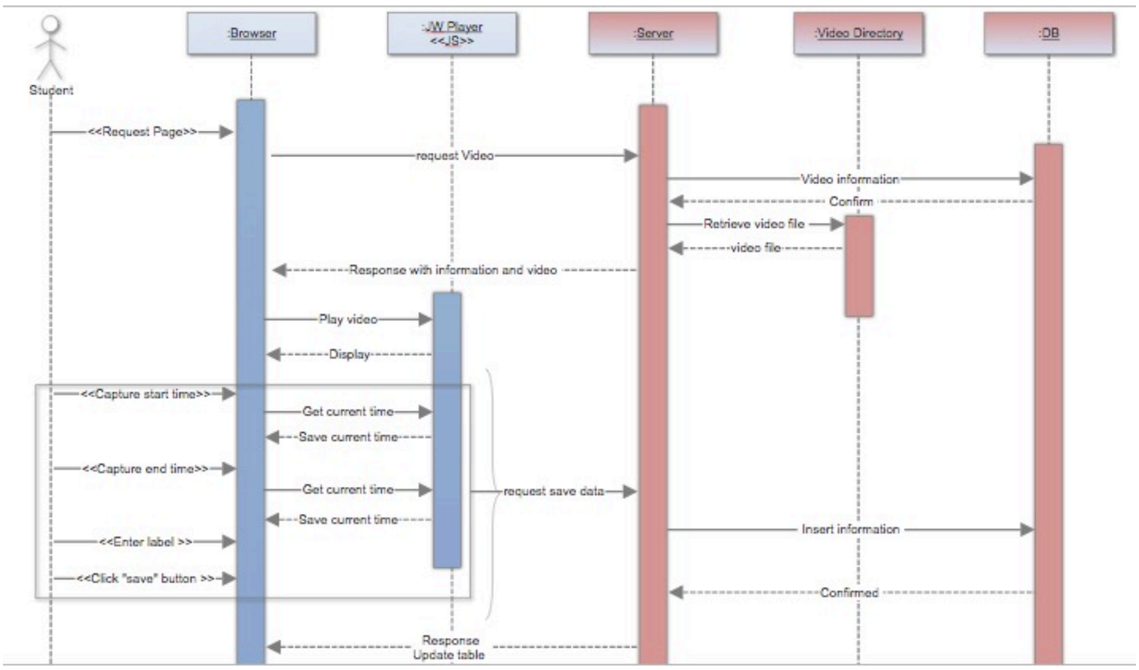


Figure 4.15: Sequence diagram depicting the capturing and saving of clips in the clip holder table

4.7 Creating the Summary Video Clip

Students can create a video clip from the scene holders created previously. At least one scene holder should be created to create a summary video clip. In this section, the process of creating a summary video clip is explained. Students can delete a scene by selecting the scene and clicking on the 'delete' button. They can also change the clip order by dragging and dropping the row wherever they like on the table. Finally, after modifying the scene order, they can select all the scenes that they want for the same summary video, and then click on the 'create video' button:

4.7.1 Deleting scenes from the clip holder table

After all the scenes are captured, students can delete any scene that they do not need by selecting the scene and then clicking on the 'delete scene' button, as shown in Figure 4.16.

Sequence diagram for deleting scenes:

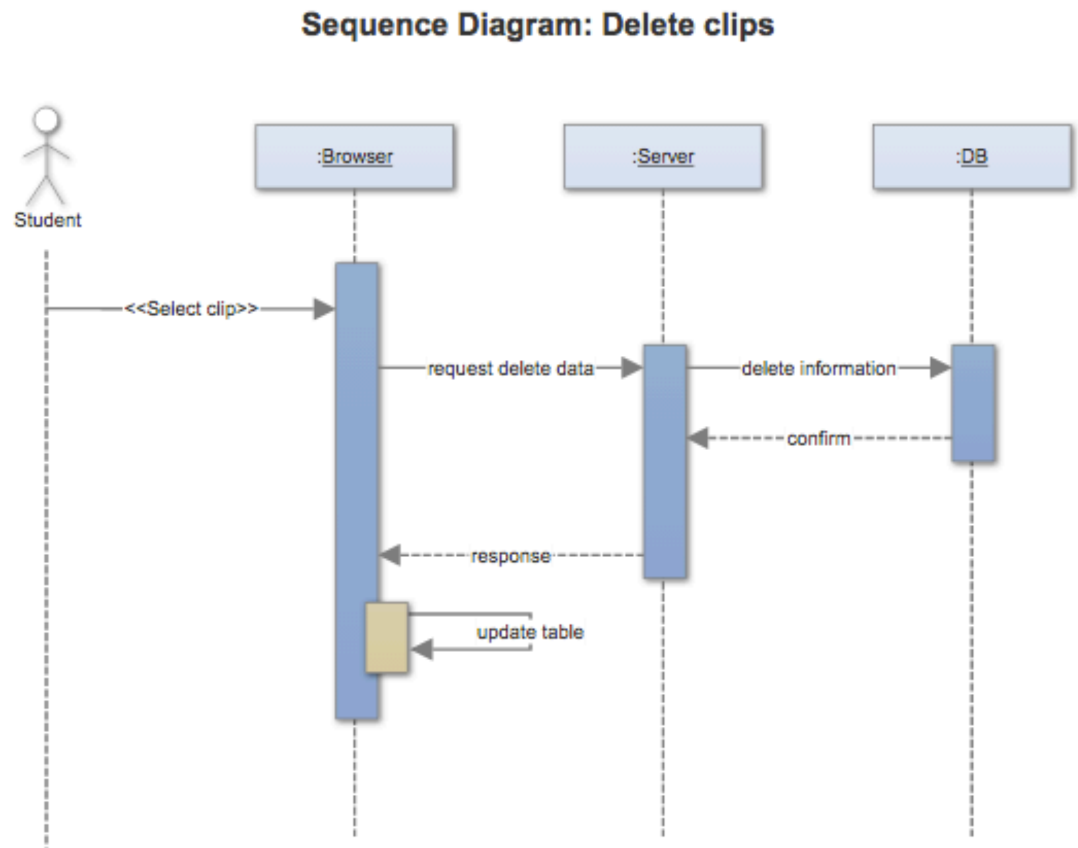


Figure 4.16: Sequence diagram for deleting scenes

4.7.2 Rearranging Scenes for the Summary Video Clip

Arrangement of the scenes is very important in the process of creating a video clip summary, as it ensures that the flow of information in the clips is in the right order. The video clip is created from the scene holders, which are arranged according to their IDs in ascending order. Since the IDs are created in an auto-incrementing pattern, the scene holder that is created first will be the first scene of the new summary video clip and so forth. Figure 4.17 depicts a table showing scene holders arranged according to their IDs.

Clip Holder List

ID	Label	Video ID	Subject	Start Time	Duration
25	re	12	Flash	5.13	4.1
26	test1	1	3d modeling	4.7	10.3

Figure 4.17: Scene Holder List

To change the order of the clips, students rearrange the IDs of the scenes so that the first scene is moved to the top. Therefore, students can rearrange the video clips by dragging and dropping the rows. When a student drags a row and drops it in the place of another row, the row IDs are switched on the server via an AJAX request. This feature is provided by the TableDND JavaScript library (jQuery, n.d).

Sequence diagram of the reorder scene:

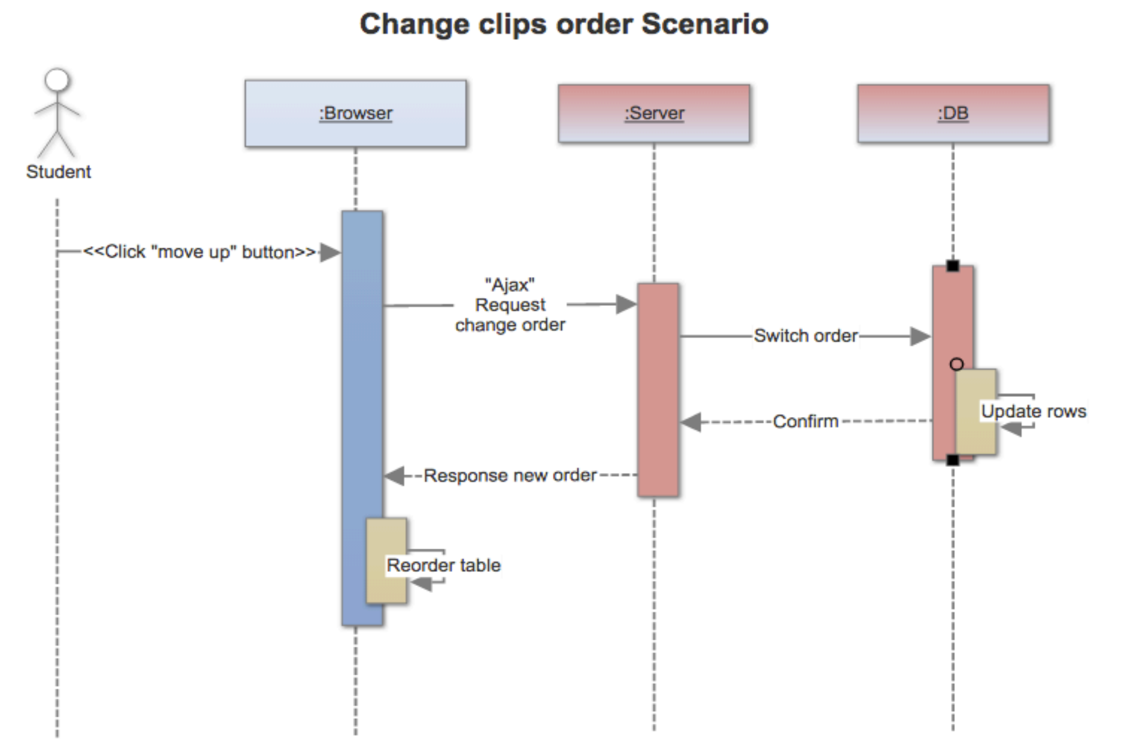


Figure 4.18: Changing the scene order

4.7.3 Creating the Final Summary Video Clip

This functionality is the most important feature of the system and is also the most complicated one. The video clips are created using FFMPEG (FFMPEG software, n.d), which is a software project library that transcodes multimedia files. The software is installed separately from the web application on the server and is accessed via shell commands. Therefore, the web application must have access to the server shell in order to invoke FFMPEG commands. The process of creating a summary video clip is as follows:

- When students create new summary video clips from the selected scene holders, all the selected scene holders are updated in the database.
- A random name is generated for a temporary file that is created.
- An integer is created and added to the end of the random string for the purpose of order and to ensure that each file has a unique name.
- For each selected scene holder, a temporary video file is created by executing an FFMPEG command in the shell (Code 4.1 shown below). The following is the code for generating an FFMPEG command.

```
$tscommand = "$this->ffmpeg -ss $start -t $duration -i $origVid -c copy -ss 0 -t $duration -map 0 -vf
scale=320:240 -bsf:v h264_mp4toannexb -vcodec libx264 -f mpegts $randomName";
```

Code 4-1: FFMPEG command

The variables in the code are described as follows (see Figure 4.19):

$tscommand : final ffmpeg command
$this->ffmpeg: path to FFMPEG application in the system e.g. usr/local/ffmpeg
-ss $start: starting time to clip. e.g. 25 seconds
-t $duration: duration of the clip e.g 10 seconds, which means it will clip from the 25th second to 35th second.
-i $origVid: path to the original video e.g. "/var/lecure_videos/2.mp4 "
-c copy: a command to copy the selected clip to a new temporary file.
-ss 0: starting time is always 0 to place the new clip at the start of the new temporary file.
-t $duration: duration of the clip is the same as the duration of the captured clip from the original video.
-map 0 -vf scale=320:240 -bsf:v h264_mp4toannexb -vcodec libx264-f mpegts $randomName: set properties of the new temporary file and save it into a temporary location with its random generated name.

Figure 4.19: Definitions of the FFMPEG Variables

The entire process of creating a temporary file is shown in the following figure:

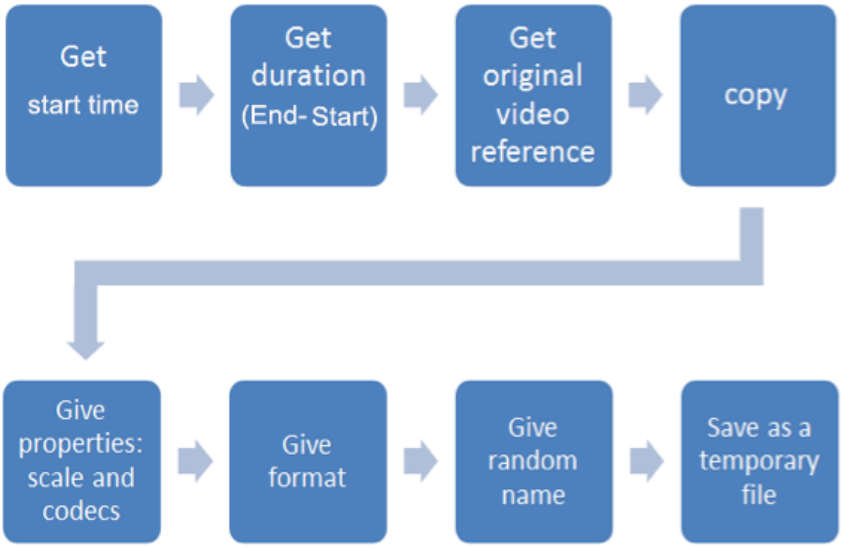


Figure 4.20: The Process of Creating a Temporary File for Each Scene Holder

- The path of the temporary file is added to a *concat* variable to be used later for combining the clips.
- The same process is repeated for each scene holder so that a temporary video file is created for each selected scene holder.
- A new record of the video clip is created in the database, and the ID is returned to the video clip.
- New records of the new video clip details from each scene holder are created so that each part of the new video clip can be referenced to its original video lecture later.
- All the temporary video clips are combined into a single video clip using the FFMPEG *concat* command. The following is the code for generating an FFMPEG *concat* command (Code 4.2).

```
$finalVid = "$this->ffmpeg -i \"concat:$concat\" -c copy -bsf:a aac_adtstoasc $this-
>student_directory/$new_vid_id.mp4";
```

Code 4-2: FFMPEG concat Command

The variables in the *concat* command code are explained as follows (see Figure 4.21):

$finalVid: final ffmpeg command
$this->ffmpeg: path to FFMPEG application in the system e.g. usr/local/ffmpeg
-i \"concat:$concat\": the concat command with the concat variable that holds the paths to all the temporary files.
-c copy: a command to copy the selected clips in to a new temporary file.
-bsf:a aac_adtstoasc $this->student_directory/$new_vid_id.mp4": set properties of the new video clip file and save it into the video clips location named by its ID in the database in an MP4 format.

Figure 4.21: Definitions of the concat Command Variables

The entire process of creating a new summary video clip from the temporary files is shown in Figure 4.22.

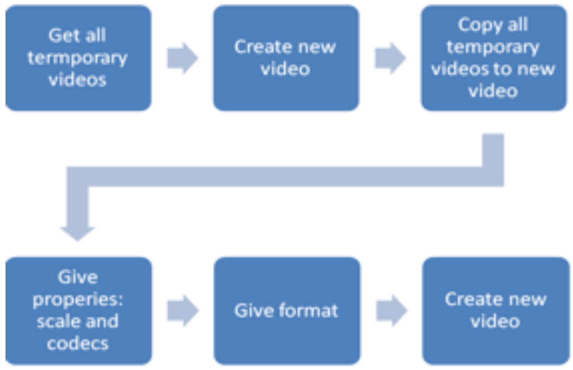


Figure 4.22: Summary Video Clip Creation from the Temporary File

- All the temporary files in the temporary directory are deleted.
- All the selected scene holders from the database are deleted.

<u>Sequence diagram for creating a summary video:</u>

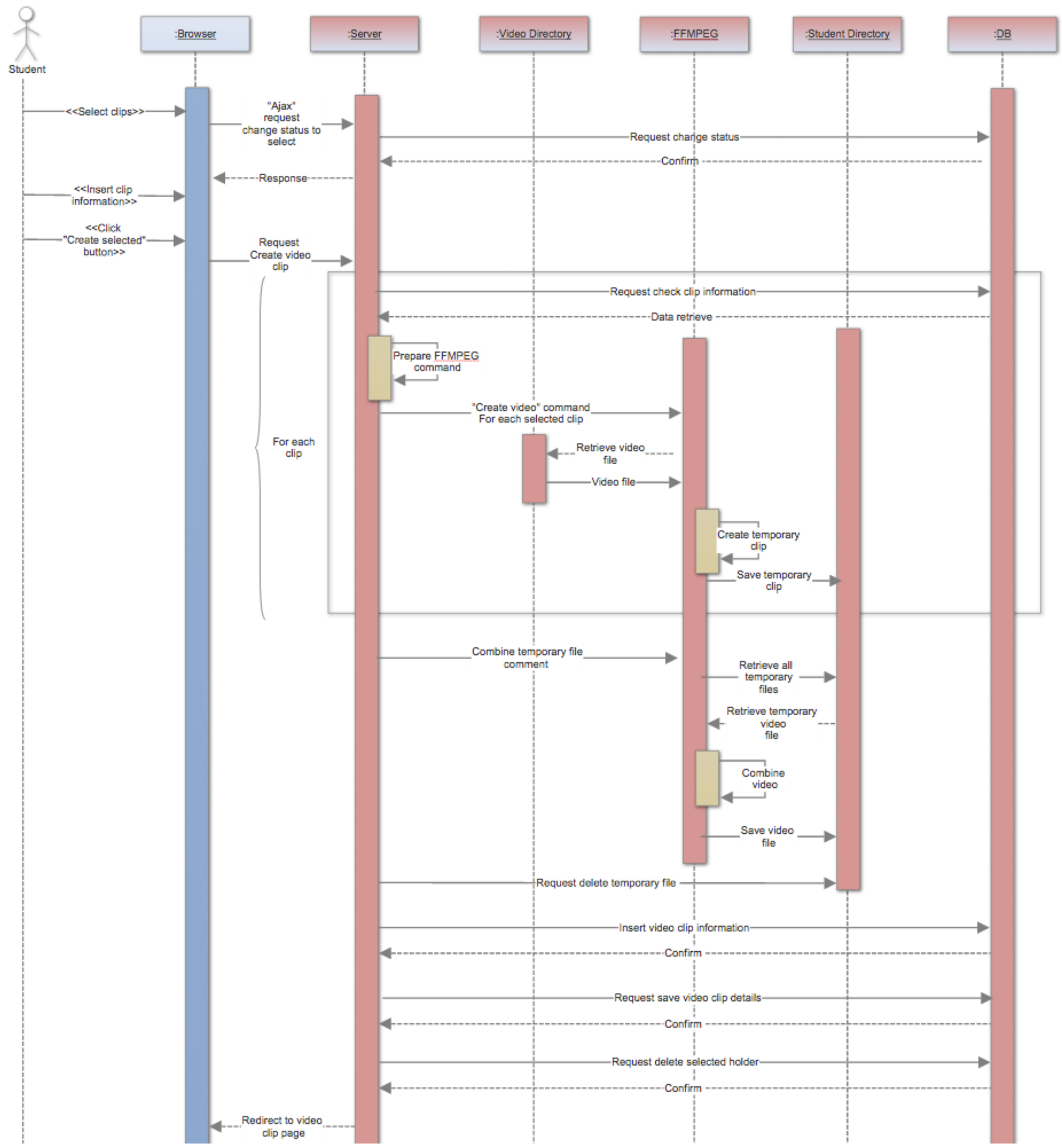


Figure 4.23: Sequence diagram for creating a summary video

4.8 Video Clip Privacy Control

Summary video clips can be viewed by other students only if the privacy is set as public; private videos cannot be viewed by other students. This setting can be changed by the student at any time.

4.9 Video Clip Display

Video clips are displayed on the video clip page by retrieving the video clip ID from the parameter. Similar to the video lecture display, the summary video clip is displayed using the same pseudo streaming functionality. JW Player is used for client display, with the video being served according to the ID of the video clip. However, there are more functionalities available in the video clip summary, including original video display and on-scene comments, which are explained in the following two sections.

4.9.1 Original Lecture Video Display in the Video Clip

As the summary video clip is composed of different scenes from different lecture videos, students may want to refer to the original video lecture from which the scene is taken without navigating away from the current streamed video. To enable this, an on-pause functionality is added to the video clip display wherein a function is triggered when the user hits the pause option. With this function, users are referred to the original video from which the scene at which the summary video is paused was taken. After the pause, a pop-up message is displayed asking whether the user wants to view the original video (Figure 4.24). The pop-up message disappears once the student clicks on the cancel button and goes back to the summary video clip. Providing this feature will ensure that the student stays focused on the current subject and can get back to the previously paused video to refer to external content.

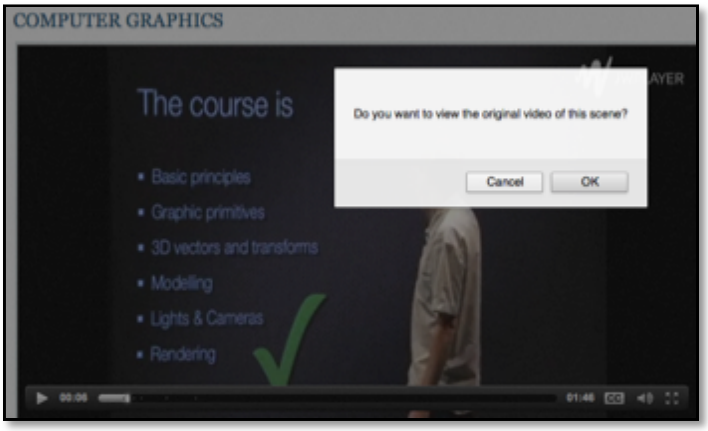


Figure 4.24: Pop-up Message Displayed in the Paused Video Clip for Viewing the Original Video

If the student decides to view the original video, a dialog will appear containing the original video played by JW Player and served using the same technique used for the video clip display and lecture video display (Figure 4.25). The dialog is a Fancybox JQuery library that will appear as a separate window inside the webpage.

Figure 4.25: Original Video Clip Retrieved and Displayed in Fancybox on the Video Clip Summary Page

<u>Sequence diagram for watching the original video:</u>

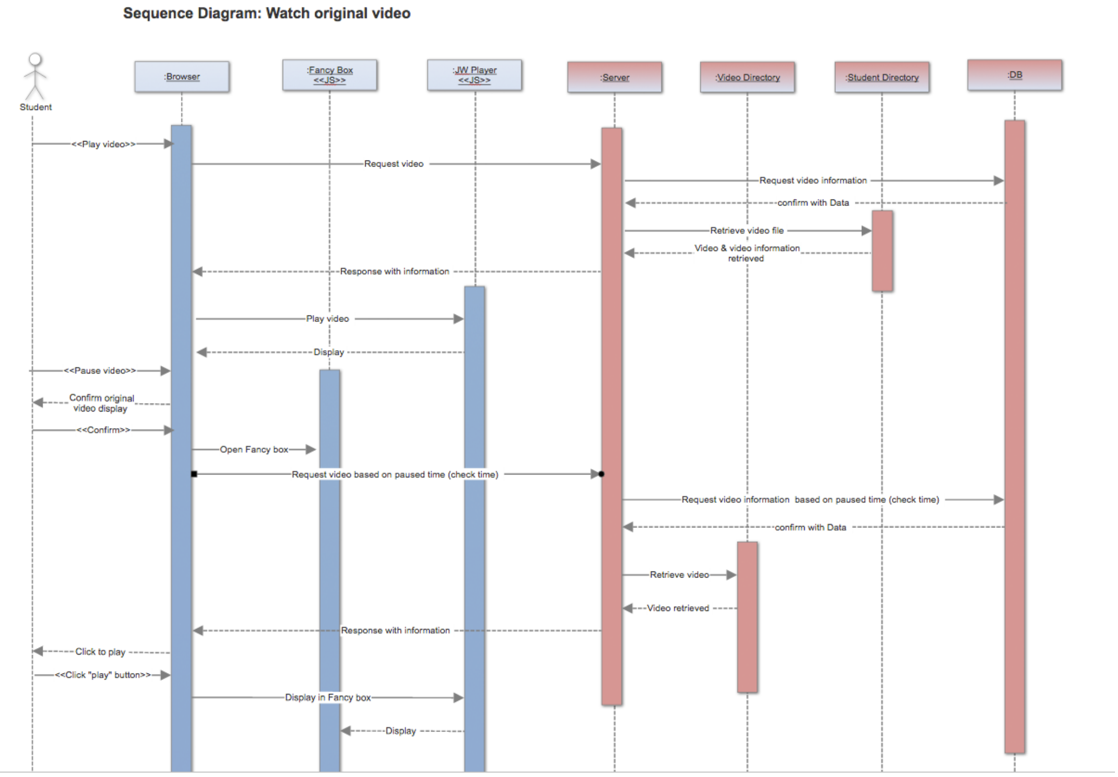


Figure 4.26: Sequence diagram for watching the original video from the created video

4.10 Adding Scene Comments to the Video Clip

On-scene comments is a feature that enables students to comment on the scenes of the summary video clip they have created. The comments appear as a subtitle in JW Player and in a separate box next to JW Player on the summary video clip page.

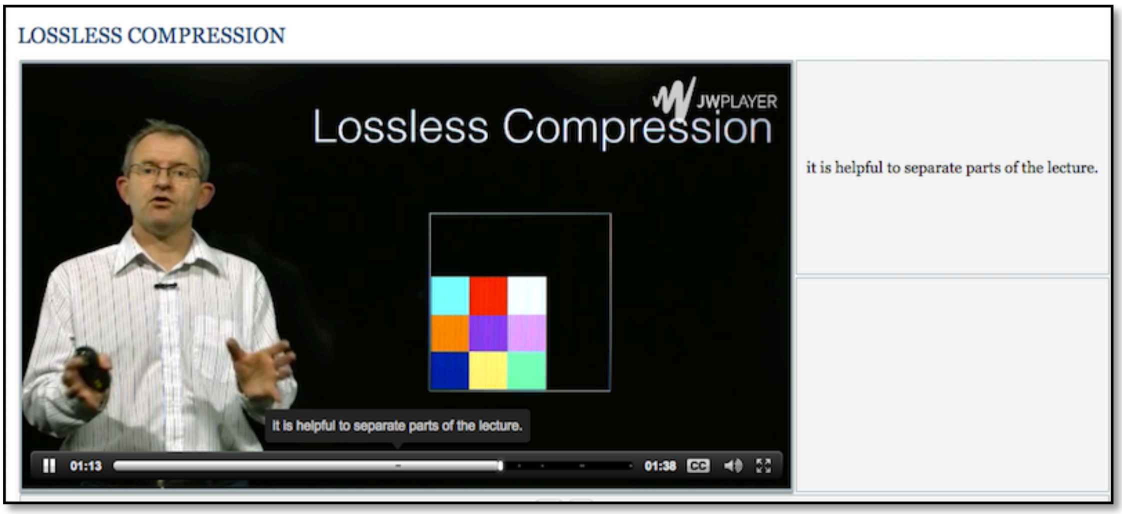


Figure 4.27: Scene Comments are Displayed as the Subtitle in JW Player

Scene comments are added from a box next to the video that appears only to the video owner, as shown in Figure 4.27. Once the comment is inserted and submitted, an AJAX request is invoked to add the comment in the database along with the elapsed time of the video clip and the video clip ID.

<u>Sequence diagram for adding scene comments:</u>

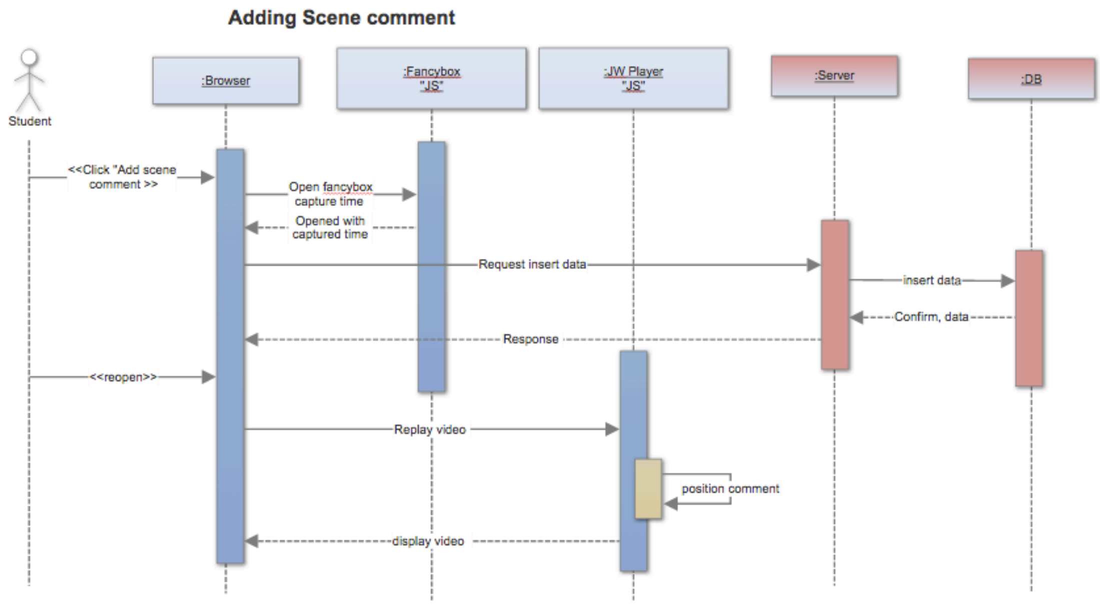


Figure 4.28: Sequence diagram for adding scene comments

4.11 Reading Scene Comments

Scene comments are retrieved from the database and displayed with the video. Each comment will have an associated appearance time to determine when it is displayed during the playing of the video clip. The comments are first retrieved and placed in two parallel arrays: the time array and the comment array. The time array contains the time of the comments while the comment array contains the body (message) of the comments (see Code 4.3).

```
foreach ($video_comments as $comment) {
   $timeArray[] = $comment['comment_time'];
   $commentArray[] = $comment['body'];
}
```

Code 4-3: Code for Adding Scene Comments at a Specific Time

These PHP arrays are converted to JavaScript arrays using the JSON Encode method so that they can be read by JW Player at the client end.

Scene comments also appear in JW Player as subtitles. The comments are retrieved on the JW Player setup with the tracks attribute. The tracks attribute will have two sub-attributes: chapters and captions. Captions are the comments to be displayed, and chapters are the separation points that appear in the player timeline indicating a comment. The comments are served by PHP as a VTT file that can be identified by JW Player as the subtitle file.

4.12 Video Clip Rating

Video clip rating is a feature that was added using the JQuery Raty library. This feature enables students to evaluate summary video clips. The rating feature validates the video clip and indicates its acceptance among students and its validity according to their perspective. Students can rate each video clip only once. The average rating will appear under the student rating.

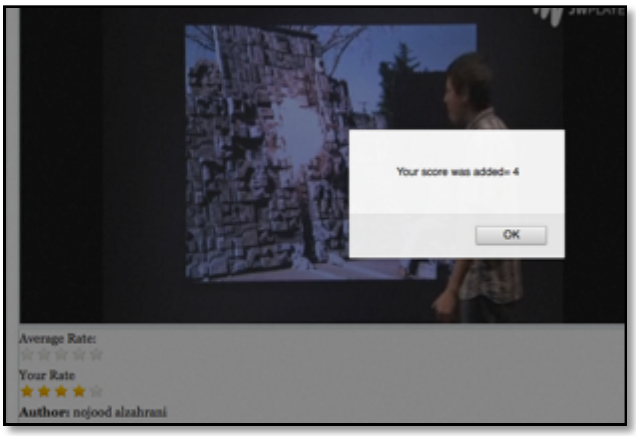


Figure 4.29: Adding Ratings to the Video Clip

Students can add their rating by choosing from a scale of one to five and clicking on the corresponding number of stars, as shown in Figure 4.29. On clicking, an AJAX request is sent to the server, and the rating is entered into the database and considered in the average rating at the client end.

Sequence diagram for rating the video:

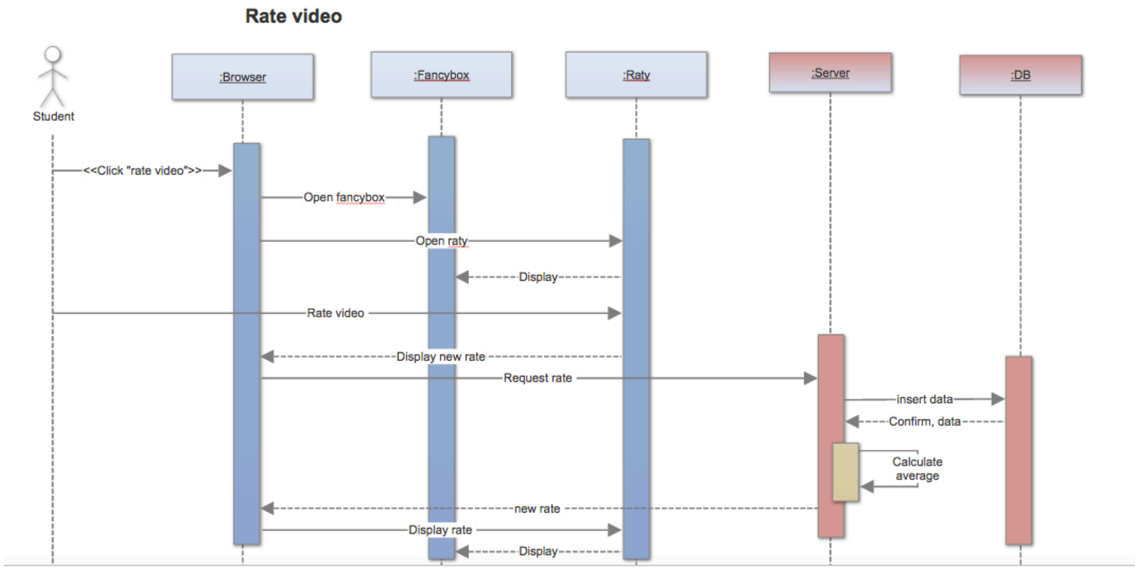


Figure 4.30: Sequence diagram for rating the created video

4.13 General Comments

General comments are comments by students as well as the video owner that appear in the discussion box on the summary video clip page. General comments can be added from a box inside the video clip page. When the form is submitted, an AJAX request is sent to the server to add the general comment in the database and update the discussion board at the client end.

Students may want to delete their general comments for a variety of reasons. Therefore, the system allows the deletion of comments by their owners. The delete request is also an AJAX request that updates the discussion box immediately after deletion.

Sequence diagram of the discussion board:

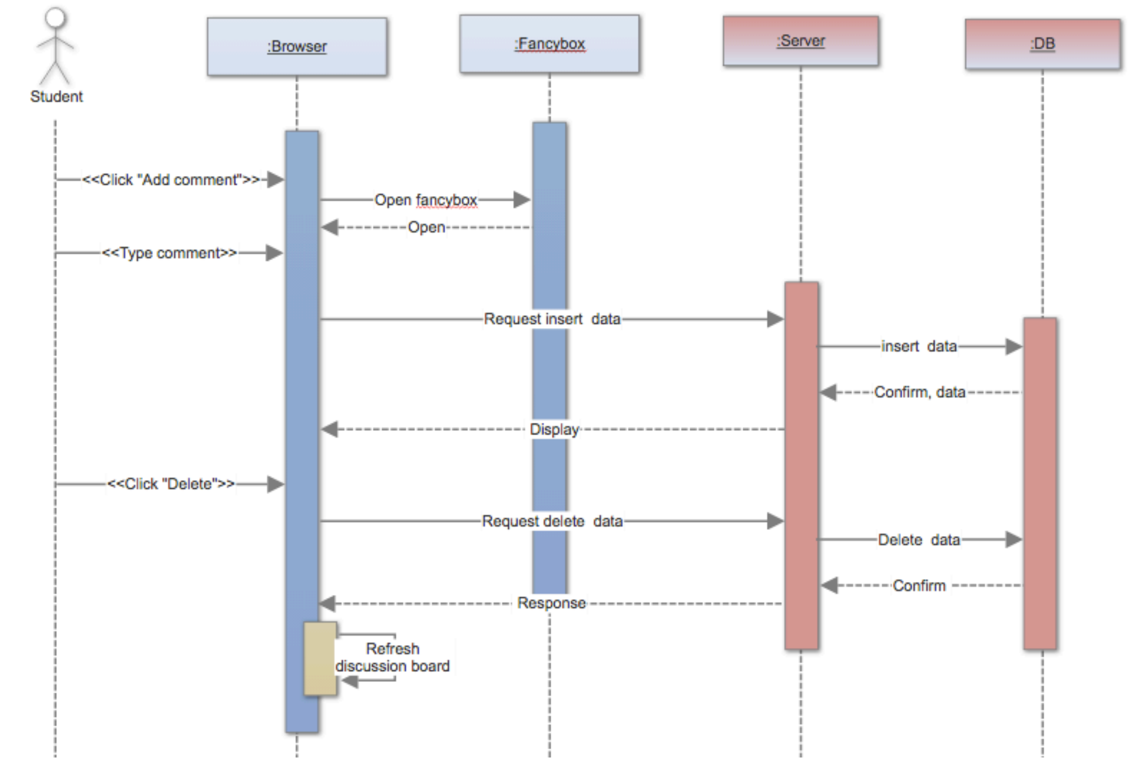


Figure 4.31: Sequence diagram for the discussion process

4.14 Friending

Friendship is another feature of this system, which allows students to view each other's video clips easily. Students who are friends are notified of each other's videos when they are created. Students can search for a friend by name, and view the search results (Figure 4.32).

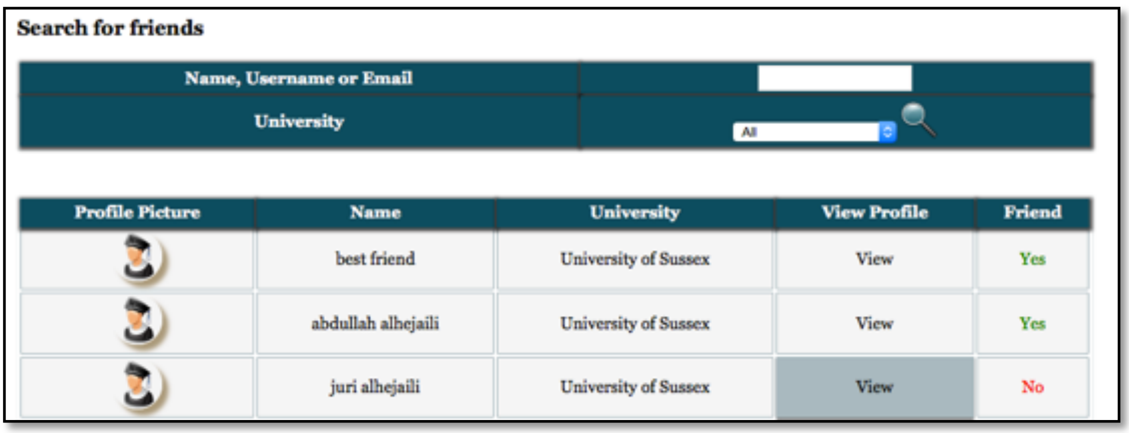


Figure 4.32: Searching for Friends in the System

Then, the student can send a friend request, which can be accepted or denied by the other person (Figure 4.33 and figure 4.34).

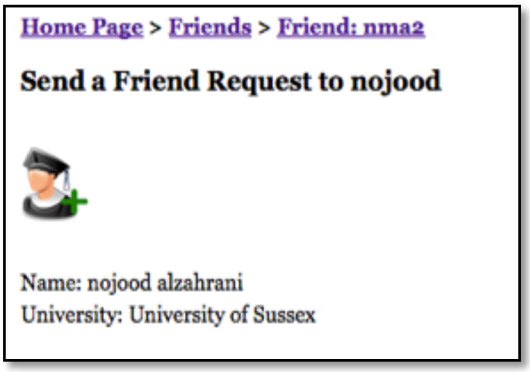


Figure 4.33: View of the Screen before the Friend Request is Sent

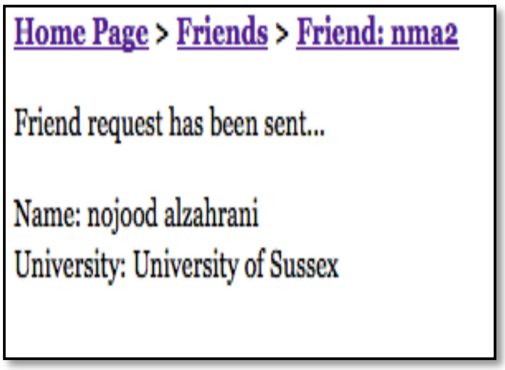


Figure 4.34: View of the Screen after the Request

If the request is accepted, both students can have access to each other's videos, and if the request is denied, the friendship request is deleted from the system (Figure 4.35).

Figure 4.35: Friend Request Notification

The friendship functionality allows students to view the list of video clips the other has created from their profile page or from the notifications on the homepage. The homepage video clip notifications consist of video clips from friends and video clips from subscriptions, which are explained in the next section.

Students can also 'unfriend' someone by clicking on the 'unfriend button' on their friend's profile page. These users will no longer be friends in the system and the summary video clips they create will not appear in each other's video feeds.

Sequence diagram of friending:

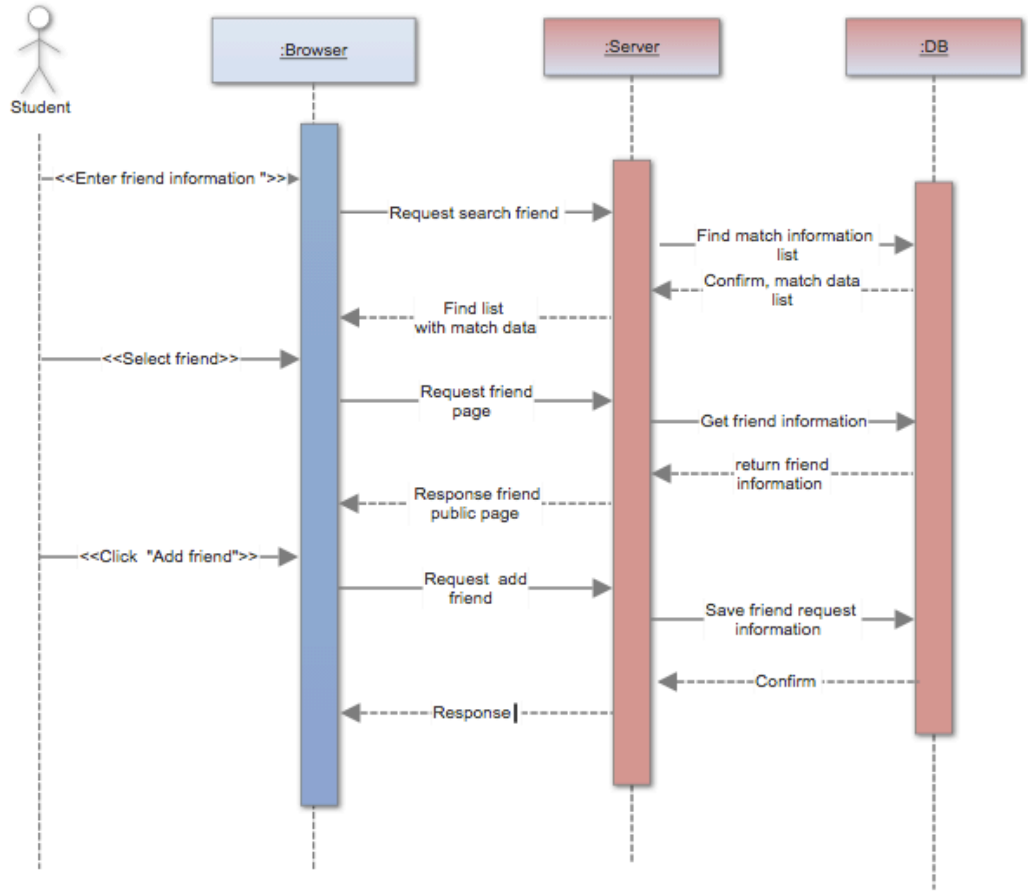


Figure 4.36: Sequence diagram of the process of sending friend requests

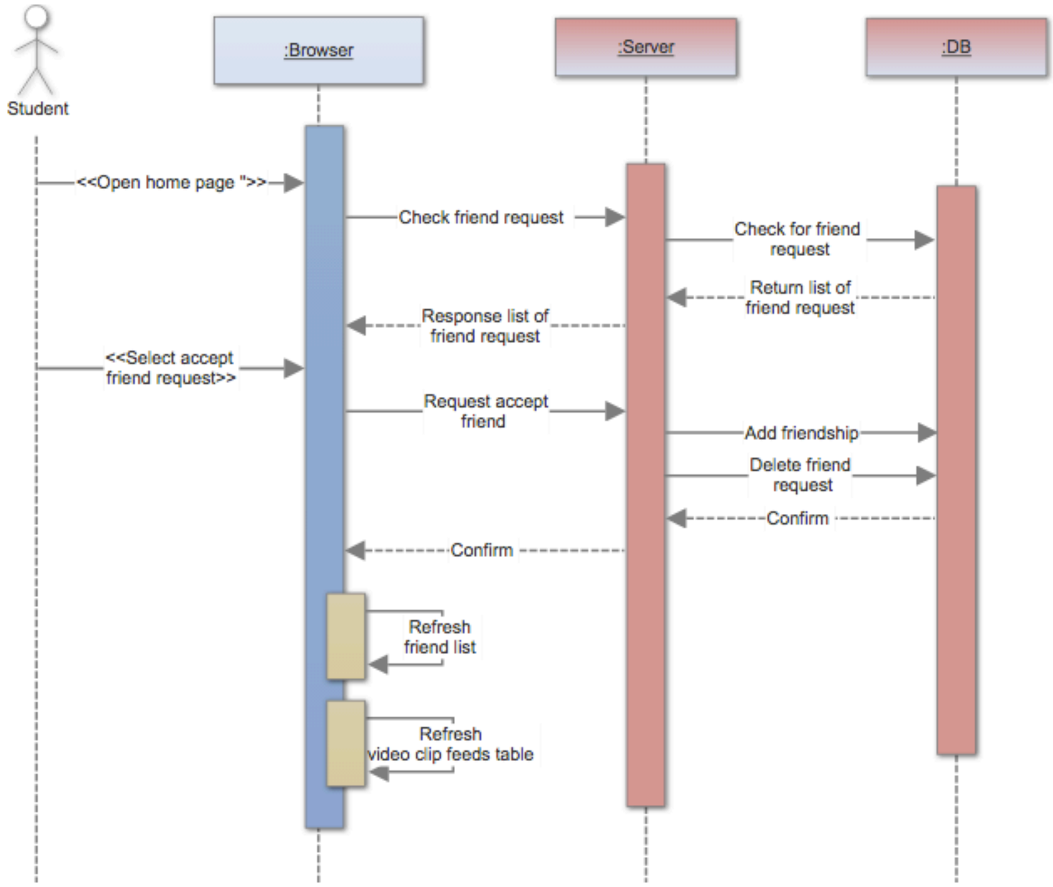


Figure 4.37: Sequence diagram for accepting friend requests

4.15 Subscription

This function allows student to subscribe to any subject and receive notifications of summary video clips created by other students in the subject even if they are not added as friends. Subjects can be found by searching for them, and students can visit the subject page and choose to subscribe or unsubscribe to the subject. However, students are subscribed to their registered subjects automatically and cannot unsubscribe from them.

4.16 System modifications for the full study:

This section discusses the modifications made to the system after the pilot study.

4.16.1 Limitations of the Pilot Study

In pilot studies, errors in the proposed experiments are almost always discovered, and certain paths of investigation that were missed out are sometimes revealed (Davis, 2013). In the case of this investigation, too, running the pilot study helped improve the system usability and interface by the modification and addition of certain functionalities that helped students interact better with the video summarization tool. In addition, it also helped the researcher to make some improvements in the experimental procedure.

4.16.2 Modification of the System

This section contains a list of the required modifications identified based on the students' responses to the qualitative questions as well as the researcher's observations. It is believed that these modifications will help improve the system further and minimize the issues found in the system used in the pilot study. The modifications are as follows:

- *Addition of Summary Notes:* The summarization will include notes that will benefit students who prefer written material to video learning.
- *Improvement of Feedback from Friends:* This could be in the form of private messages or instant messaging support.
- *Improving System Feedback:* System feedback on actions taken by the students will be improved so as to minimize confusion and prevent the creation of multiple tasks.
- *Improvement of Clip Description:* As several students stated that the description of the video clips did not adequately represent the content, this will be improved by tagging related topics or other techniques.
- *Focus on the Discussion:* The sharing of the video clip is merely based on the content of the video. This is time consuming, and therefore, the sharing and collaboration will be focused on the discussion about a topic rather than the video clip itself. This is based on the fact that several video clips will be similar and contain similar clips, which will make the video clip sharing procedure tedious.
- *Improvement of the Friending Process:* The activities that friends could engage in were very few and will be enhanced.
- *Changing the System Interface:* The interface was confusing to a certain degree for some students. Therefore, the interface and the buttons will be modified so that they are easier to understand and use. AJAX will be used more in the system design, so that students can receive more feedback to encourage them to engage with the system.

4.16.2.1 Interface Design

It was observed in the pilot study that there were some issues with the design of the system that prevented students from fully understanding the system's functions. Therefore, the interface was considerably revised to provide more visual descriptions of the actions of the system and simplify navigation. All the system functionalities were contained in a single page frame that loaded each function to the page once the request was placed, as shown in Figure 4.38. This is in contrast to the previous design wherein each functionality had a dedicated page, which made navigation confusing. In the revised interface, a list of actions are provided in the left panel of the page frame, and when each action is clicked on, its related actions are loaded into the main content area asynchronously (AJAX Load).

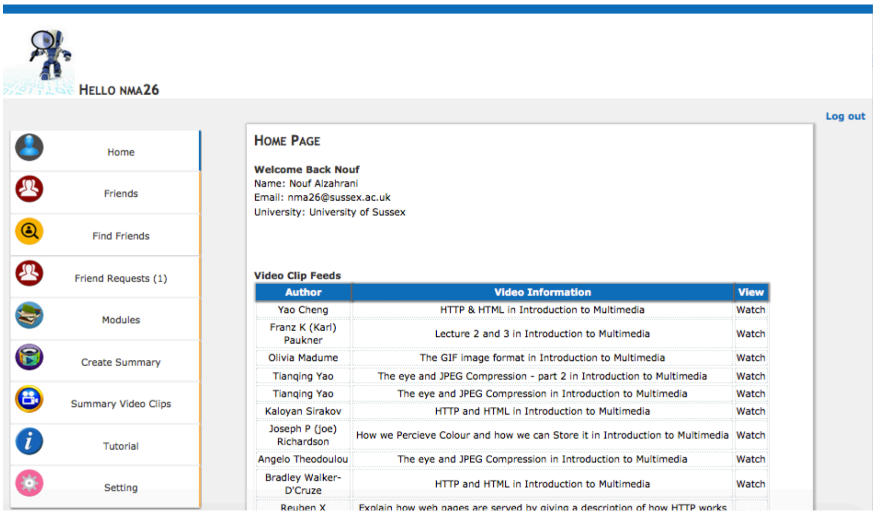


Figure 4.38: New System Interface

4.16.3 Design of the List View

In areas where limited descriptive information is required, the list view was modified to provide a better visual description and improve readability. Figure 4.39 shows the updated list view on the left and the old list view on the right. As can be seen in the figure, unnecessary information is removed and a simpler list is provided in the new design.

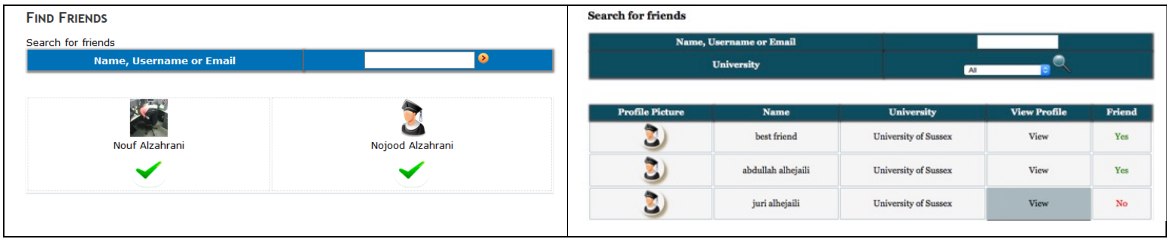


Figure 4.39: (A) The New Improved Design of the List View in the Friend Search; (B) The Old Design of the List View

4.16.4 Clip Viewer

The view of the created summary video clip was dramatically changed to provide a better experience when viewing a video clip and performing actions. When the user clicks on a created video clip, they are taken to a clip viewer page, which is divided into three sections (Figure 4.40). The first section on the left is the actions panel where all the actions that can be performed are listed. The middle section contains the video clip player with the discussion board below it, and the section on the right is dedicated to the notes uploaded to the video clip (discussed in the following section).

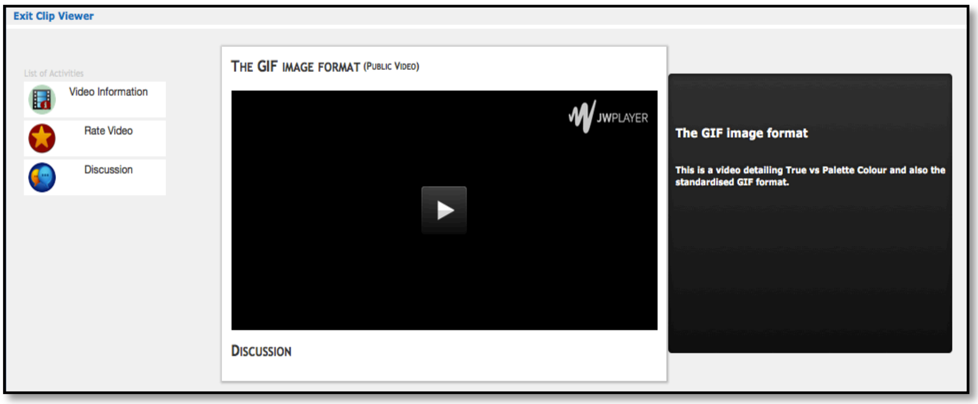


Figure 4.40: Interface Design of the Video Clip Viewer

4.16.5 Notes

In the pilot study, the students had reported that they were unable to add images and notes to the video clips. Therefore, the new system was modified so that students could add their own notes to each video clip. The notes can be in form of text or images that appear in the right panel of the video clip viewer page. Figures 4.41, 4.42, and 4.43 show how notes are added and viewed in the section.

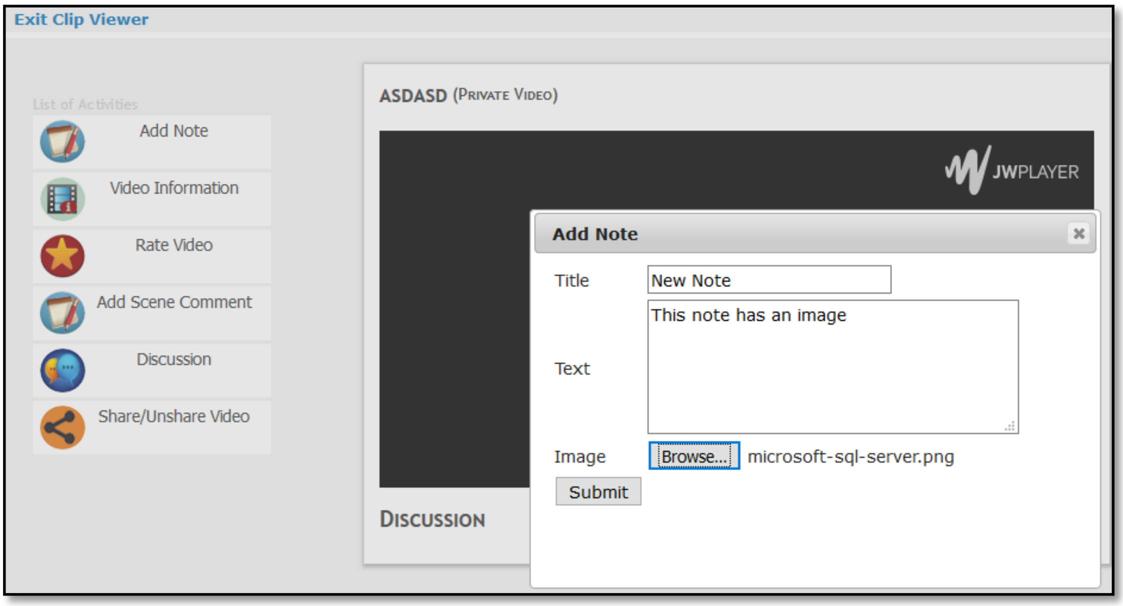


Figure 4.41: Adding a Note to the Video Clip

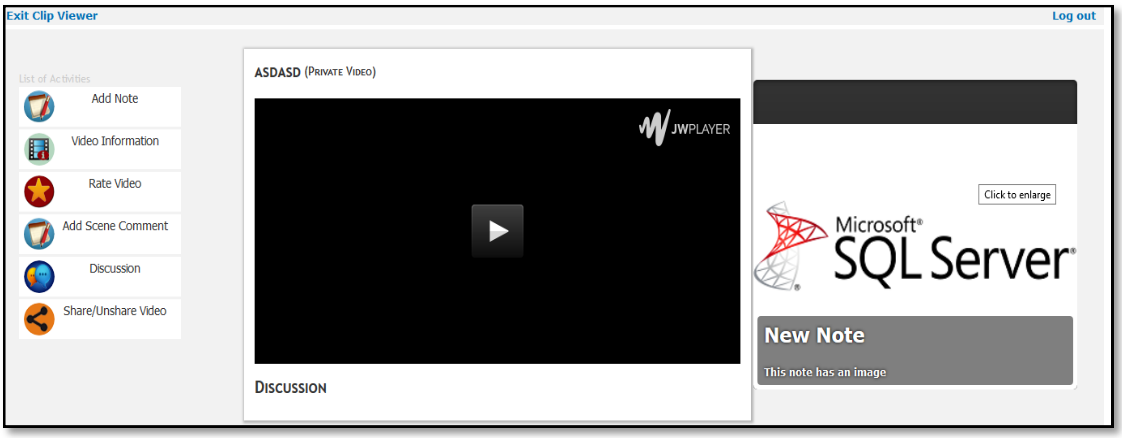


Figure 4.42: The Note with the Image Appears in the Right Panel of the Clip Viewer Page

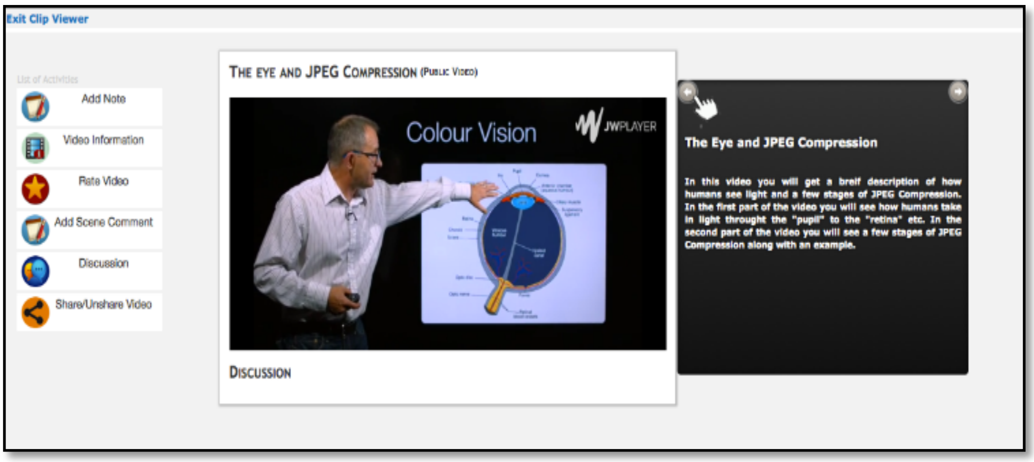


Figure 4.43: A Note Containing Only Text Appears in the Right Panel of the Clip Viewer Page

In the note panel, if students add multiple notes, each note will appear separately in rotation via a note rotator (note panel). The note panel rotates between notes at a rate of 5 seconds per note. This signals the presence of multiple notes to the students. In addition, when a student clicks on a note, it appears enlarged in a separate dialog box, which makes it easier to read the note.

4.16.6 Interacting With Video Clips

Interaction with video clips, such as rating them, adding scene comments and participating in the discussion board, are more centralized in the modified system. These interactive functions have been grouped into the action panel in the clip viewer instead of being distributed across different places on the page. This increases the readability of the system, since all the actions follow the same structure. Figure 4.44 and 4.45 depict how discussions are added and viewed in the video clip viewer.

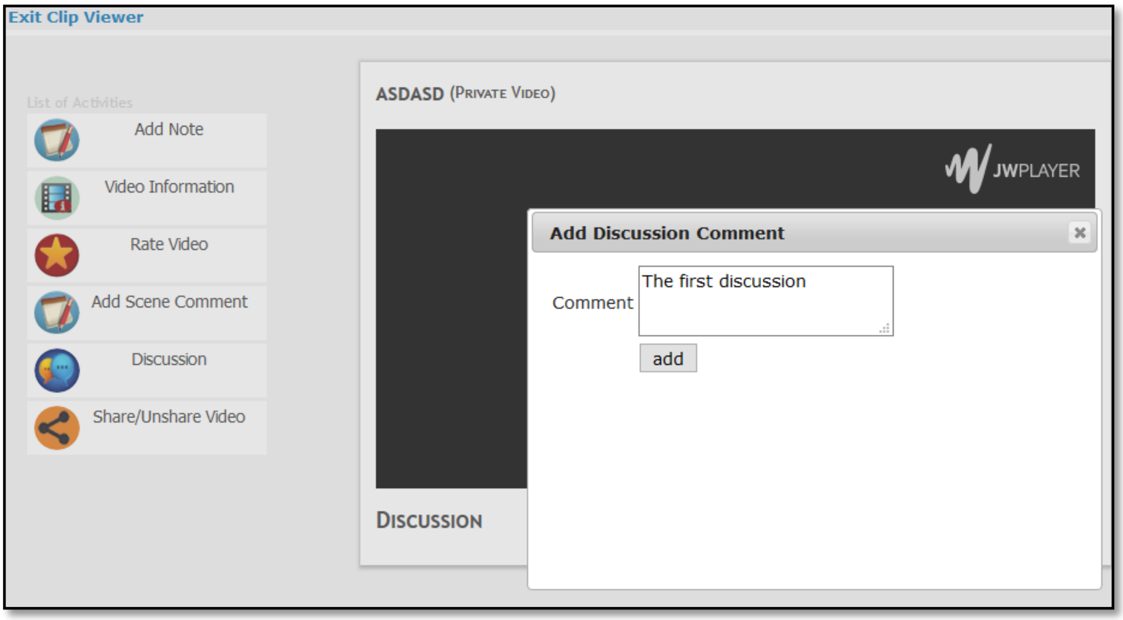


Figure 4.44: Adding a Comment to a Discussion on the Video Clip

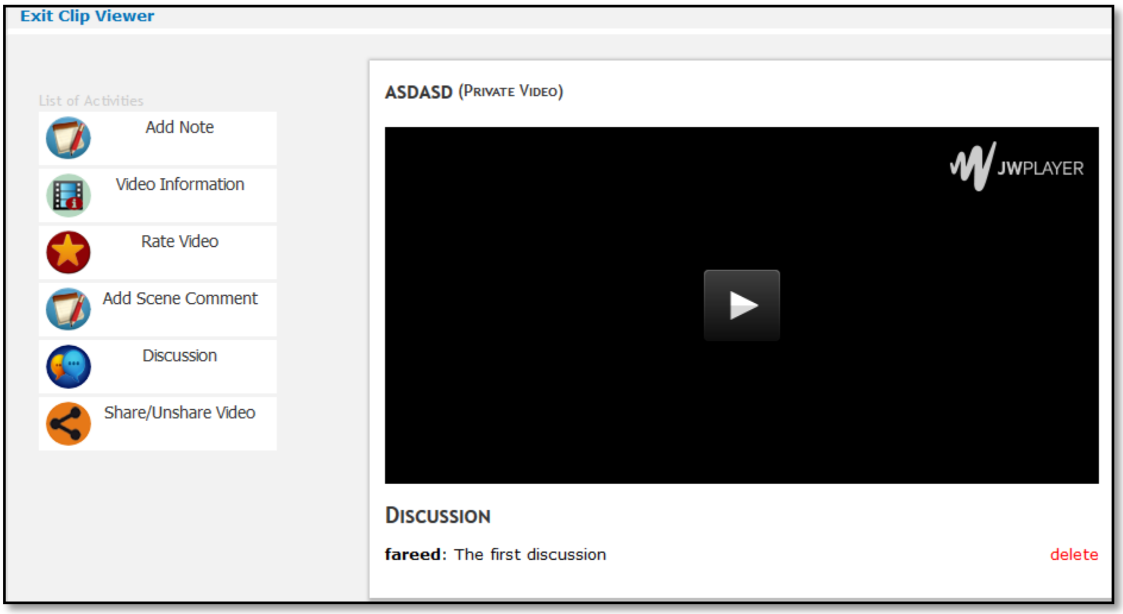


Figure 4.45: Discussion Comment as Viewed in the Video Clip Viewer

The rating and scene comments also follow the same procedure, and they can be added using a similar process to that shown for adding the discussion comment.

In the system used in the pilot study, the privacy of the video could not be set on the video clip page itself, but on a different page. This was confusing for the students, as they needed to navigate to another page to perform this action. In the new system, a button for sharing or un-sharing the video clip was added to allow students to control the video status via a more centralized action.

Additional information about the video clip was also removed from the central panel and moved to the action panel to improve the readability of the video clip and hide unnecessary information, which could be viewed on request. Figure 4.46 shows how video clip information is viewed by clicking on the video information button in the action list.

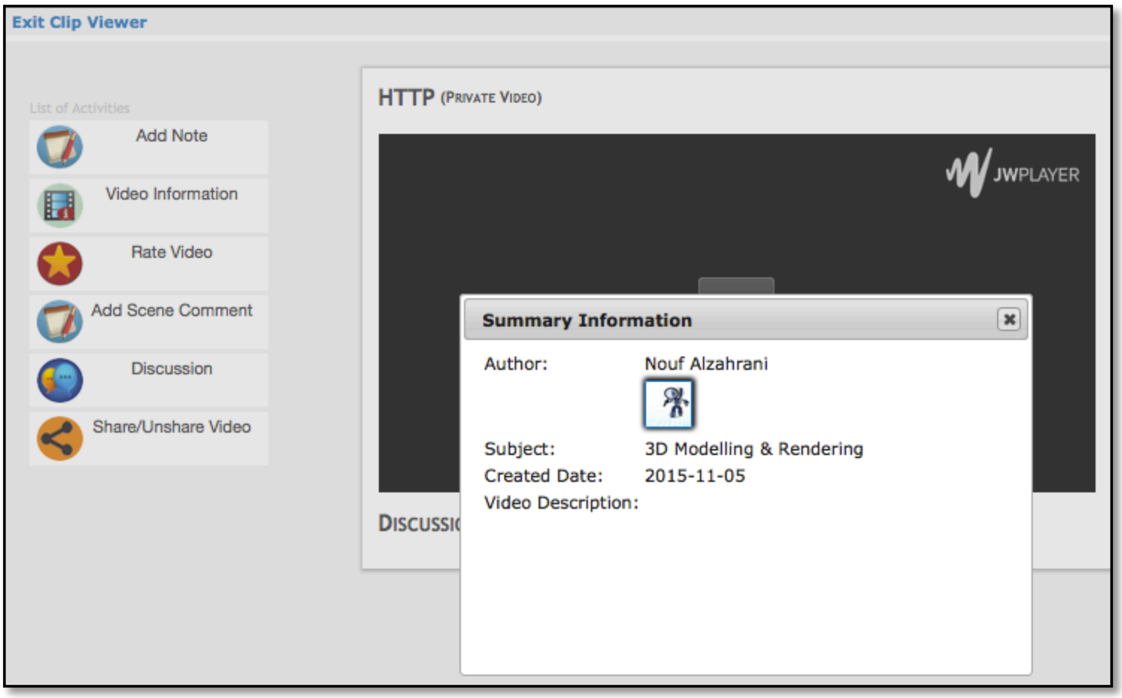


Figure 4.46: Video Information as Viewed in the Clip Viewer

4.16.7 System Action Feedback

Many students had complained that the system did not provide the necessary feedback when they performed actions, especially if the action was a lengthy one. For example, when creating a video clip, the FFMPEG software requires time for rendering a new video clip from long videos. To solve this issue, a dialog box was added to the system when the students performed this action, to notify them that the process would take some time and they would need to wait until the action was complete. Figure 4.47 and 4.48 demonstrate how this dialog box appears in the system.

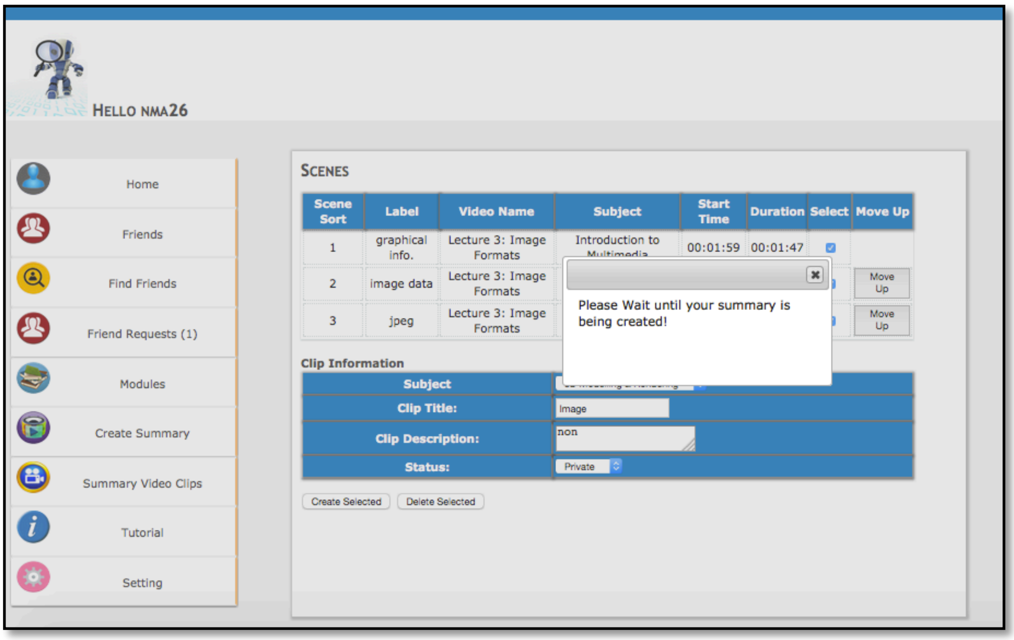


Figure 4.47: Feedback Message Notifying Students that They Need to Wait Until the Process is Complete

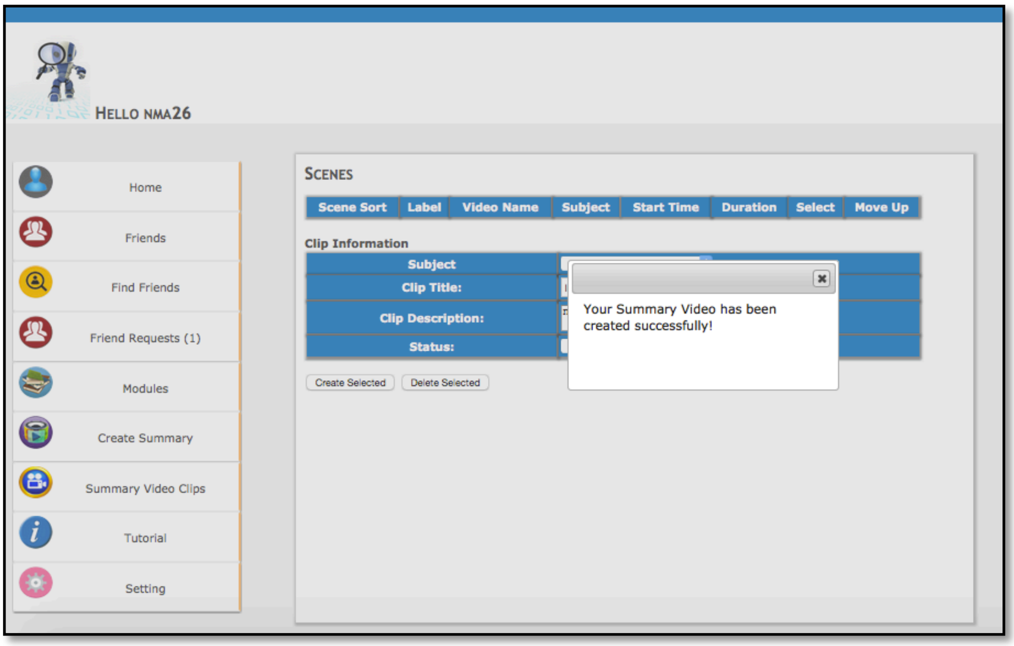


Figure 4.48: Feedback Message Notifying Students that the Video Creation Process is Complete

4.16.8 Rearranging Clip Holders

In the pilot system, video clips could be re-arranged by dragging and dropping the functionality of each holder in the list. This was not fully understood by some students, who were rather confused about how to rearrange the clip holders. This function was improved by adding a 'move up' button, which adds more clarity to this action. Figure 4.49 depicts the 'move up' button of the clip holder.

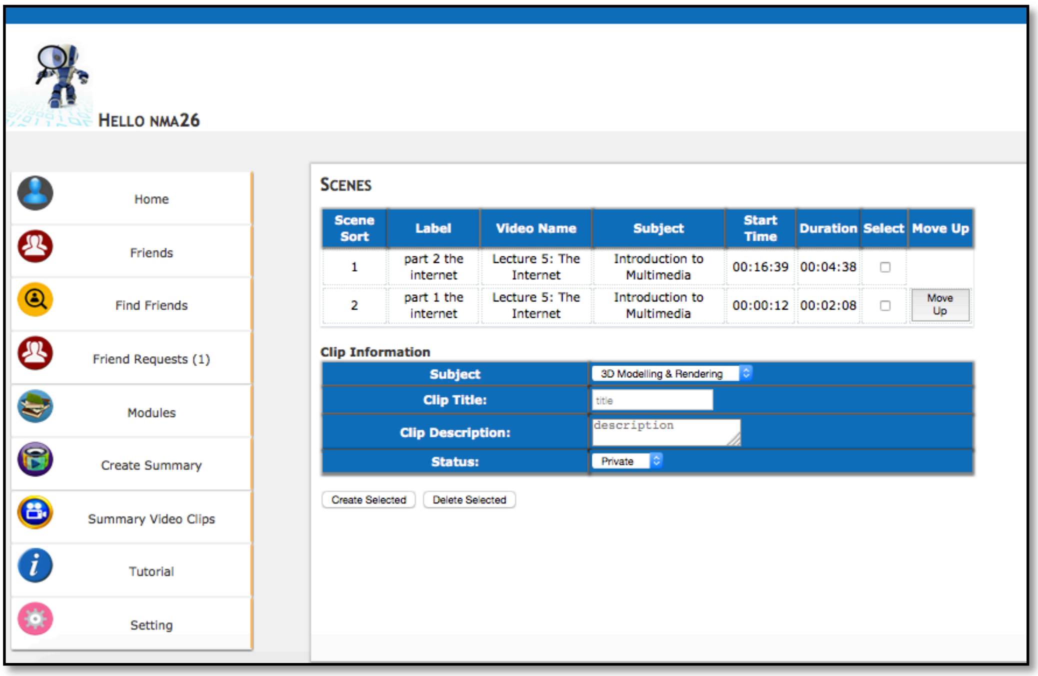


Figure 4.49: The 'Move up' Button of the Clip Holder, Which Allows Students to Rearrange the Video Clip Scenes

4.17 Results of the usability evaluation:

This section contains the results of the evaluation of system usability and the interface for both the pilot study and full study after the modifications.

4.17.1 Evaluation of system interface and usability in the pilot study:

Usability and Effectiveness of the Summarization Function

The results show that 88% of the students agreed that the system is effective for the summarization of lecture videos; 12% stated that they were satisfied; and none of the students disagreed with the statement. Further, 84% of the students agreed that the system was efficient with regard to capturing specific parts of the lecture videos, and only 4% of the students (1 student) (response number 7) did not agree with this statement. Similarly, the responses indicated that 96% of the students were at least satisfied with the speed at which video clips could be created, and only one student did not agree with the statement that video clips could be created quickly with the system. With regard to the ordering of the video clips, 68% of the students stated that they 'strongly agree' and 'agree' that they were easily able to change the order of the clips. However, the results indicated that 88% of the students were at least satisfied with the system in this regard. In addition, all the students agreed that they were easily able to add comments and descriptions to the created video clips, or were satisfied with the ease of using this functionality.

Q#	Question/Statement	SA	A	S	D	SD
2	I can effectively summarize video lectures using this system	12%	76%	12%	0%	0
3	I am able to efficiently capture specific parts of the lecture videos using this system	24%	60%	12%	4%	0
4	I am able to change the order of clips easily in this system	16%	52%	20%	8%	4%
5	I am able to create my own video clips quickly using this system	24%	48%	24%	4%	0
6	I am able to add my own descriptions and comments on my own video easily using this system	48%	44%	8%	0%	0

Table 4.1: Questionnaire of Usability and Effectiveness of the Summarization Function

In general, only 5% of the responses (on average) indicated that the students were not satisfied, while 95% of the responses indicated satisfaction with the system.

Interface and System Design

The degree of disagreement in this evaluation was relatively higher than that in the other evaluations. However, it still showed a high amount of satisfaction with the system. The students were happy with the ease of using the system, as 88% of the students responded with ‘strongly agree’, ‘agree’, or ‘satisfied’. The interface design also received a positive response, as the responses of 76% of the students indicated that they were at least satisfied with the interface. Similarly, the responses indicated that 84% were at least satisfied with how comfortable the system is. Further, the results showed that only 8% of the students did not agree that the system had all the functions and capabilities they expected it to have. Overall, the responses indicated that all the students were at least satisfied with the system. However, it seems from the responses that a relatively high percentage (23%) of students were unable to correct their mistakes easily.

In general, the responses indicated that most of the students were at least satisfied with their learning productivity after they used the system, as 87% were at least satisfied with their productivity and only 13% did not agree with the statement that their productivity had improved.

Q#	Question/Statement	SA	A	S	D	SD
1	I am satisfied with how easy it is to use this system	24%	44%	20%	12%	0
10	I feel comfortable using this system	32%	24%	28%	16%	0
13	Whenever I make a mistake using the system, I recover easily and quickly ***(8% N/A)***	9%	27%	41%	18%	5%
12	I believe I became productive by using this system ***(8% N/A)***	22%	30%	35%	13%	0
18	The interface of this system is effective and easy to understand	20%	44%	12%	12%	12%
19	This system has all the functions and capabilities I expect it to have	24%	64%	4%	4%	4%
20	Overall, I am satisfied with this system	28%	40%	32%	0%	0

Table 4.2: Questionnaire of students opinion of system interface and design

4.17.2 Evaluation of system interface and usability in the full study:

To evaluate the system interface and usability in the full study, the QUIS questionnaire was used (described in Chapter 3): it contains questions on students' satisfaction with user interaction and contains four main parts, the responses to each of which are scored on a scale of 1 to 5 (quantitative questions):

1. Part 1: Overall response to ACES
2. Part 2: Visual representations
3. Part 3: Terminology and system information
4. Part 4: System capabilities.

4.17.2.1 Responses to the QUIS Questionnaire

This section highlights the responses of the students to the QUIS questionnaire. The students were asked to rate each question on a scale of 1 to 5, where 1 is the lowest and 5 is the highest score possible. As explained in the previous section, the

QUIS questionnaire comprises four parts, each of which is discussed in detail below:

QUIS Part 1: Overall response to the ACES system

As shown in Table 4.3, this part contains five questions. With regard to the students' general opinion about ACES, they were asked to rate the system from 1 to 5, where 1 indicates that they are dissatisfied and 5 indicates that they feel positive about it.

Questions		**1**	**2**	**3**	**4**	**5**	
General opinion	Dissatisfied	0%	1%	31%	56%	12%	Positive
Ease of use	Difficult	0%	10%	27%	37%	26%	Easy
Adequacy: did you feel that the system enabled you to improve your understanding	Poor	3%	13%	23%	40%	21%	Good
Motivation: how motivated did the system make you feel	Dull	3%	19%	44%	27%	7%	Stimulating
Engagement: how engaged were you by the system	Low	6%	16%	41%	23%	14%	High

Table 4.3: Distribution of Scores for QUIS Part 1

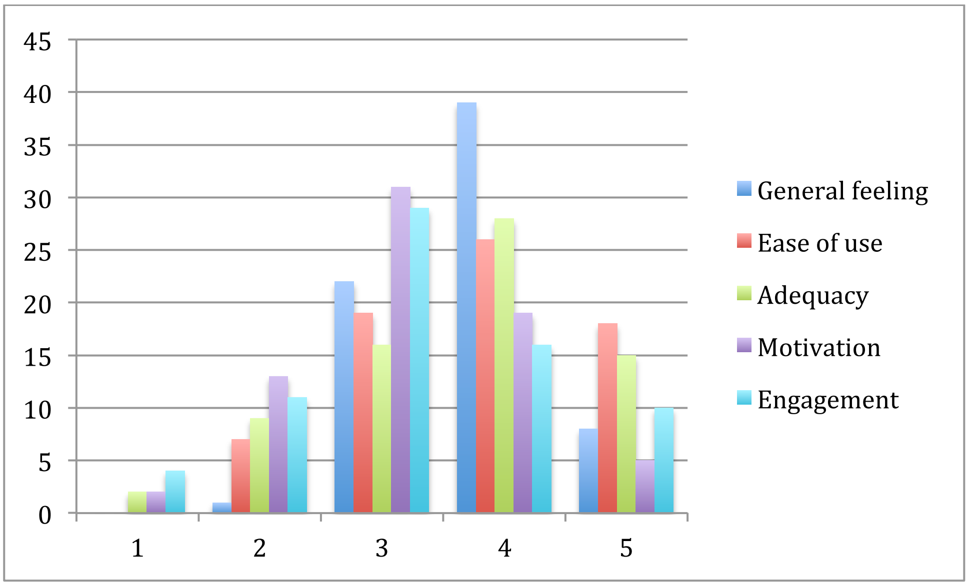


Figure 4.50: Overall response to the ACES system

As shown in Figure 4.50, the students were satisfied with the ACES tool, as the majority of the scores were between 3 and 4.

QUIS Part 2: Visual representation

This section was dedicated to evaluating the visual representation of ACES. As shown in Table 4.4, this part comprises three questions.

Questions		1	2	3	4	5	
Reading characters on the screen	Hard	0%	0%	10%	31%	59%	Easy
Organization of information	Confusing	0%	10%	14%	42%	34%	Very clear
Sequence of screens	Confusing	1%	3%	24%	42%	30%	Very clear

Table 4.4: Distribution of Scores for QUIS Part2

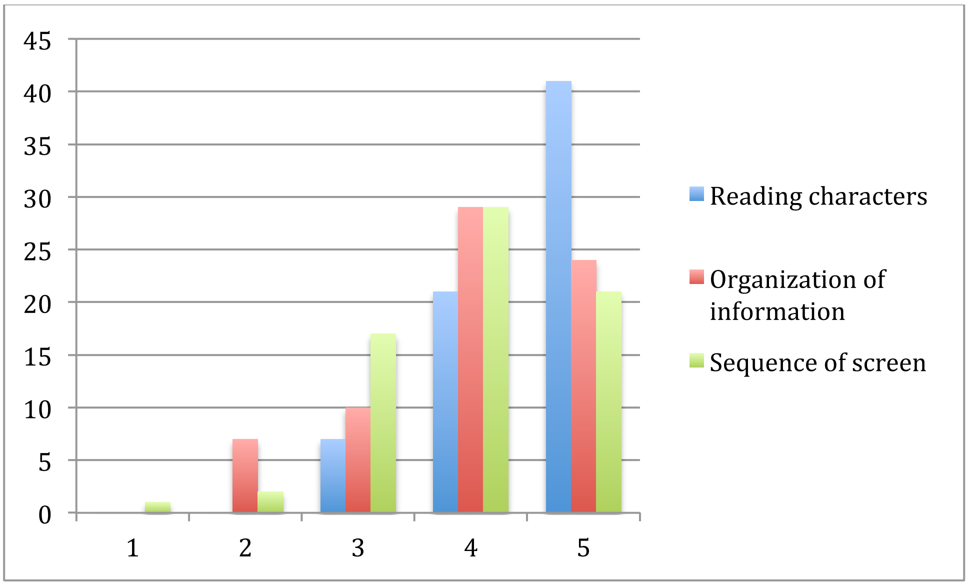


Figure 4.51: Visual representation

As shown in Figure 4.51, most students were happy with their interaction with the ACES tool, as the majority of the scores were between 4 and 5.

QUIS Part 3: Terminology and system information

In this part, the questions were related to the terminologies and the information provided in ACES. As shown in Table 4.5, this part contains three questions.

Questions		1	2	3	4	5	
Use of terms throughout the system	Inconsistent	0%	2%	16%	39%	43%	Consistent
Prompts for input	Confusing	0%	3%	26%	40%	31%	Very clear
Error message	Unhelpful	2%	8%	43%	29%	18%	Helpful

Table 4.5: Distribution of Scores for QUIS Part 3

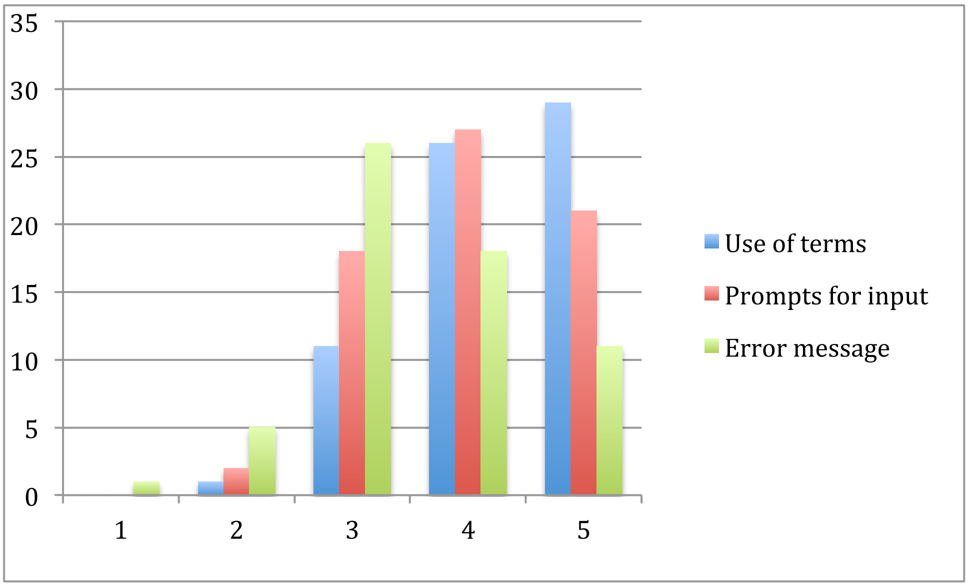


Figure 4.52: Terminology and system information responses

Thus, with regard to terminology and system information, the students were at least satisfied with the ACES tool.

<u>QUIS PART 4: System capabilities</u>

The last part of the QUIS questionnaire evaluated the system capabilities of the ACES tool. As shown in Table 4.6, this part contains four questions.

Questions		**1**	**2**	**3**	**4**	**5**	
System speed	Too slow	17%	26%	11%	36%	10%	Fast enough
System reliability	Unreliable	6%	13%	25%	43%	13%	Reliable
It is easy to remember how to use the system	Agree	31%	18%	19%	26%	6%	Disagree
ACES is designed for all levels of users	Agree	26%	23%	17%	28%	6%	Disagree

Table 4.6: Distribution of the Scores for QUIS Part 4

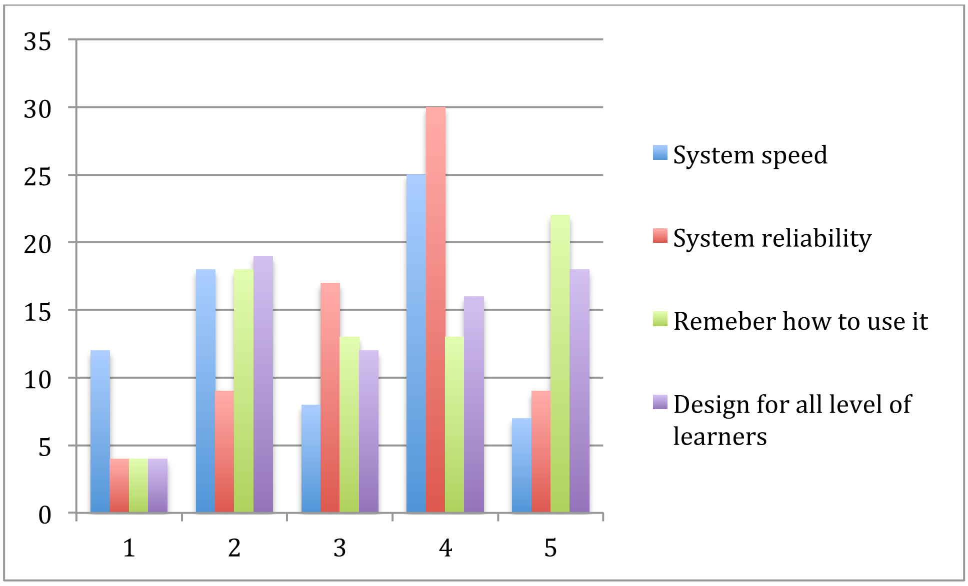


Figure 4.53: System capability responses

With regard to system reliability, speed and remembering how to use the system as showing in figure 4.53, the majority of students found the system acceptable. However, many students did not agree that the system was designed for all levels of users. However, in general, the scores for system capabilities were good.

The negative ratings for questions 1 and 2 can be explained by some technical issues that occurred in the lab session in which the questionnaire was handed out. As ACES is deployed on the university servers and relies on external resources from the Internet, it needed a reliable Internet connection to function smoothly. In the week 7 lab session (when the questionnaire was handed out), due to additional load on some of the university servers, the Internet connection for the entire campus was very slow and many students were unable to use the system efficiently. Latency and system crashes were noticed in that session and students complained about how slow the system was. This probably affected the evaluation of the system in the questionnaire that was handed out at the end of the session, as these students comprised one-third of the total respondents.

4.17.2.2 General Opinion about the Usability of the System

In the second part of the questionnaire (Part B), students were asked via open-ended questions to list the parts of the system that were easy or difficult to use.

In the first question, the students were asked to list the aspects they liked and found easy: 10 students reported that they found it easy to create the video clips. Cutting and capturing the lecture video was also a popular choice, as 11 of the responses acknowledged this function. Finding friends was another popular choice, as 10 students believed that it was easy to find friends. The other functions that were reported as easy by many students were adding scene comments, finding subjects and finding lecture videos. Some functions were mentioned only once, including communicating with friends, logging in, sharing video clips, interface and navigation. Further, one student expressed the opinion that all the functionalities were easy to use.

There were also some negative responses with regard to the usability of the system, the most notable of which was the slowness of the system. This issue was reported later on in the video creation step. However, this problem was not reported in the case of videos that were relatively small in size and was only reported when large videos were uploaded, as the FFMPEG software required more time to cut out clips from large videos and create new video clips. As a result of this issue, students re-clicked the same task button multiple times and created multiple videos.

Ajax requests were also not efficiently implemented, as some tasks required the screen to be refreshed after submission, this issue was noticed by some students. The other tasks that received some negative comments were creation of the video clips, sharing the videos with specific friends, deleting scene comments, finding subjects, interface design, lack of feedback on the performed tasks, modification of clips that was not introduced in the system, and navigation.

Notably, 6 (24%) students agreed that there were no exceptional limitations or difficulties with regard to the system.

4.18 Summary

This chapter described the architecture, modules and functionalities of the system for the pilot study. This included a graphical description of each functionality provided by the system along with the architectural design (for important functionalities). This was followed by modification of the system for the full study, and evaluation of the results of both studies with regard to system usability and interface.

Chapter 5: Pilot Study

5.1 Introduction

In Chapter 1 and Chapter 2, the research hypothesis was presented, which was based on various learning theories, including the VAK learning style, the cognitive learning theory and the constructivist learning theory, and a review of the existing literature on this subject was also presented. A solution was proposed in Chapter 3, which involved building a system that could increase student's learning motivation, understanding and engagement; this system was termed ACES (student summarization in an adaptive and collaborative e-learning environment). The system structure and study plan were presented in Chapter 3, along with the key development issues. This chapter presents the primary data analysis of a pilot study in which the pre- and post-experiment questionnaire findings are presented, along with the researcher's observations about the student-summarized video system and collaborative e-learning within the system. The data were collected and analysed based on the goals presented in Chapter 2, which were to improve understanding and enhance motivation in learners by using video summarizing and collaborative e-learning tools. The main purpose of the pilot study was to test the usability of the ACES system and understand how well students receive the system before launching the full study. Before the actual study was commenced in the autumn term of 2015, the system was modified based on the findings of the pilot study.

The findings presented in this chapter demonstrate the potential for merging learning theories and learning practices. At the end of this chapter, the findings are recorded and their contribution to the research is explained and discussed.

5.2 Target Population

The target participants of this pilot study were postgraduate students from the second term and undergraduate third-year students enrolled for higher education courses at the University of Sussex; they were therefore from different age groups and genders. Specifically, students who enrolled for the Multimedia Design and Application module offered by the School of Engineering and Informatics at the University of Sussex and volunteered for the experiment were included. In total, 41 students participated in this experiment, including 12 postgraduate students (Master students) and 29 undergraduate students (third year). The gender composition was 25% female and 75% male students from different age groups. All participants attended the Multimedia Design and Application Lab, and they used the University of Sussex student portal Study Direct (based on Moodle) to access the system, where they could perform various tasks including watching video lectures, summarizing video clips and collaborating with other students.

The sample size is critical for research of this magnitude. However, a small sample size is sufficient to test the usability of the system. The project was considered low risk, and the findings were anonymised. Only a small group of students was included, in order to gain an understanding of the general responses of the students to the system, in addition to their experience and comments.

5.3 Experiment Procedure

After ethical approval for the study was obtained, the students were asked to answer the pre-experiment questionnaire. The questionnaires were distributed to evaluate the students' previous experience with using video lectures in e-learning systems and to find out if they had previously used video summarization tools. The students were required to sign a consent form before they could start using the system.

The tools and tasks were explained to the students who provided their consent. The functionalities of the system were explained to the students, included how to watch lecture videos, how to capture parts of different videos, how to combine them together into a single summarized video clip, how to add friends, and how to subscribe to a subject to view video clips created by other participants in the system. In the final part of the study, which took place at the end of the term, the participants were asked to answer a post-experiment questionnaire that contained questions related to their experience with the proposed system.

5.4 Overview of the Questionnaires

This section provides a more detailed explanation and overview of the questionnaires. The questionnaires are designed to evaluate and compare the users' experience before, during and after using the system. The pre- and post-experiment questionnaires contain questions related to behaviour and attitude.

Pre-Experiment Questionnaire

This questionnaire was distributed in the Multimedia Design and Application module lab in March 2015. It evaluates students' previous experience with using videos as learning tools in education and previous video summarization tools that the students used. The pre-test questionnaire contains five open-ended and eight close-ended questions, as shown in Appendix 2.1. The questions are divided into four domains: learning preferences, time spent on learning, video learning experience, and video summarization experience. The results of this questionnaire will provide information about user background in e-learning in general and their previous experiences with summarization tools. This is important in determining the degree of novelty in the learning experience the system can provide.

Post-Experiment Questionnaire

This questionnaire was set to evaluate the usability of the system and students' experience with the learning system (Appendix 2.2). The findings of this questionnaire are important for understanding students' evaluation of the system and how useful it was to their learning experience. The questionnaire contains 23 close-ended questions and 11 open-ended questions.

5.5 Pilot Study Findings

In this section, the results of the close-ended questions are evaluated quantitatively using IBM SPSS (IBM SPSS Software, Ver. 22). The results of the open-ended questions are evaluated qualitatively along with data extracted from the system and the researcher's observations. After all the results from the questionnaires, observations, and system data are analysed, they are discussed with regard to their contribution to the research outcomes.

5.5.1 Pre-Experiment Questionnaire Findings

All 41 students who volunteered for the experiment answered the pre-experiment questionnaire. This section presents the data recorded from this questionnaire and an analysis and discussion of the data.

5.5.1.1 Learning Media

As shown in Table 5.1, 68% of the students stated that video learning was their preferred medium for learning. A considerably smaller portion (21.95%) preferred attending lectures in person, and only 10% of the students preferred other types of learning media, including written material, lecture slides and Internet searches.

Preferred Media	Frequency	Percent	Cumulative Percent
Video	28	68.29	68.29
In-Class Lecture	9	21.95	90.24
Other	4	9.76	100
Total	41	100	

Table 5.1: The Percentage of Students who Preferred Different Learning Media

The results showed that learning via video lectures is the most common style of learning among participants and that most of them chose video learning as their preferred learning style. In another question, students were asked if they had actually ever used videos as a learning tool for the purpose of education before. The results showed that almost all the students (95%) had used videos for education purposes before: only two students had not used videos for education before.

Participants were asked to express their views on video learning in comparison to traditional learning methods in an open-ended question. Twenty-three of the twenty-nine undergraduate students (79%) and eleven out of the twelve (92%) postgraduate students stated that they preferred video lectures to traditional in-class lectures. Further, several students were of the opinion that using videos in education is more beneficial when practical rather than theoretical videos are provided. This is in keeping with the kinaesthetic learning style (in the VAK learning theory), according to which students can learn by practice as they watch the experiment on the video and try to apply it in real life. In the kinaesthetic learning style, students engage in a more active learning process. That is, students are more actively engaged when they watch the video with the intention of selecting important parts as separate video clips.

Based on the student's responses, it seems that the following factors influenced the students' preference for video lectures over traditional learning:

- *Ease of use*: The video's functionalities were easy to use.
- *Time efficiency:* The students do not need time to physically attend lectures.
- *Accessibility:* The video can be accessed from any location (online video lectures).
- *Availability:* The video is available at any time and not bound by specific timings.
- *Repeatability:* The video can be viewed and repeated multiple times, unlike traditional in-class lectures.
- *Continuity:* Video lectures are continuous and not interrupted by unwanted audience participation or distraction from within or outside the classroom.
- *Manipulation:* The video can be manipulated by fast forwarding, pausing, etc.

However, the lack of feedback in video lectures was identified as a problem by a few students, as the students could not obtain immediate responses to their questions. Some of the students stated that they preferred traditional learning without providing any specific explanation.

5.5.1.2 Time Spent on Watching Lecture Videos

The results showed that more than 78% of the students dedicated at least 1 h per day on an average to watching lecture videos. The mean number of hours spent on watching videos (educational and non-educational) per week was 9.10 (±4.55) in the sample of 41 students who answered the pre-experiment questionnaires. This indicates that most of the students were very familiar with video lectures and videos in general, as they watch videos for educational and other purposes on a regular basis. Figure 5.1 represents the frequency distribution of the hours spent watching videos on different social networks in general.

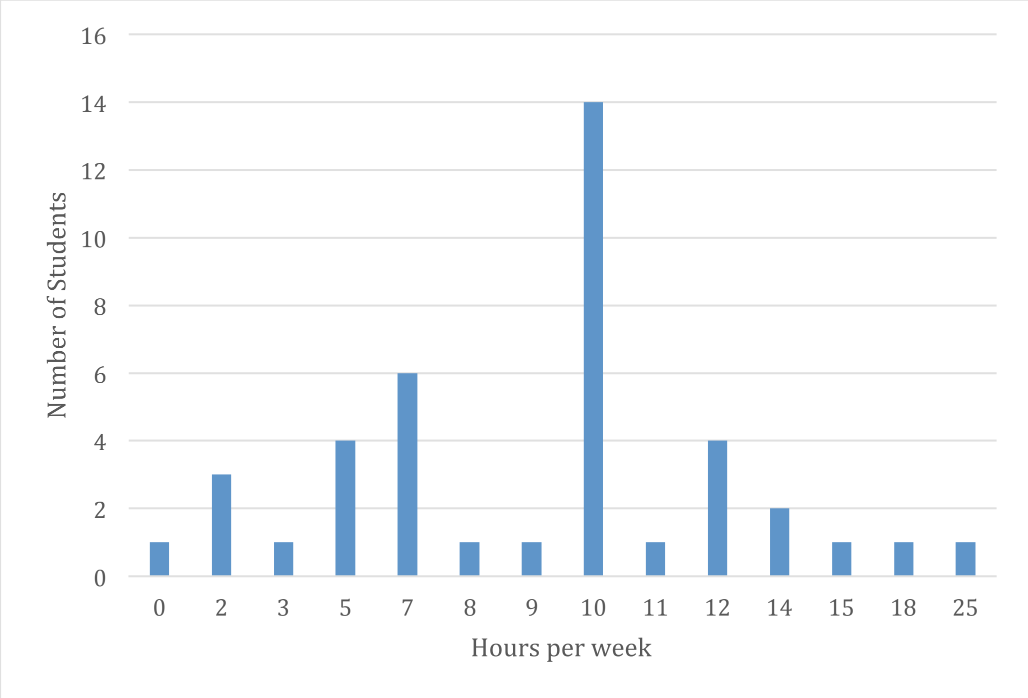


Figure 5.1: Frequency Distribution of the Hours Spent Watching Educational and General Videos on Social Networks

5.5.1.3 Summarization Experience

To examine students' attitudes toward the summarization of video lectures, students were asked if they had ever summarized a video lecture before using any method of summarization, such as taking notes, mind mapping, lecture slides, and writing down key points. Of the 41 students, 28 students (68%) replied that they had used summarization methods before and 13 students (32%) replied that they had not used any video summarization method before. Thus, one-third of the students had not engaged in video summarization before. Further, none of the students had used special technological tools for editing videos, apart from the methods mentioned above. From among the 28 students who reported that they had used summarization methods, three reported that they had done so by highlighting important information. This may not have applied to video lectures; however, it is possible that the students meant that they wrote down information from the video and then highlighted the important information. It is also possible that the students who responded as such did not understand the question correctly. As any of these assumptions could be correct, these responses were considered as invalid and not included in the data analysis. The results obtained after elimination of these data show that almost two-third of the participants

(57%) tended to write down a summary and key points or draw mind maps when watching video lectures, a small percentage 5% of students used related lecture slides as their summary method, 34.21% did not use any summarization method while watching video lectures, and a few students used multiple methods. The breakdown of the data is shown in Figure 5.2.

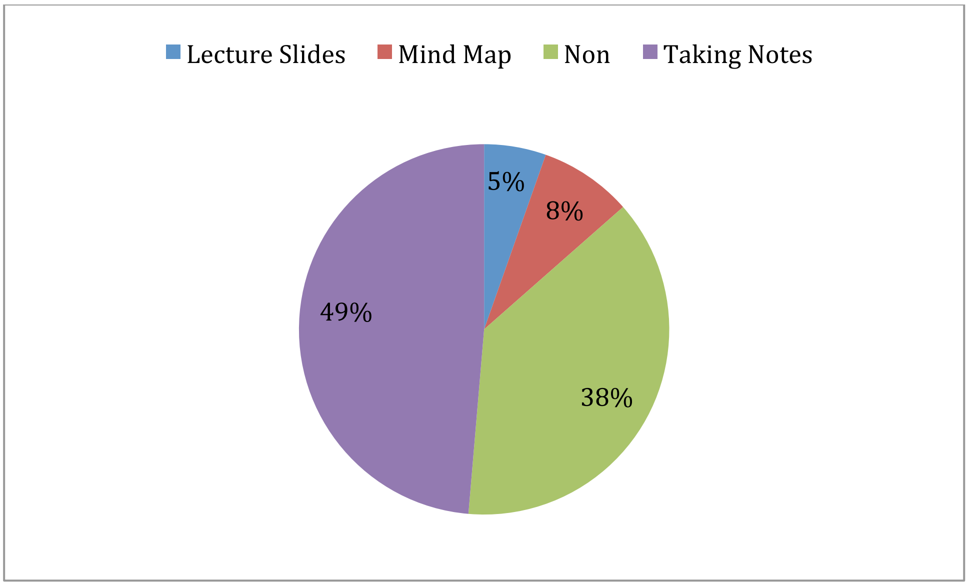


Figure 5.2: Breakdown of the Summarization Methods used by the Students

In another question, the students were asked whether they had previously used any special tool for summarizing video lectures. All the respondents reported that they had not used any special tools for editing lecture videos before. This indicates that the summarization tool in the system in this experiment would be a completely new tool for all the students.

5.5.1.4 Students' Opinion about Summarization

The students were asked for their opinion on the summarization of video lectures and its effects on their level of understanding. The majority of the students agreed to the statement that summarization of video lectures helps in improving their understanding: 36 students (89%) responded with a 'yes' and only 5 students (11%) did not agree.

5.5.1.5 Discussion of the Pre-Experiment Questionnaire

The objective of administering a pre-experiment questionnaire was to evaluate users' experiences with video lectures and summarization. The results of the pre-experiment questionnaire implied that the students had a considerable amount of experience in video learning, and that video learning is popular in modern e-learning systems and is preferred over other types of learning media in most circumstances. The findings also showed that students preferred to invest their study time in watching educational videos rather than reading through other learning material: the students reported that they spent an average of 10 hours a week watching educational and other videos.

The responses to the open-ended questions in the pre-experiment questionnaire indicated that many factors contribute to the preference for video lectures over traditional learning methods. The ease of learning, accessibility and availability of video lectures are among these factors, as expressed by the participants. Further, with regard to the students' experience with video lecture summarization, none of the participants had previously engaged with such tools. This means that the summarization tool was completely new for the students who participated in the study.

5.5.2 Post-Experiment Questionnaire Findings

Out of the 41 students who answered the pre-experiment questionnaire, only 25 participated in the experiment and answered the post-experiment questionnaire. One of the reasons why all the students did not complete all the phases of the experiment was that the post-experiment questionnaire was distributed during the final exam preparation weeks. Therefore, many students did not have enough time to participate fully in the experiment and a number of students did not participate at all. The low participation rate will be discussed below and will be covered in the general discussion section (Section 5.6).

This section presents the data recorded from the post-experiment questionnaire and their analysis and discussion.

5.5.2.1 Sample

The 25 students who answered the post-experiment questionnaire included 16 male students and 9 female students. With regard to the age group segregation, the sample comprised 13 undergraduate students and 12 post-graduate students, with an average age of 23.6 years (±2.04). Information about the participants was acquired from the University of Sussex study portal, where the questionnaire was posted and answered.

This questionnaire contains three parts: Part A contains close-ended questions about the different functionalities of the system, Part B contains open-ended questions about the usability of the system which was explained in chapter 4, and Part C contains open-ended and close-ended questions about the contribution of the system to learning. The following sections analyse the responses to these three parts of the questionnaire. The sequence and order of questions in each part are irrelevant, as the distribution of questions in the questionnaire was not clear. The format of the questionnaire will be altered in the full study (described in Chapter 6, section 6.4).

5.5.2.2 Organization of Part A of the Questionnaire

Part A of the questionnaire covered the system interface, the summarization video, system functionalities and the collaborative environment. It contained 20 scale questions, with the scale comprising of the following responses: Strongly Agree, Agree, Satisfied, Disagree, and Strongly Disagree. The questions are distributed across the sections as follows (the complete questionnaire can be found in Appendix 2):

- Section 5.5.2.2.1 will cover questions 11, 16 and 17, which are related to learning with the system and the effectiveness of the tutorial.
- Section 5.5.2.2.2 will cover questions 7, 8, 9, 14, and 15, which are related to the collaboration function of ACES

5.5.2.2.1 <u>Learning with the System</u>

To ensure that it was easy to learn with the system, a tutorial section was added to the system so that it could be referred to at any point of time. The tutorial contained visual and written instructions on how to use the system functionalities. In addition, a tutorial section was presented to all participants in the module lab before they used the system to ensure that the students were aware of all the functionalities of the system and the tasks that they could perform on the system.

The results for this section showed that 92% of the students were at least satisfied with how easy it is to learn using the system. Moreover, 75% of the students agreed that the information provided in the tutorial was easy to understand, and 21% were satisfied with this aspect. In addition, the tutorial was a very popular task, as the responses indicated that 95% of the students were at least satisfied with how the tutorial had helped them complete the tasks of the experiment.

Q#	Question/Statement	SA	A	S	D	SD
11	It was easy to learn with this system	40%	12%	40%	8%	0
16	The information provided by the tutorials is easy to understand ***(4% N/A)***	33%	42%	21%	4%	0
17	The tutorial is effective in helping me complete the tasks ***(8% N/A)***	36%	45%	14%	5%	0

Table 5.2: Questionnaire for learning with the system.

5.5.2.2.2 Effectiveness of the Collaboration Tool

The students seemed to be largely satisfied with the collaboration functionalities. Only 4% of the students reported that they were not able to easily share their videos with their friends. The responses indicated that all the students were at least satisfied with how it easy it was to discuss videos with their friends; this finding indicates that the system successfully promotes discussion of the video clips. Only 4% of the students (1 student) (response number 22) faced difficulties in accessing the created video clips by subscribing to the relevant subjects, and the rest of the students were at least satisfied with this aspect.

The results also showed that finding friends on the system is easy, as 68% of the students agreed with the statement that finding friends is easy and 24% reported that they were satisfied with this functionality. Similarly, the results showed that the majority of the students found it easy find subjects on the system, as 84% of the students agreed with this statement. The responses indicated that 12% of the students found it difficult to find friends, and 4% found it difficult to find subjects.

Q #	Question/Statement	SA	A	S	D	SD
7	I am able to easily share my videos	25%	42%	29%	4%	0

	with friends using this system					
8	I am able to discuss videos with friends easily using this system	20%	40%	40%	0%	0
9	I am able to get all the created video clips quickly by subscribing to the specific subjects using this system	16%	48%	32%	4%	0
14	It is easy to find a friend	28%	40%	20%	12%	0
15	It is easy to find the subjects I want ***(4% N/A)***	42%	42%	12%	4%	0

Table 5.3: Usability and effectiveness of the collaborative tool

5.5.2.3 Contribution of the System to Learning

The third and most important part of the questionnaire (Part C) was related to the learning support provided by the system, which was directly related to the research questions. These questions were set with the aim of understanding the students' general opinion about the system with regard to how it has contributed to their learning, engagement and motivation.

5.5.2.3.1 Q1: Did the system help in the creation of summary materials?

In the first question, the students were asked whether the system had helped them create summary material with a brief explanation on how to do so. Out of 20 students who provided valid answers, 5 students provided invalid answers, as they were not related to the question or left blank; 16 (80%) agreed that the system had helped them create summary material; and 4 (20%) did not agree with the statement.

Some students believed that the short video clips containing important points and key footage created from lecture videos were helpful in revision. However, some students found that the summary technique does not provide meaningful summary material, as the videos are only captured from the lecture videos and no meaningful notes are summarized. One particular student stated that although the concept of the system was good, he/she preferred paper notes for revision.

5.5.2.3.2 Q2: Did the summary materials help you to have a better understanding of the subject and improve your knowledge?

In the second question, the students were specifically asked whether the created summary material helped them to gain a better understanding of the topic and improve their knowledge. The question was set to measure how the system has contributed to improving their knowledge and understanding. The degree of agreement with the statement was high, as 21 students (84% of the valid answers) believed that the system did improve their understanding. Based on the answers, a common belief among the students was that the system provided them with a helpful tool for creating a customizable video clip that they could view for revision instead of reviewing each long lecture video. On the other hand, four students (16%) did not believe that the system had helped improve their understanding. One student highlighted a key point, which was that since they were preparing for their written exams, they would prefer written material over short video clips.

5.5.2.3.3 Q3: Did you find other students' videos helpful in improving your knowledge and understanding?

The third question was set to determine how helpful students' summary videos were in improving other students' understanding. This question is important as it examines how the system utilizes collaboration to improve the understanding of users. The results varied, as only 44% of the students found it helpful. The general belief was that other students' video clips would help their understanding by repeating or highlighting important issues they had missed. However, the answers were theoretical rather than practical in their implications, as the students stated that they believed this would be helpful and they did not actually review or understand the videos. A search of the database showed that 23 out of the 30 videos created were shared between students. The rate of creation of video clips was low, and this is discussed further in the discussion section.

A majority of the students did not find other students' videos helpful, and they cited various reasons for this. The most common reason was that they could not find their friends' videos. This probably occurred because they had not added their friends on the system, they had not subscribed to the relevant subjects, or their friends did not create any video clips for them to review. This issue is a key point, which will be addressed in the main study.

Four students (16%) had mixed feelings about the tool. One student found that his own video sufficed and that he did not need to view other students' video clips. The other students were careful in stating their opinion about the tool, as they believed that there were several factors that could affect its usability: for example, the content of other students' videos and their understanding might differ from the understanding of another student.

5.5.2.3.4 Q4: Is the sequence order of the scenes important in improving understanding of the content?

The fourth question was set to determine the importance of sequential ordering of the clips: the students were asked whether the sequence of clips in a single summarized video clip was important for their understanding in general. Eighteen (78.26% of the valid answers) students found that the sequential order of the clips in a summary video is important for creating a structured and meaningful video clip. Three students (13.04% of the valid answers) did not find the order to be an important factor in contributing to their general understanding.

Two students stated that the type of content was important, as some types of material need ordering and some do not. In addition, two other answers were considered invalid, as it seemed like the students did not understand the question. The results indicated that the order of clips is an important feature of the system and is required to create a more meaningful learning product.

5.5.2.3.5 Q5: Did you find this tool helpful for solving the learning problems you faced?

In Question 5, the students were asked whether the tool in general was useful in finding answers to the problems they faced in learning. Thirteen students (54.17% of the valid answers) agreed that the system was useful for finding answers to their learning difficulties. However, 7 students (29.17% of the valid answers) did not find it useful for finding answers to their learning problems. Among the reasons cited was the lack of written content with each video, as they had to go through the entire video to find an answer to a specific problem. Another important reason was that there were very few videos available for review.

Four students (16.67% of the valid answers) were not sure about the statement as they lacked practice and did not interact too much with other students and the system. One particular answer was considered invalid, as it was not related to the question.

5.5.2.3.6 Q6: Does the collaboration function improve learning?

In the sixth question, the students were asked about their opinions regarding the contribution of collaboration in the system to improving learning in general.

Seventeen students (73.91% of the valid answers) believed that it is a great tool for promoting collaboration in order to improve learning in general. Two students (8.70% of the valid answers) did not feel that the system provided a useful collaborative tool. Four students partially agreed about its usefulness for collaboration. One student did not find that collaboration was heavily implemented in the system, but agreed that the concept was good. Other important issues were the timing of the experiment, as it was conducted during the preparation weeks for the final exams.

5.5.2.3.7 Q7 and Q8: Does the collaboration aspect of the ACES tool increase motivation? Did you enjoy using the ACES system?

In questions 7 and 8 in part C, the students were asked whether collaboration in the system played a role in increasing their motivation for learning and made the study experience more pleasant.

The responses to Question 7 (how motivation is affected by the collaboration function of the system) were mixed, as 16 (66.67% of the valid answers) of the students believed that they were motivated or that the system promoted motivation and five students (20.83% of the valid answers) did not provide a firm answer. However, three students did not believe that the collaborative aspect of the system had an effect on motivation in any form. One response was considered invalid as the student did not comment on the statement.

Question 8 sought the opinions of the students about whether the system made the learning experience more pleasant. The author believed that the responses would be similar to those for question 7, but the findings were quite unexpected: it appears that motivation and the pleasantness of the learning experience are not necessarily related, as only 11 students (52.38% of the valid answers) agreed that the collaboration function offered by the system made the learning experience more joyful. Further, 9 students (42.86% of the valid answers) believed that the collaboration aspect of the system does not make the learning experience more fun, and one student did not have a clear answer. Four responses were found to be invalid as the student did not respond to the question.

5.5.2.3.8 Q9: Did you find the created video more understandable and accurate than the original video?

Question 9 was very important to the research, as it asked the students to compare the summarized video clips to the original video lectures with regard to the understandability of the learning material. The majority of the students (18 students, 72%) believed that the summarized video clips emphasized on the important points to a greater degree than the original lecture videos did. However, 5 students (20%) did not agree with this point, and their reasons were either related to the slowness of the system (which prevented them from focusing on the video clips) or related to their personal preferences. Two other students were not sure about the statement, because they believed that they had not interacted enough with the system to provide a valid judgment.

5.5.2.3.9 Q10: What are the advantages and disadvantages of the ACES tool?

In question 10, the students were asked to list the advantages and disadvantages of the tool with regard to the learning process in general. The following table summarizes the key advantages and disadvantages.

Advantages	**Disadvantages**
Usability	

Ease of use	Tedious
Ease with which friends can be made	Getting a good cut is hard
Fun and engagement involved in learning with friends	Requires watching the entire lecture video to identify the needed section to cut
Clear understandability	Lack of feedback when user takes action (such as clicking on a button)
Design	
Collaboration without the need for face-to-face study sessions	Not good if long summary video clips are created
Creation of personally tailored summarization videos	Students do not have time to use it frequently
Creation of concise videos	No chatting feature
Student motivation to create summary clips	Button design could improve
Efficient summarization	Requires a lot of overheads
Covering of missed points by watching other videos	Requires refreshing with some functions
Discussion of the video	Lack of instant feedback from users
Sharing of video clips	Lack of feedback on video clips
Logic	
Combination of multiple clips of key footage and concepts into one video	Not a reliable summary tool for sharing as important points may vary in students' opinions
Discussions related to the areas of learning	
Very powerful	Face-to-face sessions are preferred
Usefulness as an organization tool	Does not increase learning speed
Support provided for efficient learning	
Better alternative to bad lecture videos	
Very helpful for revision	

Table 5.4: Advantages and Disadvantages of the System

As seen in Table 5.4, the advantages and disadvantages can be categorized as those related to usability, design and logic. They are discussed in detail in the following observation and discussion sections.

5.5.2.3.10 Q12: Rate the ACES tool with regard to its effect on enhancing learning and understanding

In Question 11, the students were asked to provide an overall rating for how the system had affected the understanding of the learners in general. The respondents rated the system on a scale of 1 to 10 (except for one answer, which was rated on a scale of 1 to 5). The average rating was 7.37 (M = 7.37, SD = 1.96, N = 11), and only one rating was below 5. The rest of the answers were qualitative in nature, and indicated a similar rate of acceptance as in the quantitative responses. From the 14 respondents who provided qualitative responses, 13 (92.86% of the qualitative answers) believed that the system had a positive effect on their understanding; only one student did not find this statement to be true.

5.5.2.3.11 Q12: Rate the ACES tool with regard to its effect on increasing motivation

In the last question, students were asked for a general overview of how the system had affected their motivation. The results showed a high degree of acceptance among the participants, who reported that the system had a very positive impact in increasing motivation by stimulating students to participate in the system activities along with friends. The quantitative and qualitative responses varied. In 10 quantitative answers, the system was rated on a scale of 1 to 10 (except for one answer, which was on a scale of 1 to 5). The average rating was 6.4 (M = 6.4, SD = 2.99, N = 10), with two of the ratings being below 5. The rest of the answers were qualitative in nature and implied a better rate of acceptance: the students agreed that the system had indeed motivated them to engage in learning. Among the 15 students who provided qualitative responses, 14 (93.33% of the qualitative answers) believed that the system had motivated them and only one student did not believe this (this student preferred written material).

5.5.3 User Data

After the database was reviewed, the following information was recorded:

- Four video lectures were uploaded as part of the pilot study.
- Twenty-seven video clips were created, with an average of 1.08 video clips per student.
- Thirty-nine clips were created, which indicated that each video clip consisted of an average of 1.44 clips.
- Forty-five friendships were created, with an average of 1.8 friends per student.

- Twenty-nine scene comments were added, which indicated that each video clip contained 1.07 scene comments added by the owner of the video clip.
- Ten ratings of the video clips were found, which indicated that only 37% of the video clips were rated.
- Seventeen general comments were found in total, which indicated that each video clip had an average of 0.63 comments.

The user data showed a very low participation rate, so a detailed analysis would not provide meaningful findings. The participation rate was affected by several factors, which are identified in the next section.

5.5.4 General Study Observations

Ideally, the experiment was planned so as to eliminate any distraction factors, as mentioned in chapter 3, section 3.5.1. However, several issues affected the successful implementation of the experiment in its ideal form. One of the main issues was that although the system was completely developed in October 2014, the experiment did not take place until March 2015. This was because of technical problems with installation of the system and inconsistencies in versions of the installed libraries. As a result of this delay, the experiment commenced in the two months before the final exams in May 2015, so students did not have sufficient time to use the system. This issue was pointed out by some students in the post-experiment questionnaire and in person. This loss of interest obviously affected the results of the experiment, as some students treated the system as a trial system and not as a revision tool to some degree. Further, as the system required the upload of very large lecture videos, it was not possible to host the application on an external virtual server provided by a commercial host. This was due to the cost of the huge data transfer to the commercial host server. Therefore, the ideal choice was to host the system on an internal server provided by the Information Technology Support Department (ITS) at the University of Sussex.

5.6 Summary

This chapter discussed the implementation and results of the primary data analysis of the pilot study designed for this research. The data were processed so that the research questions posed in Chapter 2 could be answered. That is, the aim of the analysis was to improve understanding and enhance motivation by utilizing video summarizing and collaborative e-learning.

Chapter 6: Video Summarization: Full Study

6.1 Introduction

The full study is the main experiment that was conducted in this research to explore the research hypothesis (in section 1.6) and contributions outlined in section 1.7. The experiment is similar to the pilot study, except that some modifications were made to the system and the experimental procedure based on the analysis and feedback from the pilot study, described in Chapter 4.

6.2 Target population

The target students of this full study were higher education undergraduate students from the Department of Informatics at the University of Sussex. The target population included 121 first-year undergraduate students who registered for the Introduction to Multimedia module. This module was selected because it provides video lectures in a SussexDL format for the students. The students were from four different majors in the informatics school, but they all shared the module. Their majors were as follows: BSc in computer science, BSc in computing for business and management, BSc in computing for digital media, and BSc in games and multimedia environments.

In compliance with the ethical review guidelines of the University of Sussex, the participants were informed that the data would be anonymous (see Appendix 1). Although 121 students had registered for the module, only 97 of them volunteered for the study and signed the informed consent form (76% of the target population). The population comprised 84% male and 17% female students (Table 6.1).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	81	83.5	83.5	83.5
	Female	16	16.5	16.5	100.0
	Total	97	100.0	100.0	

Table 6.1: Gender Distribution of the Study Participants

The average age of the students was 20 years, and the age range was 17 years to 29 years. The participants in this module were divided into three groups according to their lab schedules: the first group comprised 38 students who had their lab session on Wednesday; the second group comprised 42 students who had their lab session on Thursday; and the third group comprised 41 students who had their lab session on Friday. However, this group segmentation according to time-table does not affect the findings, as all students had access to the system at any time and both on and off campus. Further, their details were kept anonymous.

6.3 Experimental Procedure

The experiments were conducted in the autumn term for 12 weeks (September to December 2016). The students were asked to create their own video clips and add notes and images, share the videos with friends, and use all the provided functionalities in the system. In compliance with this, students were able to withdraw from the experiment whenever they wished to by clicking on the 'delete me' button provided in the modified system. Documentation of the ethical review can be found in Appendix 1.

The system was presented to the students as a tutorial lab in the first week of the term. In this introductory lab session, the process of making and sharing videos was explained in more detail to the participants. Before the experiment was commenced, students were asked to answer the pre-experiment questionnaire in order to evaluate their previous experience with using video lectures in e-learning systems. Then, the participants were asked to sign the consent form before they were given access to the system and before the start of the experiment. All students who had registered for the Introduction to Multimedia module could access the system even if they had not volunteered for the experiment, as this was the only delivery method for the recorded lectures available to them and no other sources were provided.

After the participants provided their consent, they were asked to first try out the system and provide their feedback (that is, their first impression of the system in general). The post-experiment questionnaire was made available from week 7, and students' participation was confirmed only after they completed the post-experiment questionnaire. The experimental procedure was identical to the one used in the pilot study. Therefore, this section will not discuss the questionnaires in detail. Table 6.2 explains the differences between the pilot study and the full study.

Item	Pilot study	Full Study
Task	Create videos and use all the functions for the purpose of testing the system, with no specific topic	Create videos that answer specific questions and share them with friends: Different conditions were tested: Condition 1: Watching the video Condition 2: Watching and summarizing the video Condition 3: Watching the video, summarizing the video and sharing it with others.
Participants	25 undergraduate and post-graduate students registered for the MDA module	121 first-year undergraduate students registered for the IM module 97 filled in the pre-experiment questionnaire (80% of the population) 70 filled in the post-experiment questionnaire (59% of the population and 73% of the participants who filled in the pre-experiment questionnaire)
Group	Divided into postgraduate students and undergraduate students	Divided into three groups according to the schedule of the lab sessions
Location	Co-present	Co-present and online learning (Distance)

System Introduction	Online tutorial	2 hours of an introductory lab session, plus online tutorial.
Study Period	30 March 2015 to 30 April 2015	21 September 2015 to 31 December 2015
Research Instrument	Questionnaire, data analysis and researcher observations	Questionnaire, data analysis and researcher observations

Table 6.2: Comparison of the Pilot Study and the Full Study

6.4 Full Study Findings

In this section, the responses to the close-ended questions are evaluated quantitatively using IBM SPSS (IBM SPSS Software, Ver.22), and the responses to the open-ended questions are evaluated qualitatively along with the system data generated from the database and the researcher's observations. After all the results are analysed, they are discussed with regard to their contribution to the research outcome.

6.4.1 Pre-Experiment Questionnaire

6.4.1.1 Learning Method:

The students' preferred learning styles (explained in chapter 2, section 2.1.1) were determined, and Figure 6.1 below shows the distribution of visual learners, auditory learners, kinaesthetic learners and other types of learners.

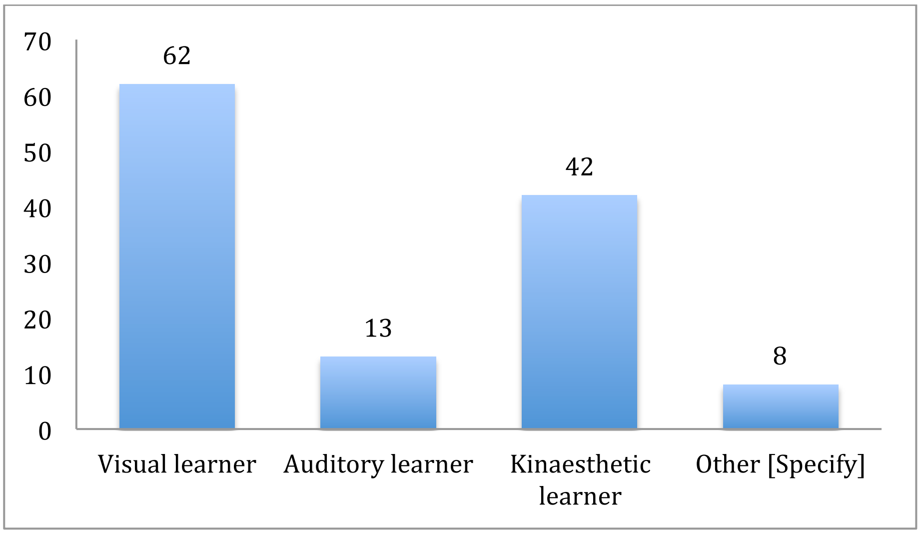


Figure 6.1: Distribution of Different Learning Styles in the Study Sample

The results show that 64% of the students were visual learners (62 students), 43% (42 students) were kinaesthetic learners, and only 13% (13 students) were auditory learners. Eight students preferred other delivery methods. These percentages include students who have chosen more than one learning style, so the total number is greater than the total number of participants included in the evaluation. The details of the answers are shown in the table 6.3 below.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Auditory	2	2.1	2.1	2.1
	Kinesthetic	24	24.7	25.5	27.7
	Mix between VAK	31	32.0	33.0	60.6
	Visual	37	38.1	39.4	100.0
	Total	94	96.9	100.0	
Missing	N/A	1	1.0		
	Other	2	2.1		
	Total	3	3.1		
Total		97	100.0		

Table 6.3: The Learning Styles Preferred by the Students

The table shows that the number of students who learn by listening (auditory learners) was lower than those who learn via visual and kinaesthetic learning styles. Additionally, all auditory learners also chose a learning style other than auditory, such as the kinaesthetic or visual learning style. Most of the students preferred visual and kinaesthetic learning. This system combines visual and kinaesthetic learning by applying the summarization tool. The researcher believes that most of the students will benefit from the system, as it is in-line with their preferred way of learning.

To determine whether the system supports multiple learning styles, SPSS was used to produce a cross-tabulation table that shows the percentage of learners with different learning styles and their preference for different methods of learning such as watching videos, attending lectures and both methods. The data were analysed by controlled comparison, and the data were presented separately for respondents who used multiple methods, respondents who attended lectures, and respondents who watched online videos.

The null hypothesis proposed in this section is that there is no difference between preference for the kinaesthetic style between different categories of learning styles. The alternative hypothesis is that kinaesthetic learners prefer traditional learning as a learning medium over video learning and mix methods of learning.

In the cross-tabulation table, two types of information are presented in each cell: the number on top is the observed frequency (count), and the number below it is the expected frequency (expected count) (Kirkpatrick and Kidd, 2013). The table below shows the number of valid responses and the number of missing responses. The number of responses in which 'other' was stated as the learning style and preferred learning media was 5%, which accounted for the missing cases.

			Student learning style				Total
			Auditory Learner	Kinesthetic	Mix between VAK	Visual Learner	
preferred media of learning	Both (Video & Traditional)	Count	0	1	9	9	19
		Expected Count	.4	4.3	6.6	7.6	19.0
		% within Student learning style	0.0%	4.8%	28.1%	24.3%	20.7%
	Traditional (attending lecture)	Count	2	14	16	17	49
		Expected Count	1.1	11.2	17.0	19.7	49.0
		% within Student learning style	100.0%	66.7%	50.0%	45.9%	53.3%
	Onlin Video	Count	0	6	7	11	24
		Expected Count	.5	5.5	8.3	9.7	24.0
		% within Student learning style	0.0%	28.6%	21.9%	29.7%	26.1%
Total		Count	2	21	32	37	92
		Expected Count	2.0	21.0	32.0	37.0	92.0
		% within Student learning style	100.0%	100.0%	100.0%	100.0%	100.0%

Table 6.4: Cross-tabulation of the Preferred Medium of Learning and Students' Learning Styles

The output suggests that among the kinaesthetic learners, there was a significant difference between the number of students who preferred traditional learning and the number of students who preferred online videos. In the blue column, it can be clearly seen that a higher number of traditional learners than video learners identified themselves as kinaesthetic learners (66.7% vs. 28.6%). In the second row of the table, it can be seen that students who preferred traditional learning, preference for the learning styles is similar. This is not the case for the auditory learning style, which was not a popular choice among all preferences Moreover, more traditional learners than visual learners identified themselves as kinaesthetic learners (66.7% vs. 45.9%) or VAK learners (66.7% vs. 50.0%). The result shows a significant difference in students' learning styles, as most students who preferred traditional learning media identified themselves as kinaesthetic learners.

Additionally, in the third row of the table (highlighted in green), it can be seen that among students who preferred to watch videos, the percentage who identified themselves as kinaesthetic, VAK, and visual learners was similar. However, the percentage of visual learners is slightly higher than the percentage of VAK and kinaesthetic learners. Thus, a greater percentage of students who preferred videos as the learning medium identified themselves as visual learners than kinaesthetic learners (28.6% vs. 29.7%).

Thus, based on the data in the table, the null hypothesis was rejected, as the results clearly show that the percentage of kinaesthetic learners is higher among traditional learners than other categories of learners, especially auditory learners. In particular, the difference between traditional learning and video learning is clearly high, with a difference of 38%.

As mentioned previously in Gilardi et al. (2015), the SussexDL format has the highest level of engagement, which is similar to the engagement level of the in-person lecture tutoring format. The SussexDL format introduces the presenter in the video lecture and allows the students to view the tutors' reactions and body language while they explain the content. According to Gilardi et al. (2015), this is also the case in in-person tutoring, where students are able to observe the tutors' reactions and body language while they explain the content. Therefore, the SussexDL format was used in the ACES system in order to help both students who prefer traditional learning and those who prefer video learning, as the format provides the same level of engagement.

6.4.1.2 Use of Videos in Learning

The table below shows the number of students who prefer using videos as a learning medium in education. Of the 97 students, 42 used videos in learning (35%). Further, 58% (69 students) preferred the traditional way of learning by attending lectures, and 20 students selected both as their preferred learning type. However, 4 students (4%) preferred other types of learning including traditional or video learning with practical sessions, one-to-one tutoring, self teaching, and research; two students preferred both videos and traditional methods mixed with practical learning.

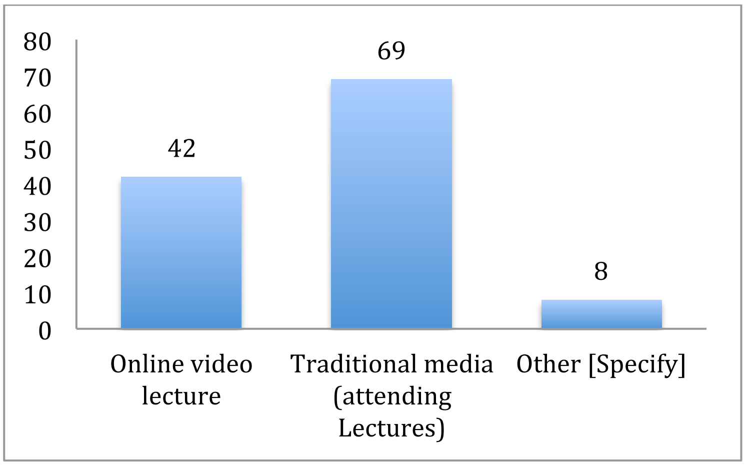


Figure 6.2: Number of students who preferred different learning media

The results show that the traditional way of learning is more commonly preferred than video learning. In addition, it would be challenging to try out the system with these participants as most of them preferred to attend lectures rather than watch videos. However, the number of students who had used videos as a learning tool for education was higher than the number of students who preferred videos in learning: 84 students had used videos for learning, and only 13 students had not used videos for learning before. It is possible that the preference for videos was lower because the quality of the students' previous experience with teaching videos was substandard. As the engagement level is an important factor that affects students' acceptance of a learning system, the SussexDL format for the videos in ACES will be useful to students who prefer traditional learning.

Students were asked whether they found the video learning experience similar to, better than or not better than traditional learning (Table 6.5).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Better	28	28.9	30.4	30.4
	Not Better	11	11.3	12.0	42.4
	Similar	53	54.6	57.6	100.0
	Total	92	94.8	100.0	
Missing	N/A	5	5.2		
Total		97	100.0		

Table 6.5: : Students' Opinions About Video Learning in Comparison to Traditional Learning

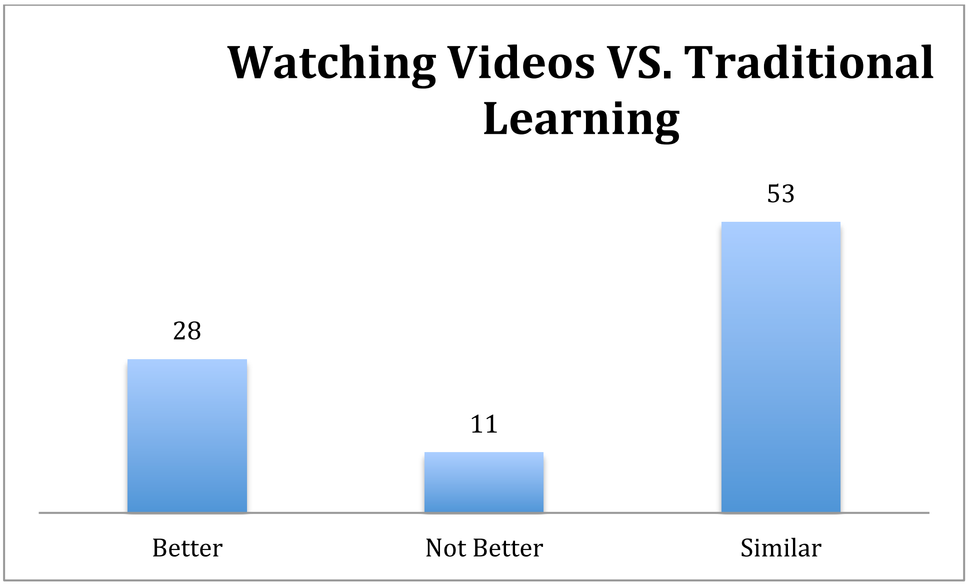


Figure 6.3: Students' Opinions About Video Learning in Comparison to Traditional Learning

The results in Table 6.5 and Figure 6.3 show that 29% of the student found video learning to be better than traditional learning. Moreover, only 11% of the students found traditional learning to be better than watching videos, and 55% found both learning methods to be similar. These were some of their responses:
'*It is similar because they both have audio and visual explanation but watching videos provides a better visual explanation that helps in remembering better.*'

'*Video lectures allowed me to learn at my own speed and pause the video when I did not get the information; however, traditional learning allowed me to ask questions.*'

This is the response of a student who liked both video and traditional learning: '*Videos and lectures both carry their own benefits. I prefer a video over a lecture when the lecture in question is say, a maths one, due to the fact that I have trouble keeping up with the pace of the lecture as I need to think about the problems that I am looking at. Watching a video allows me to rewind and watch again at my own will.*'

The results also showed that 27 students who preferred traditional learning found that watching videos for learning is similar to traditional learning (Table 6.5). However, 7 students who preferred the traditional method of learning found that watching videos was better than traditional learning. In addition, 6 students who preferred both methods also found video learning to be better than the traditional method. These findings seem to indicate that even students who learn the traditional way require videos to help them revise the content of the lecture. This was reflected in response number 65 (by a student who prefers the traditional method of learning, but finds videos better than traditional lectures): '*this is because of the ability to replay certain areas that I wasn't able to understand at first.*'

6.4.1.3 Time Spent Watching Lecture Videos

The students were asked about the amount of time they spend watching online videos for learning, and the results showed that the majority of students spend between 0 to 4 hours a week. As shown in Table 6.6, 42% of the students spend less than 2 hours a week watching video lectures. Similarly, 42% of the students spend between 2 to 4 hours a week watching learning videos. This means that the majority of the students (84%) do not watch online learning videos for more than 4 hours a week. This was considerably less than the number of hours reported in the pilot study. The difference arose probably because the students in the full study were first years and not final-year students as in the pilot study; they may therefore not have had as much motivation to watch educational videos. In addition, students in the full study reported the time they spent watching learning videos only and not all videos in general, while the students in the pilot study reported the amount of time they spent watching all types of videos.

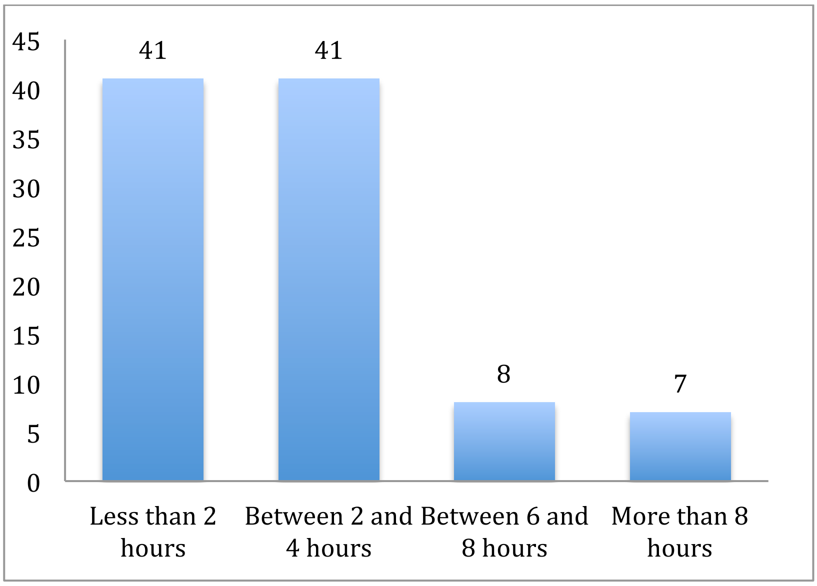


Figure 6.4: Time Spent on Watching Learning Videos per Week

		Frequency	Percent	Valid Percent	Cumulative Percent	Bootstrap for Percent[a] Bias	Std. Error	95% Confidence Interval Lower	Upper
Valid	Less then 2 hours	41	42.3	42.3	42.3	-.3	4.9	33.0	52.6
	Between 2 and 4 hours	41	42.3	42.3	84.5	.1	5.0	32.0	52.6
	Between 6 and 8 hours	8	8.2	8.2	92.8	.1	2.8	3.1	14.4
	More than 8 hours	7	7.2	7.2	100.0	.0	2.6	3.1	12.4
	Total	97	100.0	100.0		.0	.0	100.0	100.0

Table 6.6: Time Spent Watching Learning Videos per Week

6.4.1.4 Summarization Experience

The findings showed that 81% of the students had not summarized video lectures before by any means of summarization, including traditional methods such as writing notes, mind mapping, and highlighting key points.

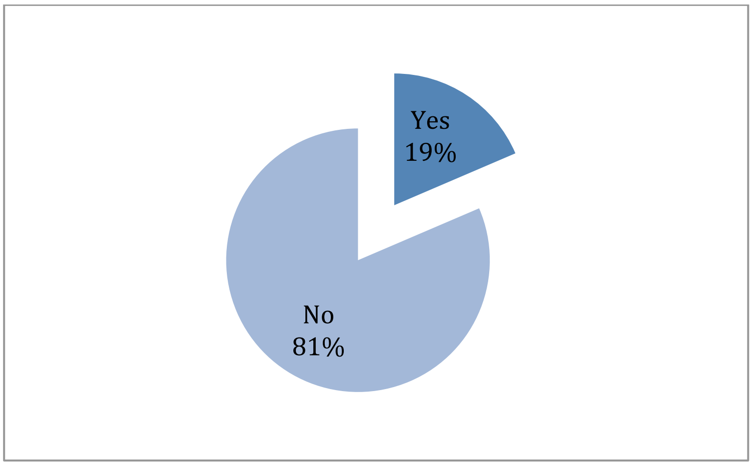


Figure 6.5: Percentage of Students who had Summarized Videos Before

		Frequency	Percent	Valid Percent	Cumulative Percent	Bootstrap for Percent[a] Bias	Std. Error	95% Confidence Interval Lower	Upper
Valid	No	79	81.4	81.4	81.4	-.2	4.0	73.2	88.7
	Yes	18	18.6	18.6	100.0	.2	4.0	11.3	26.8
	Total	97	100.0	100.0		.0	.0	100.0	100.0

Table 6.7: Number of Students who had Summarized Video Lectures Before

Only 19% of the students had summarized videos before by using traditional methods, and the most common method of summarizing videos was writing notes (17 students reported that they had used this method of summarizing). Most students used mix methods, which included writing notes with mind mapping or highlighting key points. Nevertheless, out of the 97 students, only one student had used a special tool for summarizing videos, called *Video Note*. The student explained that the Video Note system 'allows users to take notes while watching the video, and then these notes are synchronized to the time at which they were written.' The student explained that the system was difficult to use, as it had several glitches and the time signatures on the notes were not that well synchronized to the video. The student also mentioned that 'the Video Note tool is not very useful as it is not practical,' and using the tool required double the video playing time (e.g. if the video was 10 minutes in length, it took around 20 minutes to summarize it).

6.4.1.5 Opinion of the Students about Summarization

Although 81% of the students had not tried any video summarization methods before, 90% of them agreed that summarizing videos is a good way of improving understanding. These were some of the responses:

'*By summarizing the key points of a lecture, I think it'll be easier to narrow down the topics which may be tougher for an individual and allow targeted work on the said topic(s).*'

'*Going over a lecture and summarizing it allows for the subject matter to become stored into long term memory*.'

'*When in a lecture it is quite difficult to separate key information from background knowledge than isn't essential to your learning. And a summary gives you a clear understanding of what you absolutely need to know.*'

6.4.2 Student Feedback after Their First Experience with ACES

Some of the students provided qualitative feedback about the system, the concept of the student-summarized video system and the benefits of the system in the future.

'*The first thing I noticed about the system is that it is very user friendly and allows the user to quickly capture parts of the lecture that they need through 2 easy-to-use buttons.*'

'*Also, the fact that the system stores a library of all your summarized video clips is also really good as this allows me to quickly find a lecture clip I want to re-watch.*

However, this section of the system does not provide a "search" or "order" feature to help categorise the video clips. This would become very useful should the user create many video clips as they can search for a specific name or order by subject.'

'*I think the "Video Summarisation System" is an excellent way to aid in a students' learning. It is simple and easy to use so anyone of any age and technical abilities is able to use it. I also like the fact that you can add friends and see their videos.*'

'*The tool is very useful and I would use it again to summarize my future lectures. In order to improve it I would make it so the notes/comments that appear during the video stay on the screen for longer. This would give me a better chance to read them. Other than this the system was great and the ability to add notes to different parts of the video is very helpful.*'

'*The video is effective, mainly because you are able to leave comments at different points. You are able to save any good parts of the video with a simple click. The other aspect of the website is that you are able to share videos with friends*.'

'*The system is very simple and straight forward to use; the idea of the system is a really great tool for videos and helps to memorize what we studied*.'

'*From what I have used so far, it seems it will be very handy at summarising lectures for use to get to the key points. The ability to add scene notes I feel will definitely helpful as I can add things, which I feel relate to a point being made that is not said in the lecture. It is very easy to use and I hope it proves helpful for the rest of this module*.'

'*Useful tool, the summary clips, whilst useful, having to wait till the end of the video or prematurely jumping forward to the end is not ideal. The system works well as a whole and appears professional in its design; it provides freedom to record important moments within a video and this is very useful to a student*.'

To sum up, the qualitative feedback on the system was positive, based on the responses of the students who used it for the first time. They found the concept of summarizing the key points that they need to be really useful and time-conserving when they needed to go back to specific points later on.

The next section discusses the results of the post-experiment questionnaire.

6.4.3 Post-Experiment Questionnaire

The post-experiment questionnaire findings contain the students' responses to using videos, video summarization and collaboration. However, only 70 students' responses were obtained, as 27 students who participated in the first week and signed the consent form did not continue with the experiment.

In week 7, in each lab session, three different questions were presented to the students, and each student was randomly assigned one of the questions to be answered by creating a summary video. The purpose of having different questions is to share ideas and building a ground for discussion rather than have repetitive videos.

According to the Shulman formulation of pedagogical content knowledge, in the summarization process, the student takes on the role of the knowledge presenter instead of the teacher. Creating videos helps students to build on their own understanding by trying to find the answers to questions through the videos provided in the system, gradually build their own understanding and knowledge, create a summary video that demonstrates their understanding, and finally share this video with other students to help them understand the content. This can also be described as cooperative learning, as students acquire knowledge through other students who have the same level of knowledge (Topping, 2005) and not through teachers.

The post-experiment questionnaire was divided into the following two sections (Appendix 3.2): the QUIS questionnaire (for assessing satisfaction with user interaction), which was described in Chapter 4, and the USE Questionnaire (for assessing usefulness, satisfaction and ease of use). More details will be provided in later sections (6.4.3.2.1 and 6.4.3.2.2).

6.4.3.1 Post-Experiment Questionnaire Participants

The number of students who participated in the post-experiment questionnaire was 70, which corresponds to 72% of the students from the pre-experiment questionnaire who completed the experiment (81% male, 17% female and 1% other) (Table 6.8).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	57	81.4	81.4	81.4
	Female	12	17.1	17.1	98.6
	Other	1	1.4	1.4	100.0
	Total	70	100.0	100.0	

Table 6.8: Gender Distribution of the Participants

The participants were from different program courses, as shown here: BSc in computer science (n = 45; the majority of the students were from this course), BSc in computing for business and management (n = 7), BSc in computing for digital media (n = 8), and BSc in games and multimedia environments (n = 10). The course that the participants had signed up for did not affect the experimental process.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BSc Computer Science	45	64.3	64.3	64.3
	BSc Computing for Business and Management	7	10.0	10.0	74.3
	BSc Computing for Digital Media	8	11.4	11.4	85.7
	BSc Games and Multimedia Environemts	10	14.3	14.3	100.0
	Total	70	100.0	100.0	

Table 6.9: Distribution of Participants According to Course Subjects

As in the pilot study, the students were divided into three groups according to the schedule of their lab sessions (Wednesday, Thursday and Friday). The size for each group is as the following, group 1: 38 students, group 2: 42 students, and group 3: 41 students. The students were assigned their tasks as described in Chapter 3, section 3.6.1.

6.4.3.2 Results and Evaluations

The analysis of the results will be divided into two sections: analysis of the USE questionnaire results, and analysis of user data generated from the database.

- The USE questionnaire is divided into two sections:
  - Quantitative questions rated on a scale of 1 to 5:
    1. Ease of learning (usefulness)
    2. System functionalities (ease of use)
  - Qualitative questions where students need to write about:
    1- The summarizing process and ACES functionalities
    2- Collaboration between users (sharing of summary videos)
    3. Their general opinion and feedback.
- User statistics generated from the database

Data on both the summarization and collaboration functions were obtained from the database. The summarization variables included the number of summarized lectures created by the students and the number of scene comments and notes added to the summarized video clips. The collaboration variables included the number of friend requests and friendships made and the number of comments added.

6.4.3.2.1 USE Questionnaire Analysis: Quantitative Section

As explained earlier, the USE questionnaire is divided in two sections: quantitative and qualitative questions. The quantitative section contains two parts: Part 1, ease of learning; part 2, system functionalities.

Ease of learning

In this part, ACES was evaluated for its ability to promote learning. As shown in Table 6.10, this part contained ten questions.

Questions		**1**	**2**	**3**	**4**	**5**	
How easy did you find learning to operate the system?	Difficult	0%	4%	17%	37%	41%	Easy
How easy did you find remembering names and use of commands?	Difficult	0%	3%	19%	49%	27%	Easy
Performing tasks is straightforward with ACES	Agree	20 %	24 %	20%	27%	9%	Disagre e
Does the ACES system improve your motivation	Unhelpful	3%	13	36%	36%	13%	Helpful

to learn?			%				
Does reducing the video to key points help to increase your focus?	Unhelpful	1%	4%	23%	37%	34%	Helpful
Does summarizing the video help you to interact by answering questions?	Unhelpful	4%	7%	30%	36%	23%	Helpful
Does a combination of summarizing videos and sharing it help to improve knowledge?	Unhelpful	0%	10 %	27%	34%	26%	Helpful
Does summarizing videos help you as a practical learner to understand the video content (as you created your own video)?	Unhelpful	1%	9%	20%	44%	26%	Helpful
Does summarizing videos help you to answer questions more accurately by watching the summarized video later rather than watching the whole video again?	Unhelpful	0%	6%	13%	43%	39%	Helpful
Do you feel that the sequence order of the scenes in a single summarized video clip is important to improve understanding?	Not important	0%	4%	29%	37%	30%	Import ant

Table 6.10: Distribution of Scores for Part 1 of the Quantitative Section of the USE Questionnaire

Ease of learning

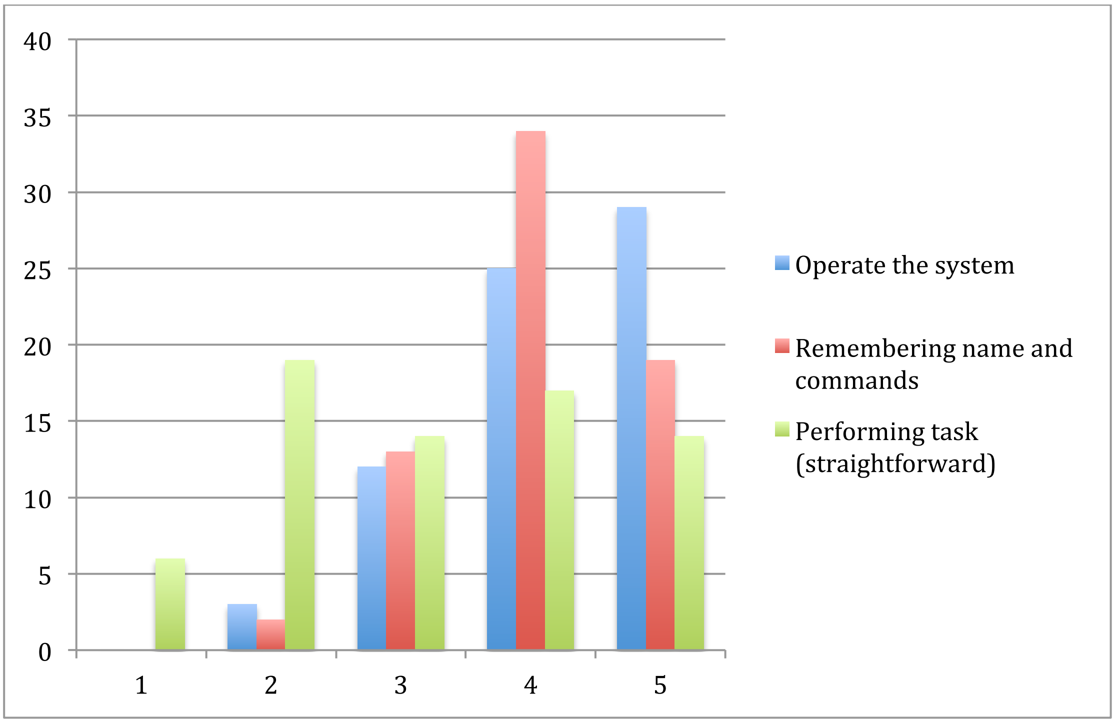


Figure 6.6: Overall ease of learning

The histogram shows that a high percentage of students agreed that the system was easy to use.

Enhancing learning and motivation

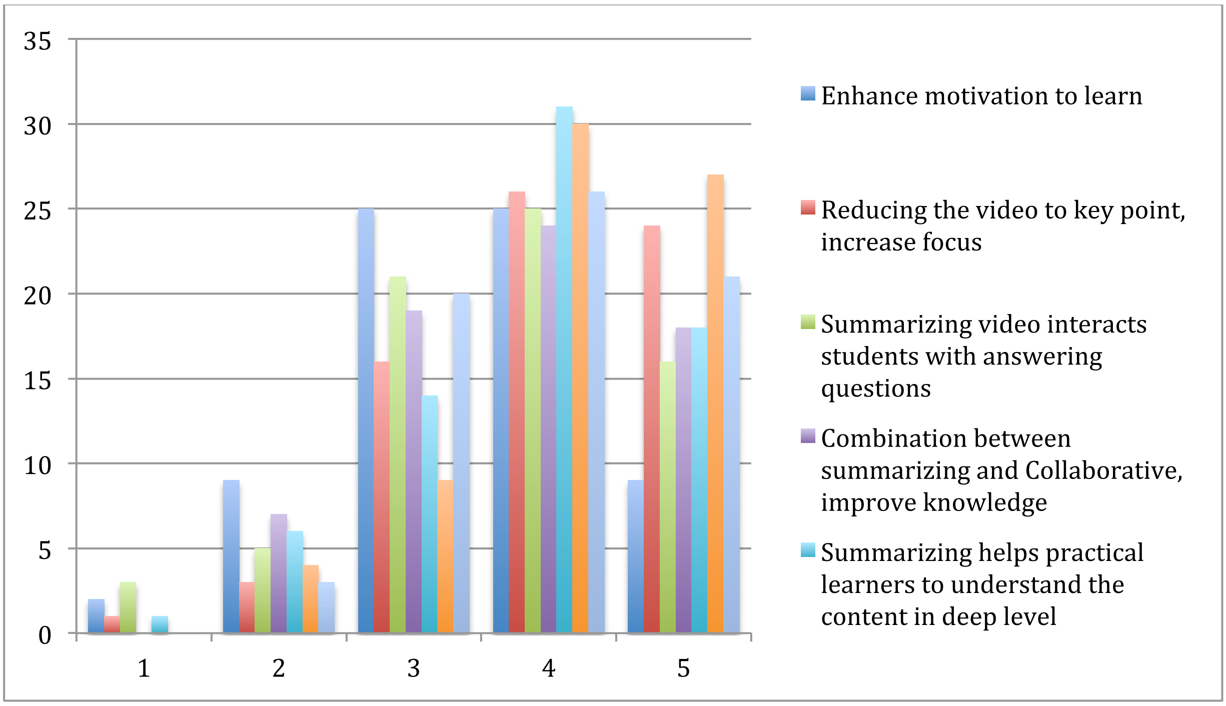


Figure 6.7: Overall responses to enhancing learning and motivation

As seen in the diagram, most of the students agreed that the ACES tool enhanced learning, as most students rated it 4 out of 5.

System functionalities

The system functionality part of the USE questionnaire evaluated the functionalities of ACES. This is important because if the students had experienced difficulties in using ACES, it would have affected the overall results to some extent. As shown in Table 6.11, this part comprises eleven questions.

Questions		1	2	3	4	5	
Capturing specific parts of the video	Difficult	7%	11%	23%	26%	33%	Easy
Changing the order of clips	Difficult	0%	10%	24%	30%	36%	Easy
Adding notes and descriptions	Difficult	0%	9%	16%	39%	37%	Easy
Sharing the created video with friends	Difficult	1%	7%	21%	34%	36%	Easy
Discussing the created video with friends	Difficult	0%	10%	39%	36%	16%	Easy
Searching and adding friends	Difficult	4%	10%	24%	31%	30%	Easy

Uploading images	Difficult	3%	7%	34%	30%	26%	Easy
Creating a summary video	Difficult	0%	6%	21%	43%	30%	Easy
Adding scene comments	Difficult	0%	7%	21%	34%	37%	Easy
Deleting clips	Difficult	3%	9%	27%	37%	24%	Easy

Table 6.11: Distribution of Scores for Part 2 of the Quantitative Section of the USE Questionnaire

In all the questions in this part, the students were asked to evaluate the difficulty or ease of each functionality.

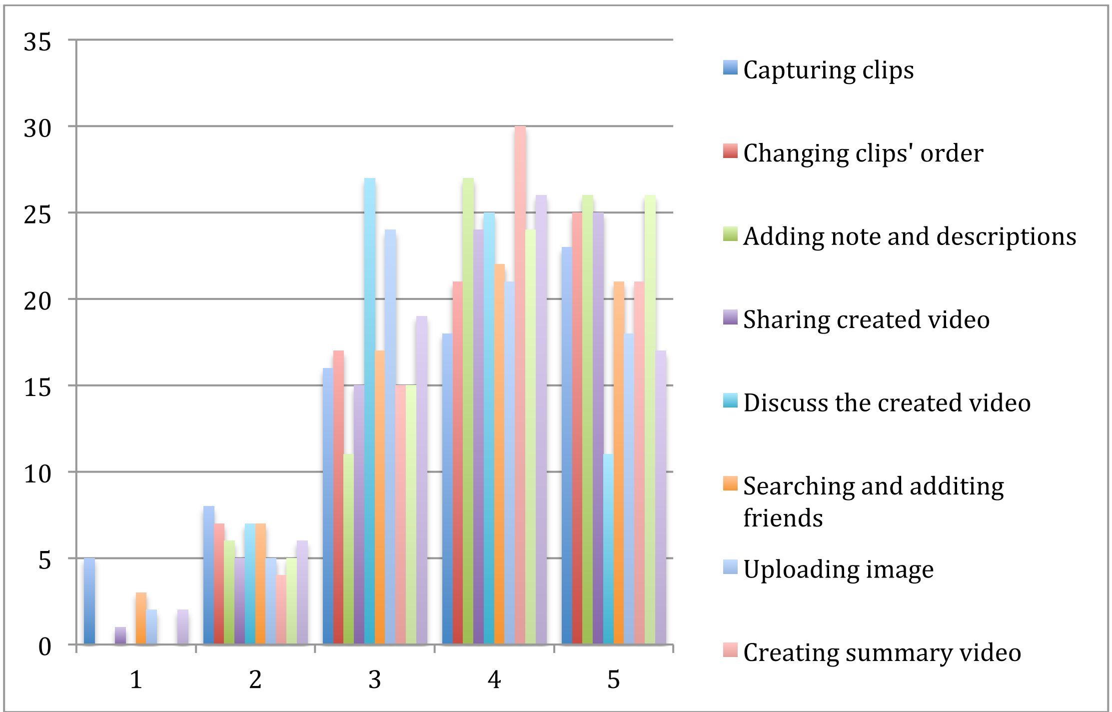


Figure 6.8: Overall responses to system functionalities

The students' rating ranged between 3 and 5, but the majority of the students scored it 4 as they found it easy to use.

6.4.3.2.2 Qualitative questionnaire:

Evaluation of Video Summarization and System Functionalities in the Qualitative Section of the USE Questionnaire

In this section of the questionnaire, students were asked to provide their feedback and their impressions of ACES in more detail in an open-ended format. Although the pre-experiment questionnaire showed that 89% of the students had not been exposed to video summarization tools before, the majority of the students who completed the post-experiment questionnaire believed that the ACES system was an effective tool for video summarization.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	62	88.6	88.6	88.6
	No	7	10.0	10.0	98.6
	N/A	1	1.4	1.4	100.0
	Total	70	100.0	100.0	

Table 6.12: Responses to the Question 'Do You Have Previous Experience with Video Summarization Tools?'

Although one student did not provide information about whether he/she had used such tools before, 10% of the students stated that they had summarized videos before using other tools. Some of these students who had used summarization tools before mentioned that the ACES system is much easier to use and faster than the other tools they had used, while other students preferred the other tools to ACES.

Here is some of the positive feedback provided by these students:

> '*I have summarized videos before; however, this tool seems to be much easier because it is very easy to navigate.*'
>
> '*The website videonot.es is a similar tool but does not have the ability to create custom clips. It simply allows a user to add comments with a time stamp for a specific point in that video. Furthermore, it allows users to have videos streamed using the YouTube video player, which is much smoother and supports keyboard shortcuts for play/pause, aiding in usability. The current player is very difficult to use. However, this is a more powerful tool than videonot.es*'

From the comments that were received, it seems that the students found the ACES tool easier to use than the other tools they had used before. The specific functions that were commended were the ease of navigation and the ability to create custom clips, combine them in a specific order, and add notes to each one after capturing it. Moreover, summarizing the video helped them to save time, as they did not need to watch the original video to search for specific points.

Two students had some negative feedback about ACES:

> '*Having used other video editing tools, this one still lacks a lot of basic functionality, such as allowing the user to apply custom start-end times for clips through an input box, rather than clicking, or letting the user edit the start and end time if a few seconds need to be changed. Transition effects would be good, and a more precise slider on the original video player would make it easier to find the desired cut point.*'

> '*I have used different software such as Windows Live Movie Maker and final cut to summarize video content. In comparison I prefer the software listed above as it gives you more freedom in what you want to create.*'

It seems that these two students were comparing ACES with video-editing tools rather than other video summarization tools. Therefore, these feedback are not included in the analysis.

In general, the feedback from students who used the system for the first time was positive. Some of their comments were as follows: '*It's better than editing it in a more confusing piece of software*' and '*I would say that this tool is very effective.*'

The students were asked whether the system had helped them to successfully create the summarized materials that they were expected to create. The results showed that most of the students (91%) found that ACES had motivated them to successfully create summary material. Only 6% of the students responded otherwise, and the remaining 3% marked the question as 'not applicable', left the response blank, or provided an unrelated response.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	64	91.4	94.1	94.1
	No	4	5.7	5.9	100.0
	Total	68	97.1	100.0	
Missing	N/A	2	2.9		
Total		70	100.0		

Table 6.13: Responses to the Question 'Can Summarized Material be Successfully Created with ACES?'

As mentioned before, the issue with the server had slowed down the system in one of the lab sessions, and this probably affected these findings. Issues such as slowness, navigation issues and videos not being played have been addressed in the negative feedback provided by the respondents. Therefore, most of the negative feedback was related to this problem.

Nevertheless, the majority of students provided positive feedback, as listed below:

> '*The system has helpful and accurate instructions that are easy to follow and guide towards the summarization.*'

> '*I was able to create a good video summary of the key points pertaining to the question at hand. This was accomplished through the simple clip creator*.'

> '*It helped me to create a summarized video more easily than downloading the video and then having to edit it in an Adobe software for example*.'

> '*Having the summarization system next to the player makes it easy to create snippets in real time, compared to an editing suite.*'

> '*It was easy to find particular parts of the lecture that I needed to re-visit to fully understand. The capture method made it easy to capture scenes between two time points. These little "snippets" of the lecture allow for a bite size chunk that can then be used as a revision resource.*'

Out of the 91% of the students who successfully created summary material, 83% stated that the material created from the original video by capturing the key points and the relevant information from different videos helped to keep the content more focused and to have a deeper understanding and improve knowledge.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	58	82.9	82.9	82.9
	No	6	8.6	8.6	91.4
	Probably	3	4.3	4.3	95.7
	Somewhat	2	2.9	2.9	98.6
	N/A	1	1.4	1.4	100.0
	Total	70	100.0	100.0	

Table 6.14: Responses to the Question 'Does Summarized Material Improve the Understanding and Knowledge of Students?'

Further, 7% of the students were not convinced about the positive effects of the system, as they had used the system for the first time and could not have known whether the created video had helped them to improve their knowledge and understanding in the short time span (4%, probably; 3%, somewhat). In contrast, 6% of the students did not find any improvement in their knowledge and understanding, as feedback from some students showed that they still found attending lectures and writing notes to be more effective than watching the videos.

Thus, the majority of the students found that summarizing videos through ACES helps them to enhance motivation, increase knowledge and improve understanding of the content in depth.

Some positive feedback is listed as follows:

> '*When having a specific question or problem, summarized materials can be more helpful than watching the entire video.*'
>
> '*A quick reference video with links to certain points for specific explanations is very handy especially for taking notes.*'
>
> '*The summarized material helps to create a revision resource and enabled me to understand more about the lecture.*'

'As it motivated me more to revise knowing I had narrowed down a 40-minute lecture to a 5-minute clip.'

'In some ways the main improvement for me would be review later on in cases where information did not sink in the first round.'

However, there was some negative feedback too, as shown below:

'Not really - I attend all lectures and make notes and pay attention during those lectures - If there is anything that I don't understand there then I would have looked it up after the lecture. There is no new information when I am re-watching these lectures.'

'I prefer to just watch the whole video and summarize it myself in a notebook.'

In another question, students were asked if they found the summarized videos more understandable and whether it solved problems more accurately than the original video lectures. The majority (79%) of the students agreed that was indeed more understandable and more accurate in solving problems.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	55	78.6	78.6	78.6
	No	11	15.7	15.7	94.3
	Not sure	3	4.3	4.3	98.6
	N/A	1	1.4	1.4	100.0
	Total	70	100.0	100.0	

Table 6.15: Responses to the Question 'Are Summarized Videos Better than Original Videos with regard to Understandability and Accuracy in Problem Solving?'

This is some of the positive feedback that was received:

'ACES successfully allows me to omit the information I understand, meaning I can focus on the topics that I'm less confident with.'

'*Rather than just listening, I am doing the work myself and searching for the right information.*'

'*By seeking to summarize the video, I had to pay closer attention to the material. This makes the lecture more understandable. Also, the fact that it is the second time revisiting the material improves the understanding.*'

Additionally, 4% of the students were not sure whether the context of the original video or the summarized video helped them better to solve the problem and make the video content more accurate and understandable. However, 16% of the students did not find the summarized video to be more accurate than the original video, and as mentioned before, some students struggled with creating the video because of the server problem. The comments provided are listed below:

'*In theory, the summary videos would be good; however, when the time taken to create them is much longer than the time of the final clip, it becomes a bit redundant to spend that extra time, e. g. spending 20 minutes making a 10-minute clip, when it is quicker just to find those points in the original video*.'

These are the comments of students who did not find ACES helpful in problem solving in comparison to the original video:

'*By summarizing it I am only identifying what I think is key information.*'

'*The original lecture builds context for concepts over the course of ~40 minutes which is lost in sterile summary clips. Sometimes this is good (getting rid of waffle and inane points) but some things need to be followed step by step for an entire 40 minutes.*'

To sum up the results, it seems that the summarizing tool achieved the goal of improving students' understanding and encouraged them to improve their knowledge and motivation. The majority of the students were motivated with the summarizing tool as they believed that the activities involved helped them have a deep understanding of the topic.

The next section will evaluate the collaboration function of ACES and how collaboration between students helps to increase understanding, improve knowledge and enhance motivation.

Evaluation of Collaboration between Users in the Qualitative Section of the USE Questionnaire

The status of a video can be changed from private to public to make it available for viewing to users in the friends and subscription list. During the lab session in week 7, different questions were assigned to the participants to encourage them to create videos and collaborate with each other in solving and discussing answers. This collaboration allows students to mutually learn from the material in the summary video, from the discussions around it, and from summary notes and images attached to the summary video.

Students were asked about whether collaboration between users was helpful in increasing their understanding. As shown in Table 6.16, the majority of the students (74%) found the collaboration in ACES to be helpful in increasing their understanding.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	52	74.3	74.3	74.3
	No	9	12.9	12.9	87.1
	N/A	9	12.9	12.9	100.0
	Total	70	100.0	100.0	

Table 6.16: Responses to the Question 'Does the Collaboration between Students in ACES Increase Learning?'

Some of the answers to this question are listed as follows:

> '*Collaboration is always great with learning since you could learn from the other person and this tool makes that easier.*'

‘*Collaboration can make the important information more widely available to us since we don't need to spend time reviewing information that is irrelevant.*’

‘*Because one user may identify a topic within a module that needs to be revised that another has overlooked.*’

‘*In some ways as there might be a topic, which you understand differently to others. So you might want to learn differently.*’

‘*It will be, especially as we will all be doing the same assignments, it will let us share lecture “notes” on specific subjects together.*’

However, a small percentage of the students (13%) did not answer this question and their data were therefore inapplicable. Further, another 13% did not find collaboration to be helpful in increasing learning by using ACES. Some of the comments are listed below:

‘*In theory it would be good to see what other students find useful or focus more on, as it could show you what you missed, but it only works when many people use it regularly which currently is not the case.*’

‘*Not really, I prefer to work independently as I have my own way of understanding things.*’

The important implication from the first negative comment is that the system clearly needs a highly active user base in order to function as it is supposed to. This will be discussed in detail in the discussion chapter.

In another question, students were asked if they found the videos created by their friends to be helpful in improving their knowledge and understanding. The summary videos are a reflection of each student’s distinct point of view and interests with regard to the original video. Therefore, by sharing these videos, they would be sharing their views with their friends.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	36	51.4	51.4	51.4
	No	16	22.9	22.9	74.3
	N/A	18	25.7	25.7	100.0
	Total	70	100.0	100.0	

Table 6.17: Responses to the Question 'Were Other Students' Video Clips Helpful in Improving Knowledge and Understanding?'

The results showed that slightly more than half of the students (51%) found that their friends' videos were useful and helped them improve their knowledge and understanding.

Some of the positive feedback is listed below:

> '*When I create my own video, it is created based on my own understanding, but once I watched other people videos I just recognized there are some points that are important that I had not added, and my friend made it clear to me after he created the video with the note he added.*'

> '*Others have different information that they thought was relevant to the question, so their videos can be helpful if the questions go down a different path when it comes to the exam.*'

> '*Sharing material and commenting on it allows us to explain from different viewpoints. This helps us understand the material better.*'

> '*Since it allows me to see what others considered important and gives me a more complete understanding.*'

> '*Finding other people's shared videos would be useful in the future as they may also not understand the same areas of a lecture as you, and their resources could help you.*'

'*It allows me to look at their summarization of certain topics, which I can then use for revision myself.*'

However, a high percentage of students (23%) found that their friends' videos were not helpful in improving their knowledge and understanding. Many of them have not provided clear reasons, while some stated that they preferred watching their own videos. Other negative feedback included not using the system enough to provide positive feedbacks and the similarity between their own videos and their friends' videos where they could not find much difference between them.

Some of the negative feedback is listed below:

'*Not really as their videos are only useful if it covers the areas I struggle in and cover the specific points that I struggle with in that section.*'

'*This relies on my knowing several people's names in the class, which may not necessarily be the case at this point in term 1 of year 1. This also relies on everybody using it regularly, which given the early stages of the tool is not likely.*'

In addition, 26% of the answers were not applicable because they were left blank or because the students stated that they did not have friends whose videos they could view.

In order to utilize the collaboration functions, students need to have friends who study the same modules so that they can exchange information. This environment could not be provided due to understandable limitations in setting the ideal environment for the experiment. The results showed that students need a longer time to familiarize themselves with the features and functionalities of the system, and they also need a longer time to understand each other personally. The more time students spend together on the system, the stronger will their relationship be in the learning context. Moreover, students can build trust in the long run by constantly watching each other's videos.

In the next question, students were asked whether collaboration was helpful in increasing motivation. Collaboration between students through ACES was found to be a motivating factor by 56% of the students.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	39	55.7	55.7	55.7
	No	18	25.7	25.7	81.4
	N/A	13	18.6	18.6	100.0
	Total	70	100.0	100.0	

Table 6.18: Responses to the Question 'Does Collaboration Between Students in ACES Increase Motivation?'

Some of the positive feedback is listed below:

> '*As you received some information that you missed or was maybe was not clear enough for you before, but with collaborative learning those problems would be solved.*'

> '*Knowing you can watch someone else's summary without having to go through the system and create one yourself does provide people with more of an incentive to revise since the content is readily available.*'

> '*It definitely will be as I imagine lots of people will want to create clips to help friends and will learn more while creating them themselves.*'

On the other hand, 26% of the students believed that their motivation had not increased through collaborating with others in ACES.

This is some of the negative feedback that was received:

> '*Some would be more motivated to find out that others struggle in similar areas to them but whether others have similar problems to me only makes me feel that that topic is even more difficult than it really is.*'

> '*Not particularly because I have to be motivated by myself even to summarize clips. But sometimes you can be motivated by other users.*'

Additionally, 19% of the students did not state their opinion on whether the collaborative function of ACES increased their motivation.

6.4.3.2.3 Students' General Opinion and Feedback

In this section, students were asked about the advantages and disadvantages of using ACES, and how it helped them to increase their motivation and improve their understanding. This section contains a summary of all the responses, which provides a picture about the general opinion of the students.

The majority of the students were of the opinion that ACES had helped them to organize and summarize the key points of different videos. The general perception was that this system motivated them to summarize more video lectures and combine relevant information from different videos into one video for the purpose of revision. According to them, this is useful as they will be able to directly access the information they had found interesting or important earlier instead of going through the whole lecture video again. It is not only the summary video that can be referred to later, but also the notes and discussion around it.

Other students found that their level of motivation and coherence had increased because of the collaborative feature in ACES. This is because receiving feedback from their friends and watching their videos played a big role in encouraging them to understand the topic in depth and discussing their points of view. By creating an effective summary video with additional features, such as adding notes and sharing it with others, students can understand specific information in a variety of ways.

With regard to how ACES had improved their understanding, the students explained that the learning activities in ACES, such as summarization of the videos and addition of notes, are very useful in understanding the content of the video at a much deeper level. Instead of just watching the video, students are engaged in more learning activities, which helps them to explore additional information related to the subject.

The freedom of choosing the way in which information can be presented and writing additional notes in a way that students prefer is very important in the learning process, as the level of understanding of a subject differs between students. Summarizing the videos and watching other students' videos helped them understand this difference from their perspective. They therefore believed that they were able to understand the subject at a deeper level and from different points of view.

Another advantage is the time saved in finding answers during revision. Students can insert multiple answers in a single video for later revision. This is important, as students can refer to these answers in the summarized video instead of going through the entire original video again.

Some of the advantages listed by the students are as follows:

> '*[Summary videos] offer a quicker pace in acquiring the information.*'

> '*[ACES] helps organize and summarize specific parts of different lectures, which I find very useful.*'

> '*[Summarizing videos] help in remembering the lecture better. Do not have to watch the entire lecture.*'

> '*The ability to add comments to highlight what part of the lecture covers*'

> '*The ability to share and view other persons clips*'

> '*Can summarize how to answer exact questions so you don't have to needlessly search through a 50 minute long video*'

> '*It allows you to select the key info, and organize in the way that makes the most sense to you*.'

On the other hand, the common disadvantages that the students listed were related to the time taken for creating a video. As discussed before, this problem was due to the issue with the university server and could not be helped. Another disadvantage that the students listed was the difficulty and confusion in capturing clips from the original video. One student asked for more system feedback while the video was being created, such as the percentage of progress in the video-creating process.

Some of the disadvantages the students found in ACES are listed below:

> '*The compiling and creating of the video, mine took 20 minutes to compile and I had no idea whether it was frozen or working so I left it, but some people may think that it's not working and refresh and quit the page. Some sort of progress bar would be best.*'
>
> '*It takes a while to use it and create a short concise presentation. I think it is encouraging people to not turn up to the actual live lectures - and just watch it once online instead. I think the time when you really want to make notes is straight after the lecture so that you have a short little summary video to refer back to whenever you want.*'

Overall, the students' opinions were relatively positive, as 60% found that a combination of video summarizing and collaborative e-learning is helpful to a great extent for improving knowledge and enhancing motivation.

6.4.3.2.4 User Data (Database)

The user data were collected from the database between 21 September 2015 and 31 December 2015, and all the codes used for calculating the results are available in Appendix 5. The following information was recorded:

<u>Number of Users</u>

The total number of registered users in the database was 272, among whom 269 were students. Of the 121 students who had enrolled for the Introduction to Multimedia course, 97 had volunteered for testing ACES. The total number of log-in's was 920, which meant that each of the 121 students may have logged in to the system at least once. The number of active students was **120** for the full study. The data for the inactive students who did not log into the system were removed from the results.

Original Videos

The total number of original videos uploaded to ACES was 54. However, of this number, only **17** video lectures for the *Introduction to Multimedia* course were intended for this experiment. Students did not have access to the other videos. All the lecture videos were in the SussexDL format.

Video Clips

The total number of video clips found in ACES was 244, but only **199** of these were created for this experiment. The rest of the video clips were either test videos or created during the pilot study. This accounts for 1.66 video clips per student and 11.71 video clips per original lecture video. These 199 video clips comprised **515** clipped scenes, which corresponds to an average of 2.59 clipped scenes per video clip. A total of **74** notes were added to some of the created video clips, which corresponds to an average of 0.37 notes per video clip. A total of **162** scene comments were written for the video clips, which corresponds to an average of 0.81 scene comments per video clip. A total of **43** ratings were provided for the video clips, which made the average 0.22 ratings per video clip. The average rating of the video clips was 3.72 out of 5. A total of **21** general comments were written in the video clip discussion board. This corresponds to an average of 0.11 comments per video clip. The video clips were visited **459** times, with an average of 2.31 visits per video clip.

Friendships

A total of 90 active students have had friendship in ACES. This leaves 30 active students (from actual 120 active students) who did not have a friendship in ACES. Only 73 of the students sent friend requests, and 17 students engaged in friendships only by accepting the received requests and did not send out any friendship invites. Only one comment was made by an active student who did not have any friends.

6.5 Summary

This chapter has presented the results of the full study, which took place in the first term in 2015, from September until the end of December. The participants were first-year students from the Department of Informatics who had registered for the Introduction to Multimedia module. The experiment was performed in three stages, with the same participants. Based on the experimental design, the students were required to use ACES for watching only the original lecture video, after which they were required to summarize the lecture videos they had watched, adding notes, comments, and uploading images as required. Finally, in the last step, they were required to share the summary videos with friends, discuss them and also discuss other students' videos.

Analysis of the results was divided into three main sections: analysis of data from the pre-experiment questionnaire, analysis of data from the post-experiment questionnaire and analysis of user data from the database. The findings were discussed in light of the thesis contributions presented in Chapter 1, which include how ACES was developed in accordance with various learning theories and how it fared in embodying these theories.

Chapter 7: Discussion

This chapter contains the discussion part of the research and consists of two main parts:

- Discussion of the results of the pilot study
- Discussion of the results of the full study

7.1 Discussion of the results of the pilot study:

Unlike the pre-experiment questionnaire, the post-experiment questionnaire data showed that the students had a low level of engagement with the system: the post-experiment questionnaire was filled in by only 25 of the 41 students who answered the pre-experiment questionnaire. As discussed in the observation section, this was due to the delay in distributing the questionnaire, which was given out in the preparation week of the final exams.

The degree of novelty of the system could have an effect on the perception of the user toward the learning style. The results showed that most of the students preferred video learning to other types of learning; however, the same deduction cannot be made about the summarization feature of the system. In the pre-test questionnaire, it was found that 45% of the students do not summarize the lecture videos they watch with any form of summarization. This is a high number and highlights the attitude of students toward summarization of video lectures. This means that almost half of the students were about to engage with a system that promotes a 'new' style of learning instead of an 'alternative' way of learning, as is the case with those who usually summarize lecture videos using other techniques such as mind mapping and writing down important points. The findings of the current experiment do not clearly indicate whether the novelty of this summarization technique motivated or demotivated the participants with regard to using the summarization tool offered by the system. However, this will be considered in the full study in order to obtain a bigger picture of the background of the participants and relate it to the findings of the post-experiment evaluation.

The design of the system interface and navigation was very important for this experiment. The interface was designed using web technology with simple and user-friendly functions to prevent the participant from being distracted by factors that could hinder their progress. The intensive effort put into the interface and design is reflected in the findings from the usability evaluation in the post-experiment questionnaire: most of the students were very happy and satisfied with the usability of the system. However, there were some shortcomings pointed out in the open-ended comments in the same questionnaire that required attention in the full study (as addressed in the following section). Nonetheless, in general, the responses to the questionnaire implied that the system design was smooth and helpful and allowed students to focus on the system functionalities, and that the students did not have any difficulty with using the design or interface.

With regard to the engagement of the students with the system, the general finding from the questionnaire results is that the majority of the students were satisfied with how the system encourages them to engage more in the learning process. For instance, 80% of the participants agreed that the system is helpful for the creation of summary material (section 5.5.2.4.1). This percentage is high compared to the percentage (45%) of students who reported that they did not use any summarization methods in the pre-experiment questionnaire.

Motivation was evaluated after the students engaged with the system in several ways. First, the effect of collaboration on students' motivation to learn was questioned. A greater percentage of the participants (66%) agreed that the collaborative feature of the system had motivated them. However, there were some disagreements with the statement as well, with the slowness of the system and lack of instant feedback cited as the main reasons for the disagreement. Another measure of motivation is presented in section 5.5.2.4.11, where students were asked to rate the effectiveness of the system in motivating learners to engage more in the study activities. The average rating of the quantitative responses was 6.4 out of 10: this corresponded to 93.33% positive qualitative responses in support of the system. The reasons why the students did not find the system effective were not explained in most cases. However, some students indicated that they preferred written material and therefore did not have a positive view of the system.

Increase in understanding and knowledge was also evaluated in the experiment via various questions (sections 5.5.2.4.3, 5.5.2.4.5, 5.5.2.4.6, 5.5.2.4.9, and 5.5.2.4.11). In general, the responses were in agreement with the claim that each component of the system had a positive effect on learner understanding and knowledge. The last question asked for an overall evaluation of the effectiveness of the system as a whole in increasing students' understanding and knowledge. The average rating was 7.37, which was reflected in the 92.86% positive qualitative responses obtained. All these findings indicate that successful implementation of the theories and hypothesis in the system resulted in an increase in learners' level of understanding, engagement and motivation.

An important issue that was noticed is that most of the answers in the post-experiment questionnaire are based on students' opinions, which are based on their theoretical perception of the system rather than their participation in the system. As stated before, the participation rate was low because of the timing of the experiment, which was too close to the final exams. The students considered the system as a trial application and did not invest time in exploring how the system functions, which would have helped them in the long term. While it is possible to measure motivation and engagement even when students are not highly engaged with the system, it is not as easy to measure understanding and coherence in such a context. This is because students may be overoptimistic about how new technology can help them achieve a higher level of coherence. Thus, when measuring coherence, the participation rate and frequency of usage need to be considered.

7.2 Discussion of the results of the full study:

In this section, the results of the full study will be discussed in the context of the theories and previous works cited in the earlier chapters. In addition, this section answers the research hypotheses and research contributions that presented in the first chapter. This research investigates:

- How using videos in learning through ACES supports the Piaget theory of constructivism and transforms passive learners into more active ones
- Students' interaction with ACES and how this summarization tool helps them improve their understanding and enhance their motivation, in light of the theories mentioned in Chapter 2 (the cognitive learning theory and Mayer's theory)
- How the combination of summarizing videos and collaborative learning helps to improve motivation and understanding by sharing of knowledge based on the constructivist learning theory
- How the technological and pedagogical content knowledge formulation can be applied to students who use summarized videos in an adaptive collaborative e-learning environment instead of teachers.

As was shown in section 6.4, before they used the system, 99% of the students were new to summarization tools. Further, 18% of the students had used traditional methods of summarizing videos such written notes and mind mapping, and only one student had used a video note application to add notes to a video clip. The result suggests that ACES as a tool was novel and innovative to the majority of the students.

The students' feedback was used to determine whether the ACES tool accomplished its aim of improving learning. Three different conditions were set for using ACES, as listed below:

- Using ACES for watching videos (WV, condition 1)
- Using ACES for watching videos, summarizing videos, adding notes and comments and uploading images (WVS, condition 2)
- Using ACES for watching and summarizing videos, adding notes and comments, uploading images, sharing the videos with friends, and discussing the created videos (WVSC, condition 3).

Under Condition 1 (WV), the core features are ignored and ACES is only used to watch video lectures. The video lectures cannot originate from any other source, and therefore, the students treated only ACES as the source of video lectures. Under Condition 2 (WVS), the students were required to use the summarization features, but they did not use any of the collaborative features of the system. Under the last condition (WVSC), the students were required to use all the core features of ACES including the summarization and collaboration features.

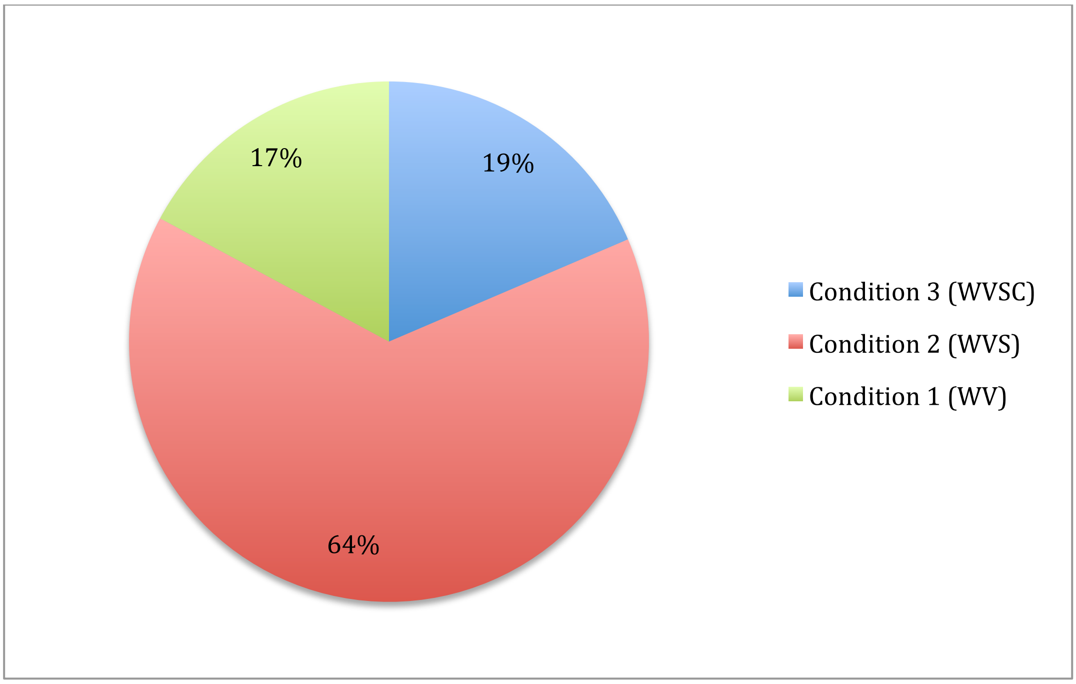


Figure 7.1: The Percentage of Students Who Preferred Each Condition

The aim of this research was to encourage the use of ACES in the third condition (WVSC), as it encompasses the summarization and collaboration aspects, which lay the basic premise for this research. However, the results of the full study showed that most of the students preferred the second condition (WVS), which is watching videos with a summarization tool. In the following sections, the implications of this condition and why most of the students preferred it are analysed and discussed, along with the reasons for the lack of engagement with the third condition. There will also be an in-depth analysis and discussion of the changes that occur after ACES is used.

The next sub-section will present the results for the three conditions according to gender and course subject.

Role of the Gender Variable in ACES

Although the sample was male dominated (81% vs. 17%), more females than males reported that the WVSC condition had benefited them and increased their knowledge. The results showed that 33% of the females found that WVSC has increased their knowledge, while only 16% of the male students reported an improvement.

			Gender			Total
			Male	Female	Other	
Which one of the following did you find most useful	Summarizing video with adding notes, coments and share it with friends	Count	9	4	0	13
		Expected Count	10.6	2.2	.2	13.0
		% within Gender	15.8%	33.3%	0.0%	18.6%
	Summarizing video with adding note and comments	Count	37	7	1	45
		Expected Count	36.6	7.7	.6	45.0
		% within Gender	64.9%	58.3%	100.0%	64.3%
	Watching video without summarize it	Count	11	1	0	12
		Expected Count	9.8	2.1	.2	12.0
		% within Gender	19.3%	8.3%	0.0%	17.1%
Total		Count	57	12	1	70
		Expected Count	57.0	12.0	1.0	70.0
		% within Gender	100.0%	100.0%	100.0%	100.0%

Table 7.1: Gender-based Preferences for Different Functions in the ACES System

There is a difference of 17% between the two genders in the WVSC benefit, and to investigate this, a number of studies on the relationship between gender and social learning were referred to. In particular, the findings of Jonassen et al. (2008) have shown that females have a more positive attitude toward using technology when learning in cooperative groups. In another study, Chan et al. (2013) investigated gender-based differences in collaborative learning through online social network behaviours and found that female participants are more active than males in terms of social interaction and communication. Similar results were reported by Kimbrough et al. (2013). Palonen and Hakkarainen (2003) also showed in their experiment that female students dominated discourse interaction in a computer-supported collaborative learning environment class and shouldered the main responsibility of collaborative knowledge building. According to their findings, male students had a weaker presence than female students in the context of using computer networks for knowledge building. Male students were less willing than female students to share their intuitive physical or biological concepts. On the one hand, the posts by male students were more authoritative in nature and appeared to be a good starting point for lively discussions. On the other hand, the posts by female students often represented their own intuitive theories and concepts, which offered more ground for discussion than the authoritative statements of the male students. In addition, female participants in the experiment had already made friends.

The difference in perception between the two genders in the ACES experiment is in line with the other mentioned studies. The main reason for this could be psychological and general personality differences between the two genders. However, conducting an in-depth investigation into this is beyond the scope of this research. Therefore, based on the findings of the previous studies, the greater preference for the third condition (WVSC) among female students is justified. It also appears that the percentage of females who continued with the study till the end was greater than the percentage of male students who completed it.

Role of the Course Subject Variable in ACES

There were four different course subjects for which ACES was used: computer science (CS, 64% of the total population), computing of digital media (CDM, 11% of the total population), computing for business and management (CBM, 10% of the total population), and games and multimedia environment (GME, 14% of the total population).

Course * Which one of the following did you find most useful Crosstabulation

			Which one of the following did you find most useful			
			Summarizing video with adding notes, coments and share it with friends	Summarizing video with adding note and comments	Watching video without summarize it	Total
Course	BSc Computer Science	Count	7	31	7	45
		% within Course	15.6%	68.9%	15.6%	100.0%
	BSc Computing for Business and Management	Count	1	4	2	7
		% within Course	14.3%	57.1%	28.6%	100.0%
	BSc Computing for Digital Media	Count	4	3	1	8
		% within Course	50.0%	37.5%	12.5%	100.0%
	BSc Games and Multimedia Environemts	Count	1	7	2	10
		% within Course	10.0%	70.0%	20.0%	100.0%
Total		Count	13	45	12	70
		% within Course	18.6%	64.3%	17.1%	100.0%

Table 7.2: Course-based Preferences for Different Functions in ACES

The results showed that CDM had the highest percentage of participants (50%) who believed that WVSC had helped them increase their knowledge. This percentage was much higher than that for the other courses (15% for CS, 14% for CBM, and only 10% for GME). It is possible that the findings are related to the course itself, as the nature of the CDM course encourages students to interact more with social media and videos, whereas the nature of the CS course, for example, encourages students to be more interested in databases and programming. Similarly, CBM encourages students in engaging in more business-related content and GME encourages game development and modelling. Further, the findings can also be explained by the fact that students in the CDM course required to engage a lot with videos, as there are three different modules in CDM that are related to watching videos. Some of their activities include video editing and video capturing. These students were therefore more likely to be interested in video components, and therefore, engaged more with ACES compared to students from other courses.

The next section will evaluate the results of the combination of the summarization and collaboration features by explaining how the ACES system has achieved the objectives described in the conservationist learning theory, Mayer's theory, the cognitive load theory, and the technological pedagogical content knowledge formulation. In addition, it evaluates how the research has achieved the goal of increasing students' understanding and enhancing coherence and motivation. This section also explains how ACES has helped in the transformation of learning style by using videos, from the visual and auditory learning style to the kinaesthetic learning style, and has encouraged traditional learners to engage with video learning.

The Relevance of Learning Theories in the Context of ACES

Removing temporal redundancies and using new video objects to create a shorter version of the video is defined as summarization of a video according to Ren and Zhu (2008). According to the cognitive load theory and Mayer's theory, providing redundant or irrelevant information will increase extraneous load, which will negatively affect the concentration of the learner. Therefore, in order to achieve the most effective learning, multimedia material should be designed such that the amount of irrelevant information is reduced. This is what the ACES tool provides with its summarization feature, to which the students responded well. With regard to how helpful the system was in reducing the content of the original video and creating a summary video with only key points, 71% of the respondents found it helpful, and only 6% found it unhelpful and preferred the traditional methods of summarizing.

Since the learning styles of individuals vary, an effective tool would be one that provides them with a way of summarizing and positions them as the sole knowledge provider instead of giving this privilege to the instructor. With ACES, learners can adapt the material to fit their learning style better and have complete control over the selection and capturing of parts of the video that they find interesting and important. In addition to being more efficient and less time consuming, this method provides more relevant summary material to the students. Additionally, the process of summarizing engages the students in more learning activities, which positively affects their motivation and engagement levels. As a result of this higher engagement and learning motivation, their coherence and level of understanding are also increased.

Based on the findings of previous studies, which are discussed in Chapter 2, to ensure meaningful collaboration between learners and achieve the goal of the constructivist learning theory, the learning system should be easy to use and should promote engagement. In accordance with Piaget's theory of constructivism, ACES provides a more self-directed method of learning as it promotes activity and engagement. Learners interact and engage more in problem solving when they construct their own knowledge and understand it using different activities rather than when they are only given theoretical knowledge. This was proven in the experiment, as 83% of the students found that ACES had helped them to learn in a more efficient way.

The results proved that levels of motivation, engagement and coherence were higher as a result of the students' engagement in video summarizing. This is in line with research by Bartherl et al. (2013), Hsin and Cigas (2013), and Wen-Chi (2012). Thus, higher engagement and motivation levels lead to a higher level of understanding and coherence.

<u>Ease of Use and How it Enhances Motivation</u>

Rodrigues et al. (2011) showed that the ease of using collaborative tools helps students share the information smoothly, as in the PLEBOX system, where they found that the ease of using the pedagogical system improves the quality of collaborative learning and the level of engagement and motivation. Therefore, ACES was designed such that it is easy to find and add friends and to share information.

With regard to the ease of using the ACES system, students were first asked how novel the ACES experience was to them before they were asked about how easy it was to use ACES. This is important, as the ease of using the system has a considerable effect on motivation. The more difficult a system is, the lower is the students' motivation level. The results showed that even though 89% of the students had not used summarizing tools before, after the experiment, 91% of the students found that ACES was easy to interact with, and a very small percentage of students reported that they preferred their own style of summarizing instead of a specialized system built for that purpose. Further, with regard to the effect of ACES on students' understanding and knowledge level, 83% of the students found ACES to be effective. In the corresponding open-ended question, students stated that ACES was an effective time-saving tool for revision, while some students stated that although ACES was a good tool, they would need more time to adapt to it to create high-quality videos.

With regard to the collaboration feature, the students were asked three questions about how easy they found it to use this function of ACES (Section 5.6.3.2.2). With regard to searching for and adding friends, only 14% of the students found it difficult. This was despite the fact that the participants were first-year undergraduate students who may have not known the names of all their classmates to begin with. With regard to sharing the created summary video with friends in ACES, 70% of the students said that they found it easy and only 8% found it difficult. With regard to discussing the uploaded videos, 52% of the students found that discussing the videos was easy and smooth, while 39% thought it was only fair. Further, only 10% found this task to be difficult. Although the majority of the students found the tasks easy, a considerable percentage of the respondents did not find them easy. However, there was no feedback available about the issues that caused the difficulties. The lack of familiarity between students could have been a reason, as the students were in their first year of school and were not friends with each other in real life. Among the total students, 90 students had friends and 30 students did not. Thus, students who did not have friends in ACES did not have the opportunity to discuss videos with friends and only did so by way of subscription. According to the data, only one student (from 42) who did not have any friends made a comment in the video discussion, and this student had only made 3 (from a total of 475 visits of all students in the sample) visits to the system to view summary clips. This confirms that not having friends affected the findings related to collaboration.

Promotion of Engagement

Greenberg et. al. (2012) demonstrated that the level of engagement and activity is higher with videos, as the students interact with visual content and remember better in video learning than in traditional learning via reading. In addition, Merkt et al. (2011) confirmed that interactive video learning has better outcomes than textbook learning in terms of knowledge acquisition. Additionally, Gilardi et al. (2015) examined the level of engagement for different video formats and found that the SussexDL format led to an increase in engagement level that was comparable to that of in-person lectures; it was found to be better than other video formats in this regard. In this research, the SussexDL format was used in ACES in addition to the collaborative activities, to provide a high level of engagement. The increase in the level of engagement is likely to increase the motivation level, as the two concepts are interconnected.

To examine the level of engagement provided by the collaborative activities in ACES, students were asked three questions (Section 6.4.3.2.1). In response to the first question, 61% of the students reported that they found it easy to search for and add friends and 14% found it difficult. With regard to how useful the collaborative activities were in increasing their motivation, the majority of the students (55.7%) believed that their motivation level had increased; however, 26% did not feel so. According to the student's subjective responses to this question, obtaining feedback from other students on their own videos motivated them to create more videos and to become more engaged with ACES. However, some students believed that their own videos were sufficient for revision. Further, they believed that the comments of other students did not affect their motivation, as they viewed other students as being on par with them and having the same level of understanding as them.

With regard to the effect of the collaborative activities on the level of learning, 74% of the students found that their level of learning had increased after using ACES while 13% did not find this to be true. According to the students' subjective answers, the comments provided by other students and watching other students' videos were the factors that improved their learning, as it gave them new information that they were earlier not aware of. This seems to reflect Vygotsky's theory, according to which the more knowledgeable other can play the role of the instructor in collaborative learning. The findings are also in line with Boud et al.'s (2014) theory, according to which learning can be highly improved by sharing ideas and by participating in peer-learning. In the process of these activities, students develop skills in organizing and planning learning activities. Working in collaboration with others, giving and receiving feedback, and evaluating their own learning add to learners' understanding, which is in sync with what ACES offers with its collaborative platform.

Some students did not find an increase in their learning level. This is probably because they preferred the individual style of learning to the collaborative style of learning. Moreover, they stated that they did not always obtain the information they required from the created videos, as the titles and descriptions of the videos did not always reflect their actual content and they had to go through the entire summary video to decide if there was any information that was useful to them.

Finally, in an open-ended question, students were asked whether the created summary videos were helpful in improving knowledge and understanding, which is different from the previous question as it is more related to understanding and general knowledge rather than the learning process. The results showed that only half of the respondents (51%) believed so, and 23% did not find them helpful. Among the 51% who responded positively, several believed that their friends' videos had helped bring to their notice important information that contributes to their knowledge and understanding and that the notes provided were very helpful in understanding the subject. Some of the reasons cited by the students who responded negatively were that they preferred the individual style of learning to the collaborative one and that they did not have friends whose videos they could watch and discuss.

To summarize, on the one hand, the summarization system seems to motivate learners and improve their level of understanding and knowledge. On the other hand, it seems that the system does not encourage students to engage or interact with each other. This could probably be explained by the lack of familiarity between students as they were in their first year and had not made friends in real life yet. Despite this, a rather high percentage (74%) of students found the collaborative features to be helpful in increasing their level of learning.

Applying Learning Formulations to Learners in the Context of ACES

<u>The constructivist learning theory</u>: There are two views of the constructivist theory—the self-initiated discovery theory suggested by Piaget and the social constructivist learning suggested by Vygotsky (Section 2.1.4 and 2.1.5). Both views are supported within ACES. In keeping with Piaget's view, students can engage in self-initiated discovery by actively participating in the problem by summarizing lecture videos. Further, according to Vygotsky's theory, students can play two different roles, as an MKO or the more knowledgeable other and as a learner.

<u>The (T)PCK formulation:</u> The teacher needs to have a deep level of understanding about the subject to be able to effectively present the content to learners. ACES promotes the role of students as MKOs as it engages them in interactive activities, which according to the constructivist theory should increase their level of learning. ACES embodies the TPCK formulation by using technology as a tool for both learning and communication. According to Tervakaru et al. (2012), students benefit more from MKOs than teachers as they are more comfortable with and can communicate with fewer inhibitions. For example, students may feel embarrassed

about asking teachers low-quality questions, but posing these questions to MKOs who are their peers is less stressful and causes less embarrassment.

All these theories were carefully considered and applied to create a technology that is capable of offering content that is more effective in terms of its adaptability to students' learning preferences and also in terms of improving the motivation and knowledge level of learners. ACES is designed to encourage students to be more active learners instead of being passive learners. Thus, individual understanding is increased through activity and engagement, and collective understanding is also increased through collaboration and sharing.

ACES only allows the use of existing video content provided by the instructors; however, allowing students to import external videos into ACES could benefit the learners greatly as it would enrich the content. External video content is however not allowed into the system so as to prevent the flow of incorrect and unrelated material into the system. External video material may be used to incorrectly relate to subjects that are not part of the course, or even for entertainment purposes. As mentioned in chapter 1, the large amount of content can confuse learners and make it difficult for them to find the relevant information (Louvigne et al., 2012). This is why external videos were not included in the system.

The advantages of the learning material produced in ACES are two-fold:

1- When watching other students' videos, discussing them, reading the notes and rating videos, students are engaged in an instant active learning process. This activity increases their engagement and motivation, which results in higher quality understanding than being a passive learner who only receives information without interacting with it. Students can also revise the product of this interaction later on, which is very helpful in memorizing material as it is organized according to their own preference (Bruner, 1960, cited in life circle). This is reflected in the findings, as 83% of the students found that the summarization activity helped them gain a better understanding and motivation to learn. Considerable positive feedback was received on how summarization has helped students gain a better understanding of the subject.

2- When watching the MKO's videos, students enter the zone of proximal development (ZPD), which gives them a better understanding of the material provided by the MKOs. As mentioned before, interaction with peers is an effective way of developing skills and strategies (Vygotsky, Section 2.1.4 and 2.1.5). Further, cooperative learning is beneficial to less competent learners, as they develop skills with the help of their more skilful peers. Boud et al. (2014) explained that students can increase their learning level by explaining their ideas to other students and by participating in activities in which they can learn from each other. The MKO peers can help other students more than a teacher can as they can use different techniques to present the information to their peers, as they have an equal status (Topping, 2005 cited in Sole et al 2012; Falchikov, 2001).

Having a ZPD is very important in the learning process. According to the Shulman formulation, this allows the learning to not only be bound to teachers, but also to the students via self-directed learning. The students play the role of teachers in delivering the information and gain deeper knowledge through investigating the videos and being engaged with more learning activities. This increases the engagement and collaboration levels among students and the goals of higher quality education are met, as students' level of understanding and motivation is considerably increased.

In addition to the benefits the students gain from being engaged in summarization and collaboration activities in ACES, teachers themselves can also benefit from the students' summarization. The produced videos allow teachers to have a better picture of the students' level of understanding, and reviewing students' videos and discussions gives them a clear idea of which part of the subject the students are struggling with.

According to the Shulman formulation, knowledge is not only to be transferred from the teacher, but is also to be transferred from the learners (MKOs). As mentioned in relation to the TCPK formulation, students have fewer boundaries when communicating with each other and they can therefore communicate more freely with peers. This allows the information to flow better than it did when the information came from the teachers. The flow of information depends on three factors (these are described in the context of ACES):

1- Understanding the content: The self-directed learning method in ACES aids students' understanding of the content, as the students are engaged in finding information and creating summary videos that solve problems, which deepens their understanding of the subject.
2- Using technology: In ACES, students find information using the system's technology to produce adaptive summary material that explains the problems they were asked to address.
3- Sharing the produced material with other students: The adaptive collaborative learning style in ACES allows MKOs to share the video summaries they produce with other less knowledgeable friends who can benefit from the summary content and the discussion around it.

Thus, according to these theories, collaboration between learners greatly improves their understanding via higher engagement and motivation. Students learn how to produce summary material from longer videos. For example, they learn how videos are created, organized, and discussed. Moreover, they learn more about the subject from their peers by viewing the information they present and creating a discussion around it. This is reflected in the finding that 74% of the students believed that the summary creation process had increased their knowledge in several ways.

How Practical Learning Can Increase Motivation in the Context of ACES

In the pre-experiment questionnaire, when students were asked about their preferred media for learning, traditional learning was found to be the most preferred medium among the students, with 71% opting for it. Video learning was popular, with 43% of the students opting for it, while 8% chose other media (the percentages add up to more than 100 because the students were allowed to choose more than one medium) (Q1). Further, with regard to their learning style, in the pre-experiment questionnaire, 65% of the students stated that they were visual learners; 14% stated that they were auditory learners; and 44% stated that they were active learners. Another 8% chose activities that involved another style of learning. Therefore, most students preferred to do activities with percentage of 53% (Q2). In the post-experiment questionnaire, students were asked whether the summarization had helped them as practical learners to understand the video content based on Piaget's theory, as they needed to engage in more activities to solve the problem. The results showed that 70% of the students found it helpful, 20% were in the middle and 10% found it unhelpful (Q3).

The associations between Q1, Q2 and Q3 may not be very obvious, but if the values are examined closely, the following pattern emerges: In Q3, 70% of the students found video summarization to be a helpful learning activity, although 71% had opted for traditional learning and only 43% had opted for video learning in Q1. Thus, the positive respondents in Q3 also include those students who did not prefer video learning but preferred traditional learning in Q1. This is implied from the differences between the percentages: only 43% of the students preferred videos before the experiment, so 57% preferred traditional learning or another type of learning. After the test, 70% of the students found that summarization was helpful; even if it is assumed that all the 43% who preferred videos found summarization to be helpful, it leaves 27% who did not prefer video learning before. Therefore, these findings imply that ACES was successful in convincing students who preferred traditional learning that video summarization is a useful product in learning.

The following conclusions can be derived from this discussion:

1. Students who preferred video learning in Q1 liked the video summarization tool and found it helpful as it promotes activity rather than passiveness. Based on Dewey's theory of constructivism, students learn when they practice and construct their own knowledge and develop self-directed skills rather than when they just receive information (Ord, 2012). Additionally, this is also supported by Mctighe and Seif (2011), according to whom

> learning is enhanced when students are able to explore, organize, connect, process, and apply information and ideas.

The data indicate that the students who preferred traditional learning in Q1 showed a preference for video summarization after using ACES, which may imply that ACES helped them to achieve a higher level of motivation and understanding.

With regard to Q2 and Q3, the percentage of students in Q3 who found summarization helpful was 70%, while previously, 53% of the students in Q2 preferred more activities instead of just watching the video. This indicates that ACES has attracted a percentage of those students who earlier did not prefer activities while learning. According to Mishra and Koehler (2006), the design of the learning technology affords students the opportunity to transcend from the passive learner role and to take control of their learning. Thus, it seems that ACES has attracted non-active learners by engaging them in a summarizing activity. This needs to be further analysed in studies that are beyond the scope of this research, which are discussed in Chapter 8.

7.3 Summary

This chapter has presented a discussion of both the pilot study and full study. The findings of the pilot study were recorded and the results are explained and discussed with regard to how they have contributed to the system and evaluation of the technology. In general, most of the students expressed their satisfaction with the system and believed that it would be a great tool for revision. Based on the feedback and suggestions of the participants in the pilot study, the system was modified for the full study to provide better support for learning and eliminate the problems identified, in order to increase engagement and motivation by eliminating any distracting features.

The results of the full study showed that more than half of the students were engaged with ACES, as the students found that the summarization activities in ACES had enhanced their understanding and motivation. However, they found that the collaborative activities were less promising with regard to increasing their motivation. This was probably because they were first-year students and were expected to collaborate with classmates whom they were not familiar with. Thus, the overall findings seem to be in favour of ACES as a promising adaptive and collaborative tool for learning.

Chapter 8: Conclusion and Future Work

8.1 Conclusion

The summarization of lecture videos and the adaptive collaborative environment that are features of ACES are obtaining a higher level of understanding and deeper knowledge about the subject. Learners need to have a high level of engagement and motivation in order to reach a higher level of understanding. The use of technology and videos in higher education are now considered important, especially in e-learning environments, as these methods can give distance learners access to learning material and allow them to watch video lectures online regardless of the time and place. Using technology in education has a positive impact and is a necessary step for improving students' knowledge and providing information for learners in the easiest way possible. Providing extra activities that encourage students and motivate them to understand video content at a deeper level requires a multimedia framework that can promote engagement and motivation.

The main aim of this research was to improve learning and develop a higher level of knowledge and understanding in learners by drawing on several learning theories, including the constructivist learning theories, and taking into account the already known benefits of e-learning, self-directed learning and collaborative learning. In addition, the technological pedagogical content knowledge (TPCK) formulation was applied, with the learners taking on the role of teachers and using technology to improve knowledge. Thus, in this research, the students took on the role of knowledge providers. As students have few communication barriers between each other, it is easier to share and learn in such a context. For instance, students may be aware of topics that other students struggle with, and may be able to explain it to their peers from their perspective. Furthermore, this research applies the constructivist approach in the e-learning environment by using videos as the learning media and engaging learners in kinaesthetic activities.

This chapter starts with a brief explanation of the main features of this study, which include the research contributions listed below, first shown in section 1.3:

A. Creation of an e-learning system that effectively combines video summarization and collaboration, published in (Alzahrani, 2015).
B. Creation of a video summarization and collaboration tool that has detectable effects in improving student motivation, understanding, and engagement by reducing the transfer of unnecessary information from the core components (which is in line with the cognitive load theory [CLT] and cognitive theory of multimedia learning [CTML]), by increasing knowledge sharing through sharing of summary material, and by providing students with a deeper understanding of the subject through the creation of their own learning material and summary (in line with the Shulman formulation and the technological pedagogical content knowledge [TPCK] formulation.

The minor contributions are:

C. The ACES tool engages students in a more active learning process.
D. The web-based interface of the system is easy to use.

This chapter then discusses future research work in this area, by outlining the implications of these findings for the different stakeholders, such as policy makers, teachers, and future researchers.

8.1.1 Summary of the Main Contributions and Research Questions

ACES provides more activities for e-learning students and by doing so promotes kinaesthetic learning in an online environment, which is currently not provided by any learning system. Learners can summarize the provided video related to their module based on their preferences and share it with friends; this makes the ACES learning environment an adaptive one in that the content is adapted by peers for their peers. ACES is also adaptive in that it promotes students' preferences in the learning process rather than the passive transfer of learning material. Summarizing videos and sharing them with friends requires a higher level of engagement and interaction, which ACES achieves.

This section will present the main contributions of the research that answer the following research questions:

- Will an e-learning system based on student-summarized videos in an adaptive and collaborative e-learning environment improve motivation, understanding and knowledge?

This question contains two main components:

1- Will summarizing videos using the tool improve motivation, understanding and knowledge?
2- Will the collaborative e-learning environment improve motivation, understanding and engagement?

8.1.1.1 Effective video summarization and collaboration E-Learning environment (Contribution A)

The results from Chapter 6 showed that an effective video summarizing tool was developed, which students could use to create short summary videos that could be collaboratively shared and discussed. The e-learning system that was developed in this research (ACES) combines summarization with collaborative learning, and is beneficial to both learners and teachers, as 63% of the students were shown to find the system easy to use and only 10% of them not agreeing so. Moreover, 68% of the students having generally positive feedback about ACES and 31% satisfied with the system interface.

8.1.1.2 Video summarization for effectively improving motivation and understanding (Contribution B)

This section summarizes the research question 'Will an e-learning system based on student-summarized videos in an adaptive and collaborative e-learning environment improve motivation, understanding and knowledge?'

ACES helps learners to improve their knowledge, increase their understanding, and enhance their level of motivation and engagement through adaptive summarization and collaboration (70%). This research has examined the potential of this tool in helping learners to increase their understanding and knowledge level and solve problems either by self-directed summarization; overall, 83% sought help from other learners who have a higher level of understanding or via a social e-learning environment, and 74% found that watching their friends' videos helped to increase their learning level. These percentages of both self-directed summarization and peer learning show the valid result of effective increase in understanding and learning. In addition, the activities provided in the system engaged the students to summarize the video, which positively affected the motivation and coherence of students.

8.1.1.3 Advantages of Video Summarization with regard to Eliminating Unnecessary Content and Improving Learning

This section summarizes the responses to the sub-question 'Will summarizing videos by using the tool improve motivation, understanding and knowledge?'
The cognitive load theory and Mayer's theory support the summarization of videos and its role in improving students' understanding, knowledge, motivation and coherence. This is also in accordance with Piaget's constructivist learning theory, which implies that self-directed learning wherein learners interact and engage with problem-solving techniques helps them understand the subject more clearly.

Video summarization is one of the main features of ACES that allows learners to convert lengthy lecture videos to shorter versions and thus allows the deletion of extra unnecessary information in the lengthy videos (Contribution C). According to the cognitive load theory and Mayer's load theory, providing redundant or irrelevant information via visual and verbal channels hinders the learning process as the extraneous cognitive load is increased. In order to reduce extraneous cognitive load, the video content should have less redundant information and be shorter and straightforward. In ACES, the process of summarization is the responsibility of the learners themselves. This benefits students in several ways:

- Students are more engaged in actions that promote kinaesthetic learning rather than passive learning.
- Students can identify the parts of the videos that meet their learning preferences.
- Students can create summary material based on their own perspective that can be reused later for faster revision.

The post-experiment questionnaire results showed that 83% of the students stated that summarizing videos helps them gain a better understanding of the subject and increases their level of knowledge. Moreover, 79% of the students thought that the created video summary was clearer than the original video. For each of these percentage values, the corresponding percentage of students who disagreed was less than 10%. These promising results show that the interactive interface of the ACES system has indeed helped students engage in a better learning process and be more motivated with regard to exploring videos and information. As explained in the previous chapters, the summarization tools provided by ACES are easy to use, help students to interact, and motivate them to engage in learning activities. This is evident from the results of the post-experiment questionnaire.

The results also show that summarizing videos is an important factor that can increase students' level of understanding and ensure that accurate information is provided. As the engagement and motivation levels are increased, learners explore more information and have a better understanding of the subject. This is evident in the finding that 82% of the students found that searching for significant information and combining it in one video for revision helped improve their understanding of the information. This is reflected in Piaget's theory of constructivism, according to which the self-directed learning in the form of exploring and summarizing videos allows learners to engage in and interact with problem-solving techniques. In addition, according to Piaget's theory of constructivism, the self-directed learning that is promoted by ACES allows learners to actively engage and interact with the problem. The results showed that 79% of the students believed that the videos created using the interactive tool helped them solve problems more accurately than watching the original videos, as they were more motivated and engaged in the learning process with ACES.

Organizing information based on students' preferences is important: as explained by Burner's theory of instruction, the sequence of information is an important factor that contributes to the general understanding of information. With ACES, students can arrange their chosen clips in any order they prefer to create the summary video clip. It seems that the students were satisfied with this feature, as 67% believed that the sequence of clips is important for creating more understandable video clips, 29% were satisfied with this feature, and only 4% believed otherwise.

8.1.1.4 Advantages of Collaboration with regard to Improving motivation, understanding and Engagement

This section summarizes the responses to the sub-question 'Will the collaborative e-learning environment using the ACES tool enhance motivation, understanding and engagement?'

Vygotsky explained in his version of the constructivist theory that learners can construct their knowledge not only by self-directed methods, but also by collaboration and engagement with other learners. The collaborative learning environment of ACES allows students to share knowledge and create videos for others, who can benefit from collaborative learning by accessing those videos and the related information and discussing them (Contribution A). However, the present results show that although the level of learning (Contribution B) showed a considerable increase on account of the collaborative activities, the level of motivation did not show such a pattern. On the one hand, 74% of students believed that their level of learning increased as a result of the collaborative activities in ACES. On the other hand, only 56% of students believed these activities have increased their motivation level. Further analysis into this showed that the participants did not know each other well in real life as they were first-year students who had met only recently. This may have affected their motivation to make friends and engage in collaborative activities in ACES. Therefore, this leads to the assumption of a key link between real life friendship and collaborative learning in e-learning environment. However, an exploration of this link is beyond the scope of this research.

Students who engaged in the collaborative activities believed that they could benefit from other students' videos, both from the content provided and from the discussions they had engaged in. For example, some learners who struggled with some points in the original video and found them difficult to understand found that seeking help from more knowledgeable friends was very helpful and had contributed to their understanding. Moreover, some students mentioned that observing other friends' videos can also help them identify points that they missed in the original videos. This is explained by the cognitive load theory and Mayer's theory, according to which the extraneous load in these videos is very high and causes learners to lose their focus.

Although collaborative activities in ACES have helped students have a better learning experience, only 51% of the students found that other friends' videos had helped them improve their general knowledge and understanding. This shows that to some extent, the collaborative feature of ACES did not have a significant effect on students' learning. More investigation into this would help shed more light on this finding.

8.1.1.5 Advantages of the Extra Activities Related to Creating Videos and summary of the research question

Both constructivist theories in combination (self-directed learning and collaborative learning) are in keeping with the TPCK formulation and the Shulman theory, as the knowledge provider role is transferred from teachers to learners. This transfer of responsibility helps students gain a better understanding of the subject as a result of the engagement and extra activities associated with creating a summary video.

In ACES, knowledge is constructed from the extra activities that learners are engaged in while summarizing videos. These self-directed activities help students construct knowledge more effectively than when it is passively received from a knowledge provider. This knowledge construction allows students to have a deeper knowledge of the subject, and in turn, it helps them to play the role of a knowledge provider. Based on the findings in this research and the learning theories discussed earlier, the new TCPK formulation proposed is as follows:

Self-directed learning (Piaget's theory of constructivism with the learner as the provider) + Collaborative learning (Vygotsky's theory of constructivism with the learner as the provider) = TPCK formulation (with the learner as the provider instead of the teacher)

This formulation is in keeping with the concept of an adaptive and collaborative e-learning environment with video summarization tools, such as ACES. Students who are engaged in video summarization are capable of learning the material at a deeper level (self-directed learning), which allows them to produce an effective video summary that can make the subject matter more logical to others (collaborative learning). ACES enhances self-directed learning and collaborative learning to a great extent, and this is evident from the results of the experiments.

Students are more ideal knowledge providers as they often learn from their peers more comfortably than they do from teachers. However, this does not eliminate the role of instructors as knowledge providers, as the content is provided by the teacher in the original lecture videos. Students' level of understanding before and after engaging in collaborative learning with their peers needs to be investigated in future studies.

8.1.1.6 Minor advantages of ACES (Contributions F and G)

Some of the other advantages listed by students were the ease of use of the system interface and its usefulness as a traditional and visual learning tool. Moreover, in accordance with Dewey's theory of constructivism, ACES also supports activities in learning.

A smooth interface that is easy to use is important for engaging students and increasing their interaction with the summarization and collaboration features. The smooth interface of the ACES system improves students' motivation and engagement levels, as the results showed that 68% of the students had generally positive feedback about ACES and 31% were satisfied with the system interface. Only 1% of the students reported that they did not favour the system in general. More importantly, the majority of students found the interface easy to use and its functions to remember, as 62% were satisfied with these features. Moreover, 90% of the students also stated that the characters on the screen were easy to read, 74% felt that the organization of information was clear, and 72% found the sequence of the screens to be well defined. The ratings of one group of students were influenced by a technical glitch in the system that caused the system to slow down in one of the lab sessions; as a result of this event, 43% of the students found the system speed to be too slow, with the majority of them belonging of this group of students.

Fifty-eight percent of the students who participated in this experiment preferred attending lectures to watching videos, as they believed that it provided more engagement. To increase their engagement with ACES, the SussexDL video format was used, as it is believed to provide the same level of engagement as in-person lectures (Gilardi et al., 2015). Apart from the high-quality interface, a high-quality video format is required to ease the process of summarization, which is also provided with SussexDL. The level of engagement is further enhanced with ACES, as it provides additional activities and actions such summarizing videos, sharing them, adding notes and images, adding comments and discussing the video.

Although the results of the pre-experiment questionnaire showed that only 34% of the students use videos to learn, the post-experiment questionnaire results showed that the percentage of those who found video summarization helpful in understanding was 70%. Thus, ACES was successful in attracting a percentage of students who did not earlier prefer online videos. According to the results of the pre-experiment questionnaire, traditional learning by attending lectures is the most common type of learning, followed by video learning. In addition, most traditional learners prefer to learn by doing rather than just watching. The percentage of visual learners who preferred to learn by using videos was slightly higher than the percentage of students who preferred active learning methods. Therefore, the challenge was to employ a system that supports the kinaesthetic learning style and encourages traditional learners to engage with learning by using videos. ACES was designed to promote activities in video learning, which would suit those who prefer video learning and constructive learning alike. Accordingly, the transformation of the learning style from a traditional one to a video learning one requires a system that promotes activities in online video systems, which is also a feature of ACES.

The ACES tool engages students in a more active learning process, which means that such tools have the potential to transform visual or auditory learners to more active learners. This is backed by the Piaget theory and Dewey's theory of constructivism, as learning is promoted and enhanced by increasing motivation and engagement via an active rather than a passive process. The percentage of learners who preferred activities before the experiment was 22%, but this percentage dramatically increased to 70% after the experiment. This result suggests that ACES encouraged traditional learners to learn constructively via videos and enhanced their understanding and engagement.

The hypothesis for this research is that the summarization and collaboration features of ACES enhance motivation, understanding and engagement in learners. The evidence provided in this research does prove that building an e-learning system that supports both self-directed learning and collaborative learning helps students increase their level of learning, motivation, understanding and engagement. However, although both summarization and collaboration are believed to promote learning, the students' feedback shows that interaction was greater in the summarization process than in the collaboration process. Further, the motivation level was higher with summarization activities than collaborative activities. As mentioned before, the lack of familiarity between the students in real life may have prevented them from actively engaging in collaborative activities in the system. Thus, making friends in ACES requires more time, as students can interact better within the system only if they are comfortable with each other in real life. Therefore, ACES would be more effective if it was used as the main learning portal over a longer period of time.

8.2 Limitations of this study

The study and results in Chapter 6 present some limitations. As mentioned before, ACES needs to be used over a longer period to increase interaction and friendships. As the time period for this thesis was limited, it was also not possible to have a third group of students for whom the creation of summarized videos would have been voluntary. The findings from such a group would be a good indicator of how successful ACES is with regard to engaging students. Moreover, it would useful to apply Service Oriented Architecture (SOA) to increase the speed of the system for receiving feedback about the progress of the video creation process.

8.3 Future work

The direction of future work in this area is divided into two categories: (1) suggestions for policy makers and practitioners and (2) areas for further research.

8.3.1 Suggestions for institutions and practitioners

These are the main recommendations for institutions, based on the findings of the study:

- The university should recruit high-level learners such as Master's students and PhD students to monitor the created videos and rate them, as done in the full study. The more effective videos would have higher ratings and would therefore be recommended to other learners. Moreover, these videos with high ratings should be made available to all students registered for the module so that everyone can benefit from them.
- The university should encourage students to summarize lecture videos and share their knowledge with others by providing such a system to all students all year round and providing an online video for all modules.

8.3.2 Suggestions for future researchers

There is a lot of scope for future research in this area, based on the some of the limitations of the current study with regard to investigating the effects of summarizing videos and collaborative e-learning. For example, a third experiment is required with statistical analysis and needs to be run wherein the creation of summarized videos is voluntary, in order to determine how engaging the ACES system is. Further, empirical studies need to be conducted at different schools and at different levels to understand the attendance for lectures and online video lectures. Future research should focus on the evaluation of students' grades before and after they use the tool and the sharing of knowledge with others. In addition, another experiment could be conducted to test how the created videos may help teachers to collect information regarding the students and evaluate their level of understanding. This would help teachers to have a better understanding of the learners' level of understanding and the problematic areas, which need further investigation in the future.

For further research, the collaborative aspect could be improved by enhancing interactive features: for example, a 'drag and drop' option can be introduced for adding clips, as the current feature requires students to select the start and end points. In addition, higher-level students could be allowed to edit an already created video so that they can correct or add points and then re-share it with others. Moreover, more functionalities could be added to increase the level of coherence and motivation in collaborative learning.

Finally, more research should be conducted into how the TPCK formulation can support learners by constructing their knowledge and improving collaborative learning via the use of videos and online documents. Further study in this area, such as how this formulation fits students, and what technological tools could benefit them more effectively, could set the foundation for future research.

To conclude, this thesis has provided a video summarization technique in a collaborative adaptive e-leaning environment as an interactive medium to improve interactivity, engagement and motivation in order to change the traditional learning experience. The thesis started with a literature review that outlined various learning theories in general, and specifically those that assessed video technology. That was followed by a review of the past research conducted in this area. Based on the information obtained and a clear lack of interactivity in video learning, a summarization tool was developed to fill in the gaps found in this area.

The evidence from experiments in this research showed that applying this technique backed by various learning style theories had a positive impact on student general knowledge. This research should be used as a roadmap for future video learning to introduce more interactivity to enhance the learning process in general.

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Appendices

Appendix 1: (Ethical Review Requirements):

1. Information Sheet:

University of Sussex

PARTICIPANT INFORMATION SHEET TEMPLATE

Self-Summarized Videos in Adaptive Collaborative E-Learning Environment

**

You are being invited to take part in a research study. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

What is the purpose of the study?

The purpose of this study is to evaluate your learning experience and satisfaction level during your participation in the Self-Summarize Video Generating System (Referred to as the system)

Why have I been invited to participate?

As a student who has undertaken the Multimedia Design and Application Course, and who has access to online video lectures, it of great value to have you participating for the purpose of this research.

Do I have to take part?

It is up to you to decide whether or not to take part to this research. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. Choosing to either take part or not take part in the study will have no impact on your marks, assessments or future studies.

What will happen to me if I take part?

If you decide to take part in this study you will complete a pre-test and a post-test questionnaire, and will participate in using the system. You may review the questionnaires before deciding whether take part.

What are the possible disadvantages and risks of taking part? (where appropriate)

The project is a term-long experiment and your participation will be needed during the whole term.

What are the possible benefits of taking part?

Taking part in this study will help the lecturers improving the delivery method of information and module materials by providing a different tool for learning, and helping them understand what can be improved to make learning more enjoyable and effective

Will my information in this study be kept confidential?

The data you produce during this study will be kept confidential and your name will not be used nor associated with the data in papers, dissertation, thesis, reports, or any printed or non-printed volumes associated with this study.

What should I do if I want to take part?

If you wish to take part in this research please contact Nouf Alzahrani either telling her in person or emailing her at N.M.Alzahrani@sussex.ac.uk

What will happen to the results of the research study?

The result of this research will be used in thesis for PhD degree and also for publication purposes. They can be accessed through the university archived theses and/or published sources. The data generated from this experiment can be re-used with other research publications in the same area.

Who is organizing and funding the research?

The organizers of this research are Mrs Nouf Alzahrani, Dr Paul Newbury, Dr Phil Watten.

Who has approved this study?

This research has been approved by the Sciences and Technology Cross-Schools Research Ethics Committee (CREC: crecscitec@sussex.ac.uk) or through the School of Informatics ethical review process

Contact for Further Information

For further information on this research you can contact:

Nouf Alzahrani

Chichester 1 room CI 128

N.M.Alzahrani@sussex.ac.uk

Thank you for taking time in reading this information sheet

Date: 22 Jan 2015

2. Consent Form

University of Sussex

CONSENT FORM FOR PROJECT PARTICIPANTS

PROJECT TITLE:	**Self-Summarized Videos in Adaptive Collaborative E-Learning Environment**
Project Approval Reference:	

I agree to take part in the above University of Sussex research project. I have had the project explained to me and I have read and understood the Information Sheet, which I may keep for my records. I understand that agreeing to take part means that I am willing to:

- Participate in the use of the system and complete all the required tasks.
- Complete pre-test and post-test questionares based on my own previous knowledge and experience with the system .

I understand that any information I provide is confidential, and that no information that I disclose will lead to the identification of any individual in the reports on the project, either by the researcher or by any other party.

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way.

I consent to the processing of my personal information for the purposes of this research study. I understand that such information will be treated as strictly confidential and handled in accordance with the Data Protection Act 1998.

Additional Optional Agreement:

☐ I consent to the reuse of the data collected in this research in future research projects

Name: ____

Signature ____

Date: ____

3. Recruitment Email

I am a student at Engineering and Informatics school at University of Sussex, and I am conducting a research on video summarizing adaptive and collaborative e-learning environment. The purpose of this study is to enhance coherence and motivation of learning by utilizing video summarizing and collaborative tools.

Being a student who is studying Multimedia Design and Application Course. I am looking for participants and would be very grateful if you would be willing to take part in my study. If you do so, you will have the chance to find out more about the study before coming to any decision. You would be under no obligation to take part and this will have no impact on your marks, assessments or future studies. It is completely up to you whether to participate in this research study.

The duration of the test is around an hour to an hour and half, however you will have the chance to be familiar with new educational tools. The data produced from your participation will be kept confidential and your name will not be used nor associated with the data in papers, dissertations, or any printed or non-printed volumes associated with this study. The result of this study will be used in my thesis for PhD degree and also for publication purposes and can be accessed through the university archived theses library and/or published sources.

My research is supervised by Dr. Paul Newbury and Dr. Phil Watten and they can be contacted on: P.Newbury@sussex.ac.uk and P.L.Watten@sussex.ac.uk respectively. The use of email to recruit participants for this study has been approved by the Sciences and Technology Cross-Schools Research Ethics Committee (CREC: crecscitec@sussex.ac.uk) .

Thank you and Best Regards,

Nouf Alzahrani

Engineering and Informatics School

Department of Informatics

University of Sussex

N.M.ALZahrani@sussex.ac.uk

Appendix 2: (Experiment- Pilot study)

1. Pre Questionnaire

Thank you for your time to complete this survey. Your feedback is very important to my research. This survey should only take about 5 minutes of your time. Your answers will be completely anonymous and survey results may be published for educational purposes.

Pre-Experiment Questionnaire:

1. What is your preferred media of learning?

   ……………………………………………………………………………………

   ……………………………………………………………………………………
2. How much time do you spend on watching videos in social networks in a week?

   ……………………………………………………………………………………

   ……………………………………………………………………………………
3. Have you used video as a learning tool before?

   ……………………………………………………………………………………

   ……………………………………………………………………………………
4. Have you used videos from social networks or other sources to help you understand course materials?

   ……………………………………………………………………………………

   ……………………………………………………………………………………
5. How often do you watch video lectures a week?

   ……………………………………………………………………………………

   ……………………………………………………………………………………

   A. How did you find watching video lectures compared to traditional learning?

   ……………………………………………………………………………………

   ……………………………………………………………………………………

6. Do you think that summarizing a lecture is a useful way to improve your understanding?

   ……………………………………………………………………………………

……………………………………………………………………………………

7. Have you ever tried to summarize a video lecture?

……………………………………………………………………………………

……………………………………………………………………………………

If yes

A. How did you summarize it?

……………………………………………………………………………………

……………………………………………………………………………………

B. Have you ever used a special tool to summarize a video?

……………………………………………………………………………………

……………………………………………………………………………………

If yes

I. Please write in more details the name of the tool and how easy did you find it.

……………………………………………………………………………………

……………………………………………………………………………………

II. How long did it take to watch and summarize the video lectures?

……………………………………………………………………………………

……………………………………………………………………………………

III. How useful was the tool in improving your understanding?

……………………………………………………………………………………

……………………………………………………………………………………

2. Post Questionnaire (USE Questionnaire)

A. On a scale of 1 to 5 please answer the following questions:

Questions	Strongly agree	Agree	Satisfied	Disagree	Strongly disagree
1- I am satisfied with how easy is to use this system.	O	O	O	O	O
2- I can make effective summarized video lectures using this system	O	O	O	O	O
3- I am able to efficiently capture specific part of the lecture videos using this system	O	O	O	O	O
4- I am able to change the order of clips easily in this system	O	O	O	O	O
5- I am able to create my own video clip quickly	O	O	O	O	O

	using this system					
6-	I am able to add my own descriptions and comments on my own video easily using this system	0	0	0	0	0
7-	I am able to easily share my videos with friends using this system	0	0	0	0	0
8-	I am able to discuss videos with friend easily using this system	0	0	0	0	0
9-	I am able to get all the created video clips quickly by subscribing to the specific subjects using this system	0	0	0	0	0
10-	I feel comfortable using this system	0	0	0	0	0
11-	It was easy to learn this system.	0	0	0	0	0
12-	I believe I became productive using this system	0	0	0	0	0
13-	Whenever I make a mistake using the system, I recover easily and quickly	0	0	0	0	0
14-	It is easy to find a friend	0	0	0	0	0
15-	It is easy to find subjects I wanted	0	0	0	0	0
16-	The information provided by tutorials is easy to understand	0	0	0	0	0
17-	The tutorial is effective in helping me to complete the tasks.	0	0	0	0	0
18-	The interface of this system is effective and easy to understand	0	0	0	0	0
19-	This system has all the functions and capabilities I expect it to have	0	0	0	0	0
20-	Overall, I am satisfied with this system	0	0	0	0	0

B. Please briefly answer the following questions

1- Which parts of the system were easy to use?

……………………………………………………………………………………………

……………………………………………………………………………………………

2- Which parts of the system were difficult to use?

………………………………………………………………………………………

………………………………………………………………………………………

C. Please briefly answer the following questions

1- Did the system help you successfully creating summarized materials? Explain how

………………………………………………………………………………………

………………………………………………………………………………………

2- Did the summarized materials help you to have a better understanding and improved your knowledge?

………………………………………………………………………………………

………………………………………………………………………………………

3- Did you find other students' video clips helpful in improving your knowledge and understanding? Explain how

………………………………………………………………………………………

………………………………………………………………………………………

4- Was the sequence order of the scenes in a single summarized video clip important in improving understanding? Explain

………………………………………………………………………………………

………………………………………………………………………………………

5- Was this tool useful in finding answers to the problems you have faced in your learning? Explain how

………………………………………………………………………………………

………………………………………………………………………………………

6- Do you think the collaboration between users was a helpful tool in increasing **learning**?

………………………………………………………………………………………

………………………………………………………………………………………

7- Do you think the collaboration between users was a helpful tool in increasing **motivation**?

………………………………………………………………………………………

………………………………………………………………………………………

8- Did the system make the learning process more fun? Explain.

………………………………………………………………………………………

………………………………………………………………………………………

9- Did you find the summarized video more understandable and more accurate to solve problems than watching the original video lecture alone? Explain.

………………………………………………………………………………………

………………………………………………………………………………………

10- Briefly list the main advantages or disadvantages of this tool on learning process.

………………………………………………………………………………………

………………………………………………………………………………………

11- Overall, how do you rate this tool in enhancing learning and understanding?

………………………………………………………………………………………

………………………………………………………………………………………

12- Overall, how do you rate this tool in increasing motivation in education?

………………………………………………………………………………………

………………………………………………………………………………………

Appendix 3: (Experiment- Full Study)

1. Pre Questionnaire:

Self-Summarized Videos in Adaptive Collaborative E-Learning Environment Pre-Experiment Questionnaire

Thank you for your time to complete this survey. Your feedback is very important to my research. This survey should only take about 5 minutes of your time. Your answers will be completely anonymous and survey results may be published for educational purposes.

Gender: **O** Male **O** Female

Age:

Academic Level: **O** Undergraduate **O** Postgraduate

1. What kind of learner you are

   O Visual learner
   O Auditory Learner
   O Kinesthetic learner
   O Other [specify]

   If you select other, please write down your answer:

   ……………………………………………………………………………………

   ……………………………………………………………………………………

2. What is your preferred media of learning?

   O Online video lecture
   O Traditional (attending Lecture)
   O Other

   If you select other, please write down your answer:

   ……………………………………………………………………………………

   ……………………………………………………………………………………

3. Have you used video as a learning tool before?

O Yes

O No

4. How much time do you spend on watching videos for learning purpose per week?

O Less then 2 hours

O Between 2 and 4 hours

O Between 6 and 8 hours

O More than 8 hours

5. If you have used videos for learning before, how did you find watching videos compared to traditional learning?

O Better

O Not Better

O Similar

Please write more details based on your selection

………………………………………………………………………………………

………………………………………………………………………………………

6. Do you think that summarizing a lecture is a useful way to improve your understanding?

O Yes

O No

Please write more details based on your selection

………………………………………………………………………………………

………………………………………………………………………………………

7. Have you ever tried to summarize a video lecture? (If your answer is No then go to Q12)

O Yes

O No

8. How did you summarize it?

O Writing note

O Highlight key-point

O Mind-map

O Using special tools

O Other

If you select other, please write down your answer:

……………………………………………………………………………………

……………………………………………………………………………………

9. If you ever used special tools to summarize a video, please write more details (e.g. name of the tool and how easy you found it):

   ……………………………………………………………………………………

   ……………………………………………………………………………………

10. Please write more details (How long did it take to watch and summarize the video lectures):

    ……………………………………………………………………………………

    ……………………………………………………………………………………

11. Please write more details (How useful was the tool in improving your understanding):

    ……………………………………………………………………………………

    ……………………………………………………………………………………

12. Would you prefer to share knowledge with friends (such as notes, documents or videos)?

    ……………………………………………………………………………………

    ……………………………………………………………………………………

➢ Student feedback after first usage

❖ Please write your feedback

2. Post questionnaire:

Gender: **O** Male **O** Female

Course: **O** BSc Computer Science

O BSc Computing for Business and Management

O BSc Computing for Digital Media

O BSc Games and Multimedia Environments

- ***QUIZ Questionnaire***

I. Questionnaire for User Interface Satisfaction:

➢ **Overall reaction to the Video Summarization system**		**1**	**2**	**3**	**4**	**5**	
1. General feeling	Dissatisfied	0	0	0	0	0	Positive
2. Ease of use	Difficult	0	0	0	0	0	Easy
3. Adequacy- did you feel that the system enabled you to improve your understanding	Poor	0	0	0	0	0	Good
4. Motivation- how motivated did the system make you feel	Dull	0	0	0	0	0	Stimulating
5. Engagement- how engaged were you by the system	Low	0	0	0	0	0	High
Visual representation		**1**	**2**	**3**	**4**	**5**	
1. Reading characters on the screen	Hard	0	0	0	0	0	Easy
2. Organization of information	Confusing	0	0	0	0	0	Very clear
3. Sequence of screens	Confusing	0	0	0	0	0	Very clear
Terminology and system information		**1**	**2**	**3**	**4**	**5**	
1. Use of terms throughout system	Inconsistent	0	0	0	0	0	Consistent
2. Prompts for input	Confusing	0	0	0	0	0	Clear
3. Error message	Unhelpful	0	0	0	0	0	Helpful
System capabilities		**1**	**2**	**3**	**4**	**5**	
1. System speed	Too slow	0	0	0	0	0	Fast enough
2. System reliability	Unreliable	0	0	0	0	0	Reliable
3. It is easy to remember how to use the system	Agree	0	0	0	0	0	Disagree
4. Designed for all levels of users	Agree	0	0	0	0	0	Disagree

- ***USE Questionnaire***

➢ Ease of Learning		1	2	3	4	5	
1. How easy did you find it to learn to operate the system	Difficult	O	O	O	O	O	Easy
2. How easy did you find remembering names and use of commands	Difficult	O	O	O	O	O	Easy
3. Performing tasks is straightforward	Disagree	O	O	O	O	O	Agree
4. Does summarizing video system helps to enhance motivation to learn?	Unhelpful	O	O	O	O	O	Helpful
5. Does reducing the video to key points help increase your focus?	Unhelpful	O	O	O	O	O	Helpful
6. Does summarizing the video helps you to interact with answering the questions?	Unhelpful	O	O	O	O	O	Helpful
7. Does a combination of summarizing video and sharing it helps to improve knowledge?	Unhelpful	O	O	O	O	O	Helpful
8. Does summarizing video helps you as practical learner to understand the video content (Because you created your own video)?	Unhelpful	O	O	O	O	O	Helpful
9.Does summarization of the video helps you to answer the questions more accurately rather than watching the whole video?	Unhelpful	O	O	O	O	O	Helpful
10.Do you feel that the sequence order of the scenes in a single summarized video clip is important in improving	Not Impo	O	O	O	O	O	Importa nt

understanding?							
➢ **System functionalities**		**1**	**2**	**3**	**4**	**5**	
1. Capturing specific part of the video	Difficult	**0**	**0**	**0**	**0**	**0**	Easy
2. Changing clips order	Difficult	**0**	**0**	**0**	**0**	**0**	Easy
3. Creating video easily	Difficult	**0**	**0**	**0**	**0**	**0**	Easy
4. Adding note and Description	Difficult	**0**	**0**	**0**	**0**	**0**	Easy
5. Sharing created video with friends	Difficult	**0**	**0**	**0**	**0**	**0**	Easy
6. Discussing created video with friends	Difficult	**0**	**0**	**0**	**0**	**0**	Easy
7. Searching and adding friends	Difficult	**0**	**0**	**0**	**0**	**0**	Easy
8. Uploading image	Difficult	**0**	**0**	**0**	**0**	**0**	Easy
9. Adding scene comment	Difficult	**0**	**0**	**0**	**0**	**0**	Easy
10. Deleting clips	Difficult	**0**	**0**	**0**	**0**	**0**	Easy

II. Questionnaire for summarizing video and system functionalities (Explanation):

➢ **Summarizing video**

❖ Which one of the following did you find most useful:

1. Watching video without summarize it.
2. Summarize the video with adding notes and comments.
3. Summarizing video with adding notes, comments and shares it with friends.

❖ Did the system help you successfully creating summarized materials? Explain how

- Is this your first summarization experience? Explain if not and compare it with this tool

- Did the summarized materials help you to have a better understanding and improved your knowledge?

- Did you find the summarized video more understandable and more accurate to solve problems than watching the original video lecture alone? Explain.

III. Collaboration between user (Sharing the created video)

➢ Collaboration

- Did you find other students' video clips helpful in improving your knowledge and understanding? Explain how

- Do you think the collaboration between users was a helpful tool in increasing **learning**?

- Do you think the collaboration between users was a helpful tool in increasing **motivation**?

➢ General Comments

Appendix 4: Database design and User data (Database)

Database Design

The database used in this system is a MySQL database hosted on university server. This is provided by the university. The database design and relationship between tables are shown in the following figure.

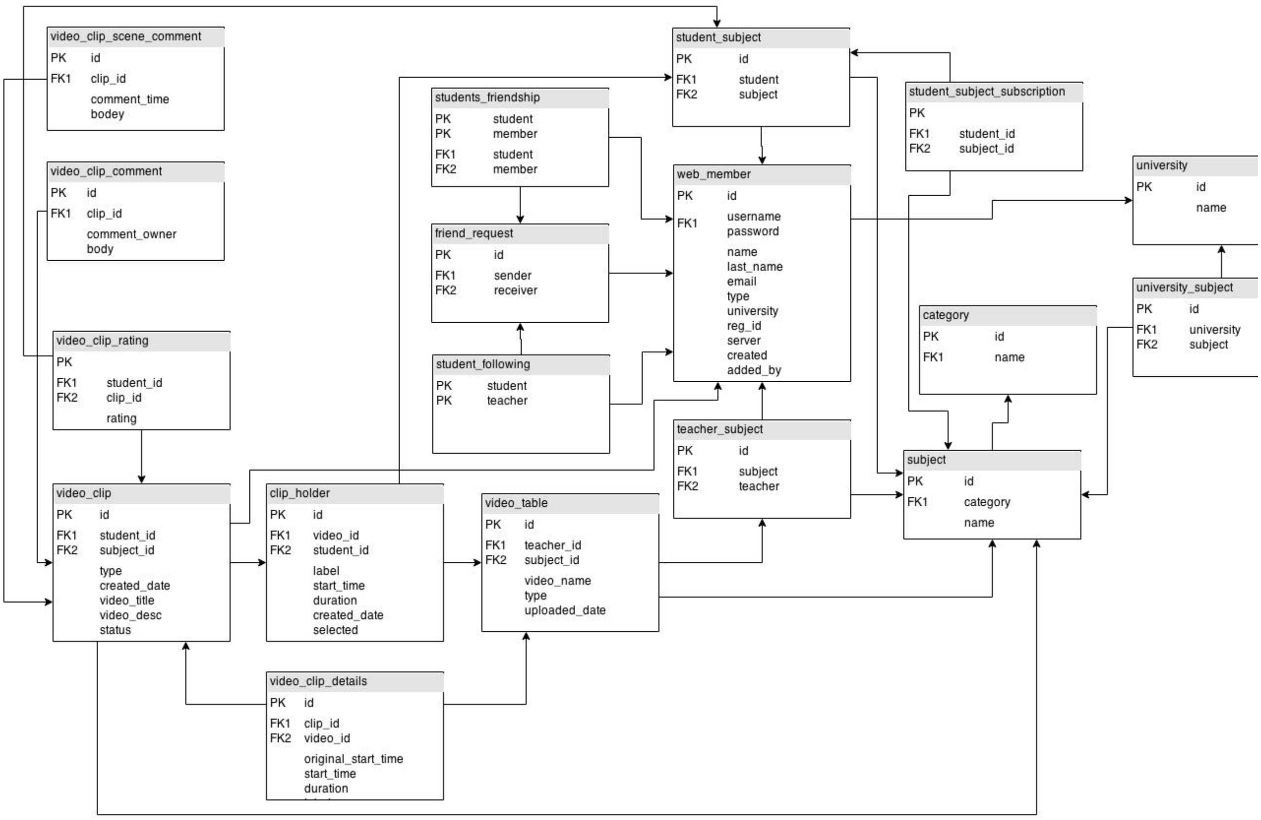

Figure: Database design diagram

This section explains all the tables in the database

- <u>Web Members</u>**:** This table contains information about all registered users including their name, email, university ID, role and created date. Admin users are added manually, coordinators by admin, and teachers and students are added by coordinators.
- <u>University:</u> University table holds the university name and added by the admin.
- <u>Category:</u> This table contains categories for the subjects. The categories are added by the admin.

- University Subject: This table links subjects and universities and added by the admin. It holds the university ID and subject ID.
- Clip Holder: Clip holders hold the scene holders information including label, original video id, starting time of capturing video, duration, student id and created date. The holders are added by students when they capture scenes from original videos. Clip holders are deleted by the system once a summary video clip is created out of them.
- Friend Request: This table contains the sender and receiver information and created by students when they send friendship request to a friend. Each request is deleted by the system when the receiver responds to the request by either accepting or refusing.
- Student Friendship: This table holds list of friendship and each row contains the sender and the receiver information. The row is deleted once either the sender or receiver unfriends the friendship relationship.
- Student Subject: This table shows registered student in each subject and contains student and subject ID's. The student subjects are added by the coordinator reflecting the students and the subjects they are registered in.
- Student Subject Subscription: This table holds the subscription information including student ID and subject ID. The row is added once the student subscribe to a subject and deleted upon unsubscription.
- Subject: This table holds the subjects information including its name and category and are added by the admin.
- Teacher Subject: This table links the subjects to the teachers and added by the coordinator. It holds the subject ID and teacher ID from the web member.
- Video Clip: This table holds the video clip information including video type, video title, video description, student ID, subject ID, status of the video. The row is created when the student creates a video clip from the scene holders.
- Video Clip Comment: This table holds the general comment information to be displayed in summary video clip discussion board. The information includes video clip id, body of the comment and the user who has written

the comment. The row is deleted once the comment owner deletes his/her comment.

- Video Clip Details: This table holds the video clip scenes information. Each row represents a scene of a summary video clip and used to refer to the original video. Each holds the scene starting time in the original video, duration, label, original video ID and video clip ID.
- Video Clip Rating: This table holds students rating of video clips with each row containing student ID, video clip ID and rating value of one to five. The row is added once the student rates a video clip. The average rating is calculated by the averaging the rating values of a video clip.
- Video Clip Scene Comment: This table holds scene comments information of the video clip including video clip id, comment time to show comment on that specific time, and comment body. The row is added once an on-scene comment is added by the student.
- Video Table: This table contains original video information including video name, video type, uploaded date, teacher ID from the web member, subject ID and generated ID. Each row represents a lecture video and added once the teacher uploads a lecture video

Appendix 5: Codes for assessing the results from the database

Number of users:

```
SELECT * FROM `web_members` WHERE id IN (SELECT member_id FROM
`stat_count_login`) AND id IN (SELECT student FROM student_subject
WHERE subject = 8)
```

Code 1: Calculating the Number of Active Students Who Registered for the Introduction to Multimedia Module

Number of original videos:

```
SELECT * FROM `video_table` WHERE subject_id = 8
```

Code 2: Calculating the Number of Video Lectures Intended for the Experiment

Number of video clips:

```
SELECT * FROM `video_clip` WHERE subject_id = 8
```

Code 3: Calculating the Number of Created Video Clips

Number of video clip details:

```
SELECT * FROM `video_clip_details` WHERE clip_id IN (SELECT id FROM
video_clip WHERE Subject_id = 8)
```

Code 4: Calculating the Number of Video Clip Details

Number of video clip notes:

```
SELECT * FROM `video_clip_note` WHERE clip_id IN (SELECT id FROM
video_clip WHERE Subject_id = 8)
```

Code 5: Calculating the Number of Written Notes

Number of scene comments:

```
SELECT * FROM `video_clip_scene_comment` WHERE clip_id IN (SELECT id
FROM video_clip WHERE Subject_id = 8)
```

Code 6: Calculating the Number of Scene Comments

Number of video clip ratings:

```
SELECT * FROM `video_clip_rating` WHERE clip_id IN (SELECT id FROM
video_clip WHERE Subject_id = 8)
```

Code 7: Calculating the Number of Ratings per Video

The average number of ratings:

```
SELECT avg(rating) FROM `video_clip_rating` WHERE clip_id IN (SELECT
id FROM video_clip WHERE Subject_id = 8)
```

Code 8: Calculating the Average Rating Per Video

Number of video discussions:

```
SELECT * FROM `video_clip_comment` WHERE clip_id IN (SELECT id FROM
video_clip WHERE Subject_id = 8)
```

Code 9: Calculating the Number of General Comments

Number of video clip visitors:

```
SELECT * FROM `stat_count_video_clip_visit` WHERE video_clip_id IN
(SELECT id FROM video_clip WHERE Subject_id = 8)
```

Code 10: Calculating the Number of Visits for Each Created Video

Number of students who made friends:

```
SELECT * FROM `web_members` AS wm
WHERE wm.id
IN (
    SELECT student FROM student_subject WHERE subject =8
)
AND (
     wm.id
     IN (
         SELECT member FROM students_friendship
     )
     OR wm.id
     IN (
         SELECT friend FROM students_friendship)
)
ORDER BY wm.id
```

Code 11: Calculating the Number of Active Students Who Made Friends

Number of comments made by active students:

```
SELECT * FROM `video_clip_comment` AS vcc
WHERE vcc.comment_owner
IN (
         SELECT student FROM student_subject WHERE subject =8
)
AND (
        vcc.comment_owner
        NOT IN (
                 SELECT member FROM students_friendship
        )
           AND vcc.comment_owner
           NOT IN (
                  SELECT friend FROM students_friendship)
)
ORDER BY vcc.comment_owner
```

Code 12: Calculating the Number of Comments Made by an Active User Who Did Not Have Any Friends