TECHNISCHE UNIVERSITÄT DRESDEN

**Department of Computer Science** Institute for Systems Architecture, Chair of Computer Networks

Master Thesis

# VISUALIZING THE TEMPORAL CREATION PROCESS OF GRAPHICAL DISCUSSION CONTRIBUTIONS

**Shen, Tong**

Born on: 22nd December 1991 in China

Matriculation number: 4020656

Matriculation year: 2013

to achieve the academic degree

**Master of Science (M.Sc.)**

Supervisor

**Tenshi Hara**

Supervising professor

**Prof. Dr. rer. nat. habil. Dr. h. c. Alexander Schill**

Submitted on: 31st January 201

TECHNISCHE UNIVERSITÄT DRESDEN

**Faculty of Computer Science** Institute of Systems Architecture Chair of Computer Networks

# MASTER THESIS ASSIGNMENT

**TOPIC:** Visualizing the Temporal Creation process of Graphical Discussion Contributions

| | | | |
|---|---|---|---|
| Name (sur, given): | Shen, Tong | Degree Programme: | Master DSE (PO 2010) |
| Matriculation No: | 4020656 | Project/Focus: | Tech-enhanced Learning |
| Responsible Professor: | Prof. Dr. rer. nat. habil. Dr. h. c. Alexander Schill | | |
| Involved Staff: | Dr.-Ing. Tenshi Hara, Dr.-Ing. Iris Braun | | |
| Start: | 19 June 2017 | Due: | 27 November 2017 |

## GOAL

At the Chair of Computer Networks a graphical discussion system (Graphicuss) is developed. Currently, it combines the features of text-based discussion systems with those of virtual interactive whiteboard systems. Users are able to quote partially created graphical content by quoting existing contributions and modifying them from a specific point in time of their creation process onwards. However, there is no intuitive representation of this time component in the moment.

The goals of this assignment are to investigate if and how the representation as a video can be considered intuitive. Alternative representations (such as step-by-step) can be taken into consideration for comparison. The actual creation of original contributions as well as quoting and modifying content shall be investigated. Corresponding workflows should be created and their feasibility investigated.

In order to achieve the goals, all aspects of modern web technologies and video representation therein need to be considered. A comprehensive state-of-the-art analysis as well as assessment of existing video solutions must be conducted. Thereafter, a feasible concept for intuitive representation of the time component as a video should be created. User interviews should be conducted with either mock-ups (paper-based or low/high fidelity programs). If time permits, a suitable proof-of-concept implementation can be created, but it is not mandatory. The focus must remain on a robust concept.

An evaluation of the concept should be executed, focussing on usability aspects, especially perceived intuitiveness, but objective measurands (such as system usability scale) should also be considered.

Prof. Dr. rer. nat. habil. Dr. h. c. Alexander Schill
(responsible professor)

## FOCUSES

- Investigation of related work as well as current state of solutions and research,
- definition of requirements and criteria,
- conception of a time-component visualization,
- conception of an evaluation method,
- conduction of user interviews,
- (implementation of proof-of-concept components,) and
- evaluation and assessment of the results.

Technische Universität Dresden/Fakultät Informatik

## Master's Thesis Application

Private Information of the Student:
Name, First Name: Shen, Tong

born on: 22 December 1991 Matr. No.: 4020656

Study Course: Distributed Systems Engineering

E-Mail Address: lsmomy@gmail.com

Subject:

Visualizing the Temporal Creation Process of Graphical Discussion Contributions

**We agree on the above mentioned subject and we will prepare a review each:**

*1st Reviewer:* Prof. Dr. Dr. h.c. Alexander Schill
(always include academic title)

Professorship: Computer Networks

☒ I supervise the thesis work Schill 14.6.17
(Date, Signature)

*2nd Reviewer:* Dr.-Ing. Iris Braun
(always include academic title)

Professorship: Computer Networks

☒ I supervise the thesis work Braun 15.6.17
(Date, Signature)

Start date: 19 June 2017 Submission deadline: 27 November 2017

The Examination Board accepts the application:

Date: 15.6.17 Chair of Examination Board: Schill

*Distribution after return: Original Student, Copy 1st Reviewer, Copy 2nd Reviewer, Copy SCIS*

TECHNISCHE
UNIVERSITÄT
DRESDEN

**Fakultät Informatik,** Service Center for International Students

## Application for Extension of Submission Deadline for Master's Thesis
(DSE)

| | | | |
|---|---|---|---|
| Name: | Shen | First Name: | Tong |
| Date of Birth: | 22 December 1991 | Semester: | 9 |
| Student ID: | 4020656 | Program: | DSE |

| | |
|---|---|
| Supervisor: | Prof. Dr. Alexander Schill |
| Start date: | 12 June 2017 |
| Submission deadline (original): | 27 November 2017 |
| Duration of Extension: | **max. 13 weeks** |
| Renewal submission deadline: | 31 January 2018 |

Explanation for Extension:

Based on significant changes in the conceptual outline of my implementation, the requirements derived from the initial user studies need to be re-evaluated. In order to guarantee a fair quality of my evaluation results, I want to conduct further user interviews. This will allow me to provide stronger evidence for my concept to be valid.

Confirmation by Supervisor: pp. Tong Shen

This application has to be submitted in time to the examination office SCIS;
a copy of the thesis topic is to be concluded.

Service Center for International Students
Distributed Systems Engineering
Fakultät Informatik
Technische Universität Dresden

27.11.2017
Date

i.A. Irina Karadschow
Signature of SCIS

**Decision by Examination Board:**

The application for extension is / ~~is not~~ approved.

6.12.17
Date

Schill
Signature
of Examination Board

## Statement of authorship

I hereby certify that I have authored this Master Thesis entitled VISUALIZING THE TEMPORAL CREATION PROCESS OF GRAPHICAL DISCUSSION CONTRIBUTIONS independently and without undue assistance from third parties. No other than the resources and references indicated in this thesis have been used. I have marked both literal and accordingly adopted quotations as such. They were no additional persons involved in the spiritual preparation of the present thesis. I am aware that violations of this declaration may lead to subsequent withdrawal of the degree.

Dresden, 2nd January 2018

Shen, Tong

Shen, Tong

02 . 01 . 2018

Dresden.

# CONTENTS

# 1 INRTODUCTION

Accompanied by the widespread tendency of the online education platforms in recent decades, users of such online tools have adapted, if not constrained, to a communication model in which the all-rounded thinking process could not be fully demonstrated but rather replaced by a simplified conclusion. This limited virtual interaction has challenged the human beings' learning habit, reducing the efficiency and deterring the interest, hence leading to an increasing focus on the efficient learning methodology which could be realized on the online platform.

Basically, there are two kinds of mature web applications for educational purpose. One is professional education websites such as *Coursera*[1]. Normally in this case, all the contents are published by authorized publishers, video contents are well edited with rich contents. The other mature education web application is discussion system such as *Quora*[2]. Users can ask and answer questions based on their field of knowledge. This kind of web application is more flexible. And Quora is a typical example of online discussion systems.

An online educational discussion platform, is to help users communicate in a way, that they can easily express their thoughts and easily understand ideas of others. Videos as a traditional media content has the advantage of containing massive information. With the timeline character of video, users can obtain more information than pure text or pure graphical elements, such as the creation metadata, time cost and creator's confident.

By our learning experience, there are two traditional ways of learning: one is sitting in a classroom listening to the teacher. The other way is reading the textbook and learn by oneself. These two situations are good examples for comparison video contents and text/graphic contents while learning online. Video is more vivid and provides more information. It is something that people can follow with. While watching a video, audience could follow the publisher easily. Different from a text or static graph, which tend to give a result of a question, a video content takes more care about the process. Based on this, video is believed to be a more impressive media content. And it is necessary to introduce video contents in online education discussion systems.

[1] https://www.coursera.org/ -accessed 9 Nov 2017

[2] https://www.quora.com/- accessed 9 Nov 2017

Videos are widely used on Internet, there are many successful websites that provide video contents such as *YouTube*[3], which has proved that videos can be used for different purposes, among which education is one of the most important application field. At the same time, websites for educational purposes also play an important role in nowadays Internet society. Combining video content into a graphical discussion system can improve both system usability and interactivity. However, even videos are more impressive and contain more information. Until now there are no website helps user express their ideas with video contents. On the one hand, it is tricky to generate videos when users have no patient to make their own. On the other hand, some ideas are now mature, further changes may be needed, and video are not easy to edit.

In this thesis a concept of using video properly in online discussion system will be introduced.

## Thesis Outline

**Chapter 2** states the research background of this visualization design. It describes the graphical discussion system firstly, and then introduces the usage of web videos. To reach the final goal of combining web video expression and discussion systems. Chapter 2 also introduces the techniques about video playing, video recording and video editing. At the end of this chapter, different implementation possibilities are analyzed.

**Chapter 3** gives the interaction design of the new discussion system tool. At the beginning, the user requirements are investigated and listed. Based on the user requirements, a detailed system design is presented with the user interface mock ups. A new answer structure is introduced here.

**Chapter 4** presents the implementation design. It analyzed which techniques should be used in the implementation phase, and then in chapter 4, a concrete implementation process is stated. Demo of the new discussion system tool are also shown here with codes and screen shots.

**Chapter 5** evaluates the design based on System Usability Scale and Perceived Intuitiveness. The evaluation results are also shown in chapter 5. This evaluation could guide the research to achieve better usability.

**Chapter 6** concludes the works in this thesis. It also contains the further research topics in future work. This could help other students or researchers understand the achievements and the weak points of this design.

[3] https://www.youtube.com/ - accessed 9 Nov 2017

# 2 STATE OF ART

The prototypical approach introduced in this thesis is basically related with the following approaches: The first is graphical discussion systems(Graphicuss) [1], which is a forum that enables user using graphical elements as well as text content. The second approach is online video services. There is a huge range of video concepts, among these concepts, the basic functions of a video content would be abstracted and the common sense does web users share about videos would be analyzed. The techniques of video recording and playing would also be introduced. Last but not least, this thesis will discuss several possible solutions for answer creation process visualization, and analyze the trade-off between different solutions.

## 2.1 ONLINE DISCUSSION SYSTEM

The use of online discussion system has nowadays been very common in many aspects of the internet world, among which some knowledge-exchange forums, for example of *Stackexchange*[4], *Quora*[5] *and Reddit*[6]*,* are successful web applications in this regard. In such applications, participants of a specific subject can raise a problem or answer a question using text content as well as other materials, for example of a link or an image. The typical function of such traditional applications has realized the purpose of knowledge exchange online, however, the sharing experience is not always efficient due to the inherited constraints of static expression. From the traditional answer creation process shown in Figure 2.1, it is evident that the content that an editor could play with is limited within static features.

However, the traditional online discussion system has set the basis for the development of dynamic illustration. It gives the basic structure of further online discussion system design. Functions such as reply, forward, quote and vote are key features for online communication among participating users of a specific topic, which should be maintained in the enhanced discussion system.

[4] https://stackexchange.com/ - accessed 9 Nov 2017

[5] https://www.quora.com/ - accessed 9 Nov 2017

[6] https://www.reddit.com/- accessed 9 Nov 2017

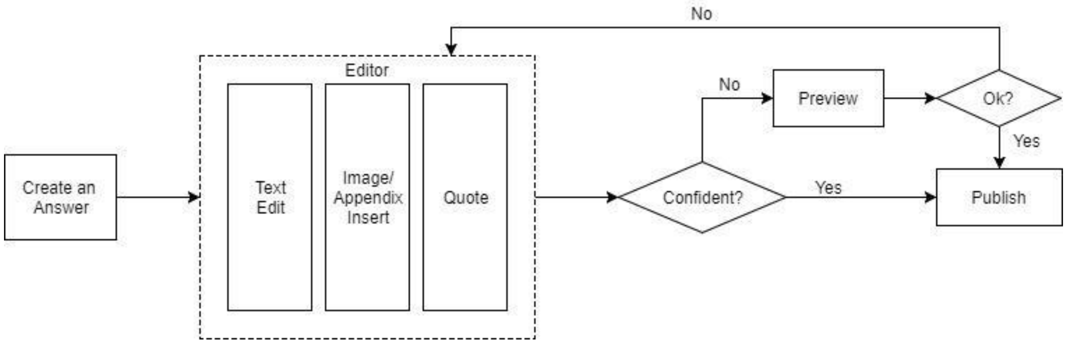


Figure 2.1: Workflow of creating an answer in traditional forums

Constrained by the thinness of plain text or static image, especially in subjects like mathematics, physics and computer science, a dynamic and intuitive graphic illustration is needed to facilitate the knowledge exchange. To achieve such a higher degree of flexibility, researchers have proposed an idea combining the traditional text-based forum with a graphical content creation tool. Inspired by the need of flexible expression and dynamic illustration in the online discussion system, *Graphicuss* has been created providing a solution. It offers a tool that helps user creates graphical content during answer creation. The uniqueness that it can record the graphic drawing process is an important innovation applying the current technology.

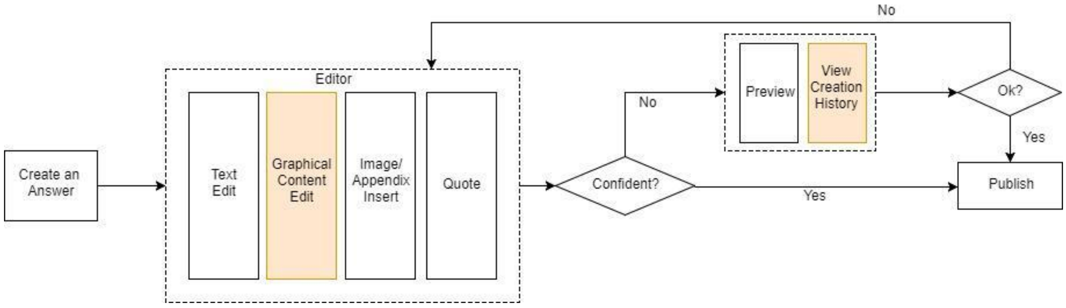


Figure 2.2: Workflow of creating an answer in Graphicuss

Graphicuss is a graphical discussion tool that developed at the Chair of Computer Networks in TU Dresden. It is a new form of online discussion system which enables the use of graphical drafts in the same way as the users use the plain text contents, the new workflow of answer creation is presented in Figure 2.2. This new system aims at designing the whole architecture of graphical discuss system, and it is composed of three main parts: Course Management, Question Management and Answer management just like traditional online discussion systems. In the Graphical Discussion System, the key innovation is the realization of dynamic graphical content -- drawing tool and temporal history of a content -- with existing technology. Through communication with dynamic graphical content, all the participants of a certain course can share their questions and understandings efficiently. The two important features, drawing tool and temporal history of a content, are explained with details as below.

Drawing Tool: Different from the traditional forum where users can only edit text and insert static graphs, Graphicuss helps the user to create their dynamic graphical content by using the drawing tool. This idea originated from the whiteboard system, however, it goes beyond the simple implementation of the whiteboard system. A set of basic drawing elements are available in the drawing tool, such as circle, rectangle or line. User can drag the basic graphs to the editing area, adjust and combine them to create a graphical element as they want. The user interface design mockup is in Figure 2.3.

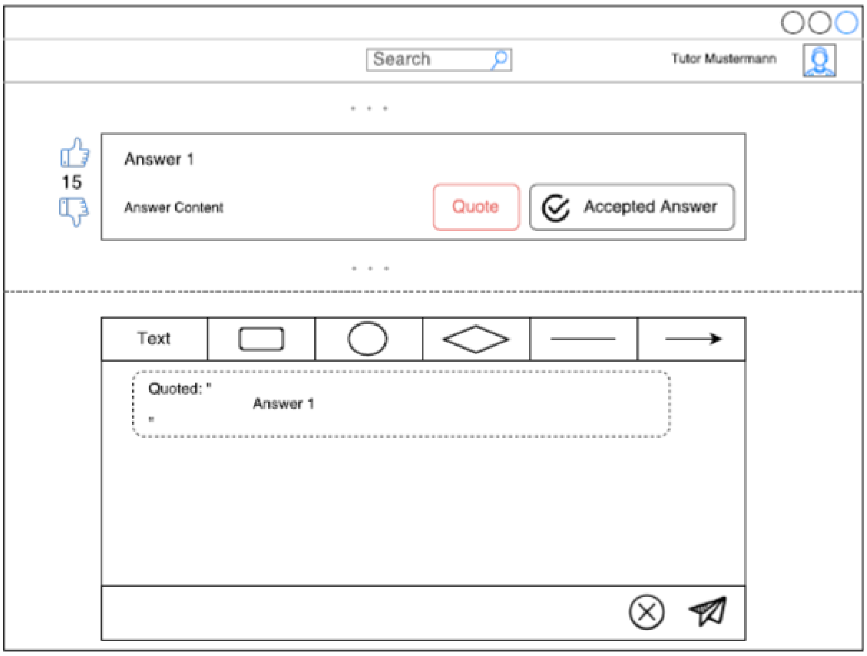


Figure 2.3: Drawing Tool in Graphicuss

The core technologies used to support the drawing tool are HTML5 canvas and Fabric.js. HTML5 canvas element is selected to present graphical elements in Graphicuss. In addition to HTML5 canvas, Fabric.js has provided interactive object models on top of canvas elements. By means of Fabric.js, objectified canvas can be implemented.

Temporal history of a content: While using the drawing tool, a history of the drawing process is stored and demonstrated in the final answer. The illustration of the drawing process is significant. For many science-based subjects, the thinking process is sometimes for more helpful than the final result in terms of understanding and solving the questions.

Take the creating process of a UML class diagram for example, the result might be very complicated and the relations between the classes are not intuitive. If one could see the dynamic solving process, it would be much easier to understand and get a full picture of the question. In addition to the convenience brought to the reader in understanding the question, the author of a comment can also benefit from the history record when revising the answer. If there is a mistake in the final graphical element, the author could go back in the history record to locate the point where the mistake is made.

The temporary history record is also important for quoting. In Graphicuss, the history record of how a graphical element is drawn is reproducible, and quotes are made possible by changing the graphical element or the corresponding history record directly. That way, submissions can be discussed and even corrected in a natural flow of discussion. For example, an incorrect graphical solution can be quoted up until the precise moment a mistake was made, and then be corrected from there.

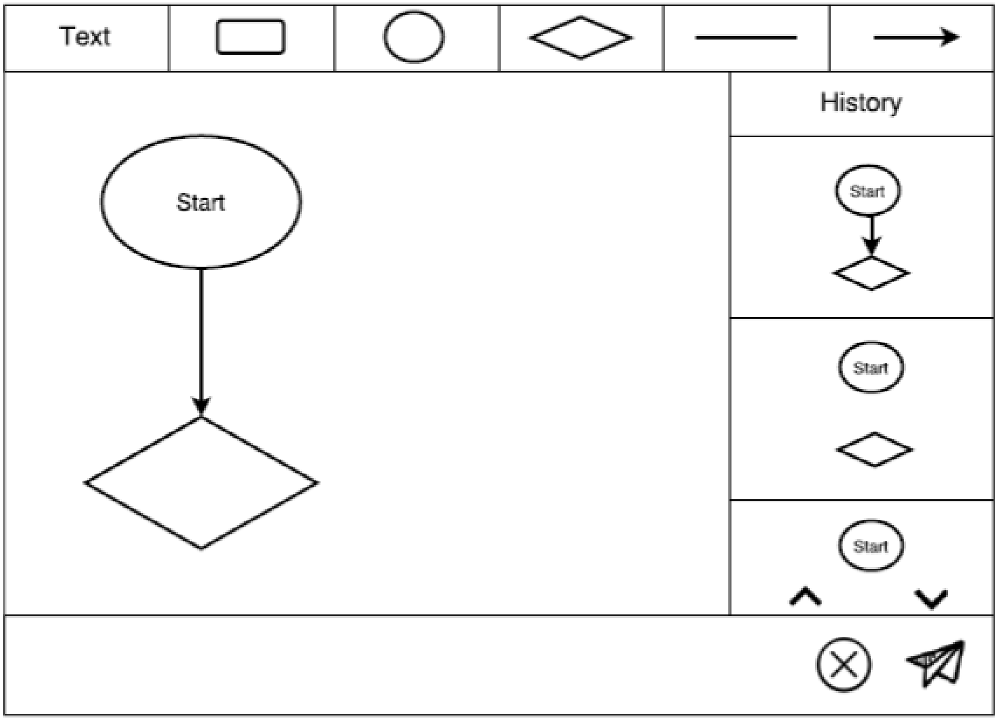


Figure 2.4: Drawing history in the drawing tool

In Graphicuss design, the creation process of a graphical content is stored with a unique timestamp. This enable the publisher review before publish. Also, it enables the others user view how the answer is created. Users should see not only an analyzing result of a problem, but also how the presenter process the ideas step by step. However, how to show the creation procedure in an expressive and user-friendly way is remain an open topic. A possible user interface design is shown in Figure 2.4, this thesis tries to present this procedure with videos.

## 2.2 WEB VIDEO USAGE

By 2017, online video will account for 74% of all online traffic, 55% of people watch videos online every day[7]. Every four out of five people would prefer to watch a video rather than to read a paper in order to get information on a certain subject. These statistics has shown how important the role of web video plays in the modern Internet world and how strong the online video is in terms of expressing ideas. In this section the thesis will look into different web-video applications and then shed some light on what kind of service the video provides and how to do the interaction design of the web video.

There are many successful websites providing different kinds of web video services for different purposes, such as TED, YouTube, Coursera and even Facebook. The typical usages of web video are shown below in Figure 2.5.

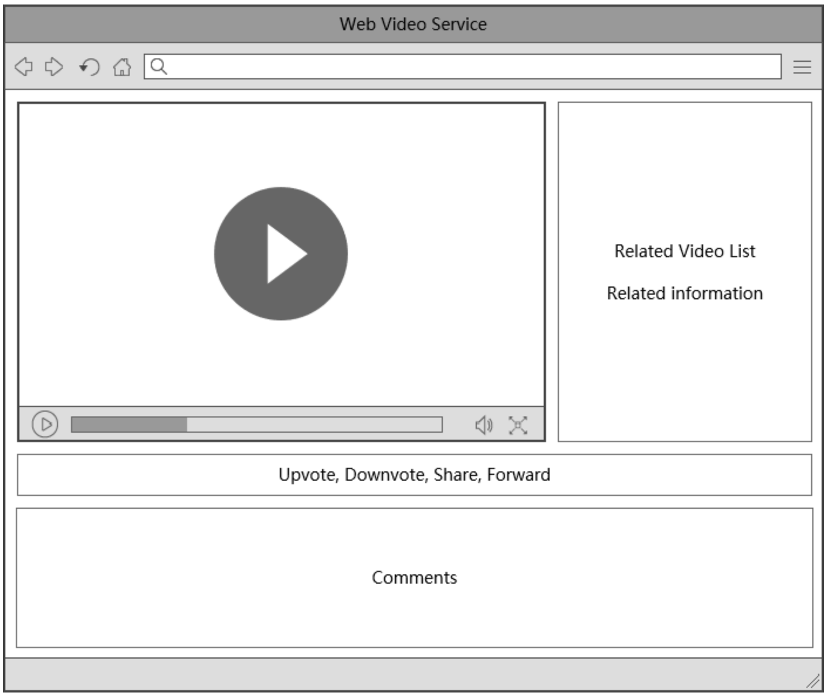


Figure 2.5: Demo of a common video site

*Traditional videos service*: Websites provide online videos. End users can browse this site and choose interesting things, but users are not given access to publish their own videos. These sites only offer professionally produced content (e.g. BBC, Netflix, Coursera) and the basic video control methods, such as play, pause, stop, full-screen and subtitle. In this case, the video is always long, professional but lacking of interactions.

[7] http://www.insivia.com/27-video-stats-2017/ - accessed 6 Sep 2017

*Video sharing service*: A video sharing site is a website that provides video hosting service. Such as YouTube, Vine and Yahoo Video. As the most popular video sharing website in the world, YouTube only provides user-generated contents. In addition to the basic control methods, YouTube has also added social networking element. The video on YouTube is not independent -- when it is uploaded, the provider can set a list of "related videos" in association with it, based on its metadata such as category, rating and time.

*Embed videos*: Most websites in the world are not video-centered, however in these sites, videos might also be a very helpful instrument to present ideas. The video content is inherently embedded in various web applications, which allows its presentation of no difference from other type of content. Like Facebook, Twitter and other sites, videos can be quoted, liked, rated and shared.

This thesis aims to use the video to show the creative process of an answer. This visualization process is based on a discussion platform. So, the practice of embedding is more appropriate.

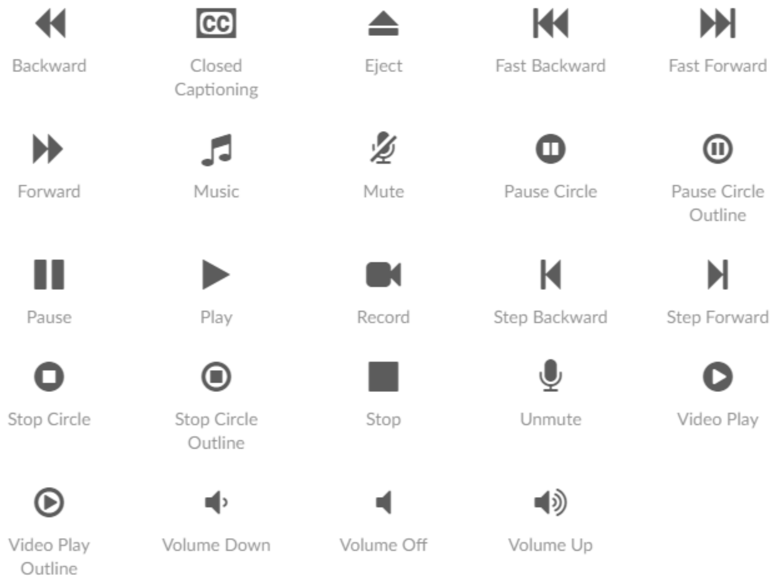


Figure 2.6: Custom icons for web video controls

Although the video content on different sites varies widely, the user's operation on the video is always similar. When watching a video on the internet, it goes without saying that the video can be paused and stopped. These are the most basic user interaction features that the web video should provide, and these features have their own custom icons. In interactive design, the custom icons should be used to maintain the user's habits as shown in Figure 2.6. The full control functions related to these icons, such as full screen, mute, fast forward, rewind, etc., are not always necessary. In the user interface design, it is necessary to analyze which functions should be included.

## 2.3 WEB VIDEO TECHNIQUES

Online video usage is widespread. With the growing requirements of online video services, the video technology has developed rapidly. In the early days, video files took up too much storage space, and online video services were limited. Then, with the development of video transmission and compression technology, online video services have been very common. Many different network technologies can realize the online video recording and playing.

### 2.3.1 Video formats

HTML5 supports certain video codecs, due to the fact that browser vendors previously had not been able to agree on a same standard. The formats of video files that are available in HTML5 include Ogg, MP4(H.264), and WebM. However, MP4 is now the format that is supported by all browsers and devices.

#### 2.3.1.1 Ogg [8]

Ogg is an open source container format from the Xiph.Org Foundation. To clarify, for videos, Ogg refers to the video-compression format. For audios, Ogg refers to the container format. It is free and has not software patents. A number of audio, video streams, text, and metadata are contained in the Ogg format. Due to its free origin it is not restricted to copyrights, and many different free as well as proprietary players have adopted the Ogg's various codecs.

#### 2.3.1.2 MP4(H.264) [2]

The H.264 format, also called MPEG-4 Part 10, MPEG-4 ADV, is a compression format designed by MPEG (the Moving Picture Experts Group). First designed for video and audio in DVD-quality in a small package, it is efficient in storage and perfect for portable players as well as on the web. The aim of the H.264 was to significantly lower the bit rates of previous standards while maintaining good video quality. At the same time, to keep the design simple enough without impractical implementation and expensive cost.  It enables resolutions up to 4096x2304, and one of the most frequently used format for video recording, compression and distribution.

#### 2.3.1.3 WebM[9]

The WebM is an open web media project sponsored by Google to develop a video format that is open and with high-quality. The video compression originally uses VP8 codec, developed by On2

[8] https://xiph.org/ogg/ - accessed 5 Nov 2017

[9] https://www.webmproject.org/ -accessed 5 Nov 2017

Technologies, which Google acquired in 2010. It updated to support VP9 video and Opus audio in 2013.

The browser support for the HTML video formats is listed in the table below[10]:

| Browser | MP4 | WebM | Ogg |
|---|---|---|---|
| Internet Explorer | YES | NO | NO |
| Chrome | YES | YES | YES |
| Firefox | YES | YES | YES |
| Safari | YES | NO | NO |
| Opera | YES<br>(from Opera 25) | YES | YES |

Table 2.1: Browser support for different video formats

In the early days, one usually has to provide at least two formats of the same file in order to gain support of all of the browsers. The combination of MP4/H.264 and WebM covers the supports of all browsers, so usually MP4/H.264 and WebM format of the same video are provided at the same time. Therefore, it not only causes a redundant of code, but also wasted storage. However, as people can see from the table above that MP4/H.264 has now become the universally supported format of mainstream browsers. This spares the need to store video files in different formats as in the early days.

The HTML5 handles video processing in the <video> element. DOM methods, properties and events are available. The developer can load, play video and set video properties in standard HTML5 element, as will be explained in 2.4.3.

## 2.3.2 Video recording techniques

The most intuitive way of explaining a solution is using videos to illustrate the process of how the problem is solved. The main goal of this thesis is to present a concept of creation process visualization feature using video. So, it needs to ensure that the video recording procedure is simple and effective. Audio as well as video need to be recorded. The recording tool need also be specially tailored to the graphic technique of the drawing pad, for example, the canvas. The recording tool need to be supported by most of the major browsers. Thus, the following popular techniques used in modern web screen recording are considered.

[10] https://www.w3schools.com/html/html5_video.asp - accessed 5 Nov 2017

#### 2.3.2.1 getUserMedia API[11]

The getUserMedia API was developed to access external devices on computers or phones to take pictures or perform web conferencing. Using navigator.getUserMedia(), one is able to take in a stream of media from microphones, webcams, etc. It takes three parameters:

- *constraints*
  The parameter specifies the type of media the API is capturing, whether it's audio or video, the size of the video, etc.

- *successCallback*
  When the media access request is approved, this function is called to perform the actions related to the recording process. It takes a single parameter, the media stream contained in the MediaStream object.

- *errorCallback*
  If the call fails, a *MediaStreamError* object is passed to the function specified by the errorCallback parameter.

Several powerful JavaScript packages are built upon the API. Among them, the MediaStramRecorder and the RecordRTC will be introduced below.

#### 2.3.2.2 MediaStreamRecorder[12]

MediaStreamRecorder.js is a cross-browser JavaScript library that supports recording video from various inputs, including the camera, microphone, screen (full screen, app's screens, tab, HTML elements) and canvas 2D as well as 3D animations. Various input combinations can be recorded together. The following recording modes are supported by the module.

*Record audio with video*

To perform audio and video recording, set the mediaConstraints of audio and video filed both to be true, and create a MediaStramRecorder object in the successCallback function. The type of the recording video is set by the mimeType method of the object, and recording is started by the start method.

*Record Multiple Videos*

A maximum of 4 videos can be recorded in a single WebM container.

[11] https://developer.mozilla.org/en-US/docs/Web/API/Navigator/getUserMedia - accessed 6 Nov 2017

[12] https://github.com/streamproc/MediaStreamRecorder - accessed 6 Nov 2017

*Record audio only*

Only set the audio field to be true then the recording type will be audio.

#### 2.3.2.3 RecordRTC[13]

RecordRTC is a free of use MIT licensed JavaScript library that supports mainstream browsers and JavaScript frameworks including Angular2, React.js, and Video.js. It is built on the WebRTC framework and supports communication of client to clients, server to clients, client to server, and server to servers [5]. The RecordRTC container supports vp9, vp8, h264, opus/vorbis, and pcm(mono/stero) codecs. Various capturing modes is available, including video with audio, audio only and multiple videos recording. It also supports canvas capturing with rich capabilities. Canvas 2D drawings can be recorded by the canvasRecorder object.

Canvas provides a drawImage() function which could take screenshots of the canvas window. As a possible workaround, one could record a series of screenshots and produce a corresponding video out of these screenshots. But this is without sound, so the sound need be considered separately, which will be more complicate to implement.

#### 2.3.2.4 JSCapture[14]

JSCapture is implemented with JavaScript and HTML5 for screen capturing. It also utilizes getUserMedia() method, and that enables the user to take screen capturing and screenshots. It has limited browser supporting.

#### 2.3.2.5 CCapture.js[15]

CCapture.js captures HTML5 and canvas animations at a fixed rate. It records every detail of the animation that results in resolution as high as the original animation. This is not possible by a screen capturing technique if the animation is detail rich. The fixed frame rate ensures that the captured video is not affected by the rendering time of the animation.

[13] https://github.com/muaz-khan/RecordRTC

[14] https://github.com/mgechev/jscapture - accessed 6 Nov 2017

[15] https://github.com/spite/ccapture.js/ - accessed 6 Nov 2017

## 2.3.3 Media players on the web

### 2.3.3.1 HTML5 Media Player

HTML does not support video element in the past, playing video in HTML documents has no uniform method. In order to launch a media player, one had to embed plugins into the document. Three different elements need to be taken into consideration [2]:

- *applet*

- *embed*

- *object*

The applet element is used only to embed java applets; therefore, it is not suggested to use in HTML 4.01. The embed element, was to allow the embedding of arbitrary data objects into a web document. The required plugin need to be installed on the user's device for the embed element to work properly. If not, a warning would be displayed. These two were replaced by the object element in HTML 4.01, which was supposed to be more general in use for media files.

However, these elements never went into the HTML standard, and they are complex in use. HTML5 provides <video> element, which makes it much easier for the embedding of multimedia objects.

The big difference is that the multimedia is a native component to the HTML5 document. It is no longer an embedded outside object to the HTML document, but as a built in native object of the document. The advantages include: No plugins are required, controls are available by the browser and fast.

There are four elements working together to make the native multimedia possible in the browser. The <audio>, <video>, <source> and <track> element.

The <audio> element enables the play and control of audio files. The <video> element provides enough control of the video playing for most scenarios. The <source> element specifies the location of the media file, and the <track> element allows captions, subtitles, and descriptions for the media file.

The main attributes of the <video> element include:

-*src*: The URI of the sound file.

-*preload*: Tell the browser whether to preload the audio source, or which part of the audio source is preloaded. Its values include none, metadata and auto.

-*autoplay*: Boolean type, Tells the browser whether to start playing the video immediately when it loads.

-*controls*: Boolean type. If set, a default control frame will be provided for the video.

-*loop:* Boolean type. Tells the browser to play the video in a loop.

-*width*: Specifies the video width

-*height*: Specifies the video height

The functionality of video playing that HTML5 provides is rich, but more control actions is also possible via its JavaScript API, which extends the basic manipulations in fascinating ways. The attributes of the video can be accessed and set by the API, which gives the possibility of building wrapping packages upon it. Video.js is one of such powerful packages.

### 2.3.3.2 Video.js[16]:

Video.js is an open source JavaScript library that makes the playing process highly customizable and easy. It supports HTML as well as flash video, provides rich control methods and makes possible the selection of special and temporal parts of the video and works in all Web browsers of latest versions [6].

There is a growing list of plugins that strengthens the functionality of Video.js. For example, with plugins, one can set actions on a specific point in time. Here introduced some of them which may facilitate the development of the Graphicuss system.

### Video.js plugins[17]:

1. VideoJS Cue Points is a plugin for Video JS player. With this plugin you can sync actions with the media timeline and make the viewer's experiences richer.

2. Videojs-seek: Seeks to a specific time point specified by a query string parameter.

3. Videojs-markers: Add customizable markers on progress bars.

4. Videojs-sharing: Add to the control bar a sharing menu.

5. Videojs-record: For recording video/audio/image files.

[16] http://videojs.com/ - accessed 8 Nov 2017

[17] https://github.com/videojs/video.js/wiki/Plugins - - accessed 8 Nov 2017

## 2.4 MEDIA EDITING TOOLS

Since quoting partial videos is needed, generating a new video from middle of an existing one, the new design need the ability to cut a video from a certain time and concatenate it to a newly recorded video. This raises the question of how to edit video contents on the web.

### 2.4.1 FFmpeg[18]

FFmpeg is an open source software that is comprehensive and well-established to perform a full-range of media processing tasks, and supports for a majority of the video/audio formats. It can be used as a command line tool, and its developer libraries can be incorporated into applications [4].

The FFmpeg project is made up of 5 main components:

1. ffmpeg: the command line tool
2. ffmserver: the media streaming server
3. ffplay:  media player
4. ffprobe:  media data analyzer
5. developer libraries

A rich variety of manipulations of the media file can be easily done with the command line tool. Here consider the following scenarios:

To obtain the metadata of a media file, use the –i option.

```
ffmpeg –i example.mp4
```

To resize a video, use the –s option. The following command changes the video to 320x240 in size.

```
ffmpeg –s example.mp4 –s 320x240 example_newsize.mp4
```

The conversion of video format is as easy as specifying a different extension name to the output file.

```
ffmpeg –i example.wmv example.mp4
```

The extraction of a portion of a video is what we need in the quoting function of the answer video. To extract a certain time period in a video, we need to specify the starting and ending time of a video. The following command extracts the example.mp4 from the beginning to 30th second.

```
ffmpeg –i example.mp4 –ss 00:00:00 –t 00:00:30 extracted.mp4
```

[18] https://www.ffmpeg.org/ - accessed 9 Nov 2017

Suppose a user has generated a new part of the answer recording, and now have to combine the beginning of the original answer video and the newly generated video together. The following command does the task.

```
ffmpeg –i beginning.mp4 –i new_recording.mp4 –filter_complex concat new_answer.mp4
```

### 2.4.2 React-html5-video-editor[19]

React-html5-video-editor is an npm library that provides rudimentary video editing with JavaScript. It is clean and simple, but does not has enough video editing functionality.

## 2.5 ALTERNATIVE REPRESENTATIONS OF CREATION PROCESS VISUALIZTION

The Graphicuss had implemented a graphical drawing tool with a stack of objectified canvas objects. In this thesis, the main goal is to find a proper way to visualize the creation process of an answer filled with text and graphical contents. However, there are several different methods to achieve this goal. In Chapter 2.5, several different visualization ways will be analyzed.

### 2.5.1 A step-by-step representation

This is the most simple and straightforward solution for the system. The answering process is to be represented on one side of the answer board, when clicking, they pop into a floating larger window showing one step of the answer process. Forward and backward arrows are available on the right and left side of the popping-up window, and they are capable of serving navigation purposes of the steps.

The drawbacks of this approach are obvious. Firstly, the creating process is not necessarily divided into separate steps. How should one component be classified into one specific step is in question. Secondly, the static nature of the step representation is not engaging enough for the user. Thirdly, there are no explanations as to how each step was done and the purpose of the step remains unclear to the user.

### 2.5.2 Screen recording + canvas stack with timestamp

If streaming videos should be used in this approach, they must be recorded. Also, manipulate the history of the drawing process is necessary, so recorded video is not enough. The stack of objectified canvas elements should exist in parallel to serve the purpose of manipulation, say, to start drawing a new graphic at a certain point.

[19] https://github.com/evgenity/react-html5-video-editor - accessed 9 Nov 2017

One problem arises is that, when selecting a certain time in the video, one cannot determine which element in the stack corresponds to the time selected. Therefore, there need also be time information in the elements of the stack. That is, when creating a canvas element, the canvas element specifications should be pushed to the stack, along with time information. By doing so, when a certain time is selected in the progress bar of the video, It is hard to know which elements are already created in the stack and which are not.

The drawbacks of this approach are as the following. First of all, videos are space consuming and requires large bandwidth. Secondly, there are redundant information. The video and the stack are essentially the same information. The stack contains most of the information that the asker wants. He or she may not need to see every bit of the drawing process that the answerer had gone through. What really matters is the sequence of the drawing process.

### 2.5.3 Canvas stack with timestamp + voice recording.

The screen recording is not considered in this approach. But we still need to produce videos to the users for better understanding. The solution is to create video from the stack. The elements will be drawn on the canvas on the same time basis as the answer originally had drawn them. Even he or she encounters problems in the drawing process, paused or thought over for a while, the recreated video should reflect the real time. This is because the recreated video should match the voice that the drawer had recorded in the process.

The upside of this approach to the previous one is that it reduced the amount of storing space significantly, but with similar performance. The other users will not see the whole drawing process, but they will see elements pop up in sequence and therefore they know how the figures are drawn out.

The voice recording part has the following drawbacks. First of all, the answer area already has static text descriptions, audios are not essential. Secondly, since the videos recording does not exist, the main components of the answer component is really text. However, one cannot overview an answer by sight. Suppose a page is piled up with dozens of answers, each with a video with sound, users may lose patience to watch all of them. Thirdly, by design, the audio part should only serve the purpose of explaining issues related to the drawing process, and other information should be put in the static text area. But this can’t be controlled. Answerers may speak other topics in the audio and infringe the answer structure. This may become a problem. Consider the following situation. If a user decided that he selects in the middle of the video and continue to draw a new graph, should the voices in the previous part be kept? The previous part may contain specifications relevant to the making process, so they are essential, but again it may contain other topics, and these topics extend to the latter part of the video. Fourthly, and very importantly, the drawing process is to be a lot of trial and error. The answerer draws an element, and deleted, and then draws it again. He may be paused and thinking for a while, or he may have some other errands, leave the computer, and return a minute later. All the time range are recorded in the audio, and thus, when recreating the fitted animation, all the unnecessary time wasting has to be reproduced. This could be a great annoyance to users who watch the video.

### 2.5.4 Canvas stack + floating comments

This time the canvas stack is without timestamp, because there is no restraint in time on recreating the animation. The explanations in the drawing process is represented in floating comments in the window beside the corresponding elements. The stack contains every bit of information to recreate the drawing process.

This is different from a step-by-step representation which is static and not engaging. The users could see the final graph in the first sight, and if he or she is confused at how the graph is drawn in sequence, he or she could get informed by clicking the video icon. Then the graph is redrawn from the stack in exact sequence and with comfortable time spacing.

The drawback is that without recorded video, some important information of the answer creating process maybe lost and unknown to the user, which could be essential.

As discussed above, the step-by-step solution lacks useful information and there are no set criteria for how to separate the steps. The video recording process contains every bit of information needed for the user, therefore it is the most comprehensive solution. The animation processes are space reserving but are not the real reflection of the answering process, therefore essential information may be lost. The drawing with text approach has the upside of easily drawing standardized diagrams, but lacks the flexibility to draw arbitrary figures. Since the answers usually involves floating thoughts, so this may be a constraint for the answer to capture what he is thinking. Therefore, the video recording + canvas stack with timestamp is chosen as the technical basis of the system.

# 3 CONCEPTS

In Chapter 1, the importance of creation process is analyzed. It can help others understand an answer by following the thinking path of an answer provider. In certain situation, to explain a complicated process, or to show a way of thinking, people need to provide a dynamic thinking path instead of a static result. So, this thesis aims to find an appropriate way to achieve this goal. Chapter 2 firstly introduces Graphicuss, which is a new form of discussion system that has introduced the graphic editor (drawing tool) together with the traditional text editor. Meanwhile, Chapter 2 has also explained that video is a strong medium for information expression. Based on the above, an idea to visualize the creation process of an answer in Graphicuss through video comes into being.

In general, the initial thought to visualize the creation process is that once an answer is created, the creation process is stored and could be illustrated in a video. When other users want to view this answer, they can see not only the static answer but also the creation process demonstrated in video. However, this idea is not explicit enough, there are some details in need of further discussions. Inspired by the initial thought, more specific requirements should be satisfied before a further system design.

## 3.1.1 User requirement interview

To carry out the user interview about the system requirement, 6 college students were founded and did a workshop with the interviewees. Taking it into consideration that students in science and engineer majors have a higher demand of using graphs to explain sophisticated content, so 5 out of the 6 interviewees are from the background of science and engineering, the other one majors in business management. All the interviewees have used different online discussion systems and have answered questions online.

The goal of the workshop is to find out their concrete user requirement in details. The workshop starts with a questionnaire about their experience using traditional online discussion systems in general, which can be found in the Appendix of this thesis. Having collected their feedback and understood their major concerns on the illustration of the creation process, I initiated an interactive session with two open questions as below, in order to work out a list of specific requirements with them.

| | |
|---|---|
| System requirement in the creation phase: | |
| 1 | the user can create both text content and graphical content in one answer |
| 2 | the system can automatically store all user actions during the creating process |
| 3 | the system can generate videos for each part of the answer, and the user can play the video at any time during the editing process |
| 4 | the user can roll back to the previous state at any point when editing a content |
| 5 | the user can decide whether or not to include the video of the creation process into the answer before submitting it |
| 6 | only the creation process of a user-specific content can be played in the video and the rest will remain static |
| 7 | for each video, the user can always mark key points on the timeline of the video |
| 8 | if there are several steps in one creation process, the user can mark the end of each step on the timeline of video |
| 9 | the user can explain the answer when editing, and the voice can also be stored in the video. |
| System requirement in the browsing phase: | |
| 10 | the user can always view an answer in static, not necessarily to play the creation process. |
| 11 | when the answer has a playable content, the user should be prompted. |
| 12 | the user should be able to view the creation process in a ‘step-by-step’ manner when possible. |
| 13 | videos can be quoted . |
| 14 | when a video is paused, the user can extract the content at that time and edit from that phase to create a new question, answer, or comment. |
| 15 | the user can comment on an answer. |

Table 3.1: User requirement list

| No. | Major of the interviewee | User Liveness of online discussion system |
|---|---|---|
| 1 | Vehicle Engineering | Frequent |
| 2 | Computre Science | Very frequent |
| 3 | Mechianical Engineering | Occasionally |
| 4 | Business Management | Occasionally |
| 5 | Software Engineering | Frequent |
| 6 | Physicis | Frequent |

Table 3.2: The primary statistics collected from the six interviewees

| Interviewee No. | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 |
|---|---|---|---|---|---|---|
| 1 | 5 | 4 | 5 | 2 | 4 | 4 |
| 2 | 5 | 4 | 5 | 3 | 4 | 4 |
| 3 | 4 | 3 | 5 | 3 | 4 | 4 |
| 4 | 4 | 4 | 4 | 2 | 1 | 2 |
| 5 | 5 | 4 | 5 | 3 | 3 | 5 |
| 6 | 5 | 3 | 5 | 3 | 5 | 5 |
| Average | 4.6 | 3.7 | 4.8 | 2.6 | 3.5 | 4 |

Table 3.3: The result of user requirement questionnaire

Summary of the workshop:

1. The 6 participants filled in the questionnaire according to their experience using the traditional online discussion systems. their feedbacks are compiled, reaching the conclusion that it’s essential to illustrate the creation process.
2. Based on the feedback, the first question is putted forward: what kind of illustration would you like to use in order to visualize the creation process? A step-by-step graph, a gif picture, a video, etc.?
3. The form of video seemed to be the most convincing option for the participants. The second question followed is: How should a video fit into a traditional online discussion system? What kind of functions should it have?
4. The discussion is guided into working out their specific requirement on the video function and then finalized a list of demand which the video design should follow.

The questionnaire is related with their experience of the traditional online discussion system, and their attitude to the idea of illustration the creation process. The primary result of the questionnaire is documented in the table 3.3 and the qualitative analysis is as below.

The questionnaire has clearly suggested that, within the current system of online discussion forum, the participants are not satisfied by the functions illustrating the final graph only. Even though the 6 interviewees are a bit timid about visualizing the dynamic creating process, they certainly showed a strong demand to include an audio in the answer to explain their ideas.

In answering the questionnaire, many participants have faced a similar situation where they need the creation process of an answer. For example, the interviewee majoring in physics explained that, to solve a mathematical problem, the solution might need several auxiliary lines. if one wants to explain the solution in a static content, then he must draw several similar graphs to explain the solution step-by-step. The interviewee majoring in computer science shared his experience that, to explain a data structure or an algorithm, he always need to draw several diagrams repetitively in order to show his thinking path. These repetitive works should be reduced or even eliminated in the new design of visualizing the dynamic creation process.

Having seen some doubt about visualizing the dynamic creation process in the questionnaire, I continued with my open questions on what kind of illustration you are thinking of to reflect your need, and what would be the format that you want to see and are likely to use, a step-by-step graph, a gif picture, a video, etc.?

Among all the potential options, video seems to be the most appropriate one, with outstanding advantages discussed in the workshop. Firstly, videos can combine the actions of the answer creator together with the audio sound to explain the answer. The audition and the vision working together will achieve a better expression effect, and also the creator could be talking about his idea while editing the answer. Secondly, video could show the creation process in a real-time manner. It is obvious to see where the creator is confident and where the creator hesitates. This could help the answer viewer better understand the thinking path of the creator. Last but not least, video is a rich information medium, it could be degraded to ‘step by step’ way, or even to static images.

At the end of the workshop, the discussion is guided into details of the specific requirement of the video function. The user requirement list in Table 3.1 is what we worked out from the workshop.

Also, to use the new system feature, the operations should not be too complicated, and the operations of the system should respect the user habits.

The further system design is based on these requirements. In the evaluation phase, it is an important criterion to check whether the system design meets these requirements.

## 3.2 FUNCTION ANALYSIS

As the new feature design will be embedded in the original Graphicuss, this will lead to some changes in the answer creation and answer browsing phase. In the previous design in Graphicuss, the author has introduced the drawing tool to create graphical elements in an answer. While using the drawing tool to edit graphical elements, the user can review the editing history of the graphical element, and recover the graphical element from any point in the editing history. However, this design is not explicit enough. Questions like “How can a drawing tool work together with a text editor?” or “How to review the creation process before submitting the answer?” require further explanation. Other than these remaining problems, this design also face some new challenges introduced by the new requirements. Therefore, a new answer editor should be designed with higher degree of flexibility. This design should be consistent with the original Graphicuss as well as satisfactory to all the requirement we discussed before. In this chapter, the design of the new system satisfying all the requirement will be introduced.

### 3.2.1 Answer Structure

Based on the result of requirement analysis, it appears that users may want to see the creation process of only part of an answer, not necessarily the full answer. In this case, the subdivision of an answer is indispensable. With this background, a new answer structure is introduced to adapt to the needs. Unlike the old design that all contents are mixed in one answer, the new design try to divide an answer into more parts in the new design which can provide a clear answer structure and allow each part to have its own display mode.

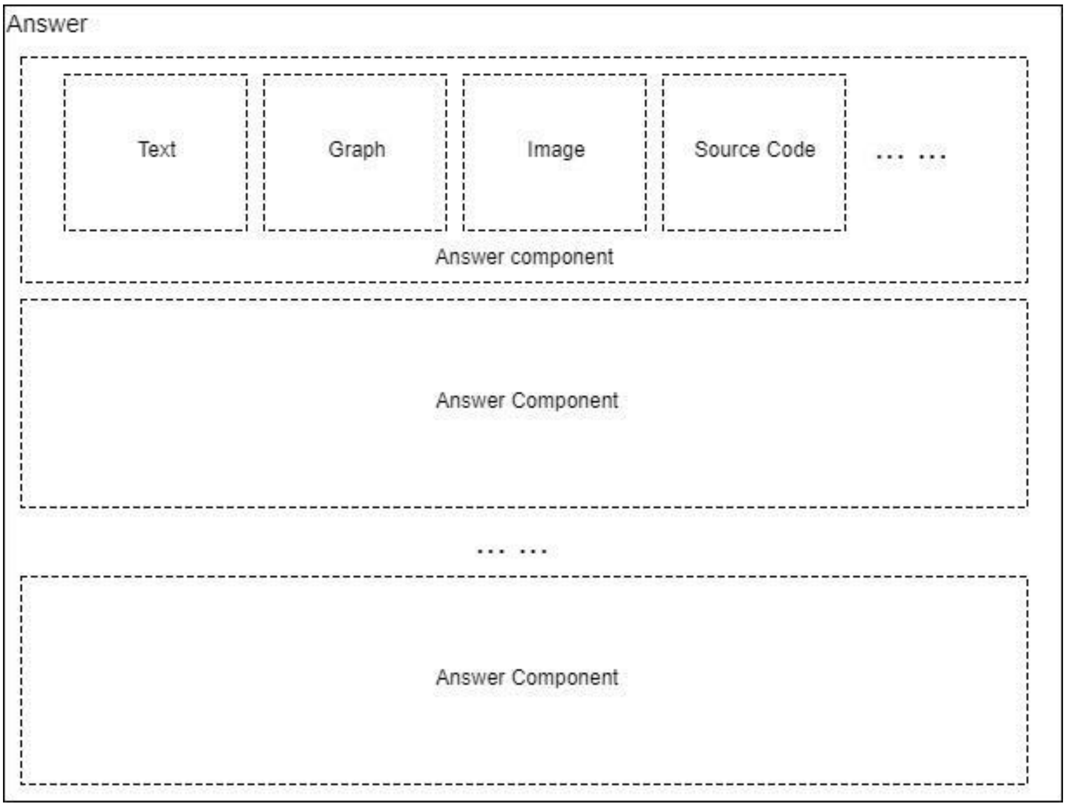


Figure 3.1: Answer Structure

The new answer structure is shown in Figure 3.1, and the new concept of *Answer Component* is introduced. An answer can have one or more answer components. An answer component can have its own content; both text editor and graphical editor can be used while creating an answer component. The creation process of each answer component is independent. And in display phase, each answer component can have its own way of display.

For example, if a user tries to explain how to draw a dataflow diagram in an answer, the user can provide two answer components. The first component explains the definition and how the data flow diagram is defined in plain text; the second answer component can give an example of how to draw a dataflow diagram showing the creation process. When this answer is shown to the other users, the first answer component would be static, and the second answer component would be dynamic and could be displayed in a video.

### 3.2.2 Answer Creation Workflow

Having explained the answer structure, in this section I will introduce the process to create an answer. This process is divided into two layers. The first layer is about answer component management which aims to create an answer structure; the second layer is about answer component editing which aims to create and edit different answer components and makes them fit into the bigger structure.

The flowchart in Figure 3.2 documents the process of answer creation in the first layer.

- At the beginning of answer creation process, the first step is to create an answer component.
- Then the second step is to edit this answer component and make it meaningful. How to edit an answer component will be discussed with details in the second layer.
- By saving an answer component, the user returns from the editing layer to the answer component management layer. In this phase, the user has several options of what to do next. The user can decide how many answer components are needed in the answer. If the user has already created all answer components, then the user can submit or preview the answer. If not, the user can create another answer component and start the procedure of ‘create-edit-save an answer component’ again.
- There should be at least one answer component before preview or submission. Before submitting the answer, the answer creator can preview the answer and edit any answer component.

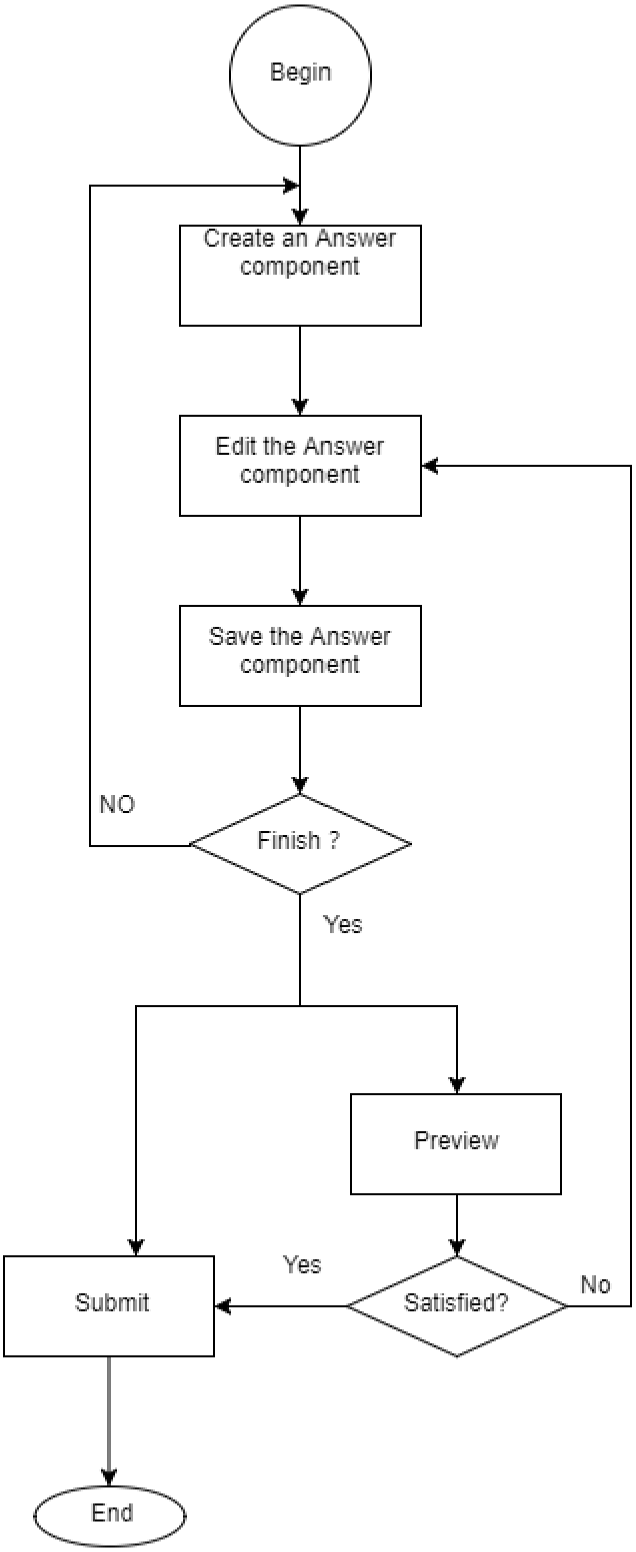

Begin
Create an Answer component
Edit the Answer component
Save the Answer component
NO
Finish ?
Yes
Preview
Yes
Submit
Satisfied?
No
End

Figure 3.2: Process of creating an answer

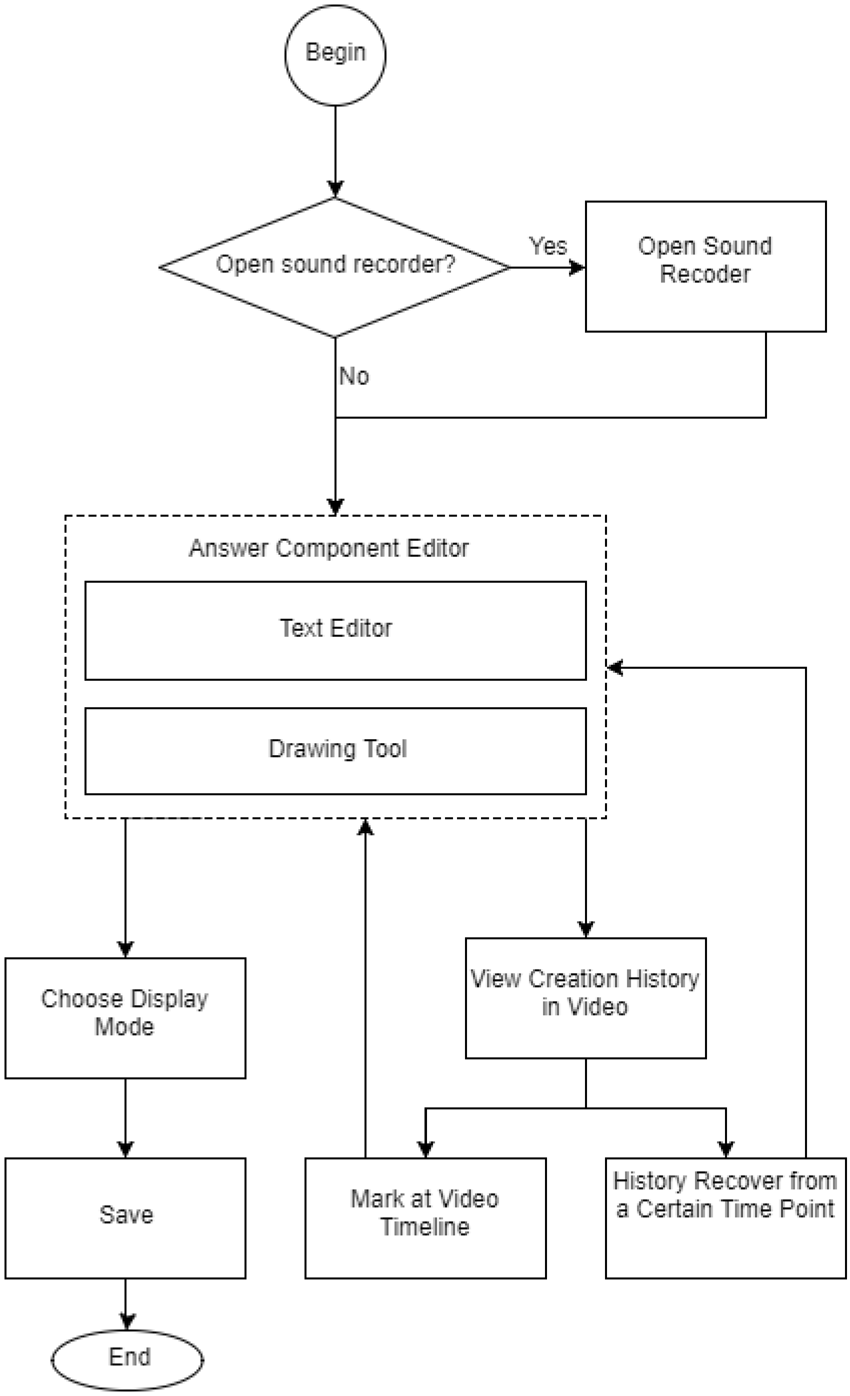


Figure 3.3: Process of creating an answer component

The flowchart in Figure 3.3 presents the process of creating an answer component within an answer.

- At the beginning, a new and blank answer component is created.
- Before the answer component editor is activated, the user needs to choose if he or she wants to open the voice recorder. If the user opens the voice recorder, then during the creation period of this answer component, the voice will be recorded. This soundtrack will

then be combined with the user actions to produce the video that shows the creation process.

- After the user makes a decision on recording the voice or not, the answer component editor is activated. Within the answer component editor, both the text editor and the graphical editor can be used.
- While editing this answer component, at any time, the user can review the creation process in video format. This video shows how the user edits this answer components, all the user actions during editing are stored and could be played in the video.
- While watching the video, the user can add comments on the video timeline. The user can add a mark highlighting 'this status on this time point is particularly important' or reminding 'this status on this time point is an end of a step'.
- Also, the user can recover the history record in the video at any point. For example, the user may find at a certain point, he/she made some mistakes which have resulted in a wrong result. It is possible to recover the history record from that time point and edit from there again to correct the mistakes.
- When the user is satisfied with this answer component, it can be saved then.

### 3.2.3 Answer Browsing

In answer browsing phase, after the user opens a question's main page, the user can see all the answers to this question. The process of answer browsing is shown in Figure 3.4.

- While browsing the answers, the user can upvote an answer, downvote an answer or add an answer to favorites.
- Users can quote this answer to create a question, an answer or a comment.
- While an answer is composed of one or numerous answer components, the author of the answer can decide which one(s), if any, he or she would like to have published with the creation process. The user can play the corresponding video in a pop-out window.
- While playing a video of the creation process of an answer component, other than the basic functions of video control, such as play and pause, the user can also see the important part of a video marked by the answer creator during the creation phase using 'step by step' manner.
- Also, when the user pauses the video, a screenshot picture of the video can be taken; the modification of the answer from that specific time point is possible.

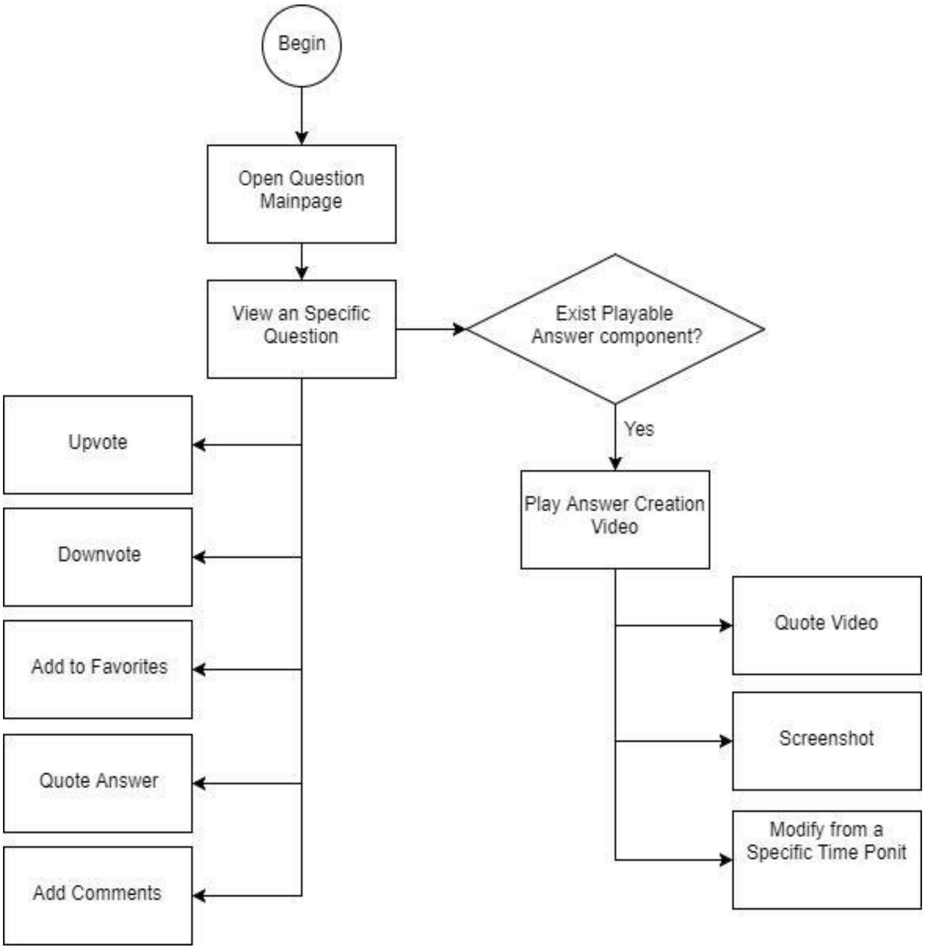

Begin
Open Question Mainpage
View an Specific Question
Exist Playable Answer component?
Yes
Play Answer Creation Video
Upvote
Downvote
Add to Favorites
Quote Answer
Add Comments
Quote Video
Screenshot
Modify from a Specific Time Ponit

Figure 3.4: Answer browsing workflow

## 3.3 INTERACTION DESIGN

This section focuses on the graphical user interface of Graphicuss in answer creation and answer browsing phase. There are five primary views in this design. The overall relations between views are relatively simple, as shown in the following Figure 3.5.

In this design, web pages are displayed in a single browser window, with the exception of Video Player, which are shown in a pop-up window. To describe this design intuitively, all the mock-ups below are filled with real world data. This makes the interface design look closer to the real website.

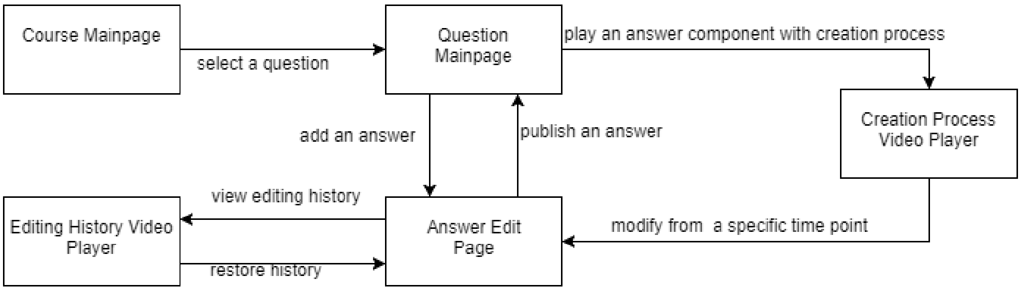
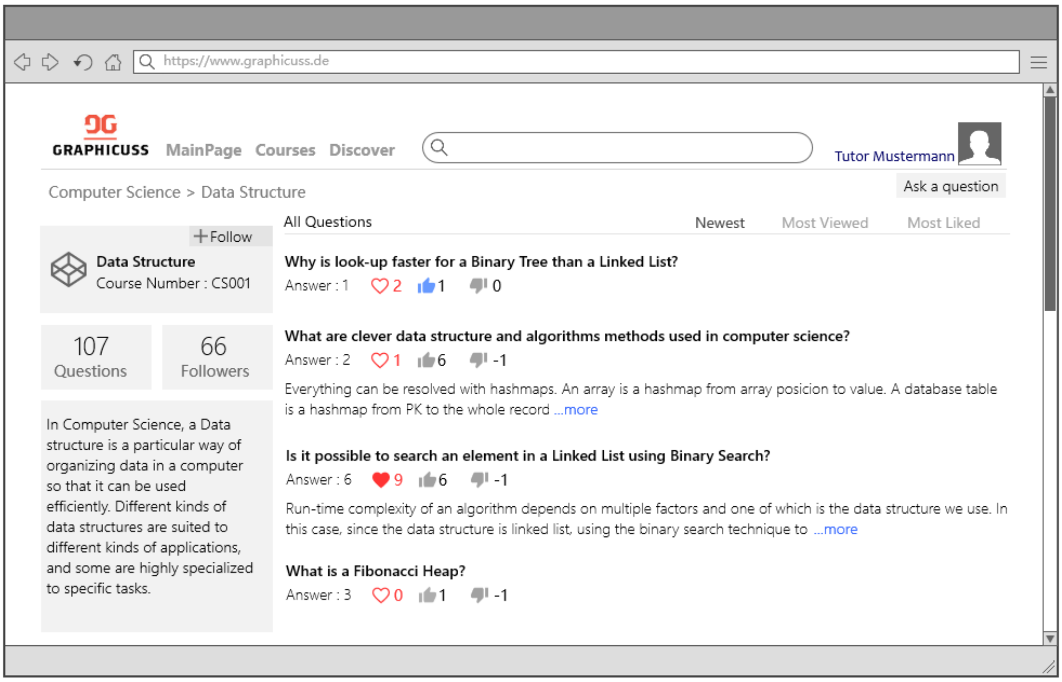

Course Mainpage
select a question
Question Mainpage
play an answer component with creation process
Creation Process Video Player
add an answer
publish an answer
view editing history
Editing History Video Player
restore history
Answer Edit Page
modify from a specific time point

Figure 3.5: Webpage relations

### 3.3.1 Course Main Page

The course main page enables the user to have a general view of the course information, and all the questions submitted for this course. This page can be accessed from the course list or search result. If a user has already followed this course, then the user can find this course in his or her personal course list.



Data Structure
Course Number : CS001

107 Questions

66 Followers

In Computer Science, a Data structure is a particular way of organizing data in a computer so that it can be used efficiently. Different kinds of data structures are suited to different kinds of applications, and some are highly specialized to specific tasks.

**Why is look-up faster for a Binary Tree than a Linked List?**
Answer : 1 ♡ 2 👍 1 👎 0

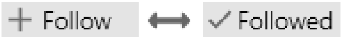
**What are clever data structure and algorithms methods used in computer science?**
Answer : 2 ♡ 1 👍 6 👎 -1
Everything can be resolved with hashmaps. An array is a hashmap from array posicion to value. A database table is a hashmap from PK to the whole record ...more

**Is it possible to search an element in a Linked List using Binary Search?**
Answer : 6 ♥ 9 👍 6 👎 -1
Run-time complexity of an algorithm depends on multiple factors and one of which is the data structure we use. In this case, since the data structure is linked list, using the binary search technique to ...more

**What is a Fibonacci Heap?**
Answer : 3 ♡ 0 👍 1 👎 -1

Figure 3.6: Mock up: Course Main Page

1. Course name and course number: This is the text field showing the course name and its course number.
2. ‘Follow’ button: This button is on the top right of the page. When the user does not follow this course, it shows a plus icon with text ‘follow’ by default, after the user clicks the button, which means the user would like to follow this course, it shows a checkmark with the text ‘followed’



3. Questions: This is a text field showing how many questions have been submitted for this course.
4. Followers: This is a text field showing how many people are following this course. The followers of this course will be automatically informed when there is any recently-submitted question.
5. Course brief introduction: This is a text field which can only be edited by the course creator. The creator can briefly introduce this course and offer some important information.
6. Question list: This is a list view showing all the questions under this course. The list can be sorted in three different ranking methods: the newest, the most viewed and the most liked.

7. Question item: A question item is a constituent part of the question list. It shows the question and its description. Both the question and its description have word limits. To achieve a better user experience with more questions on the screen, the question and its description should be limited.
8. Upvote, downvote, add to favorites: The three small buttons are attached to each question. Votes from the viewers will have an impact on the ranking of this question. If a question is added to favorites by a user, the user will be automatically noticed when there is a new answer to this question.

♡ 0 ⟷ ♥ 1 LIKE
👍 0 ⟷ 👍 1 UPVOTE
👎 0 ⟷ 👎 -1 DOWNVOTE

### 3.3.2 Answer Edit Page

The answer edit page can be accessed from the question main page by clicking the 'answer' button. In the Answer Edit Page, the user can create his/her own answer. The editing rule in the new Graphicuss will be changed because the 'Answer Component' concept is introduced. Instead of editing directly, the user will come to the answer edit page where the user can edit several answer components separately. According to the interview I made with web users on their using habits, the plus icon indicates to add content. By clicking on the dotted line area, the user can begin to edit the first answer component. Figure 3.7 shows the original state after opening the answer edit page.

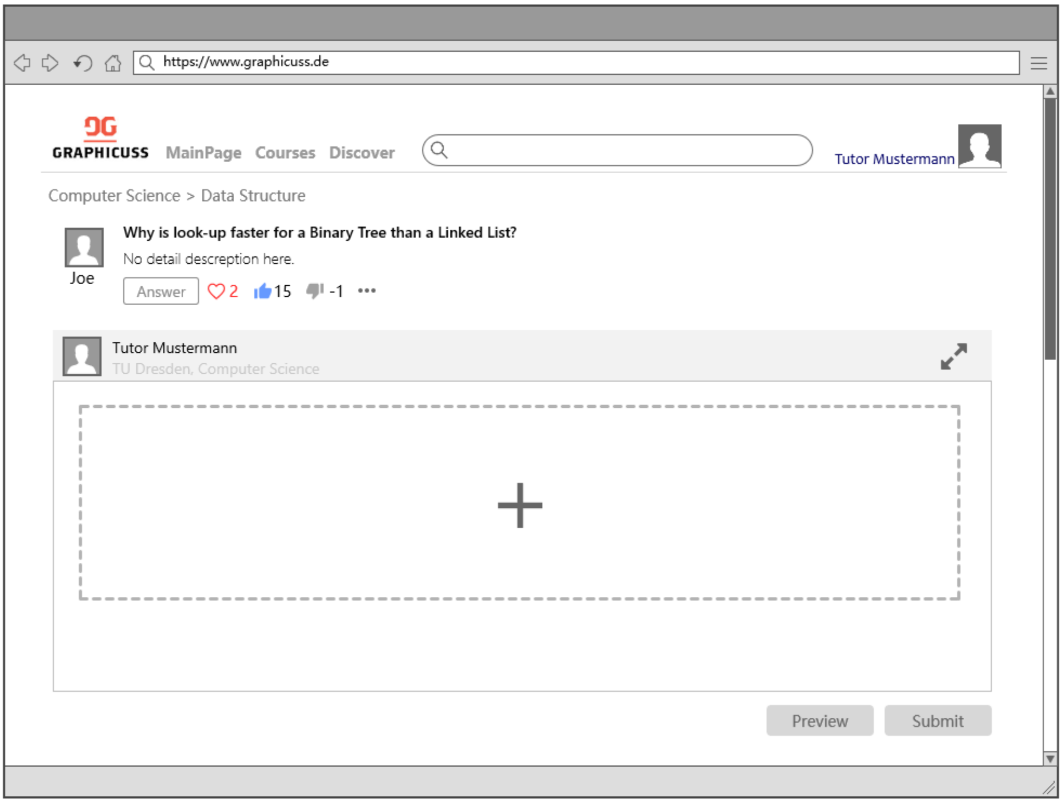
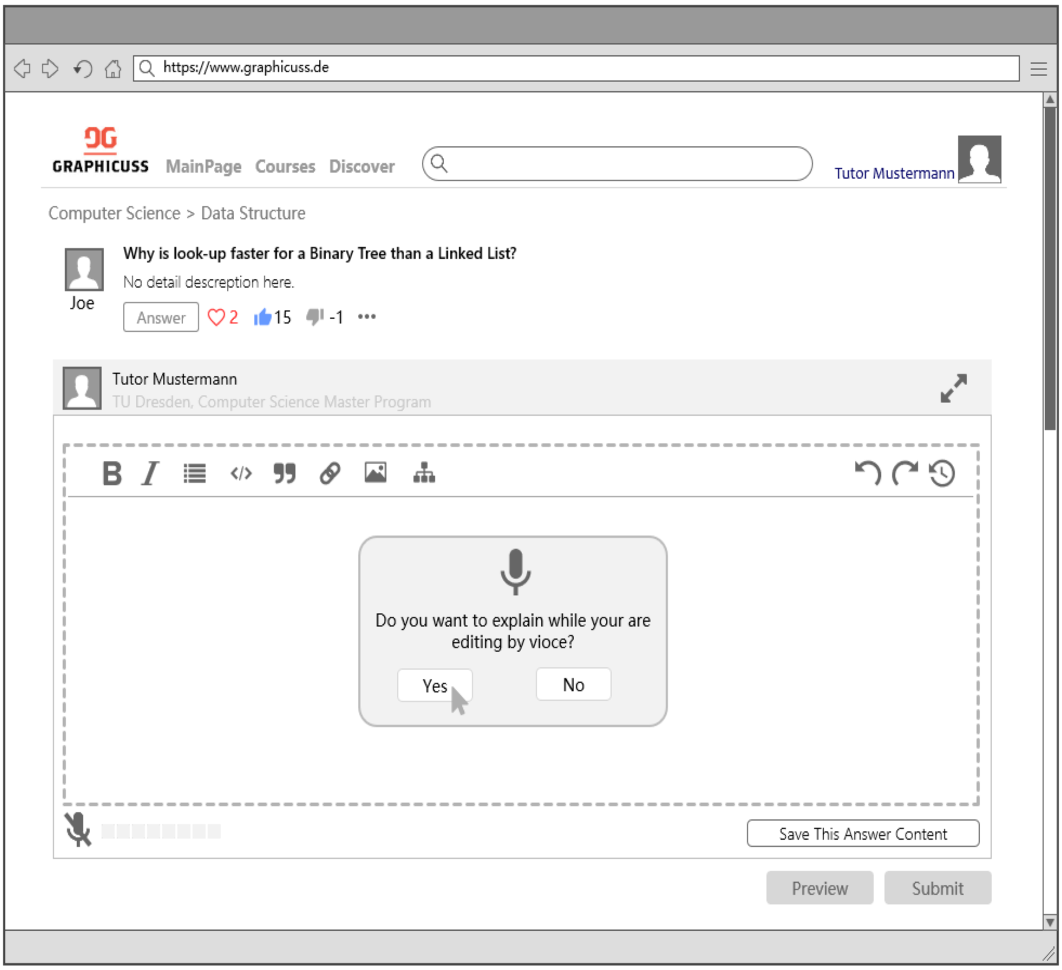

https://www.graphicuss.de
GRAPHICUSS
MainPage
Courses
Discover
Tutor Mustermann
Computer Science > Data Structure
Why is look-up faster for a Binary Tree than a Linked List?
No detail descreption here.
Joe
Answer
♡2
👍15
👎 -1
•••
Tutor Mustermann
TU Dresden, Computer Science
+
Preview
Submit

Figure 3.7: Answer Edit Page--original state after opening

The elements in the answer edit page shown is Figure 3.7 is listed and explained as below:

1. Question Description: This question description is composed of two parts, the question itself and the detailed description of the question.
2. Answer Area: The answer area is surrounded by the solid line. Within this area are three elements as below.
    a. Answer creator information: This shows the basic information of the answer creator.
    b. Maximize button for the editing area: By clicking this button, the editing area will be maximized with the full screen. This is very helpful when creating a long answer.
    c. Add an answer component: This is a hot area in the answer editor. The plus icon in this hot area is to indicate the creation of an answer component.
3. Preview: This is a button at the bottom of the answer editor to preview how the answer will be shown in the question main page. This button is only active when there is at least one answer component saved.
4. Submit: This is the button to submit the answer after the editing of all answer components is finished. This button is only active when there is at least one answer component saved.

After clicking on the plus icon in the area with dotted line, the answer component editor is activated. As shown in Figure 3.9, before a user inserts any content in this answer component, the user needs to choose if he or she would like to record his or her voice while editing, because the creation process of this answer component can be recorded and shown in a video afterwards explaining the sophisticated answer. This unique function would allow more detailed and intuitive explanation along with the answer to the question, thus very important and helpful under certain conditions.



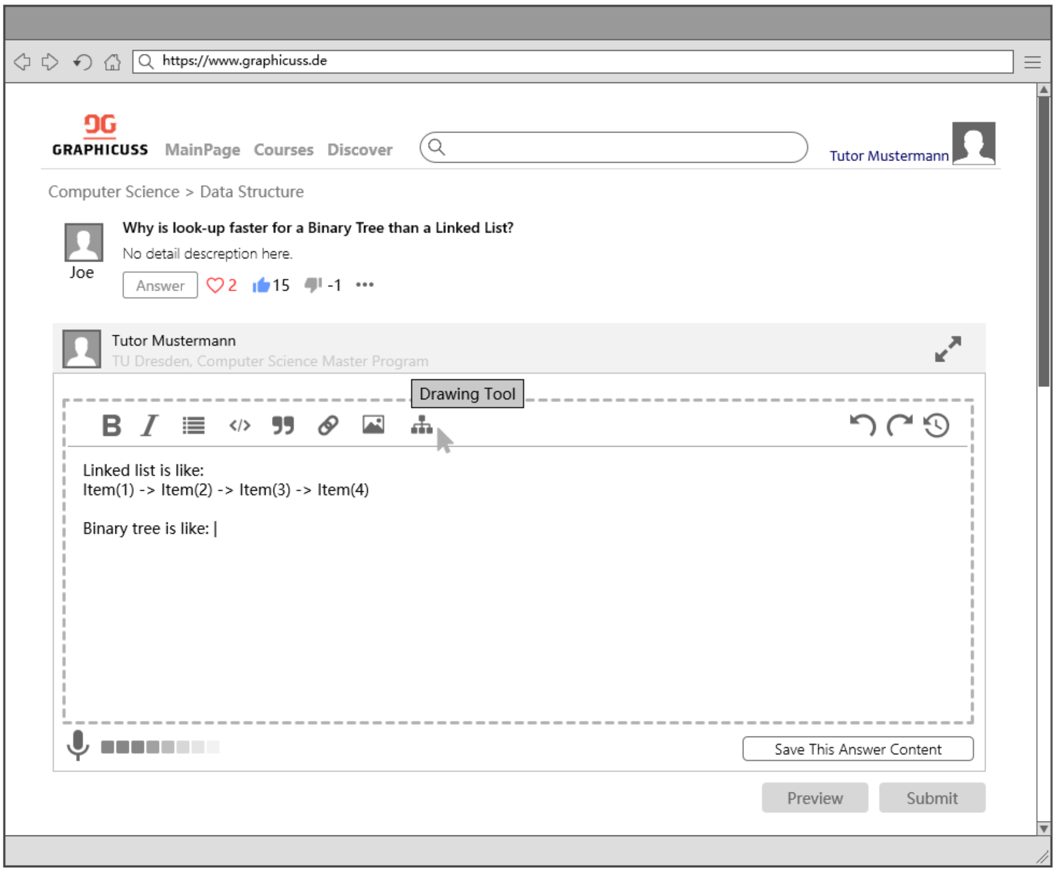
Why is look-up faster for a Binary Tree than a Linked List?

No detail descreption here.

Do you want to explain while your are editing by vioce?

Figure 3.8: Answer Edit Page--voice record option

After this option, the user can start the editing part as shown in Figure 3.9. In this answer component editor, a toolbar with common editing functions is on the top. The drawing tool can also be invoked in the toolbar. By using the drawing tool, the user can create graphical content in this answer component.



Why is look-up faster for a Binary Tree than a Linked List?

No detail descreption here.

Linked list is like:
Item(1) -> Item(2) -> Item(3) -> Item(4)

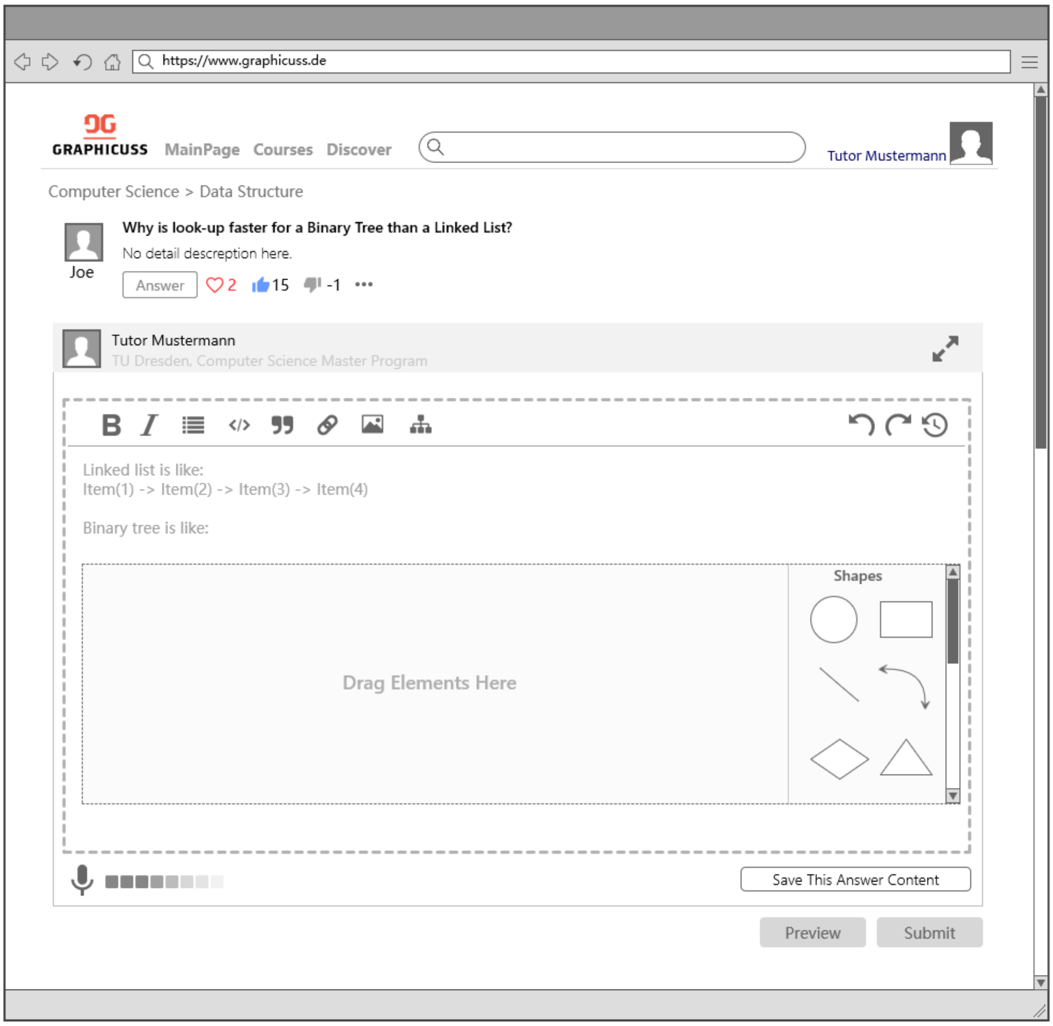
Binary tree is like: |

Figure 3.9: Answer Edit Page--answer component editing

The elements after the answer component editor is activated, as shown in Figure 3.9, are explained as below:

1. Edit Toolbar: This is a toolbar with several common editing methods. The icons in this toolbar are (from left to right): bold, italic, listed, to add source code, to quote, to add a link, to insert an image and to open a drawing tool, respectively.
2. Undo/Redo: These two functions are on the top right of the answer component editor.
3. View History: This is a button to open the editing history. The editing history is shown in a pop-up window in video format.
4. Microphone control: Under the answer component editor is the microphone control button. By clicking the microphone icon, the user can open or close the voice recorder.
5. Save This Answer Content: After finishing editing this answer component, by clicking this button, the user can save this answer component.

The drawing tool, as shown in Figure 3.10, can help the user create basic graphical element in the answer component editor, the icon for drawing tool is in the end of the toolbar.



Why is look-up faster for a Binary Tree than a Linked List?

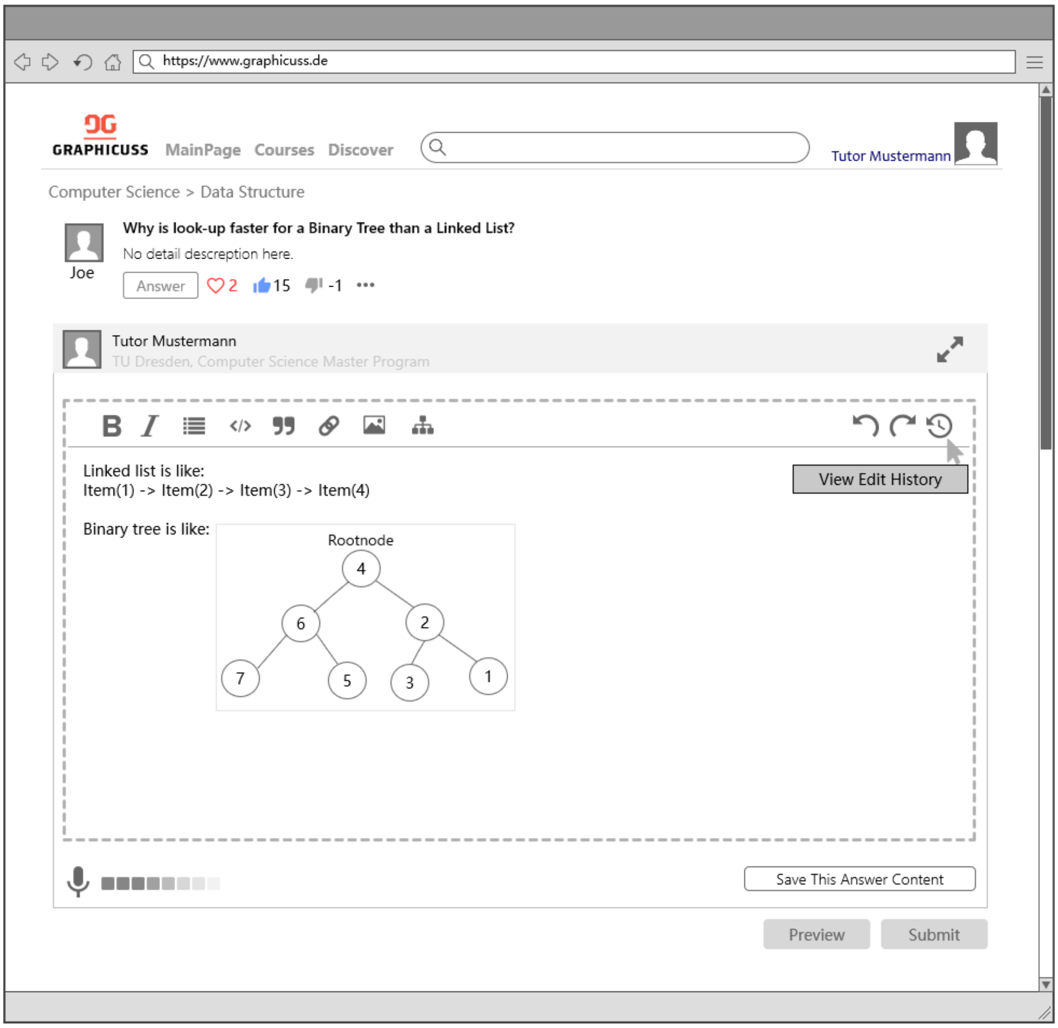
No detail descreption here.

Linked list is like:
Item(1) -> Item(2) -> Item(3) -> Item(4)

Binary tree is like:

Figure 3.10: Answer Edit Page--using drawing tool

After the drawing tool is activated, the text content will be blocked. The drawing tool will appear in the editing panel. By simply dragging the basic graphical elements provided in the drawing tool, the user can create their own graph. After the user finishes creating the graph, by double click the other edit area, the page will go back to text editor, and the graphical element will show as a picture in the editor as shown below in the Figure 3.11.



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Why is look-up faster for a Binary Tree than a Linked List?

No detail descreption here.

Linked list is like:
Item(1) -> Item(2) -> Item(3) -> Item(4)

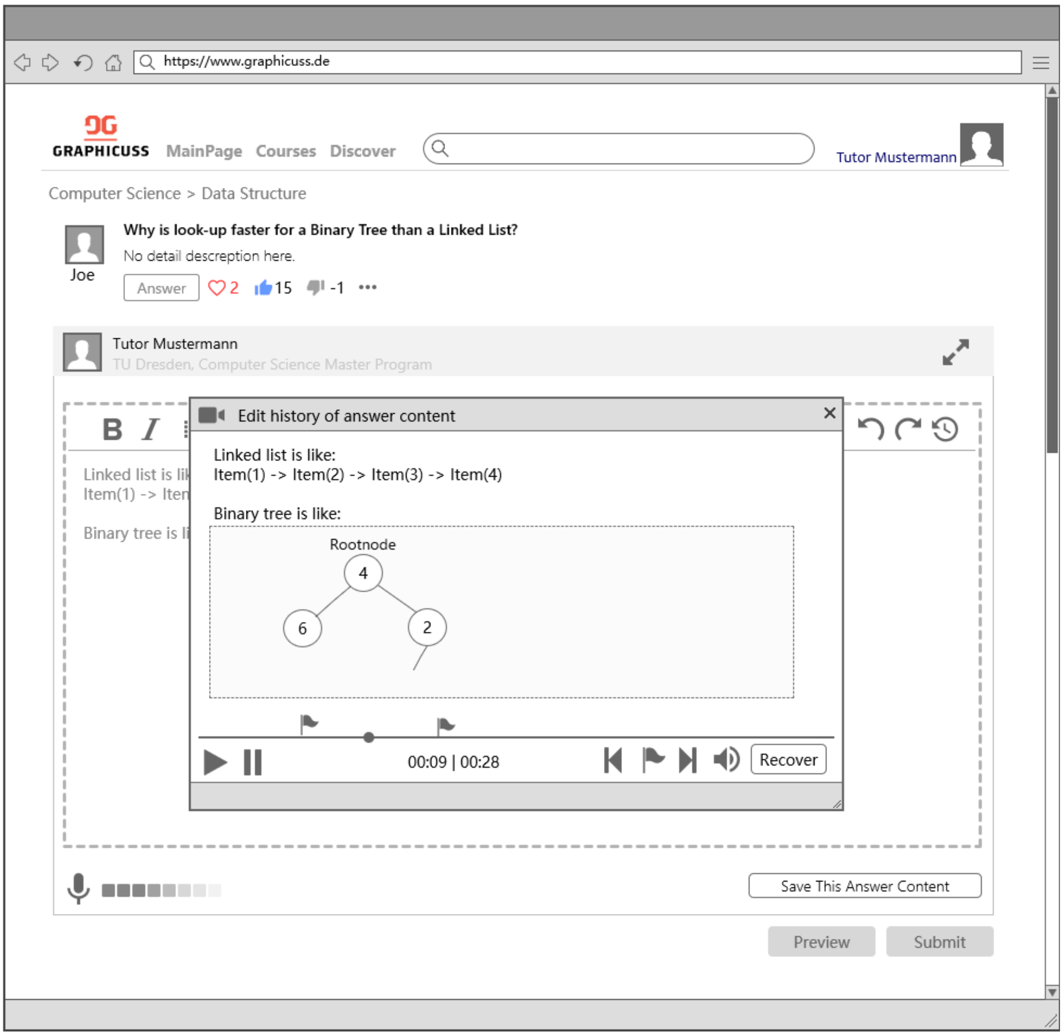
Binary tree is like:

Figure 3.11: Answer Edit Page--create a graphical element

During editing, the user can view the creation process by clicking the ’history’ button. After clicking on the button, the creation history video will come up in a pop-out window as shown in Figure 3.12. The whole creation process can be played from the point when the user activates this answer component editor to the point when the user clicks on the history button. The functions in the pop-out window are shown in Table 3.4.

| Operation | Description |
|---|---|
| ▶ | Play the video |
| ⏸ | Pause the video |
| ⚑ | Activated only when the video is paused: it is used to mark on the timeline of the video, indicating an important status (for example the end of one step) in the creation process. |
| ⏮ | Functioning only when the video is paused: Go to the last time point marked by the flag |
| ⏭ | Functioning only when the video is paused: Go to the next time point marked by flag |
| Recover | Functioning only when the video is paused: Reset all the edits to a specific status in the video. |

Table 3.4: Functions in the pop-out window



Why is look-up faster for a Binary Tree than a Linked List?

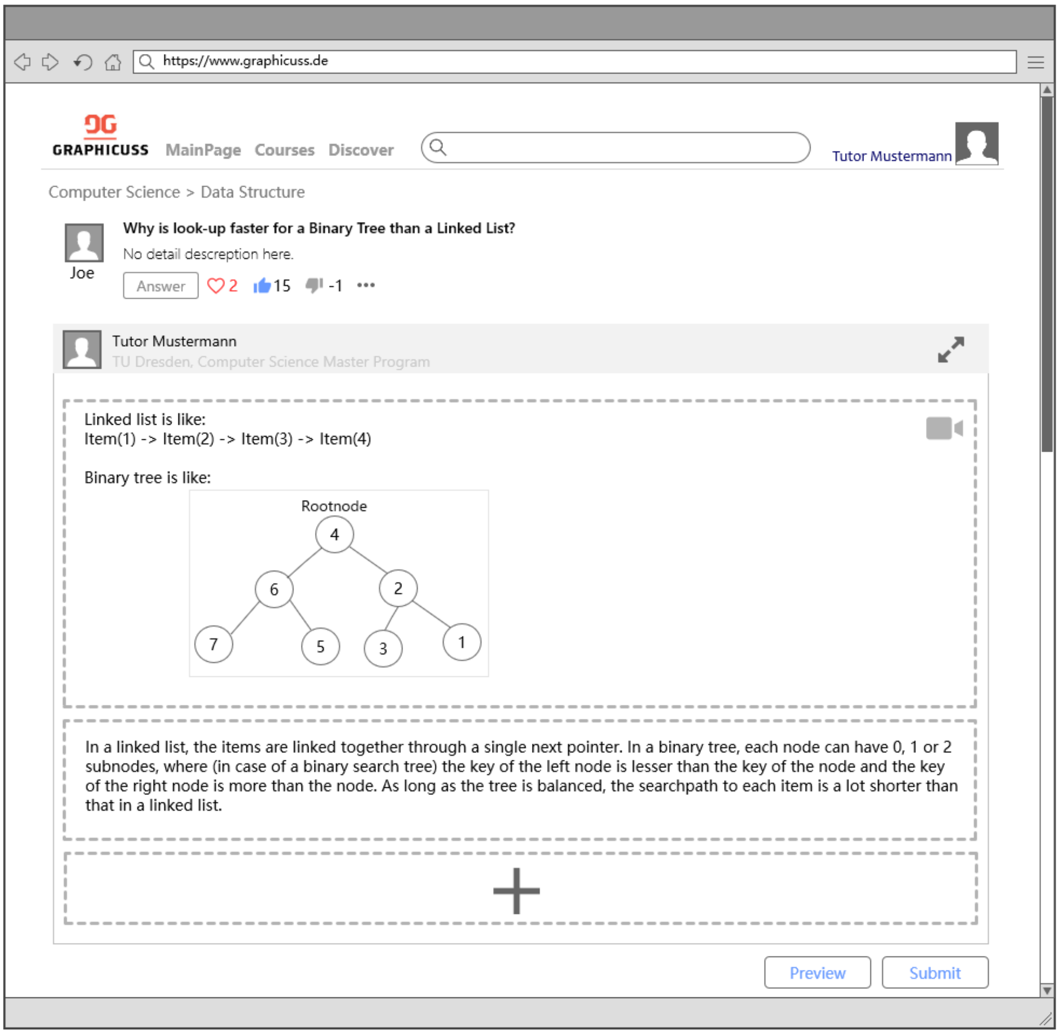
No detail descreption here.

Linked list is like:
Item(1) -> Item(2) -> Item(3) -> Item(4)

Binary tree is like:

Figure 3.12: Video Player of creation process while editing

After the user finishes editing an answer component, by clicking on the ‘save the answer content’ button, the user can store this answer component. This time the user needs to decide if he or she wants to publish a video of the creation process together with the answer component. If one answer component is playable, then a video recorder icon will appear on the top right of this answer component. After editing one answer component, the user can add another answer component or directly submit the answer. The submit button is only activated when the user has saved at least one answer component.



Why is look-up faster for a Binary Tree than a Linked List?

No detail descreption here.

Linked list is like:
Item(1) -> Item(2) -> Item(3) -> Item(4)

Binary tree is like:

In a linked list, the items are linked together through a single next pointer. In a binary tree, each node can have 0, 1 or 2 subnodes, where (in case of a binary search tree) the key of the left node is lesser than the key of the node and the key of the right node is more than the node. As long as the tree is balanced, the searchpath to each item is a lot shorter than that in a linked list.

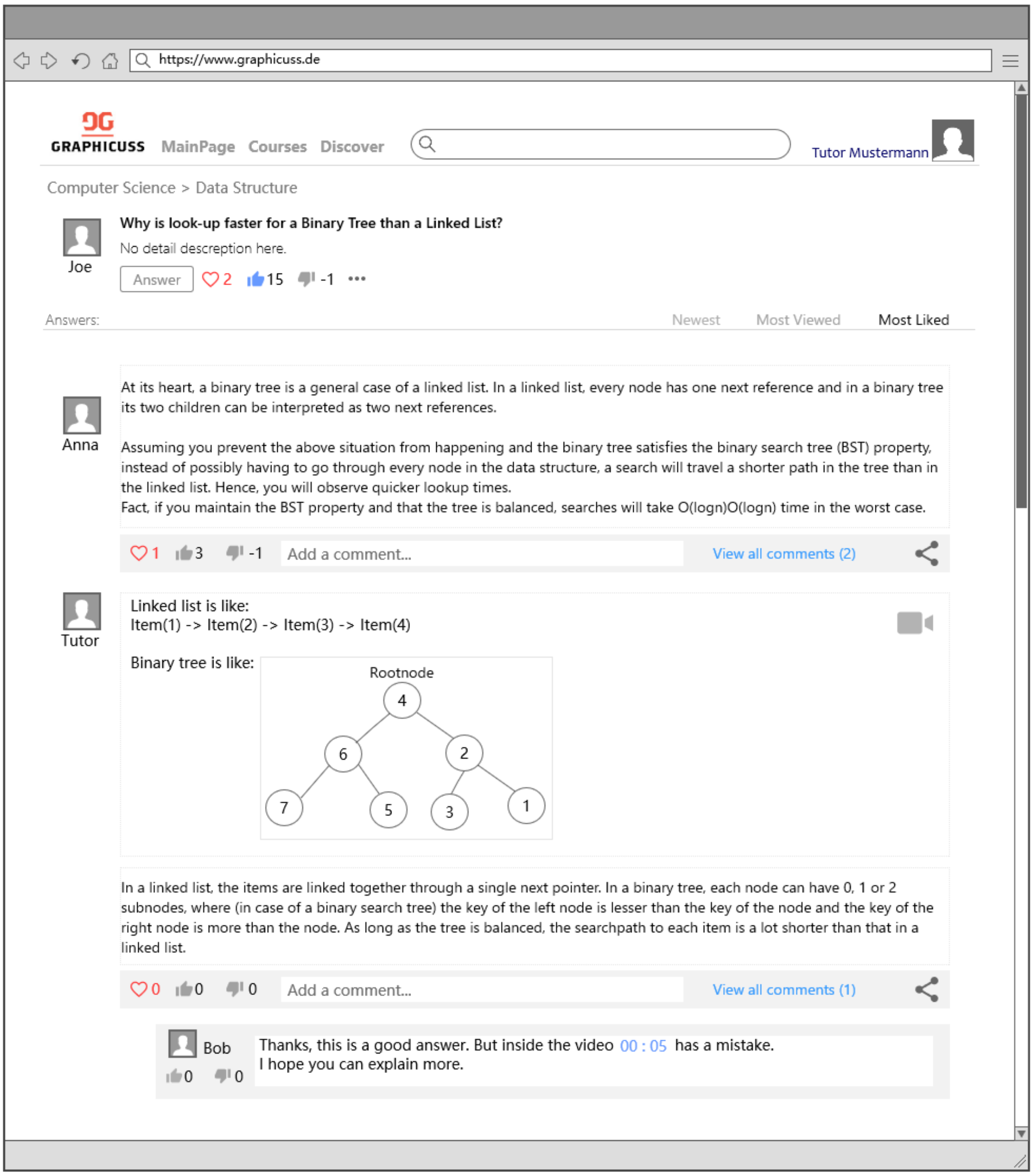
Figure 3.13: Answer Edit Page--an answer edit page before submit

After editing all the answer component as shown in Figure 3.13, the user can submit this answer, and the answer will appear in the question main page.

### 3.3.3 Question Main Page

All the answers of one question is shown in the question main page as shown in Figure 3.14. The default ranking method is the ‘Most Liked’. ‘Most Viewed’ and ‘Newest’ are two other ranking options. For each answer, the user can upvote, downvote or add an answer to favorites.

If an answer component is published with a video of its creation process, the user can find a video recorder icon on the top right of this answer component. This design enables the user not only to see the answer component in a static way as the current system would allow but also to watch the creation video attached, possibly with verbal explanation.



**Why is look-up faster for a Binary Tree than a Linked List?**

No detail descreption here.

At its heart, a binary tree is a general case of a linked list. In a linked list, every node has one next reference and in a binary tree its two children can be interpreted as two next references.

Assuming you prevent the above situation from happening and the binary tree satisfies the binary search tree (BST) property, instead of possibly having to go through every node in the data structure, a search will travel a shorter path in the tree than in the linked list. Hence, you will observe quicker lookup times.
Fact, if you maintain the BST property and that the tree is balanced, searches will take O(logn)O(logn) time in the worst case.

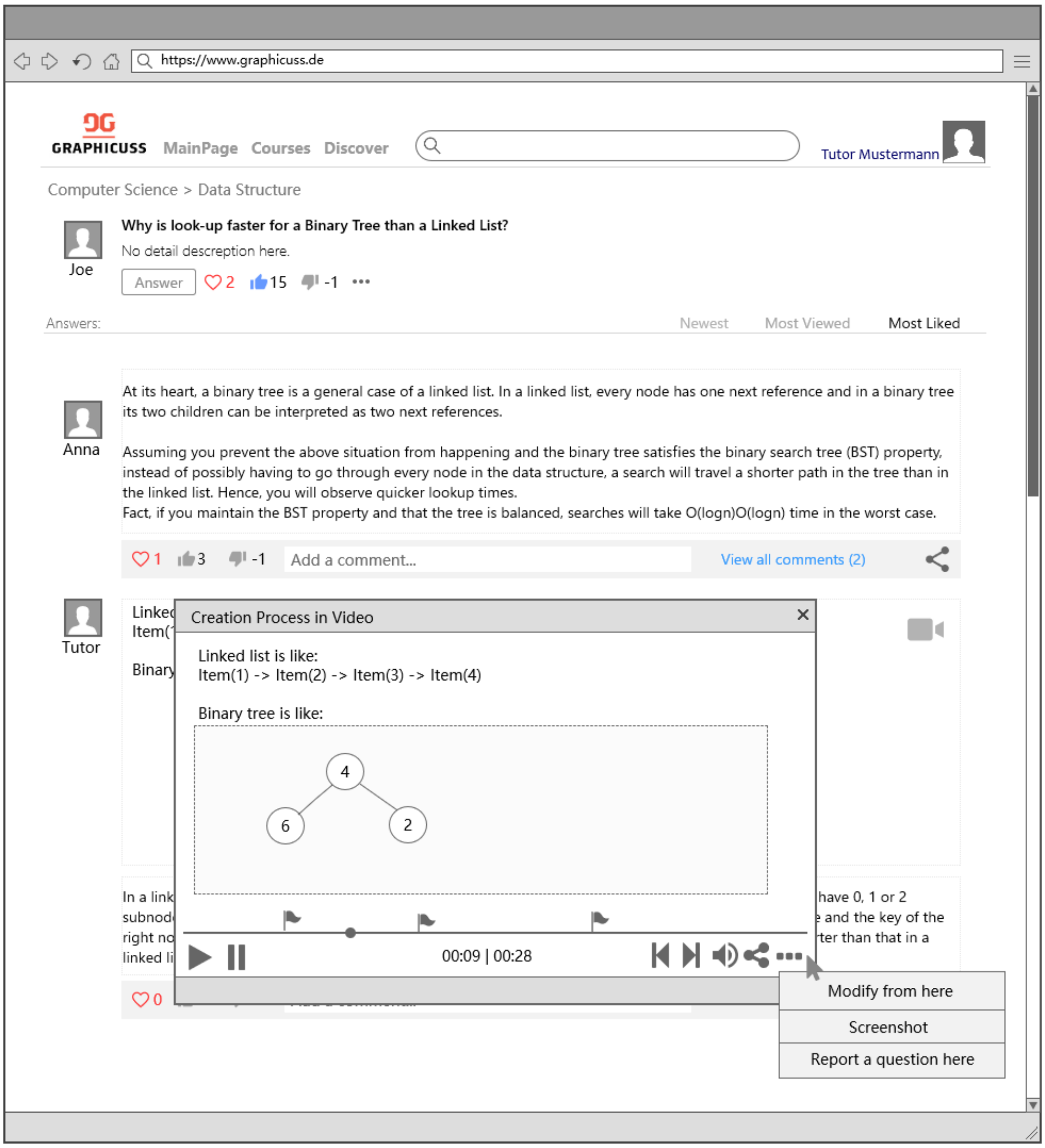
Linked list is like:
Item(1) -> Item(2) -> Item(3) -> Item(4)

Binary tree is like:

In a linked list, the items are linked together through a single next pointer. In a binary tree, each node can have 0, 1 or 2 subnodes, where (in case of a binary search tree) the key of the left node is lesser than the key of the node and the key of the right node is more than the node. As long as the tree is balanced, the searchpath to each item is a lot shorter than that in a linked list.

Thanks, this is a good answer. But inside the video 00 : 05 has a mistake.
I hope you can explain more.

Figure 3.14: Question Main Page



Why is look-up faster for a Binary Tree than a Linked List?

No detail descreption here.

At its heart, a binary tree is a general case of a linked list. In a linked list, every node has one next reference and in a binary tree its two children can be interpreted as two next references.

Assuming you prevent the above situation from happening and the binary tree satisfies the binary search tree (BST) property, instead of possibly having to go through every node in the data structure, a search will travel a shorter path in the tree than in the linked list. Hence, you will observe quicker lookup times.
Fact, if you maintain the BST property and that the tree is balanced, searches will take O(logn)O(logn) time in the worst case.

Linked list is like:
Item(1) -> Item(2) -> Item(3) -> Item(4)

Binary tree is like:

In a link… have 0, 1 or 2 subnod… and the key of the right no… ter than that in a linked li…

Figure 3.15: Playing an answer component creation video

After clicking on the video recorder icon, the user can watch the video in a pop-up window that records this answer component creation process as shown in Figure 3.15. In this window, other than the normal functions of playing and pausing a video, the answer viewer can also see the flags in the timeline marked by the answer creator. The viewer can share this video in social media, moreover with additional functions shown in the drop box, the viewer can even make screenshot, report a question or create a new answer from the video.

Other than creating an answer and then publish a video of its creation process from scratch, the user can also edit an answer from an existing one, thus creating a new answer. When playing the video, the user can pause it and click on the ‘modify from here’ button to edit the answer from the specific point of an existing answer. The option of modification will take the user to an answer edit page where all the existing contents are already set up and a new answer component could be added to create a new answer.

New pop-up window which is slightly different from the pop-up window of the original answer video, but the functions of editing remain the same. In this new window the user can see the flags on the timeline marked by the original answer creator which can be quoted or referenced when producing a new one.

# 4 IMPLEMENTATION

## 4.1 GENERAL STRUCTURE

In line with the Graphicuss system, the video representation part is developed under the Node.js framework. The client-side structure is created using React.js. The server-side framework is provided by Express.js, and Node.js serves as the environment of development. The NoSQL database MongoDB is used to store all the data structures.

**React.js[20]**

React.js an open source library for UI designing which is created by Facebook. It makes the UI components flexible and reusable, and interactive UIs are created easily. The components in React.js maintains inherent state data, which can be updated and re-rendered automatically via the render() method. The XML like syntax JSX also makes the code clearer to read and easy to maintain.

There is a vast variety of frameworks in web development. React.js is known for its clarity in the component definition and readability. The front-end such as the recording panel and video player are implemented by React.js components, and the UI appearance is rendered using material-UI.

**Express.js[21]**

Express.js is a web server based on Node.js framework. With easy configuration, it makes the Node.js web application easy and quick. The server side of Graphicuss system is developed using Express.js.

**Node.js[22]**

Node.js is a lightweight and efficient JavaScript runtime engine built on the V8 JavaScript engine of Chrome. npm is the package ecosystem of Node.js, which is essentially the largest ecosystem of open source libraries. One big advantage of Node.js is that it is asynchronous, which means that it is able to handle subsequent requests while the previous tasks are being performed. This is a big advantage over PHP or ASP.

[20] https://reactjs.org/ - accessed 8 Nov 2017

[21] https://expressjs.com/ - accessed 8 Nov 2017

[22] https://nodejs.org/en - accessed 9 Nov 2017

**npm**[23]

npm is a powerful JavaScript manager. It makes the sharing of JavaScript packages between developers standardized and easy. It keeps track of the packages installed on the project by initializing a package.json file in the root folder of the project. Whenever a package is installed or updated, the package.json is re-written to account for the changes.

It also retains dependency between packages by remembering the version of all the packages, which makes possible the rebuilt of project on other machines or at a later time when some of the packages are being updated.

**MongoDB**[24]

The NoSQL MongoDB has many advantages over traditional databases in an age when cloud computing is gaining momentum. It is more scalable and the performance is better compared to traditional databases. The advantages of NoSQL include

- Large volumes of structured, semi-structured, and unstructured data
- Agile sprints, quick iteration, and frequent code pushes
- Object-oriented programming that is easy to use and flexible
- Efficient, scale-out architecture instead of expensive, monolithic architecture

Another advantage of MongoDB is that it has the capability of storing large media files in the database, which suits our purpose of handling user generated videos. This property makes the query of video files efficient. Video files are “chunked” into multiple objects 4 MB in size and stored in BSON binary format[25].

## 4.2 TIMESTAMPED SERIALIZED CANVAS

One important issue in this thesis is to solve the problem of time representation of the canvas elements in order to work together with the video component of the answer. Although canvas makes drawing in the HTML5 document easy and has the capability of creating complex figures, it provides only rudimentary manipulations of shapes and does not preserve the history of the creation process, the canvas elements need to warp with a third-party library.

[23] https://docs.npmjs.com/getting-started/what-is-npm - accessed 9 Nov 2017

[24] https://www.mongodb.com/scale/advantages-of-nosql - accessed 9 Nov 2017

[25] https://www.mongodb.com/blog/post/storing-large-objects-and-files-in-mongodb - accessed 9 Nov 2017

Fabric.js[26] is an open source JavaScript library that comes with an object model for canvas. Rather than treating the canvas as an entire bitmap, it makes possible the interaction of existing canvas elements as well as capturing and recording all the changes made by mouse manipulation such as dragging, zooming and rotating of a particular canvas element. Each canvas element is wrapped up as an object and its properties are preserved and can be operated by the object. These objects can be adjusted, transformed, rotated, and even grouped together via Fabric.js methods.

In order to save canvas elements for future manipulation, there need to be a method of exporting the Fabric.js canvas objects other than an entire image, as the primitive canvas method does. Fabric.js provides a serialization technique that comes with three methods, toObject(), toSVG(), and toJSON(). Each of the three serve the similar purpose in different forms. The toObject() method exports the canvas elements as JavaScript objects, and the output information could be adjusted individually by customizing the function. The toSVG() method outputs the canvas as SVG format image that could be easily presented. The toJOSN() method gives a JSON string describing all aspects of the canvas information in detail that could be used to restore the canvas using loadFromJSON(). This is called deserialization.

The Graphicuss system had already taken advantage of the toJSON() method to provide the history of the drawing process. However, when there is a video counterpart for the serialized canvas, the history points of the canvas status also need time information to tell to which time spot of the video it is corresponding.

This can be achieved by adding a stack field to the canvas component, which is essentially an array of JavaScript objects. Each object is the combination of the time offset from the beginning time of the recording and the serialized JSON object. When the user starts a recording process, the stack handling method records the beginning time the video, and pushes time zero and an empty JSON string to the stack.

Whenever the user makes a change on the canvas drawing, whether it is drawing or dragging, there will be a mouseup event indicating that a change has made. The onmouseup() method of the canvas component is then invoked and the time offset is calculated by subtracting the beginning time from the current time. The toJSON() method is called to generate a JSON string, which will be combined with the time offset and pushed into the canvas stack.

There is another issue needs to be taking into consideration, that is, when the video recording process is paused by the user, the time stamp will not be the offset of the current time and the beginning time. The pausing time interval needs to be recorded and accumulated as the recording proceeds. This can be achieved by adding a pausedTime field in the recorder component with the

[26] http://fabricjs.com/articles/ - accessed 9 Nov 2017

initial value of zero. The canvas onmouseup() method then subtracts the pausedTime value each time it calculates the time offset.

Now the time representation of the canvas and the status in each timestamp is accomplished. When the user quotes a certain time on the video, the Video.js will return the current time of the video, and program then seeks through the canvas stack and finds the largest time stamp that is less than the current time. Suppose there are five time stamps in the stack, 0:00, 0:30, 1:00, 1:30, 2:00. The video is 2 minutes long and the user quotes 1:10 in the video and started a redrawing process. The latest adjustment made by the previous drawer is at 1:00, so the time stamp 1:00 and its corresponding canvas JSON string will be chosen, and the loadFromJson() of Fabric.js will be called to draw the canvas status at the time stamp to serve as the starting point of the new drawing.

## 4.3 VIDEO RECORDING

### 4.3.1 The Recording Panel

The recording panel is a composition of react components appeared on top of the drawing pad. The result is illustrated in Figure 4.1.

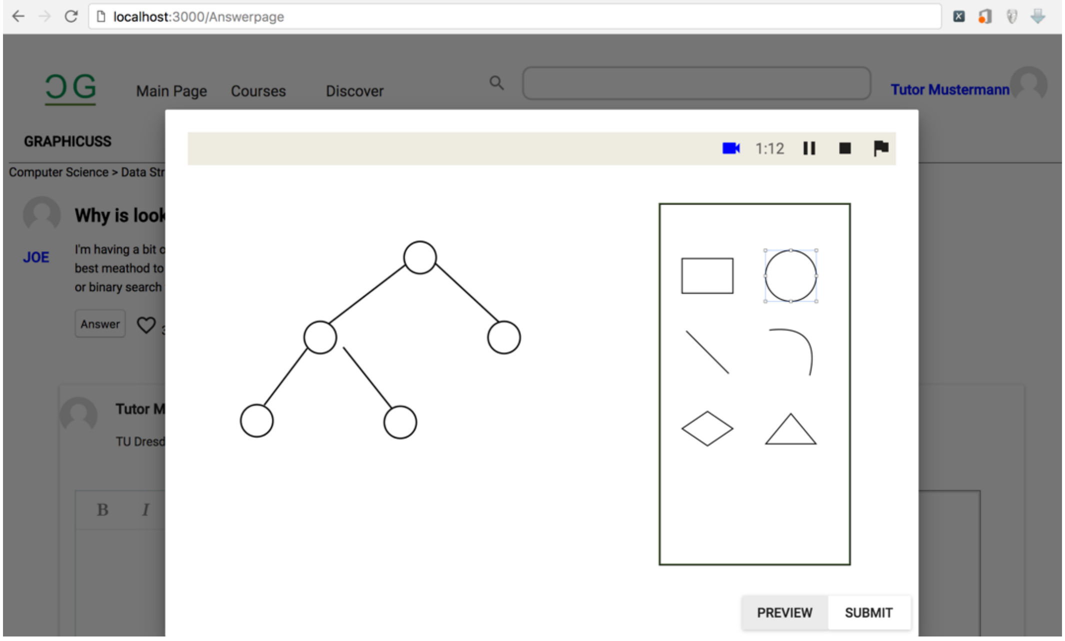


Figure 4.1: Screenshot--Recording Panel

There are five control Buttons, one Flag and a Timer on the panel.

The five control buttons serve the function of start recording, pause recording, stop recording, preview and submit recording respectively. When the ButtonStartRec is clicked, its event handle function initiates the recording process through the RecordRTC library. The browser then prompts the user for permission of screen recording and using the microphone. Each time the user makes a change on the canvas, a timestamped serialized canvas object will be pushed to the canvas stack to track user modifications, serving the purpose of synchronization of the canvas with the video.

The ButtonPauseRec pauses the recording process, and at the same time the drawing panel will be disabled and the user is unable to draw on the canvas.

When the user opens the drawing panel, he can draw freely on the panel. however, when the user decides to record and clicks the ButtonStratRec button, the button's event handling function will signal that the user starts the recording process, thus when he pauses, the drawing panel will be disabled via the ButtonPauseRec button's event listener until the user starts recording again. This is to make sure that the recorded video represents a complete drawing process that is not infringed by pausing. The user may think for a little while or may have to leave for a moment, and such incidents are not to be recorded.

When the ButtonStopRec is clicked, the recorded media will be extracted into a blob object that is able to be read by the video player. The creator can then preview the video by clicking the ButtonPreview button, navigate by the control bar as well as featured time spots.

If the user is content with the recorded answer, clicking the ButtonSubmitRec will upload the video blog to server, which will then be saved and transcoded by ffmpeg from webM to MP4 format that is recognized by all modern browsers.

If the user closes the window before submitting, the recorded video will be discarded.

The Flag is a button with a flag image to mark the important time spots in the drawing process. When the Flag is clicked during recording, a timestamp is added to the video components' featuredTimeSpot list field, which is a list that stores all the featured time spots created by the answer creator. These spots will be displayed as flags above the control bar in the playing panel through which users could quickly locate important time spots.

To make this process intuitive, there should be a mechanism informing the user that a flag has been made. A Timer on the upper left side reminds the user that this is a live process, and informs the how long the user has been drawing.

### 4.3.2 RecordRTC

At the beginning of the recording, the browser support was checked by invoking the navigator.getUserMedia() function. A message informing the user that browser does not support will be displayed on failure. On success, the browser will prompt for recording permission.

A RecordRTC stream is then created with screen and audio streams combined.

The RecordRTC() function takes two parameters. The first one is the media stream, which can be the camera, screen, or canvas. The second being the options or parameters of the media to be recorded, such as file format, video width, audio bit rate etc.

However, the canvas and the audio are separated streams and cannot be recorded together into a single video file directly. This can be solved by creating a new MediaStream object. Getting the video tracks of the canvas, adding the track to the newly created MediaStream, then getting the audio tracks of the microphone, adding the track to the MediaStream, thus creating a MediaStream that is combined with canvas and audio tracks, which will enable the sound in the recording of canvas drawing.

The recordRTC.pauseRecording() method will be invoked when the ButtonPauseRec is clicked. The start button will then resume the recording by invoking the recordRTC.resumeRecording() method.

When the recording is stopped by the user, a blob object will be obtained by the RecordRTC.getBlog() method. Blob refers to binary large object that contains the recorded media data. A DOMString that contains the URL of the video object is then generated via the URL.createObjectURL() method using the blob object as its parameter.

Video.js could then take the URL to preview the video.

The blob object will then be uploaded to the server and saved, transcoded to MP4 format via the ffmpeg package.

## 4.4 VIDEO PLAYING

Video.js is used as the video player in the project. Its powerfulness partly resides in the fact that it decorates the standard <video> element and simulates the corresponding APIs and events which results in a set of tools that is simple in use.

When the user clicks the video icon in the answer page, the Video.js will create an <video> element and a pop up video player will show up with controls and corresponding features.

The featured list created by the answerer will be read by the player component and a series of markers will be marked on the control bar via Video.js plugin videojs-markers.js.

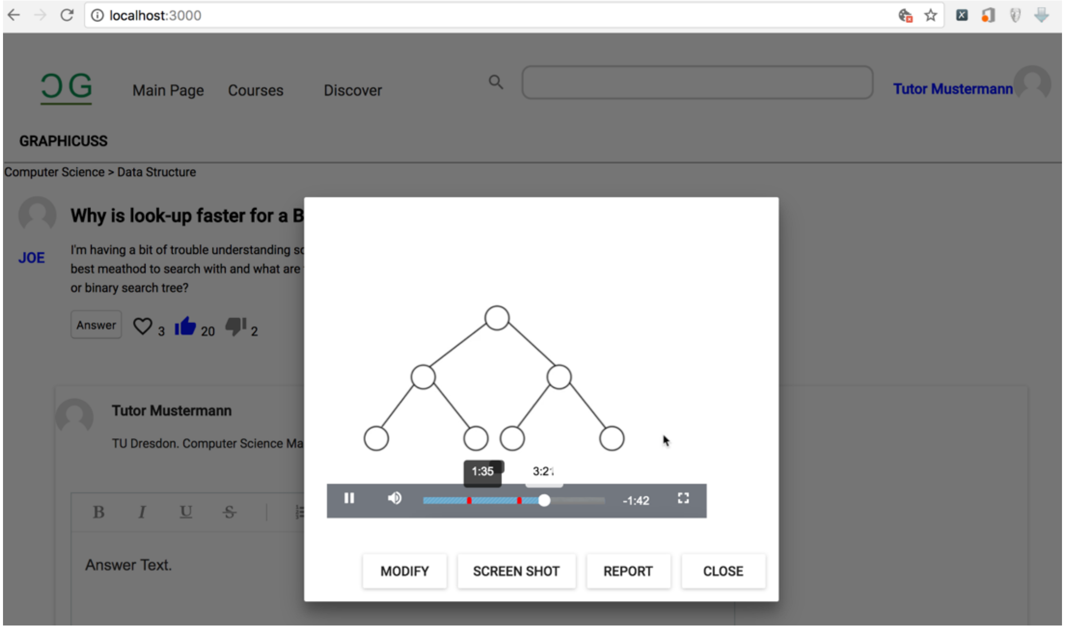
The syntax for implementing the video markers is as shown in Figure 4.2.

```
video.markers({
 markers: [
   {time: 9.5, text: " "},
   {time: 16,  text: " "},
   {time: 23.6,text: " "},
   {time: 28,  text: " "}
 ]
});
```

Figure 4.2: video-markers.js syntax

The user could quickly locate important time spots in the video. As the user is investigating the drawing instructions, new featured spots can also be created. But these spots will not be merged with the video's existing featured spots, for doing so will make the video's property be flooded by data from many users. The user specific featured spots will be destroyed as soon as the answer page is closed.

Aside from the closing button, there are three options at the lower right end of the player, "Modify from here", "Screenshot", and "Report a question here", as is shown in Figure 4.3.



Why is look-up faster for a B

I'm having a bit of trouble understanding s
best meathod to search with and what are
or binary search tree?

Answer Text.

Figure 4.3: Screenshot--video playing panel

The “Modify from here” option directs the user to a new page with a canvas drawing tool preloaded with the canvas elements created before the video’s current time. This is done by searching through the canvas stack to find the largest timestamp that is smaller than the current video time. Once the specific item on the stack is found, the loadFromJSON() method of the Fabric.js is invoked to create corresponding canvas elements on the drawing pad, and the user then could create the video recording from the point on.

A list of authors is maintained in the video component and will be stored. This is because a video may be co-authored by several contributors. Each time a video is modified by a new author, the author list will be appended by the user name that is recording the answer. A list of author names will be displayed while the mouse hovers on the video icon on the answer page.

When the video playing is finished, the dispose() method is called to destroy the video element.

## 4.5 VIDEO PROCESSING

There are three major tasks in our video processing task.

### Transcoding

The RecordRTC yields a video format of WebM. When the recording process is finished, the blob object of the video is uploaded to the server and was written to a WebM video file. The ffmpeg program on the server side then transforms the video into MP4 format for the compatibility of different browsers.

The following diagram 4.3 describes the transcoding process of ffmpeg:

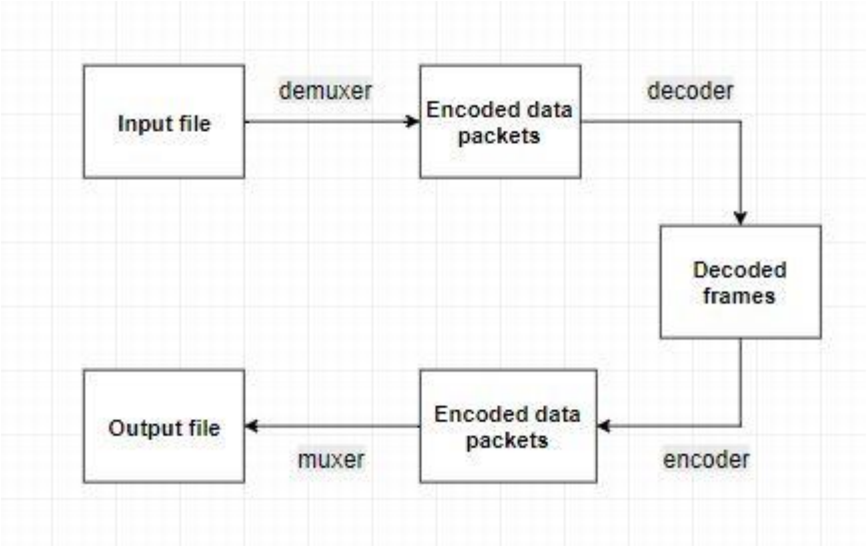


Figure 4.4: transcoding process of ffmpeg

### Splitting

When the user decided to modify a video from a certain point, the timestamp is obtained via video.js. While it is used to search through the canvas stack to find the specific canvas status to be drawn on the newly created canvas drawing pad, it is also used by ffmpeg to split the current video into two separate files. The latter one is then discarded, for this is the part that the user deems contains error.

### Combining

As the user finishes a new recording, a new video file is generated and uploaded to the server. The ffmpeg then merges the two files into one single file.

# 5 EVALUATION

Having done the construction of the video discussion forum, it is essential to evaluate the usability of its functions. Evaluation of this work should be separate into two parts. Firstly, based on the requirement list shown in Chapter 3, checking if the system design satisfied the user requirements is needed. Secondly, the usability evaluation should be established with potential users by user interview.

A checklist is shown in Table 5.1, This list shown the requirements raised by potential users. Here checking if the requirements are achieved with the new system design is significant. A '×' in front of a requirement, representing this requirement is satisified.

| | | |
|---|---|---|
| System requirement list | | |
| × | 1 | the user can create both text content and graphical content in one answer |
| × | 2 | the system can automatically store all user actions during the creating process |
| × | 3 | the system can generate videos for each part of the answer, and the user can play the video at any time during the editing process |
| × | 4 | the user can roll back to the previous state at any point when editing a content |
| × | 5 | the user can decide whether or not to include the video of the creation process into the answer before submitting it |
| × | 6 | only the creation process of a user-specific content can be played in the video and the rest will remain static |
| × | 7 | for each video, the user can always mark key points on the timeline of the video |
| × | 8 | if there are several steps in one creation process, the user can mark the end of each step on the timeline of video |
| × | 9 | the user can explain the answer when editing, and the voice can also be stored in the video. |
| System requirement in the browsing phase: | | |
| × | 10 | the user can always view an answer in static, not necessarily to play the creation process. |
| × | 11 | when the answer has a playable content, the user should be prompted. |
| × | 12 | the user should be able to view the creation process in a 'step-by-step' manner when possible. |
| × | 13 | videos can be quoted . |
| × | 14 | when a video is paused, the user can extract the content at that time and edit from that phase to create a new question, answer, or comment. |
| × | 15 | the user can comment on an answer. |

Table 5.1 Evaluation of requirement list

As the forum is intended to enable users to ask and answer questions to particular courses with rich capabilities like the process recording in videos. However, the functionality is not all that what the users want. The functions must not only be sufficient but also be efficient and easily usable.

Moreover, most of its functions must be self-evident at first sight, without thinking for a period of time. It should not be a forum with a steep learning curve.

Thus, two aspects are considered in the evaluation process. The first measurement is usability that is evaluated by System Usability Scale developed by John Brooke [7]. The second is the measurement of perceived intuitiveness, which is done by a INUI questionnaire for evaluating the intuitive interaction of product design developed by Daniel Ullrich and Sarah Diefenbach [8].

By utilizing the two questionnaires, the intangible concepts can be transformed into concreate measurements that provide an easy way for evaluation purposes.

## 5.1 SYSTEM USABILITY SCALE

The System Usability Scale(SUS) is a cross-system usability evaluation method that aims at measuring usability regardless of the differences between systems. It is a ten-item Likert scale and each item are a question with five rating scales ranging from strongly disagree to strongly agree.

The final score of the SUS is calculated by adding all the contributions of items together and multiplied by 2.5. For even items, the contribution is the scale position minus 1 and the contribution of even items is 5 minus the scale position. The final result is a score ranging between 0 to 100. This process can be summarized as the following formula:

$$SUS\ score = 2.5 \times \sum_{k=1}^{5}[(q_{2k-1} - 1) + (5 - q_{2k})] \qquad (5.1)$$

The survey is conducted with 5 interviewees, the information of interviewees and ratings are shown in table 5.2.

| Items(No.) | A | B | C | D | E | Average Score |
|---|---|---|---|---|---|---|
| Q1 | 3 | 2 | 3 | 2 | 3 | 2.6 |
| Q2 | 3 | 3 | 4 | 2 | 2 | 2.8 |
| Q3 | 5 | 4 | 4 | 3 | 4 | 4 |
| Q4 | 1 | 2 | 1 | 2 | 1 | 1.4 |
| Q5 | 4 | 5 | 3 | 4 | 4 | 4 |
| Q6 | 2 | 1 | 2 | 1 | 2 | 1.6 |
| Q7 | 3 | 4 | 4 | 3 | 3 | 3.4 |
| Q8 | 2 | 3 | 4 | 3 | 2 | 2.8 |
| Q9 | 4 | 3 | 3 | 4 | 4 | 3.6 |
| Q10 | 1 | 1 | 2 | 2 | 1 | 1.4 |

Table 5.2: Score of SUS survey

Applying formula 5.1 to the ten average scores, the final SUS score is 69 points. According to the SUS interpretation methods devised in [8], the system falls into the category between OK and good, which means that although it satisfies the basic requirements, it is still in need of significant improvement.

## 5.2 PERCEIVED INTUITIVENESS

Intuitiveness means that users can use the product as though it is natural and without much thinking. Modern products should provide intuitive interactions that requires little learning efforts. Otherwise the product such as a website or forum will not be able to fulfill its original purposes and convey its benefits to a large community of users. In their paper [8], Daniel and Sarah notes that usability is not enough, they should be "even more than usable".

However, there are no direct measurement for intuition, how the intuitiveness of a product can be evaluated is not clear. In order to tackle the problem, they designed a questionnaire that is tailored for this particular purpose. They formulated four components to capture the prominent characteristics of intuitive decision making, which are *Effortlessness*, *Gut Feeling*, *Verbalizability*, and *Magical Experience*. The meaning of the first two components is evident by their names. Verbalizability is based on the assumption that users should not be able to describe clearly what they had carried out after using the product if their actions are intuitive. Magical Experience reflects something special or even magical in using the product, exceeding the user's expectations.

Each of the four components are constructed under several questions. A total of seventeen questions form the INTUI questionnaire. This questionnaire can be found in appendix.

The questions are scored in a seven-point scale. The smaller value reflects user experience closer to descriptions on the left side of the table, and the higher value reflects user experience closer to descriptions on the right side of the table. Each question is associated with one variable, whose value was taken from the rating of the question by the users interviewed. Some variables in the variable name column are preceded by a capital "P". For these variables, the wording of questions is in reverse manner, so in the evaluation process their contribution would be 8 minus the survey value. After the survey is taken, the four dimensions of intuitiveness are calculated as below:

$$\text{Effortlessness} = \frac{\sum_{i=1}^{n}[E_{01_i}+E_{02_i}+E_{03_i}+(8-PE_{04_i})+(8-PE_{05_i})]/5}{n} \qquad (5.2)$$

$$\text{Gut Feeling} = \frac{\sum_{i=1}^{n}[G_{01_i}+(8-G_{02_i})+G_{03_i}+(8-PG_{04_i})]/4}{n} \qquad (5.3)$$

$$\text{Verbalizability} = \frac{\sum_{i=1}^{n}[V_{01_i}+(8-PV_{02_i})+V_{03_i}]/3}{n} \qquad (5.4)$$

$$\text{Magical Experience} = \frac{\sum_{i=1}^{n}[(8-PX_{01_i})+X_{02_i}+X_{03_i}+(8-PX_{04_i})]/4}{n} \qquad (5.5)$$

The final result of each component has a range from 1 to 7. Higher value indicates higher degree of intuitiveness.

Five participants were tested using the questionnaire, each of them giving their own scoring on each item, as the following table shows:

| *Participants* | *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|---|
| G_01 | 4 | 5 | 4 | 7 | 6 |
| E_01 | 4 | 5 | 5 | 6 | 4 |
| P G_02 | 2 | 3 | 1 | 2 | 3 |
| G_03 | 4 | 6 | 5 | 6 | 4 |
| E_02 | 3 | 5 | 6 | 4 | 6 |
| P G_04 | 1 | 2 | 2 | 3 | 2 |
| E_03 | 6 | 7 | 6 | 5 | 5 |
| P X_01 | 2 | 1 | 3 | 2 | 1 |
| P E_04 | 1 | 3 | 2 | 2 | 1 |
| X_02 | 2 | 3 | 2 | 3 | 2 |
| P INT_01 | 5 | 6 | 4 | 6 | 5 |
| X_03 | 4 | 3 | 2 | 2 | 3 |
| P E_05 | 2 | 3 | 1 | 1 | 2 |
| P X_04 | 4 | 4 | 3 | 3 | 4 |
| V_01 | 4 | 5 | 4 | 3 | 5 |
| P V_02 | 2 | 3 | 4 | 3 | 2 |
| V_03 | 3 | 5 | 6 | 5 | 4 |

Table 5.3: Score of INTUI questionnaire

The evaluation result of the scores of each component according to formulae 5.2-5.5, is plotting the results in the following diagram:

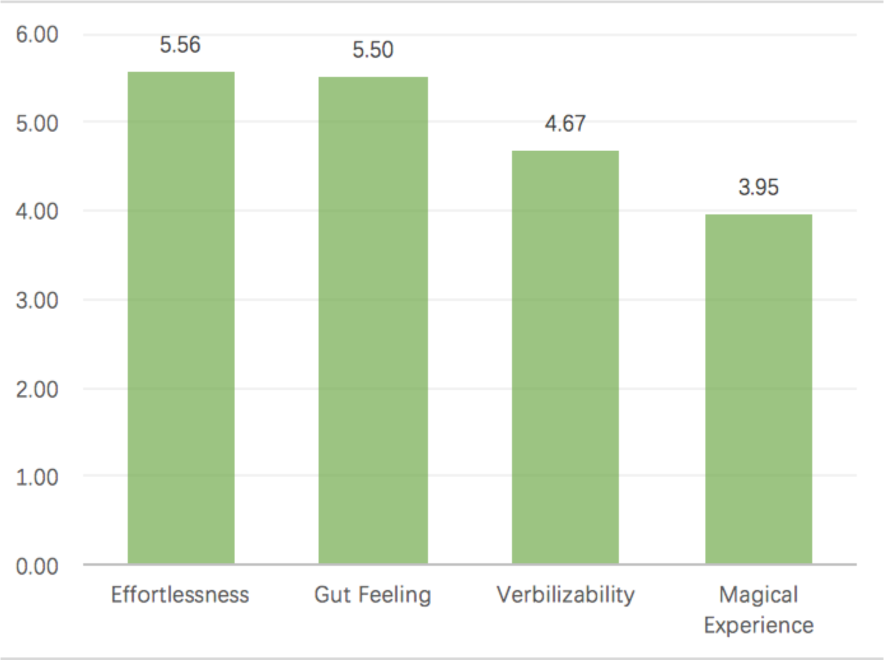


Figure 5.1: score of intuitiveness components

The results show that the scores *Effortlessness* and *Gut Feeling* are both high around 5.6 points, indicating that users generally feel natural using the forum. They are able to identify most of the functionalities without much explicit explanation. However, the relatively higher value of *Verbilizaility* of 4.67 indicates that the users are able to describe their operations browsing the forum, which means that it is not intuitive enough. This may be due to the following reasons. The authors suggest in their paper [8] that some products may have higher values of *Verbilizability* such as home appliances. The higher value here may be the result that modern answering websites follow similar design norms. The labels like “sum up”, “follow” appear in most of popular sites, thus they may remember more clearly what was going on after using the system. The last component is *Magical Experience*, which gives a lower value of 3.95, meaning that although the forum realized most of the functions and are relatively easy to use, it is far from achieving the magical experience. The page layouts, styles and special effects needs to be taken into consideration in the future to give users a more comfortable and fascinating feeling.

# 6 CONCLUSION AND FUTURE WORK

## 6.1 CONCLUSION

In this thesis a video component is added to the Graphicuss system to enable video presentation in the online answering process. Interviews with persons from different backgrounds were conducted to figure out what functionalities are needed the system should implement. Having determined the requirements, a concept of video-based answering forum was designed.

The answer editing page is rearranged with separate components that makes the answer composition more flexible. The page hierarchy is carefully considered to make the browsing process clearer and more intuitive.

Certain investigations of modern web technologies and online video techniques are carried out. The concept is implemented using modern web technologies. The time component was combined with serialized canvas to align with the video playback, enabling users to merge the utilization of video and canvas elements such as canvas editing and quoting.

## 6.2 FUTURE WORK

The SUS and INTUI questionnaire indicates that the system is good but not enough to gain popularity among users. The following two aspects should be improved.

### 6.2.1 Details

The current work fulfills the basic functionalities of a video answering site. However, a lot of details that is important to user experience is not in place.

**The hierarchy of quoting of a video could be tracked properly**. Several users may quote from the same video and edit from a certain point. Also, the same video may be quoted multiple times and each time by a series of a different set of users. These activities should be properly recorded and used as a reminder when another user is checking the video. This is important in two aspects. The first is that users will know exactly which part of the video is contributed by which user. Thus, if an error occurs or a brilliant point is made in the video, the user should know whom to blame or appreciate. Second, it also helps the protection of the authorization of the answers, which are intellectual property created through intellect and labor.

**The application range of process visualization based on video could be extended.** In this thesis the approach of using video to express a thinking path is emphasized. However, using video content expressing ideas in discussion system is just a narrow usage of video. When recording, editing and sharing videos is not a problem, more usage of this video tool could be explored.

### 6.2.2 Aesthetics

While the moderate score of *Magic Experience* component of intuitiveness show that users generally do not feel appealing while using the system, one of the future consideration should be the styling of the site. Certain design elements such as color selections fonts, page layouts, background, theme pictures should be considered.

Also, some aesthetic effects such as animations could be devised. These may involve HTML5 and CSS styling combined with JavaScript capabilities.

# LIST OF FIGURES

# LIST OF TABLES

# APPDIENX

## USER REQUIREMENT INTERVIEW QUESTONNAIRE

<table>
<tr><td colspan="7">Do you agree with the following statements? Please mark with the number you think reflects your opinion.</td></tr>
<tr><td colspan="7">1 - strongly disagree; 2 - somewhat disagree; 3 - neutral;<br>4 - somewhat agree; 5 - strongly agree</td></tr>
<tr><td>1.</td><td>Sometimes I find it difficult to explain a solution online.</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>2.</td><td>Sometimes I find it difficult to understand answers online.</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>3.</td><td>Sometimes I want to know the creation process of an answer.</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>4.</td><td>I think that to visualize the dynamic creation process is a better way to express ideas than static content</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>5.</td><td>I would like to see a dynamic record of the creation process in certain situation.</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>6.</td><td>I think it is helpful if an answer creator can explain his/her idea with an audio during his/her creation process</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
</table>

## SYSTEM USABILITY SCALE TABLE

| | | | | | |
|---|---|---|---|---|---|
| Do you agree with the following statements? Please mark with the number you think reflects your opinion. | | | | | |
| 1 - strongly disagree; 2 - somewhat disagree; 3 - neutral;<br>4 - somewhat agree; 5 - strongly agree | | | | | |
| 1. I think that I would like to use this system frequently | 1 | 2 | 3 | 4 | 5 |
| 2. I found the system unnecessarily complex | 1 | 2 | 3 | 4 | 5 |
| 3. I thought the system was easy to use | 1 | 2 | 3 | 4 | 5 |
| 4. I think that I would need the support of a technical person to be able to use this system | 1 | 2 | 3 | 4 | 5 |
| 5. I found the various functions in this system were well integrated. | 1 | 2 | 3 | 4 | 5 |
| 6. I thought there was too much inconsistency in this system | 1 | 2 | 3 | 4 | 5 |
| 7. I would imagine that most people would learn to use this system very quickly | 1 | 2 | 3 | 4 | 5 |
| 8. I found the system very cumbersome to use | 1 | 2 | 3 | 4 | 5 |
| 9. I felt very confident using the system | 1 | 2 | 3 | 4 | 5 |
| 10. I needed to learn a lot of things before I could get going with this system | 1 | 2 | 3 | 4 | 5 |

## INTUI QUESTIONNAIRE

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
|---|---|---|---|---|---|---|---|---|---|
| **While Using the product…** | | | | | | | | | Variable Name |
| …I acted deliberately | □ | □ | □ | □ | □ | □ | □ | …I acted on impulse | G_01 |
| …it took me a lot of effort to reach my goal | □ | □ | □ | □ | □ | □ | □ | …I reached my goal effortlessly | E_01 |
| …I performed unconsciously, without reflecting on the individual steps | □ | □ | □ | □ | □ | □ | □ | …I consciously performed one step after another | P G_02 |
| …I was guided by reason | □ | □ | □ | □ | □ | □ | □ | …I was guided by feelings | G_03 |
| …I felt lost | □ | □ | □ | □ | □ | □ | □ | …I easily knew what to do | E_02 |
| …I acted without thinking | □ | □ | □ | □ | □ | □ | □ | …I was able to explain each individual step | P G_04 |
| **Using the product…** | | | | | | | | | |
| …required my close attention | □ | □ | □ | □ | □ | □ | □ | …ran smoothly | E_03 |
| …was inspiring | □ | □ | □ | □ | □ | □ | □ | …was insignificant | P X_01 |
| …was easy | □ | □ | □ | □ | □ | □ | □ | …was difficult | P E_04 |
| …was nothing special | □ | □ | □ | □ | □ | □ | □ | …was a magical experience | X_02 |
| …was very intuitive | □ | □ | □ | □ | □ | □ | □ | …wasn't intuitive at all | P INT_01 |
| …was trivial | □ | □ | □ | □ | □ | □ | □ | …carried me away | X_03 |
| …came naturally | □ | □ | □ | □ | □ | □ | □ | …was hard | P E_05 |
| …was fascinating | □ | □ | □ | □ | □ | □ | □ | …was dull | P X_04 |
| **In retrospect…** | | | | | | | | | |
| …It is hard for me to describe the individual operating steps | □ | □ | □ | □ | □ | □ | □ | …I have no problem describing the individual operating steps | V_01 |
| …I can easily recall the operating steps | □ | □ | □ | □ | □ | □ | □ | …it is difficult for me to remember how the product is operated | P V_02 |
| …I'm not able to express in which way I used the product | □ | □ | □ | □ | □ | □ | □ | …I can say exactly in which way I used the product | V_03 |

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