A THESIS EVALUATION SYSTEM

by

Yanhua Zong

A Thesis

Submitted to the Faculty of Purdue University

In Partial Fulfillment of the Requirements for the degree of

Master of Science

Department of Computer Graphics Technology

West Lafayette, Indiana

May 2019

THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL

Dr. David Whittinghill, Chair

Department of Computer Graphics Technology

Dr. Carlos Morales

Department of Computer Graphics Technology

Dr. Tim McGraw

Department of Computer Graphics Technology

Approved by:

Dr. Nathan Hartman

Head of the Graduate Program

This thesis is dedicated to my advisor Dr. David Whittinghill for his constant guidance and encouragement, and my families for their love and support.

ACKNOWLEDGMENTS

My deepest gratitude goes first to my thesis advisor Prof. David Whittinghill for his constant encouragement and guidance. Prof. Whittinghill has walked me through the design of this online thesis evaluation system and steered me in the right direction in the development and testing of this system.

I sincerely appreciate Prof. Carlos Morales, Prof. Tim McGraw, and Prof. Kyle Lutes for their valuable suggestions on the design and development of this system as well as the writing of this thesis. Without their professional inputs, this thesis could not reach the present form.

I would like to thank the graduate students in Computer Graphics Technology Department who actively participated in the testing of this system. A special thank would go to Brantly McCord, Jun Zhang, and Yichen Sheng for their insightful feedbacks on this system as well as great help in my study.

Finally, my thanks would go to my beloved family especially my husband Xiangeng Meng for their unfailing support and great confidence in me all through my years of study and the writing of this thesis.

Author
Yanhua Zong

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Author: Zong, Yanhua. MS
Institution: Purdue University
Degree Received: May 2019
Title: A Thesis Evaluation System
Committee Chair: David Whittinghill

With the development of web-based technologies, online evaluation systems have been replacing paper-based ones in various domains at a fast pace because of their many advantages such as easy administration, high efficiency, and eco-friendliness. This study aims at developing an online thesis evaluation system which can act as a substitute to the paper-based one being currently used in Department of Computer Graphics Technology at Purdue. Chapter 1 is an overall introduction of this study. It starts with a brief description of the problems that currently exist in the paper-based thesis evaluation systems and the significance of the online counterparts, followed by the introduction to the purpose of this study. It is hypothesized that the developed online evaluation system could exhibit good performance, usability, and reliability. The assumptions made in this study, the delimitations and limitations of this study as well as the relevant definitions are presented consequently. Chapter 2 briefly reviews the research background of online evaluation systems developed thus far, as well as the development and assessment methods utilized in those literature. Chapter 3 describes the methodology used in this study, which is comprised of two major parts: (i) design and development of the developed online system, and (ii) assessment of the system. A description of several key features in the developed online evaluation system is included in this chapter. Chapter 4 focuses on analyses of the experimental results on the performance, usability, and reliability of the developed online evaluation system. The performance of the system is tested in three aspects including functionality, security, and accessibility. The usability of the system is tested regarding the interactivity, simplicity, navigability, and readability of the developed system. The reliability is assessed by comparing the experimental results obtained in two independent trials. Chapter 5 makes conclusions to the developed system based on the experimental results and discusses the major issues of the developed systems as well as the limitations in the adopted assessment approach. Recommendations for future studies are proposed to ultimately improve the developed system.

CHAPTER 1. INTRODUCTION

Design and development of appropriate evaluation systems is of significance in attaining timely feedbacks on the quality of products and services and eventually achieving purposely control over the quality. Previously, the evaluation systems were dominant with paper-based systems. The processing of the data obtained in such systems is often laborious and time consuming. In recent years, with the development of web-based technologies, many online evaluation systems have been developed. For instance, online evaluation of course and instruction has been widely used in colleges and universities (Burton, Civitano, & Steiner-Grossman, 2012; Capa-Aydin, 2016; El-Rahman, 2016); online testing systems have been applied to well-known exams (e.g. GRE, TOFEL). Compared to paper-based ones, the online evaluation systems have been proved to have comparable evaluation results while being more efficient and ecofriendly. As a result, more and more paper-based evaluation systems are being replaced by online evaluation systems

1.1 The Problem

The evaluation of graduate students' theses is important to a student's success and a university's reputation. Currently, the students' theses in Department of Computer Graphics Technology (CGT) at Purdue are evaluated by committee members through a conventional paper-based system. The committee members get an evaluation sheet with some basic information like the student's name and advisor, thesis title, committee members, and so on, prior to the defense. This evaluation sheet contains rubrics to assess the thesis and comment sections. At the end of the defense, each committee member fills out the evaluation sheet and turns it in to the chair of the evaluation committee. The chair then summarizes all the ratings as well as comments and provides the result to the student. A copy of the complete forms will also be sent to the associate dean for records of the graduate programs. The current thesis evaluation system, despite being used in many universities, has many disadvantages. First, the evaluations are tedious to complete and time consuming. The chair of the evaluation committee has to collect all the evaluation sheets, compare all the ratings for each rubric, and put together all the comments. Second, it is difficult and inconvenient to store and organize the ever-increasing evaluation results as well as to find a historical record. This raises concerns about possible unfairness or discrimination in the process

of thesis evaluation. Finally, by doing it with paper documents it is not ecofriendly. Considering the continuing deterioration of our environment, it is urgent to make every effort to save the natural recourses.

1.2 Significance

In recent years, the graduate school of Purdue is expanding, and the number of graduate students is increasing rapidly. In the fall of 2017, there were 9,626 graduate students enrolled, 165 more than the previous year ("Purdue sets record for student enrollment" 2017). The evaluation of students' theses with the current paper-based system has thus become a big burden to the department and the committee members. In addition, the difficulty in reviewing historical records of the evaluation results could raise doubts in the quality of the graduate students and the graduate program, which will then weaken the university's reputation. Therefore, it is of great significance to develop an online thesis system to replace the current paper-based one.

1.3 The Purpose

The purpose of this project is to develop an online thesis evaluation system and determine its potential to replace the current paper-based-one by testing its performance, usability, and reliability. It is expected that this new evaluation system will increase the efficiency in the thesis evaluation process and reduce the workload of the advisors and committee members. It will also make the storage, organization, and visualization of evaluation results easier. In addition, the visualization of the data in this system will make the evaluation process more transparent, thus help to rule out any possible unfairness or discrimination.

1.4 Hypotheses

The hypotheses that were tested are:

- The developed online thesis evaluation system can perform the required tasks correctly and securely.
- The developed online thesis evaluation system is easy to use.
- The developed online thesis evaluation system is reliable.

1.5 Assumptions

It is assumed that the users of the online thesis system have internet access and basic knowledge of using electronic devices (e.g. computer, iPhone, iPad). Also, respondents in the experiments provided truthful answers and not just the ones they thought the researcher wished to hear.

1.6 Delimitations

Because this evaluation system was tested by graduate students in Department of CGT at Purdue, due to the limited number of graduate students, the sample size was small, and the samples were convenient samples instead of simple random samples.

1.7 Limitations

Because this evaluation system was tested by graduate students in Department of CGT at Purdue, due to the limited number of graduate students, the sample size was small, and the samples were convenient samples instead of simple random samples.

1.8 Definitions

- Online course evaluation system refers to a web application for evaluating the quality of a course.
- Online testing system refers to a web application for evaluating student's knowledge after taking a course.
- Online thesis evaluation system refers to a web application for evaluating student's thesis as well as the defense.
- The performance measures if a web application meets specifications and fulfills its intended purpose (Schmidt, 2013).
- The usability is the degree to which a web application can be used by end users ("What is usability testing? | Experience UX," 2018).
- The reliability measures the probability that a web application will work properly in a specified environment and for a given amount of time (Wikipedia, 2014).

1.9 Summary

In summary, the current paper-based thesis evaluation system has many disadvantages such as laborious, time-consuming, and inefficient. Considering the success of many online evaluation systems, it's expected an online thesis evaluation system will be a good substitute to the current paper-based one. The purpose of this study is to develop an online thesis evaluation system which not only simplifies the evaluation process but also features easy storage, easy organization, and visualization of the evaluation results. Its performance, usability, and reliability were also assessed to find out its applicability.

CHAPTER 2. LITERATURE REVIEW

Online evaluation systems have been applied in many domains, from the evaluation of various products and processes to the evaluation of people and relationships. However, there is no online thesis evaluation system reported so far. In this literature review, online course evaluation systems and online testing systems were selected as a focus because of their similarities with the proposed system. The literature review was conducted in three aspects: the research background, the developing methods, and the assessing methods. The first aspect includes the development status of online evaluation systems and their advantages/disadvantages. The second one includes the structure of the online evaluation systems as well as scripting languages or frameworks used for building such web applications. The third one includes what instruments, procedures and analyses were used to assess the online evaluation systems.

2.1 Research background

Because of their well-known advantages like convenience, high efficiency, simple administration, and so on, online evaluation systems are replacing the traditional paper-based systems at a fast pace. In 2003, Hoffman surveyed 500 US institutions to identify the prevalence of usage of online evaluation of course instruction (Hoffman, 2003). The result showed that 10% of participating institutions used online surveys as a principal method of data collection. This is 8% more in usage compared to Hmieleski and Champagne's investigation of online course evaluation in 2000 (Capa-Aydin, 2016). It is also reported that most universities in Korea conduct course evaluation surveys online (Park & Cheong, 2018). In early 1990s, ASVAB and GRE began to adopt online testing systems. Since then, many admissions, placement, certification, and licensure testing programs are administered via online systems, with the number growing each year (Swygert, 2009). It is believed that all tests will one day be delivered on a computer of some sort (Bennett, 2008).

Despite their many advantages and rapid development, there are also concerns raised about online evaluation systems. For the online course evaluation systems, many people feared that going online would be accompanied by a large drop in response rates, thereby compromising the quality of the data. Some course leaders worried that disgruntled students would be more highly motivated than

other students to fill out their evaluations and, assuming a less than perfect response rate, this differential motivation would bias the results in a negative direction (Burton et al., 2012). For the online testing systems, computer anxiety, perceptions of computer self-efficacy, as well as test security and the potential for cheating are also frequently cited as concerns (Yerushalmy, Nagari-Haddif, & Olsher, 2017).

In contrast, none of the aforementioned concerns can be foreseen in the proposed online thesis evaluation system. In this system, committee chair and members will rate the students' thesis. There won't be worries about the response rates, computer anxiety, etc. In addition, the rating obtained from this system will be more reliable than that obtained from the paper-based system because with this online evaluation system possible bias of rating could be scrutinized from the visualized reports of the evaluation results. Therefore, replacing the current paper-based thesis system with online system will be a benefit without risk.

2.2 Developing methods

An online evaluation system typically includes multiple user pages. One of them is administrator page which allows administrator to modify the rating items and manage user accounts. The rest of pages allow other users to do the evaluation or view the results (El-Rahman, 2016; Mimi & John, 2011; Petrişor, Măruşteri, Ghiga, & Schiopu, 2011). The development of such system usually involves client and server technologies as well as database management system like MySQL. Nowadays, there are various technologies to help build web applications easily, such as JavaScript-based frameworks/library (Angular, React, etc.), ASP.NET-based frameworks (ASP.NET web pages, ASP.NET MVC, etc.), and so on. The JavaScript-based ones are purely client side and have to be used with server-side languages like PHP, Node.js, ASP.NET core, etc., while ASP.NET-based ones are server-side frameworks integrated with client-side scripting. There are followers to each technology and which technology to choose is generally decided by the need, skills, and preference of the developer. Petrişor et al. mentioned that they developed an online testing system using JavaScript and PHP as the client and server technologies and MySQL as a database management system (Petrişor et al., 2011). El Rahman stated that he created an online course evaluation system with ASP.NET and SQL (El-Rahman, 2015). However, there does exist an opinion that JavaScript-based technologies are better because they have an impact strictly on client

machine while ASP.NET-based ones impose extra load on web server due to rendering and their mixed-code nature makes them hard to use (Huluta, 2013).

2.3 Assessing methods

In previous studies, there were two ways to assess an online evaluation system: through comparing its evaluation results with those obtained from the corresponding paper-based or standard system, and through surveying or interviewing participant's opinions.

The former was widely used in the assessment of online course evaluation and online testing systems. Thompson et al. tried to explore whether Knowla, an online assessment tool which measures a student's reading and writing skills, is valid (Thompson & Braude, 2015). To achieve this goal, they used passages and questions drawn from established, already validated materials like SAT Practice test in the Knowla tests so that the participants' Knowla score could be compared with their previous SAT score. 225 Boston University students were randomly selected as participants and multiple regression analyses were conducted to determine whether SAT reading score and SAT writing score had an effect on Knowla scores. Similarly, Burton et al. explored the validity of an online clerkship evaluation system by comparing the response rate, rating, as well as the length and informativeness of comments obtained from the online and paper-based systems (Burton et al., 2012). Data from six-and-a-half years of clerkship evaluations were used, some collected before and some after the conversion from a paper to an online evaluation system, and the change in response rate, rating, and the length of comments due to the change from paper-based to online evaluation system were analyzed.

The latter is a general method in investigating the quality, performance, usability, and reliability of products and services. The instruments (e.g. survey items, interview questions) in this method are essential to the success of assessment. However, there is no report regarding the design of the instrument for the assessing of online evaluation system. El_Rahman used interviews to test the performance of an online course evaluation system but failed to mention what questions were asked (El-Rahman, 2016). Nonetheless, many instruments for evaluating websites and web applications have been developed (Fernandez, Abrahão, & Insfran, 2013; Fernandez, Insfran, & Abrahão, 2011; Lee & Kozar, 2012; Suarez-Torrente, Conde-Clemente, Martínez, & Juan, 2016;

Tezza, Bornia, & Andrade, 2011; Olsina, Papa, & Molina, 2007). Tezza et al. (2011) constructed an instrument with 32 items to measure usability in e-commerce websites using item response theory. Lee et al. (2012) developed an instrument measuring ten factors of website usability including simplicity, interactivity, consistency, etc., and examined the usability of the items through an exploratory factor analysis. Olsina et al. (2007) described how to measure and evaluate web applications and evaluated an Amazon shopping cart using a tool measuring functionality, content, usability, and reliability. Since online evaluation systems are also web applications, these instruments can provide useful information for constructing an instrument to assess the performance, usability, and reliability of online evaluation systems.

2.4 Summary

In summary, the research background of online evaluation systems and the methods to develop and assess them were reviewed. Online evaluation systems are replacing paper-based systems at a fast pace. Despite there are concerns about some of the systems, the proposed online thesis evaluation system is expected to be beneficial without risk. Both JavaScript-based and ASP.NET-based frameworks are promising tools for the development of online evaluation systems with JavaScript-based frameworks to be preferable. The performance, usability, and reliability of the online evaluation systems can be assessed through comparative study with paper-based or standard systems as well as surveys and interviews

CHAPTER 3. METHODOLOGY

This study includes two parts: development of the online thesis evaluation system; and assessment of its performance, usability, and reliability. The details of the experimental and the action timeline are described as follows.

3.1 Design and development of the online thesis evaluation system

3.1.1 Technologies utilized

Five technologies, including Angular 6, PHP, MySQL, D3 (Data Driven Documents), and Bootstrap, have been adopted in the development of the system. Among them, Angular 6 and PHP were used to create the proposed online thesis evaluation system, MySQL was used as the database management system, and D3 was used for the data visualization. As mentioned above, JavaScript-based technologies are perceived to be better than ASP.NET-based ones. As one of JavaScript-based technologies, Angular is selected because it is powerful, modern, and compatible with various operation platforms (web, mobile, desktop native) (Bodrov-Krukowski, 2018). In addition, Angular provides not only the tools but also design patterns for web development, and it can be easily tested. D3 is a JavaScript library for manipulating documents based on data, allowing for the building of data visualization frameworks (“Why build Data Visualizations with D3.js” 2014). PHP and MySQL are chosen as the server-side technology and database management system mainly because of their ready access and popularity. In addition to the above-mentioned technologies, Bootstrap was adopted as well to format the webpages.

3.1.2 Design of the site structure

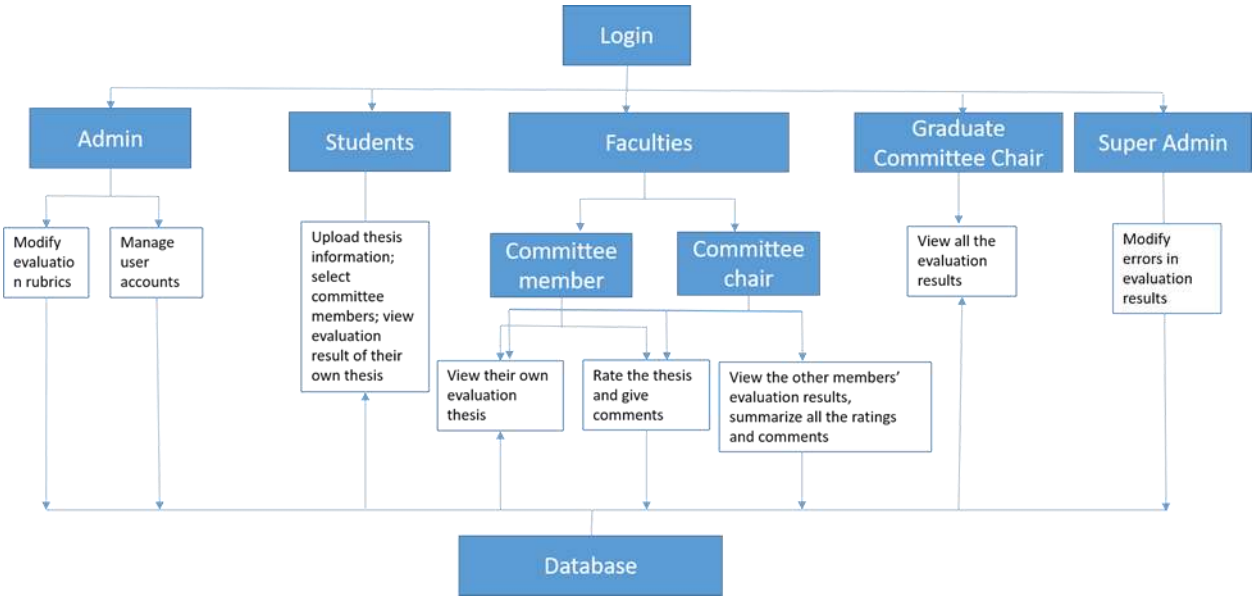


Figure 1 A schematic diagram of the site structure of the proposed online thesis evaluation system.

Fig. 1 shows a schematic diagram of the site structure of the proposed online evaluation system. This system has the following user groups: admin, students, faculties, graduate committee chair, and super admin. After login, they will be directed to different pages. Admin can modify the evaluation rubrics and manage user accounts. Students can upload their thesis and defense information, select the committee chair and members from a list of faculties, and view the final evaluation results of their thesis. Faculties can access a list of theses with their role indicated. By clicking on each of the theses, they will enter the evaluation page to either do the evaluation or view the results if the evaluation has been completed. All the evaluation results will be saved in the database. If the faculty serves as the committee chair, he/she will also be able to view the other committee members' evaluation results and summarize them as a final one. The graduate committee chair can view the trend of the evaluation results from all committee members. He/she can also select one faculty to view the trend of all his/her evaluation results of different theses and select one of the theses that this faculty has reviewed to examine the corresponding evaluation results. The super admin can pull out the evaluation results of any thesis and make modifications. The role and permission of the five user groups are summarized in Table 1.

Table 1 Role and permission of different user groups

User	Role	Permission
Admin	● Modify the evaluation rubrics; ● Manage user accounts.	● Read, create, and delete user information; ● Read, create, update, and delete evaluation rubrics.
Student	● Upload the thesis and defense information; ● Select committee chair and member.	● Create and modify thesis information including thesis title, committee members, and defense date; ● Read evaluation results of their own thesis.
Faculty	● Do evaluations.	● Create evaluation results; ● Read the evaluation results made by their own. ● Read the evaluation results of a thesis from the other committee members if he serves as the committee chair.
Graduate Committee Chair	● Oversee all the evaluation results to ensure the fairness of thesis evaluation and supervise the quality of students' theses.	● View the trend of the evaluation results along time, the trend of the evaluation results for students with different race, the trend of the evaluation results for students with different gender, and the trend of evaluation results from a faculty versus if this faculty served as a committee chair; ● Read all the evaluation results.
Super Admin	● Modify the evaluation results to avoid unintentional mistakes.	● Read all the evaluation results; ● Modify all the evaluation results.

To ensure the intactness of the data, faculties are not allowed to modify any evaluation results once the evaluation form is submitted. In addition, to make sure that the committee chair grades the

thesis based on the evaluation results from all committee members, he cannot grade the thesis until he receives the evaluation results from all the members. In addition, students are not allowed to make any modifications to their thesis information after their thesis is graded to avoid any breakdown of the database.

3.1.3 Site components

Based on the designed site structure, this online evaluation system mainly contains eight components: login component, admin component, student component, committee component, committee evaluation component, head component, super admin component, and update user component. The admin component has two child components: admin user component and admin rubric component. The details of each components are described as below.

3.1.3.1 Login component

Fig.2 shows the login page of the system. It simply asks users for email and password for authentication. After the correct information is provided, the user will be directed to the page that they have permission to visit. Otherwise, the user will be redirected to this page and an error message will show on the screen.

Figure 2 Login page

3.1.3.2 Admin component

Admin component serves as the home page of its two child components: admin user component and admin rubric component. It has two buttons linking to its child components and a main content area showing the child components. As default, admins will see admin user page after they login.

3.1.3.2.1 Admin user component

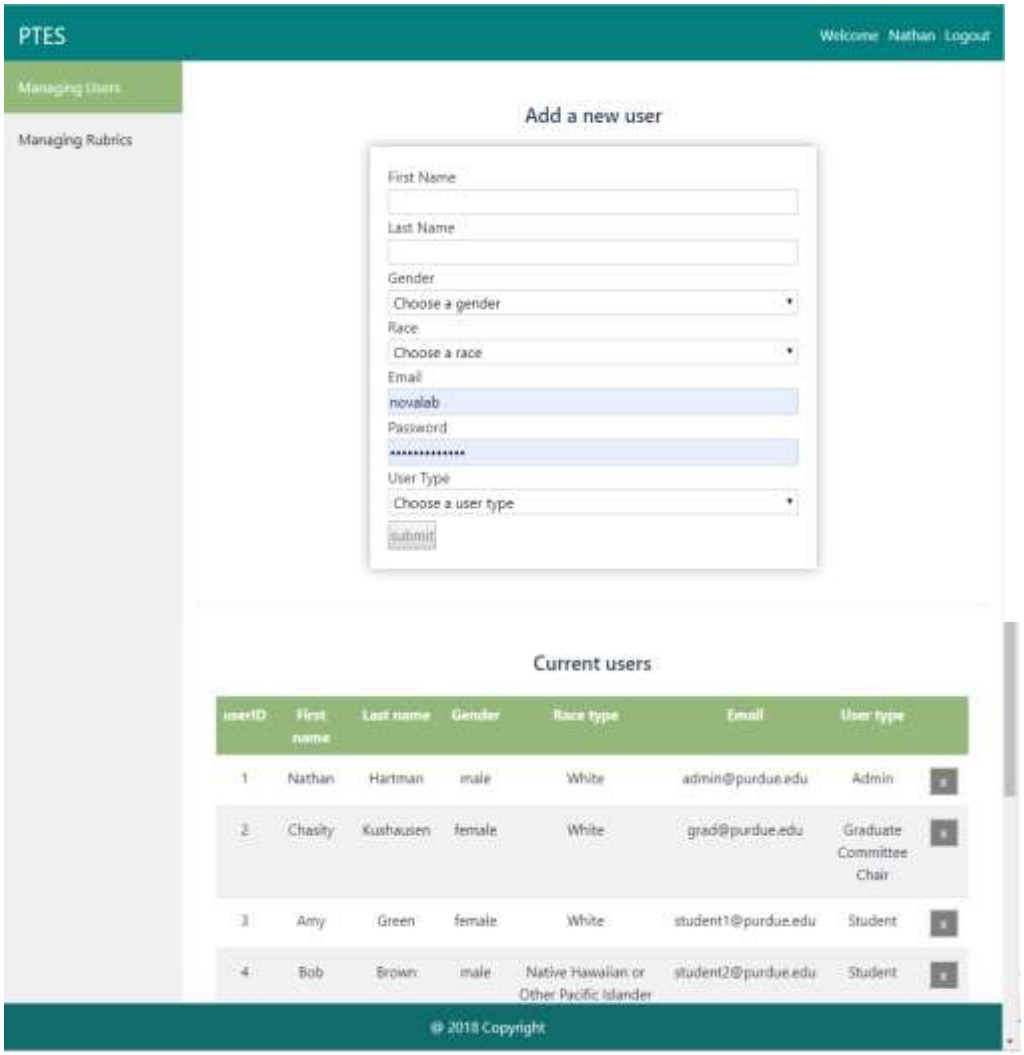


Figure 3 Admin user page

Fig. 3 shows the admin user component page of the system. It contains two parts: a form for admins to add new users and a table to display the information of all users. To create a new user, admins need to input the user's basic information like first and last name, email, gender, race, give this user account an initial password, and select a user type. The user's password can be changed later

by the user himself after he/she logs into the system. Admins can only create users for student, faculty, graduate committee chair, and admin. Considering that super admin has the power to modify any evaluation data, only one super admin is allowed in this system to ensure the security of the data, which is directly created in the database.

Admins can check the users' information from the "Current users" table located below the form. They can also delete any users except the super admin by clicking the "x" button at the row of the user to be deleted.

3.1.3.2.2 Admin rubric component

Admin rubric component is for admins to manage the rubrics for evaluating thesis document and thesis defense. Admins can fully manipulate the evaluation rubrics. They can add categories for evaluating thesis document or thesis defense, add attributes to each category, and add options to each attribute using the text boxes shown in Fig. 4. An example of a category for evaluating thesis defense can be "Quality of presentation" and an example of an attribute for this category can be "How is presentation presented?". The options are designed on a 5-scale and admins can indicate where one option is on the 5-scale by assigning the rank of this option. Admins can also edit any fields by simply clicking on the title and delete any fields by click the "x" button located to the right of the title of each field.

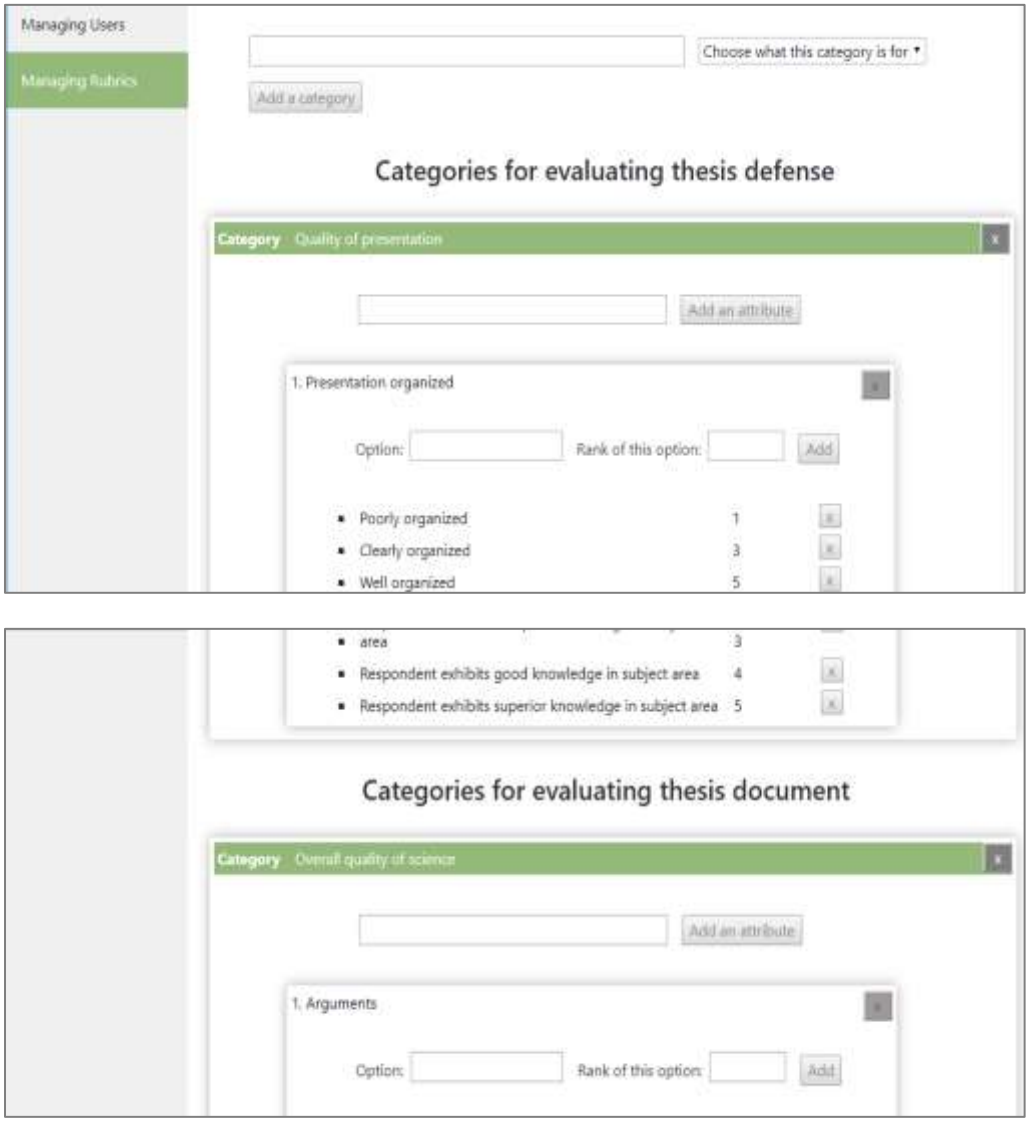


Figure 4 Admin rubric page

3.1.3.3 Student component

As shown in Fig. 5, the student page provides a form for students to input the basic information of their theses, including the thesis title, defense date, and selection of committee chair and members. A committee needs to have one committee chair and at least two committee members. The maximum number for committee members is limited to be four. Algorithm has been added to avoid the show-up of the selected faculty in subsequent selections. This prevents students from selecting the same faculty for multiple selections.

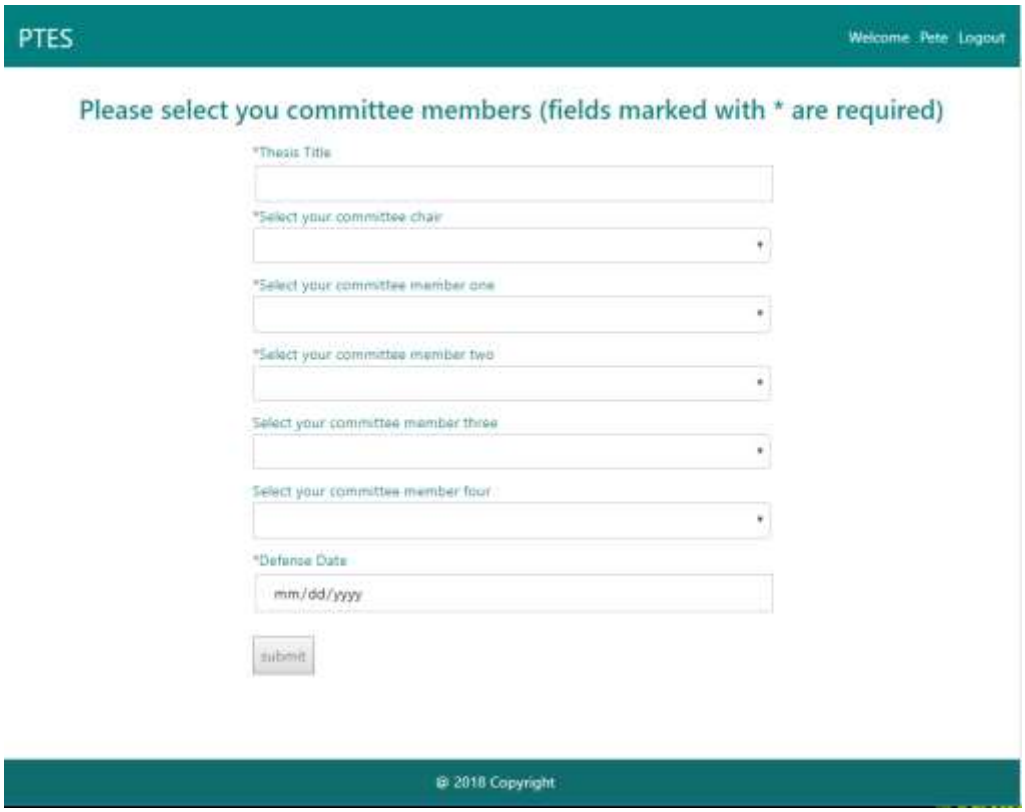
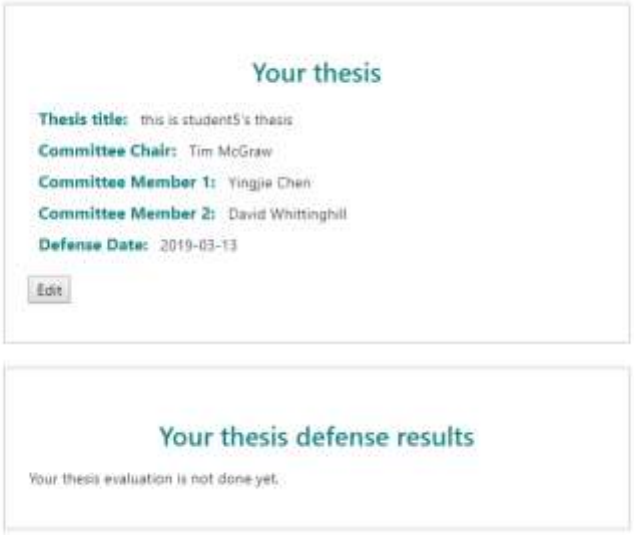


Figure 5 A student page with a form for students to input their thesis title and defense date as well as select their committee chair and members

After students submit the form, the screen will appear like Fig. 6 A). The upper section shows the information on the student's thesis and the committee. The student can make changes to this information by click the "Edit" button before the thesis defense has been evaluated. Once the thesis has been graded, the "Edit" button will hide and the evaluation results will show up in the lower section shown in Fig. 6 B).

A)



B)

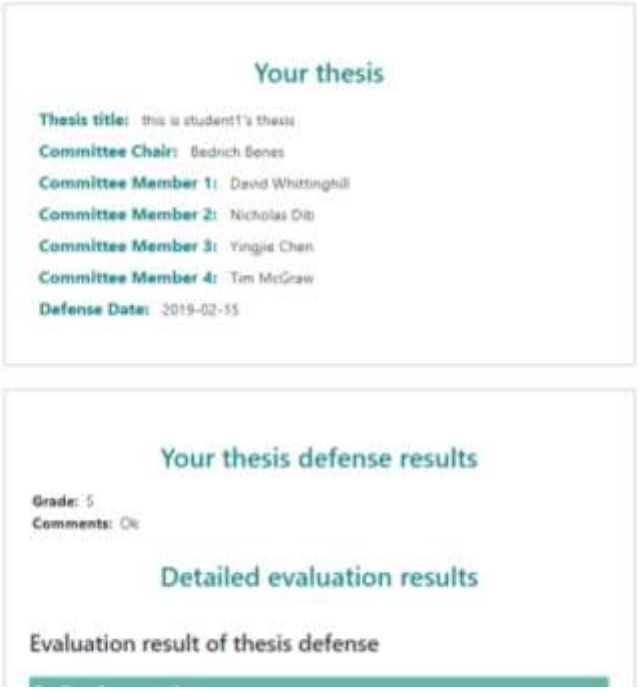


Figure 6 A student page before A) and after B) student thesis has been graded

3.1.3.4 Committee component

Fig. 7 shows a typical committee page. It lists the theses already reviewed and to be reviewed by the faculty. If a faculty serves as committee chair on a thesis, this thesis will only be listed under

“Theses reviewed” after it’s finally graded. By clicking on “View results” or “Start to do evaluation”, the faculty will be directed to committee evaluation page.

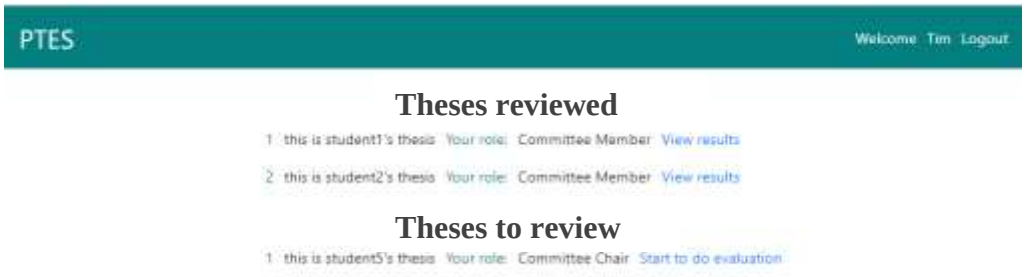


Figure 7 Committee page

3.1.3.5 Committee evaluation component

Committee evaluation page is where the faculties do the evaluations. Faculties not only need to evaluate the thesis document and defense based the rubrics admin created but also rate and comment the thesis document and defense, as shown in Fig. 8.

After the evaluation results are submitted, they will be shown on the screen, and faculties cannot make any changes anymore. If there are any unintentional mistakes, faculties have to contact super admin who will then revise the evaluation results accordingly.

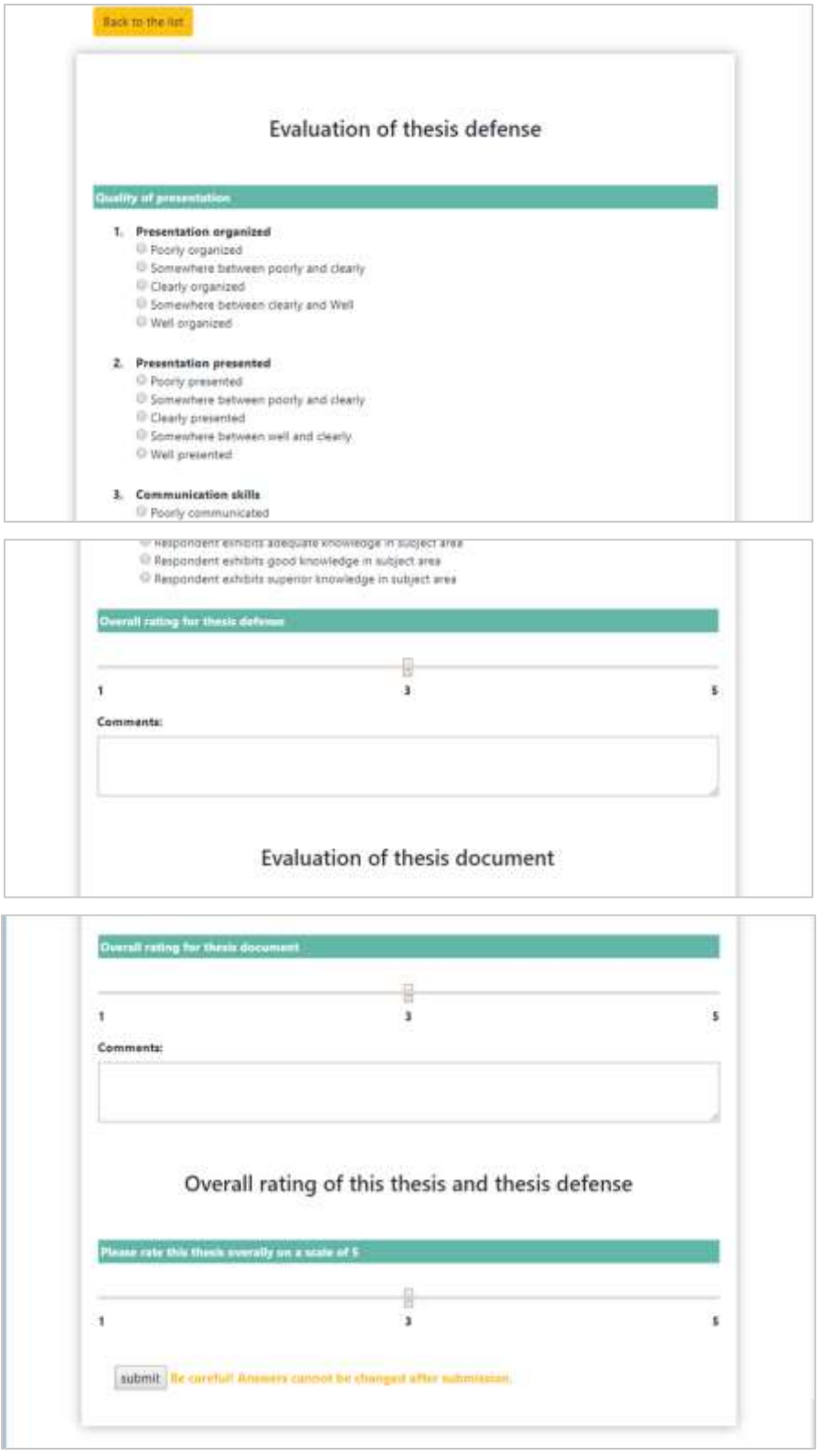


Figure 8 Committee evaluation page: form for evaluating the thesis document and defense

If a faculty serves as committee member on the thesis, after submission his job on this thesis will be finished. If a faculty serves as committee chair, after submission a button will show up at the bottom of the screen, as shown in Fig. 9.

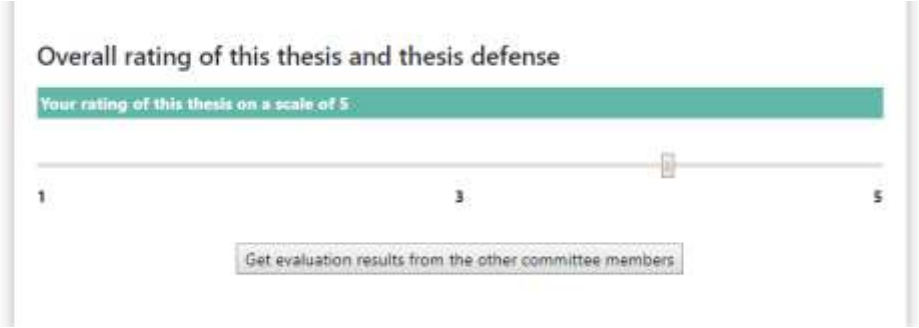


Figure 9 Committee evaluation page: button to get evaluation results from the other committee members.

By clicking this button, the committee chair can retrieve the evaluation results from all the other committee members. After all the evaluation results are retrieved, a new form will appear at the bottom, as shown in Fig. 10. Committee chair can use this form to grade this thesis and give comments based on the evaluation results from all the committee members.

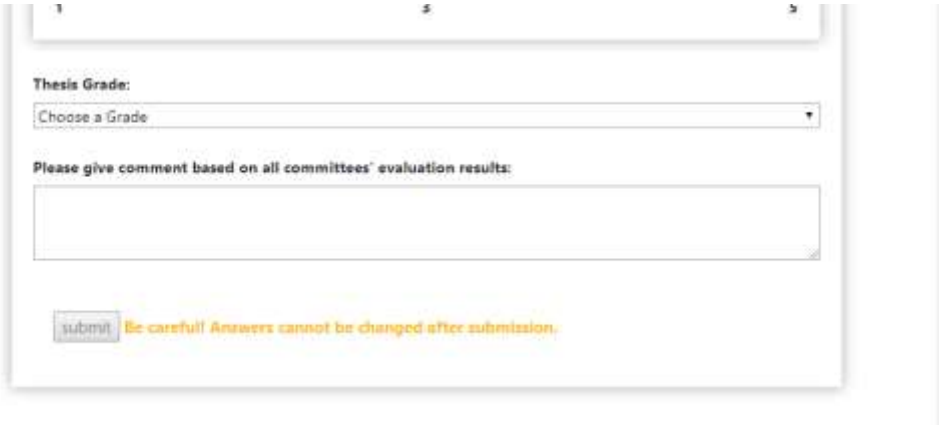


Figure 10 Committee evaluation page: form for grading the thesis

3.1.3.6 Head component

Head component is designed for the graduate committee chair to supervise the evaluation process and all the evaluation results. After login, charts of all thesis grade over time as well as versus students' race and gender are presented on the screen, as shown in Fig. 11.

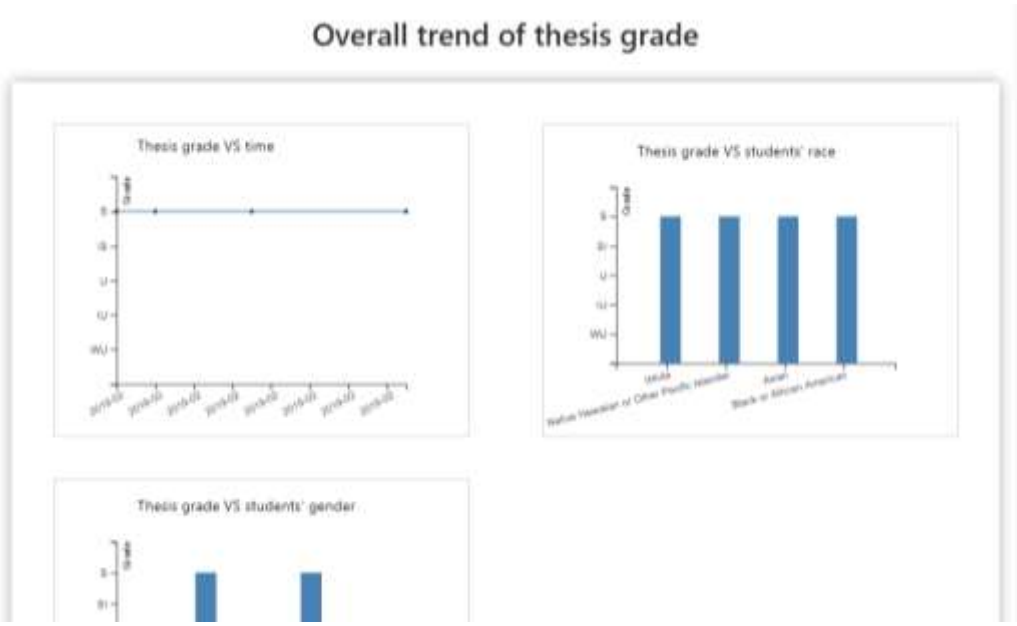


Figure 11 Head page: charts of thesis grade

At the bottom of the page are three selectors, as shown in Fig. 12. With the first selector graduate committee chair can select one specific faculty to examine the trend of his ratings, as shown in Fig. 13. The graduate committee member can further use the second and third selectors to select one specific thesis reviewed by the faculty and check his/her evaluation results, as shown in Fig. 14.

Figure 12 Head page: selectors for choosing a faculty and a thesis

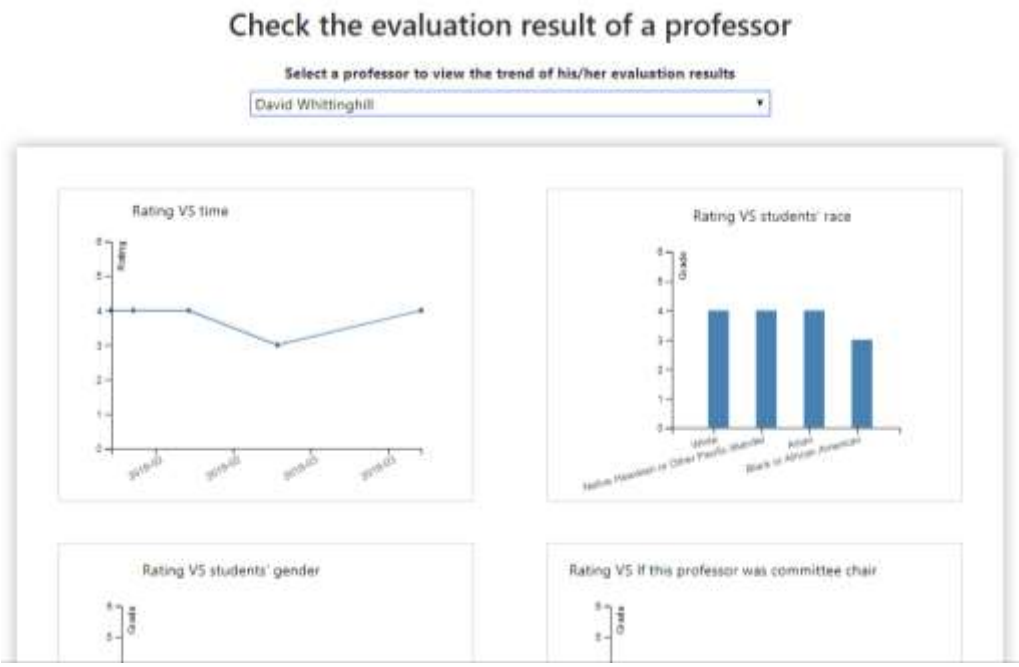


Figure 13 Head page: checking the trend of ratings from a faculty

Figure 14 Head page: checking the evaluation result of a thesis from a faculty

3.1.3.7 Super admin component

Super admin page is designed for modifying any unintentional mistakes in the evaluation results. As shown in Fig. 15, super admin can select a faculty and then select a thesis that this faculty reviewed. Evaluation forms will be pulled out with the evaluation results from this faculty

prepopulated. Super admin can make any changes in this form and submit the results to the database.

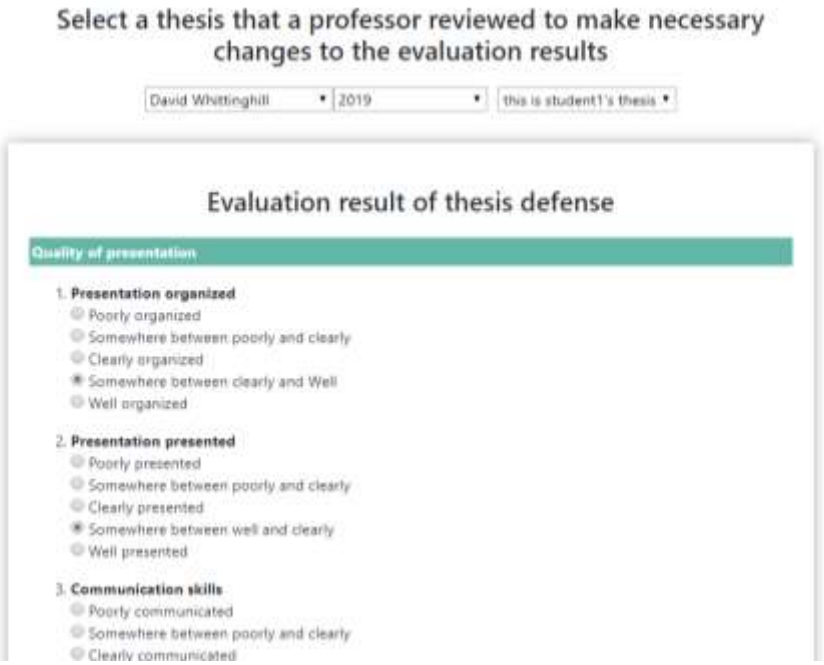


Figure 15 Super admin page

3.1.3.8 Update user component

Updated user component is designed for users to update their profile. By clicking their user name on the header of the page, they will be directed to update user page, as shown in Fig. 16. Users can update their user information and return to their previous page.

Figure 16 Update user page

3.1.4 Site security

The security of a web application is crucial because such application is internet-exposed and can attract attackers from different locations and various levels of scale and complexity. In this project, JSON web Tokens (JWT) based authentication and input coding were implemented to ensure the site security.

JWT is a JSON-based open standard used for securely transmitting information between parties (Dalisay, n.d.; Mushtaq, n.d.). They are encrypted and designed to be very compact and URL safe. An example of JWT is shown below:

```
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJpYXQiOjE0MTY5MjkxMDksImp0aSI
6ImFhN2Y4ZDBhOTVjIiwic2NvcGVzIjpbInJlcG8iLCJwdWJsaWNfcmVwbyJdfQ.X
CEwpBGvOLma4TCoh36FU7XhUbcskygS81HE1uHLf0E
```

It contains three strings which are separated by a dot. The first string is the header component which contains information about how JWT signature should be computed. The second one is the payload component which is the data such as user ID, name, etc. that is stored inside the JWT. The third one is the signature component which contains a cryptographic signature for being decoded to binary data. To create the signature component a secret key is required. This secret key will then

be used to verify the signature against the contents of the token when it's received by an application. In this project, A JWT-helper library is used to generate a JWT based on the provided email and password and to decode the JWT to fetch the user information.

Angular Route Guards were implemented to ensure that certain user groups can only assess certain pages and keep a user's session persistent. They are interfaces which can tell the router if it should allow navigation to a requested route. The setup of routes in this project is shown below:

```
Routes = [
  { path: '', redirectTo: 'login', pathMatch: 'full' },
  { path: 'login', component: LoginComponent },
  { path: 'admin', component: AdminComponent, canActivate:
[AuthGuardService],data:{permission:{only:['user','Admin'], redirectTo:
'login'}},children:[
    { path: '', redirectTo: 'adminuser', pathMatch: 'full' },
    { path: 'adminuser', component: AdminUserComponent},
    { path: 'adminrubric', component: AdminRubricComponent}
  ]},
  { path: 'student', component: StudentComponent, canActivate:
[AuthGuardService],data:{permission:{only:['user','Student'], redirectTo:
'login'}}},
  { path: 'committee', component: CommitteeComponent, canActivate:
[AuthGuardService],data:{permission:{only:['user','Faculty'], redirectTo:
'login'}}},
  { path: 'committee/:id', component: CommitteeEvaComponent, canActivate:
[AuthGuardService],data:{permission:{only:['user','Faculty'], redirectTo:
'login'}}},
  { path: 'head', component: HeadComponent, canActivate:
[AuthGuardService],data:{permission:{only:['user','Graduate Committee Chair'],
redirectTo: 'login'}}},
  { path: 'super-admin', component: SuperAdminComponent, canActivate:
[AuthGuardService],data:{permission:{only:['user','Super Admin'], redirectTo:
'login'}}},
  { path: 'update', component: UpdateUserComponent, canActivate:
[AuthguardUpdateUserService]}
];
```

Two services were created: AuthGuardService and AuthGuardUpdateUserService. The former was used to ensure certain users to be navigated to certain routes, and the later was used to allow all type of users to be navigated to UpdateUserComponent to update the user information.

To avoid SQL injections, input validation was used in the PHP files with functions like “mysql_real_escape_string()” to ensure that any dangerous characters like “'” are not passed to a SQL query in data.

Another layer of implemented security measure is the log file. Whenever a user tries to log into the system, a log containing the login email, time, and the login status will be created in the mylog.txt file. This file can be used to track any malicious use of the system including unauthorized login, unauthorized change of the data, etc.

3.2 Assessment of the online thesis evaluation system

As mentioned above, there were two ways that have been reported to assess online evaluation systems: 1) assessing online evaluation systems through comparison between the evaluation results obtained from the online and paper-based system; and 2) assessing online evaluation systems through surveys. In the present study, committee members and chair will rate students’ thesis and make comments in a similar way they do in the paper-based system. It’s expected that the first method won’t provide useful information on the performance, usability, and reliability of this system. Therefore, the survey-based method was used to assess the developed system in this study. The details of the experimental design are described as follows.

3.2.1 Population and sample

The population involved in the survey is graduate students from CGT department. Since this study had a relatively short time span, a small number of participants were managed to participate in the experiments. The samples for two trials of the experiments were 10 and 5 students, respectively.

3.2.2 Variables

The performance of this online thesis evaluation system was assessed through the measurement of its functionality, security, and accessibility. The functionality measures if all functionalities of the system meet the requirements; the security measures if this application is protected from security risks; and the accessibility measures the loading speed of the webpages and if they are viewable in different browsers or operating systems. As a limitation of this study, the accessibility for disabled people was not addressed. The usability of this system was measured with respect to the

interactivity (how interactive the webpages are), simplicity (how easily the contents on the webpages can be understood), navigability (how easily to go between different webpages), and readability (how clear the website's wording is) (Lee & Kozar, 2012). The reliability of the system was measured by comparing the performance measured from two trials of the experiment.

3.2.3 Method

An admin, a graduate committee chair and a super admin account were created prior to the testing. After signing the consent form, the participants were recommended to do the following tests:

- Log into the system as an Admin and test the Admin page by manipulating the evaluation rubrics and user accounts. Create at least one student account and three faculty accounts and then record the accounts' information.
- Log into the student account created to upload the information about a thesis.
- Log into the faculty accounts created to do evaluations.
- Log back into the student account to check the evaluation results.
- Log in as a super admin to make some modifications to the evaluation results.
- Log back into the faculty accounts to check the modified evaluation results.
- Log in as a graduate committee chair to check the evaluation results.

The participants were asked to fill out a survey form after the testing. About one week later the second trial of the experiment were conducted. The same participants were asked to repeat the above testing, check the data generated in the first trial, and fill out the survey again.

3.2.4 Instrument

The survey instrument consists of 5-point Likert-type items with response choices ranging from "strongly disagree" to "strongly agree" and a few comments area to collect participants' opinions. It was built based on common questions to access the validation of web applications as well as reported items for accessing web pages (Fernandez et al., 2011; Matera, Rizzo, & Carughi, 2006; McKibbin, 2007; "Website Evaluation Questions," n.d.). The details are shown in the appendix.

3.3 Timeline

This study lasted six months, from October 2018 to April 2019. The literature review was done in the first two months. In the first two weeks of October 2018, information about expectations and suggestions on the system was gathered and the structure of the proposed system was designed. The next three months (Oct. 14th, 2018 – Jan. 14th, 2019) were spent on developing the system. After that, the samples were selected, and the survey instrument was constructed and validated during this period of time. From Feb. 14th to Mar. 14th, 2019, the survey was conducted, and the results were analyzed. The final report was written and revised in March and early April and final examination was made in late April. A GANT chart of time action plan is shown in Table. 2.

3.4 Summary

In summary, an online thesis evaluation system was developed in this study by employing Angular and PHP as the front and back end technologies, MySQL as the database management system, and D3 for the data visualization. It has five user groups: admin, students, faculties, super admin, and graduate committee chair. The admin can modify the evaluation rubrics and manage user accounts. Students can add their theses' information, select the committee chair and members, and view the evaluation results. Faculties can do evaluations and view their own evaluation results (and the other committee members' evaluation results if they serve as committee chair). The super admin can modify any evaluation results to avoid unintentional errors. The graduate committee chair is able to view all the evaluation results. The performance, usability, and reliability of the system were assessed through surveys. The participants were professors, staff, and students from CGT department. The survey instrument consists of 5-point Likert-type items and comment areas that are constructed based on the reported instruments to measure the performance and usability of the system. Two trials of experiments were done with a one-week interval and the survey results were compared to examine the reliability of the system. The whole study was finished in six months.

Table 2 A GANT chart of time action plan

	Duration of Activity													
Review of the literature														
Gather information about expectations and suggestions on the system														
Design the system														
Develop the system														
Select the sample														
Develop the survey instrument														
Validate the survey														
Analyze the collected data														
Follow up non-responding sample														
Develop findings and conclusions														
Interact with major professor to finalize the final report														
Committee review of final report														
Final examination														
Make final edits														
Submit final thesis to Polytechnic Graduate Student Office														
	Oct 1	Oct 14	Nov 1	Nov 14	Dec 1	Dec 14	Jan 1	Jan 14	Feb 1	Feb 14	Mar 1	Mar 14	Apr 1	Apr 14

CHAPTER 4. ANALYSIS

The participants in the experiments are graduate students from the CGT department who would be involved in the thesis defense soon and thus could provide useful feedbacks on this thesis evaluation system. Below are the results obtained from the experiments.

4.1 The performance of the system

As mentioned above, the performance of the system was accessed in line with three aspects: functionality, security, and accessibility. Each aspect was overall rated by the participants and then comments from the participants were collected.

4.1.1 Functionality

Fig. 17 shows the rating of the functionality of the system in the first experimental trial. Among all the participants, seven rated the system as "Most functionalities meet the requirement" while three rated the system as "All functionalities meet the requirement". The average score is 4.30 on a scale of 5. All the participants agreed that this system met the requirements for basic functions like creating users, creating and modifying evaluation form, collecting and displaying evaluation results, etc. However, some parts of the system were found to be not working properly, as listed below.

- One participant observed that on committee evaluation page the committee members' answers were not pulled out correctly when the questions were same for both evaluating thesis document and thesis defense, meaning the evaluation results were not filtered correctly by questions' category.
- Two participants reflected that on super admin page the changes made to the evaluation results were gone after refreshing the page.
- One participant commented that when editing the thesis information on student page he tried to remove one committee member but after hitting the "Update" button that committee member was still there.

The first two problems were successfully reproduced and fixed after the second trial of the experiment. The third one could not be reproduced. However, adjustments were made to the codes

so that after users hit “Edit” button all the fields for selecting committee chair and members will be set to empty. This will ensure the existing data being completely erased and replaced.

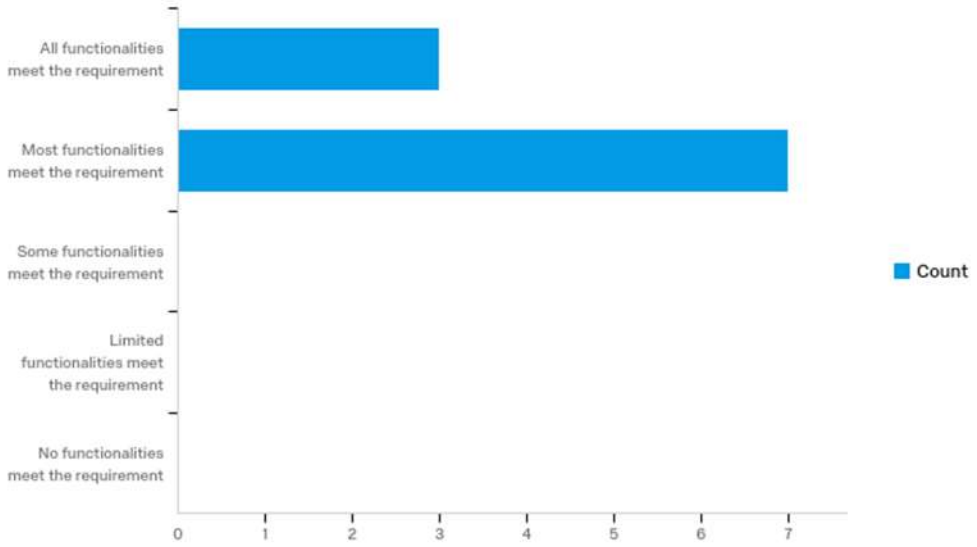


Figure 17 Rating of the functionality in the first trial of the experiment

4.1.2 Security

Web application security is a bit of a wide topic and entails different techniques to prevents various security risks. As a preliminary study, this study only implemented security measures to avoid broken authentication and SQL injection.

As shown in Fig. 18, the rating of the web application security in the first experimental trial ranges from moderately secure to extremely secure. The mean of the rating on a scale of 5 is 3.50. The low mean of the rating could be partly due to the participants’ lack of web development knowledge. In the comment area, two participants expressed that they couldn’t evaluate the security of this system; one mentioned “No password needed when the last user doesn't click "log out" and "back" to log-in page: next user on the same computer can use random user name and 4-digit password to log in that account” which couldn’t be reproduced; one reported that he could see the user’s information including the hashed password through the HTTP responses in the developer tools of the browser; and one suggested that there should be notifications to the faculties when their evaluation results were changed by the super admin. The last comment is a great suggestion that will help prevent super admin from randomly modifying the evaluation results.

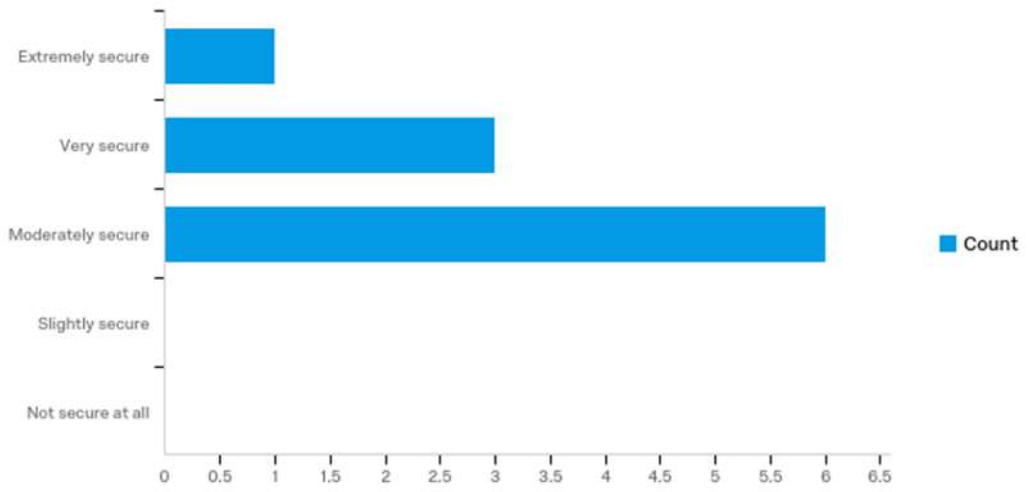


Figure 18 Rating of the security in the first trial of the experiment

4.1.3 Accessibility

As mentioned above, this evaluation system is limited to users without visual impairments. Therefore, the accessibility measured in the experiments was only about how accessible the system was to users without visual impairments. Specifically, it measured the loading speed and whether the web pages are viewable in different browsers or operating systems. As shown in Fig. 19, among 10 participants, 6 rated the system as “Extremely accessible”, 2 rated “Very accessible”, and 2 rated “Moderately accessible”. The average rating on a scale of 5 is 4.40. This could be attributed to the well optimized Angular framework as well as asynchronous nature of the data transmission between the browser and server. In the comment area, most participants stated that they had no problem with accessing the websites or the loading speed was fast. One participant commented that it needed some time to load the admin rubrics page, which could be due to the large amount of texts retrieved from the server.

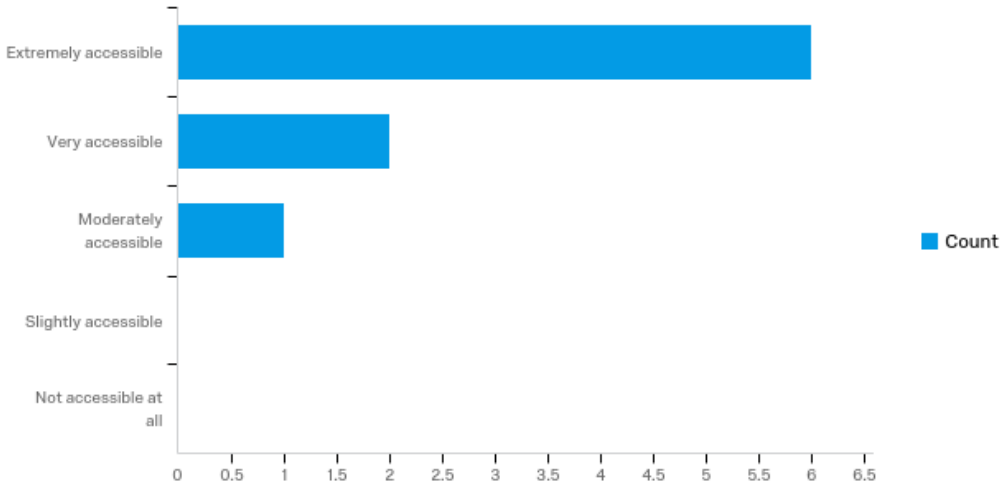


Figure 19 The rating of accessibility of the system in the first trial of the experiment

4.2 The usability of the system

The usability measured in this experiment was mainly regarding the user experience of this system. It included four aspects: the interactivity, the simplicity, the navigability, and the readability. Like the measurement of the performance described above, each aspect was rated with a multichoice question and then participants' comments were collected.

4.2.1 Interactivity

As the term suggests, interactivity of a web application is the interaction between it and its users. The more interactive a web application is, the more engaging it is to the users. Fig. 20 shows the rating of the interactivity of this system in the first experimental trial. Most participants rated it as "Moderately interactive" while some of them rated it as "Very interactive" or "Slightly interactive". The average rating is 3.20 on a scale of 5. While some participants commented that this system was easy to understand and operate, most of them suggested the interaction was not enough and more features should be added, as listed below.

- Confirmation messages before serious executive actions such as deleting rubrics and user accounts on admin page. Currently the rubrics and user accounts can be deleted by simply clicking the delete button. One participant reported that he accidently deleted all the rubrics for evaluating thesis documents and it took a long time to recreate them. Considering such

actions may cause unrecoverable losses, it's important to have users to confirm it before they proceed and thus confirmation messages should be added to this system in the future.

- Sorting the rubric's attributes by clicking and dragging a whole block up or down the admin page. Sometimes after admins add new attributes, they may want to rearrange the order of attributes. Adding such a feature can increase the interactivity of the admin page.
- Messages to users after they complete an action. Currently users can get an error message if they use wrong credentials to login; admins can get a success message after a user account is successfully created; super admin can get a success message after he makes changes to the evaluation results and submits the form. More feedback messages are suggested after actions such as admins create a new rubric category, students update the information about their thesis, etc.
- Interactive graphs on graduate committee chair page. Instead of using static graphs, interactive ones can allow graduate committee chair to look at the data closely and make the page more attractive.

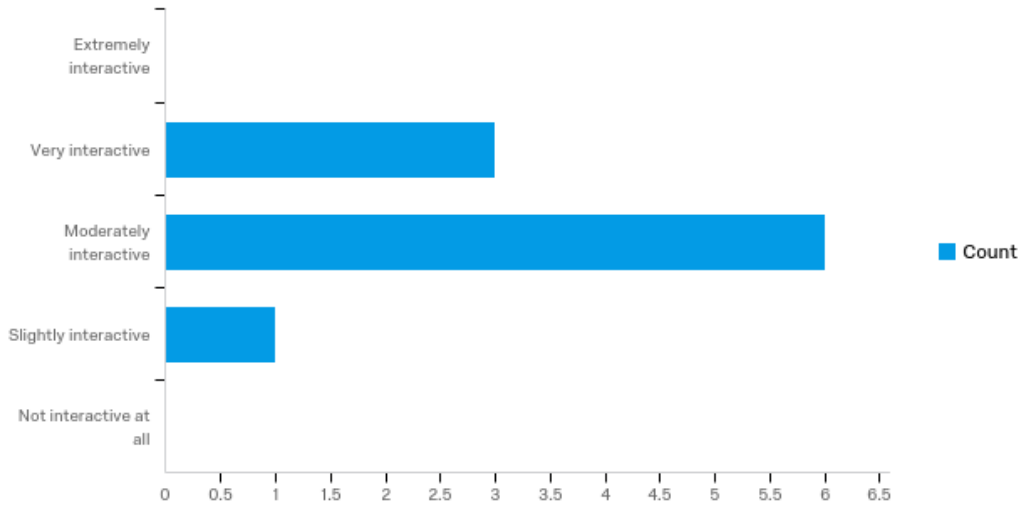


Figure 20 The interactivity of the system measured in the first trial of the experiment

4.2.2 Simplicity

Studies have found that users tend to rate "visually complex" websites as less beautiful than their simpler counterparts (Presslaber, Stöcklin, Bargas-Avila, Tuch, & Opwis, 2012). In addition, simple websites have less unnecessary elements which make them easily understood. Therefore, to a web application, the design is the "simpler" the better. As shown in Fig. 21, almost all

participants rated that it is extremely easy to understand the contents on the webpages designed in this system.

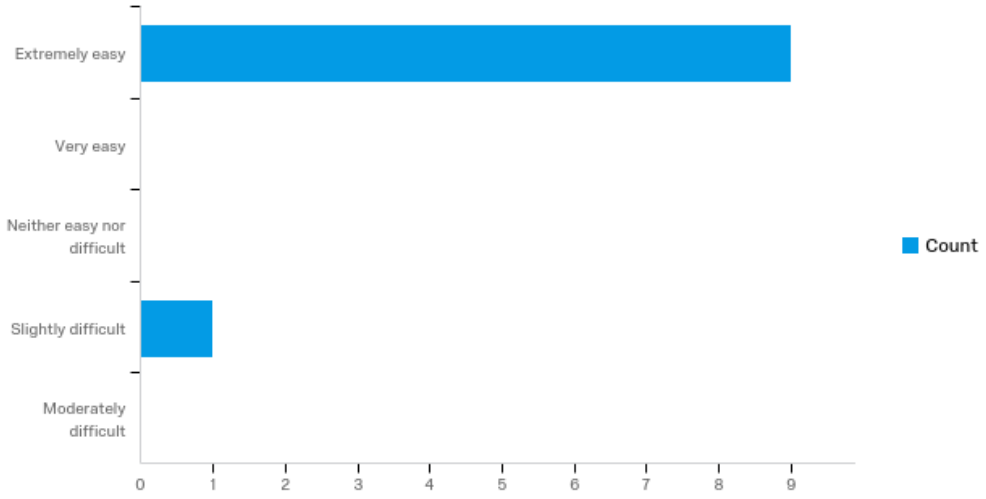


Figure 21 The simplicity of the system measured in the first trial of the experiment

4.2.3 Navigability

Navigability, or easy-of-navigation, impacts on the overall success of web applications. Improper or confusing navigation can bring very bad user experience, leaving users lost or confused. Fig. 22 shows the rating of the navigability of the system. Most participants rated “extremely easy” while three participants rated “very easy” and one rated “neither easy nor difficult”. The average rating is 4.50 on a scale of 5. The complaints about the navigability of this system are mostly about the navigation difficulty from one part to another on the same page. For example, given that the evaluation form is a little bit long, it would be helpful to have buttons at the top to help users to easily navigate to different parts in order to view the results or do the evaluation. Moreover, admins have to scroll down the page to find the rubrics to edit or delete user accounts. It is time costly and inconvenient especially when there are many user accounts in the system. Therefore, it would be helpful if search boxes can be added to help users search and locate the information they need.

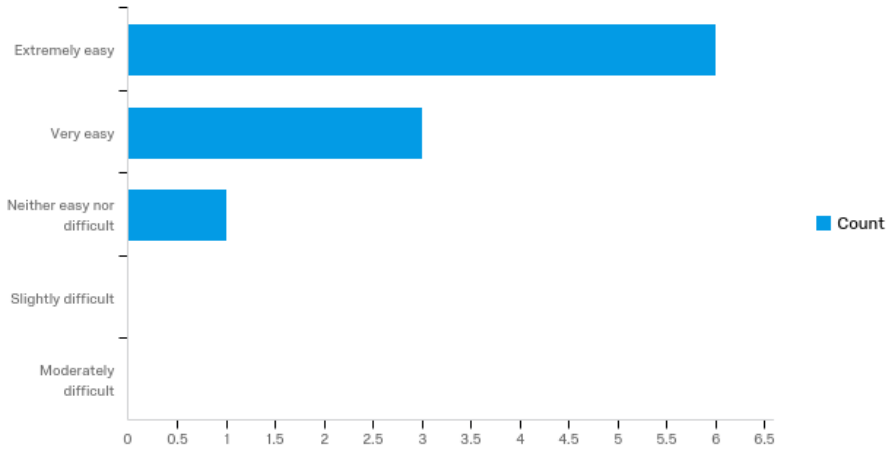


Figure 22 The navigability of the system measured in the first trial of the experiment

4.2.4 Readability

Readability of a web application measures how easy it is for users to understand the text on it. It depends on both the content of text and the typography (e.g. font size, line height). Most participants rated that the wording of this system was extremely clear, as shown in Fig. 23. The average rating is 4.67 on a scale of 5. Some misspellings have been spotted by participants such as “Select a thesis this prodessor has reviewed..." when it should be "Select a thesis this professor has reviewed...".

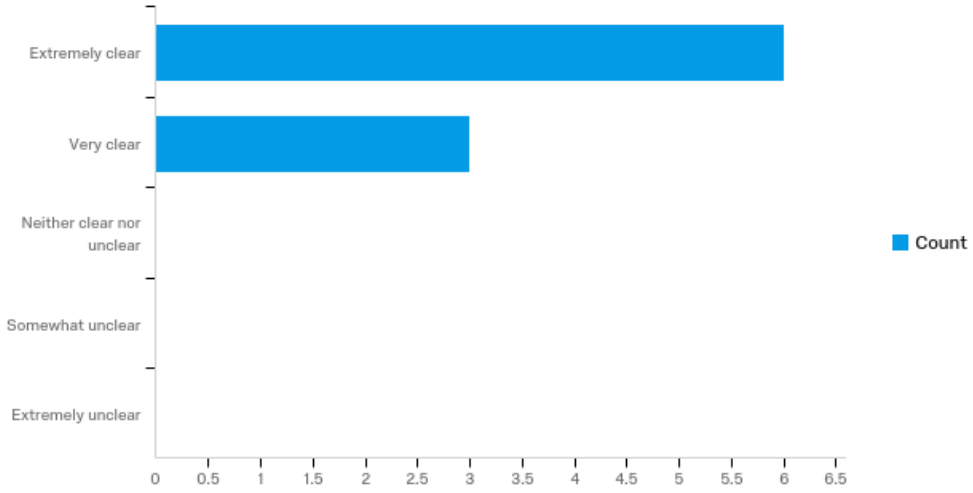


Figure 23 The readability of the system measured in the first trial of the experiment

4.3 The reliability of the system

The reliability of a web application is the probability of operating it without failure in a specific environment for a specific period of time ("Application Reliability Defined _ _FREE Demo_ _ Video Explanation," n.d.). A reliable web application should provide stable and consistent results. In this study, the reliability of the developed system was estimated through the comparison of the performance obtained in the two trials. As shown in Fig. 24, the rating of accessibility is slightly lower while the ratings of functionality and security are slightly higher in the second trial than in the first trial.

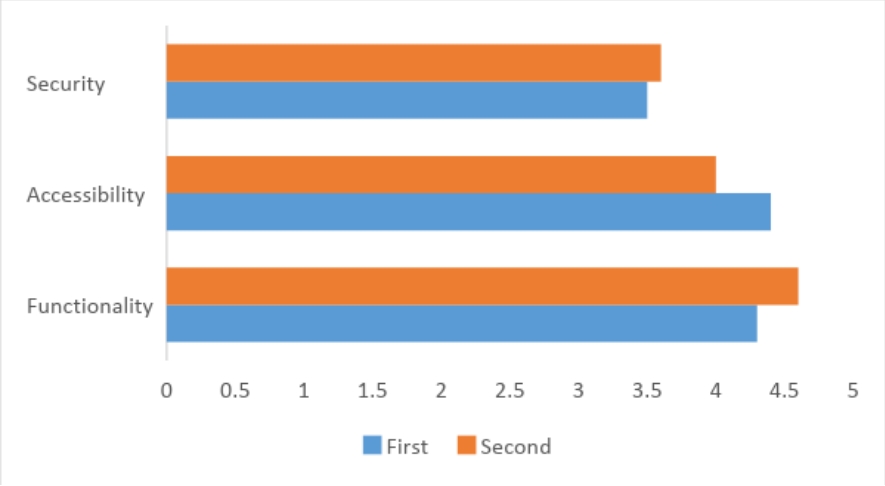


Figure 24 Comparison of the performance obtained in the two trials of the experiment.

4.4 Summary

In summary, participants' ratings and comments obtained in the experiments were analyzed to assess the system's performance, usability, and reliability. For the performance, the ratings on the functionality and accessibility were relatively high while that on the security was relatively low. For the usability, the ratings about the simplicity, navigability, and readability were relatively high while that about the interactivity was relatively low. The performance measured in two trials was compared to access the system's reliability. Comments about possible bugs and issues were also collected.

CHAPTER 5. CONCLUSION, DISCUSSIONS AND RECOMMENDATIONS

5.1 Conclusions

The aim of this study is to develop a substitute for the current laborious and inefficient paper-based thesis evaluation system. To this end, an online thesis evaluation system was developed, and its performance, usability, and reliability were assessed. The performance of the system was tested in three aspects: the functionality (i.e., if functionalities meet the requirement), the security (i.e., how secure the system is), and the accessibility (i.e., how accessible the system is). The usability was assessed in four aspects: the interactivity (i.e., how interactive the web pages are), the simplicity (i.e., how simple the webpages are), the navigability (i.e., how easy to navigate through the system), and the readability (i.e., how easy to understand the text). The reliability was assessed by comparing the performance of the system measured in two trials.

Table 3 Average ratings in the first trial of the experiment

	Performance			**Usability**			
	Functionality	**Security**	**Accessibility**	**Interactivity**	**Simplicity**	**Navigability**	**Readability**
Average Rating on a scale of 5	4.30	3.50	4.40	3.20	4.70	4.50	4.46

The average ratings obtained in the first trial of the experiment are shown in Table 3. For the performance of the system, the results indicate the system has relatively high functionality and accessibility but relatively low security. However, since most of the participants were lack of knowledge on web application security, their ratings on the security might be biased and further assessment of the security of the system is required. For the usability of the system, while the interactivity was rated relatively low, the ratings of the simplicity, navigability, and readability were high, indicating the system is simple, navigable, and readable. The average ratings for the performance of the system measured in two experimental trials are very close, as shown in table 4. Although the rating of accessibility exhibits a slight reduction in the second trial, considering the possible existing of errors in the experiment, the performance can be viewed as stable and

consistent. Therefore, the experimental results suggest that this online evaluation system has relatively good performance, usability, and reliability and thus hold potential in serving as a substitute to the current paper-based one.

Table 4 Comparison of the performance obtained in the two trials.

	Functionality	**Security**	**Accessibility**
First trial	4.33	3.56	4.4
Second trial	4.75	4.0	4.0

5.2 Discussions

5.2.1 Design and development of the system

Despite of its relatively good performance, usability, and reliability, the developed online evaluation system needs to be further improved in several aspects as commented by the participants. For example, complaints about the interactivity of the system have been raised by the participants. Specially, confusions had been caused because of the absence of confirmation or success messages when the users performed some actions like deleting a user account or a rubric. Regarding the navigability of the system, some participants pointed out that it was difficult and boring to navigate through the pages due to the existence of lengthy forms or tables. For security of the system, concerns were raised because there lacks supervision when super admin makes changes to the evaluation results and some of the user's information can be seen from the HTTP response in the developer's tool of the browser. There are also comments about malfunctions and loading speed of the system. Therefore, further design and development are necessary to improve this system.

5.2.2 Assessment of the system

In this study the system was assessed by graduate students from CGT department. Each aspect of the system was overall rated by the participants and their comments were collect. While the results have provided useful information on this system, there exist some problems in the current assessment. Firstly, the lack of knowledge on web development in the participants may bias the ratings. This could be more obvious for the measurement of the security. Some participants

indicated in their comments that they didn't know how to evaluate the security. Secondly, the functionality of the system cannot be fully measured by just one question. Different participants may put emphasis on different things in the testing, it's hard for them to find all the functionality problems without telling them exactly what to test. Finally, the samples of the experiments are quite small, 10 for the first experimental trial and 5 for the second one, which could generate obvious deviations on the results. Thus, further assessment is required to fully characterize this system.

5.3 Recommendations

As discussed above, this online thesis evaluation system still has some problems in its interactivity, navigability, etc. To make it a better substitute of the current paper-based evaluation system, the following features are recommended to be addressed for the future study.

- When users make a deletion, a confirmation message like "Are you sure?" pops out to make sure that users intend to do that.
- Show a message to users after they make deletions.
- Add buttons at the top of the page to help users easily navigate to different parts of the page.
- Add search boxes to help users search through the tables or forms.
- Make the tables or forms sortable by certain features.
- Add the charts on the graduate committee chair page to make it more interactive (e.g., be able to zoom in and out).
- Optimize the system's loading speed by splitting the modules into smaller ones or using lazy loading. By splitting the modules into smaller ones, there will be less data needed to be loaded for each module and thus will decrease the loading time. With laze loading we could load part of the page at first and the rest on demand.
- When super admin makes changes to one faculty's evaluation results and hit "Submit" button, send an email to that faculty as well as the graduate committee chair to make sure only necessary changes are made.
- Encrypt all the HTTP responses and get a HTTPS certificate to ensure secure communication between a browser and the server.

- Proofread the whole system to avoid wording problems.

In addition, the follow is recommended to better assess the system.

- Have experts evaluate the system's functionality, security, and accessibility. Experts who are experienced on web development are expected to provide more thoughtful opinions on these aspects of the system.
- Provide a detailed list of functions of the system that need to be tested for the participants.
- Recruit more people to participate in the experiment to improve the experimental accuracy.

5.4 Summary

In summary, the experiment results indicate that the online thesis evaluation system developed in this study has relatively good functionality, usability, and reliability, and thus hold potential in acting as a substitute to the current paper-based one. The possibly existing problems in this system as well as in the assessment of this system were discussed and recommendations on improving the system and the experiments were proposed.

REFERENCES

Application Reliability Defined _ _FREE Demo_ _ Video Explanation. (n.d.). Retrieved from https://www.castsoftware.com/glossary/application-reliability

Bennett, R. E. (2008). Inexorable and Inevitable: The Continuing Story of Technology and Assessment. *Computer-Based Testing and the Internet: Issues and Advances*, 201–217. https://doi.org/10.1002/9780470712993.ch11

Bodrov-Krukowski, I. (2018). Angular Introduction: What It Is, and Why You Should Use It. Retrieved from https://www.sitepoint.com/angular-introduction/

Burton, W. B., Civitano, A., & Steiner-Grossman, P. (2012). Online versus paper evaluations: Differences in both quantitative and qualitative data. *Journal of Computing in Higher Education*, *24*(1), 58–69. https://doi.org/10.1007/s12528-012-9053-3

Capa-Aydin, Y. (2016). Student evaluation of instruction: comparison between in-class and online methods. *Assessment and Evaluation in Higher Education*, *41*(1), 112–126. https://doi.org/10.1080/02602938.2014.987106

Dalisay, M. (n.d.). REST API Authentication Example in PHP - JWT Tutorial -. Retrieved from https://www.codeofaninja.com/2018/09/rest-api-authentication-example-php-jwt-tutorial.html

El-Rahman, S. A. (2016). A web-based course and instructor online evaluation system. *Proceedings - 2015 5th International Conference on e-Learning, ECONF 2015*, 144–152. https://doi.org/10.1109/ECONF.2015.24

Fernandez, A., Abrahão, S., & Insfran, E. (2013). Empirical validation of a usability inspection method for model-driven Web development. *Journal of Systems and Software*, *86*(1), 161–186. https://doi.org/10.1016/j.jss.2012.07.043

Fernandez, A., Insfran, E., & Abrahão, S. (2011). Usability evaluation methods for the web: A systematic mapping study. In *Information and Software Technology* (Vol. 53, pp. 789–817). Elsevier B.V. https://doi.org/10.1016/j.infsof.2011.02.007

Hoffman, K. M. (2003). Online course evaluation and reporting in higher education. *New Directions for Teaching and Learning*, *2003*(96), 25–29. https://doi.org/10.1002/tl.119

Huluta, M. (2013). Why I prefer a JavaScript framework vs. ASP.NET MVC - DZone Web Dev. Retrieved from https://dzone.com/articles/why-i-prefer-javascript

Lee, Y., & Kozar, K. A. (2012). Understanding of website usability: Specifying and measuring constructs and their relationships. *Decision Support Systems*, *52*(2), 450–463. https://doi.org/10.1016/j.dss.2011.10.004

Matera, M., Rizzo, F., & Carughi, G. T. (2006). Web usability: Principles and evaluation methods. In *Web Engineering*. https://doi.org/10.1007/3-540-28218-1_5

McKibbin, S. (2007). Designing Web Usability: The practice of simplicity. *Interactive Marketing*. https://doi.org/10.1057/palgrave.im.4340116

Mimi, R., & John, G. (2011). Student Evaluation. https://doi.org/10.1007/978-1-4419-6303-1

MUSHTAQ, Z. (n.d.). PHP Token Based Authentication JWT (JSON Web Tokens) - PHP Clicks. Retrieved from http://phpclicks.com/php-token-based-authentication/

Olsina, L., Papa, F., & Molina, H. (2007). *Web Engineering: Modelling and Implementing Web Applications*. *Web Engineering: Modelling and Implementing Web Applications*. https://doi.org/10.1007/978-1-84628-923-1

Park, H. S., & Cheong, Y. F. (2018). Correlates of monotonic response patterns in online ratings of a university course. *Higher Education*, *76*(1), 101–113. https://doi.org/10.1007/s10734-017-0199-9

Petrişor, M., Măruşteri, M., Ghiga, D., & Schiopu, A. (2011). Online Assessment System. *Applied Medical Informatics*, *28*(1), 23–28. Retrieved from http://search.ebscohost.com.bibl.proxy.hj.se/login.aspx?direct=true&AuthType=cookie,ip,uid&db=afh&AN=59759726&site=ehost-live

Presslaber, E. E., Stöcklin, M., Bargas-Avila, J. A., Tuch, A. N., & Opwis, K. (2012). The role of visual complexity and prototypicality regarding first impression of websites: Working towards understanding aesthetic judgments. *International Journal of Human-Computer Studies*, *70*(11), 794–811. https://doi.org/10.1016/j.ijhcs.2012.06.003

Purdue sets record for student enrollment, graduation rate. (2017). Retrieved from https://www.purdue.edu/newsroom/releases/2017/Q3/purdue-sets-record-for-student-enrollment,-graduation-rate.html

Schmidt, R. F. (2013). Software Verification and Validation Practice. In *Software Engineering* (pp. 263–273). https://doi.org/10.1016/b978-0-12-407768-3.00015-x

Suarez-Torrente, M. D. C., Conde-Clemente, P., Martínez, A. B., & Juan, A. A. (2016). Improving web user satisfaction by ensuring usability criteria compliance: The case of an economically depressed region of Europe. *Online Information Review*, *40*(2), 187–203. https://doi.org/10.1108/OIR-04-2015-0134

Swygert, K. (2009). Practical Considerations in Computer-Based Testing. *Journal of the American Statistical Association*, *97*(460), 1213–1214. https://doi.org/10.1198/jasa.2002.s246

Tezza, R., Bornia, A. C., & Andrade, D. F. De. (2011). Measuring web usability using item response theory: Principles, features and opportunities. *Interacting with Computers*, *23*(2), 167–175. https://doi.org/10.1016/j.intcom.2011.02.004

Thompson, M. M., & Braude, E. J. (2015). Evaluation of Knowla. *Journal of Educational Computing Research*, *54*(4), 483–512. https://doi.org/10.1177/0735633115621923

Website Evaluation Questions. (n.d.). Retrieved from http://depts.washington.edu/trio/trioquest/resources/web/evaluation.php

What is usability testing? | Experience UX. (2018). *Experienceux*. Retrieved from https://www.experienceux.co.uk/faqs/what-is-usability-testing/

Wikipedia, F. (2014). Software reliability testing. Retrieved from https://en.wikipedia.org/wiki/Software_reliability_testing

Yerushalmy, M., Nagari-Haddif, G., & Olsher, S. (2017). Design of tasks for online assessment that supports understanding of students' conceptions. *ZDM - Mathematics Education*, *49*(5), 701–716. https://doi.org/10.1007/s11858-017-0871-7

APPENDIX

Q1 Do the functionalities of the application meet the requirement?

- o No functionalities meet the requirement
- o Limited functionalities meet the requirement
- o Some functionalities meet the requirement
- o Most functionalities meet the requirement
- o All functionalities meet the requirement

Q2 Functionalities needed to be added or improved:

_____

_____

_____

_____

_____

Q3 How secure is the application?

- o Extremely secure
- o Very secure
- o Moderately secure
- o Slightly secure
- o Not secure at all

Q4 Comment on the security of the application:

_____

_____

_____

_____

_____

Q5 How universally accessible is the site (e.g. loading speed, viewable in different browsers or

operating systems)?

- o Extremely accessible
- o Very accessible
- o Moderately accessible
- o Slightly accessible
- o Not accessible at all

Q6 Comment on the accessibility of the application of the application:

_____

_____

_____

_____

_____

Q7 How interactive are the web pages?

- o Extremely interactive
- o Very interactive
- o Moderately interactive
- o Slightly interactive
- o Not interactive at all

Q8 Comment on the interactivity of the application:

_____

_____

_____

_____

Q9 How easily can the contents on the webpages be understood?

- o Extremely easy
- o Slightly easy
- o Neither easy nor difficult

- o Slightly difficult
- o Moderately difficult

Q10 How is the navigability of the application (e.g. How easily is it to go between different web pages or different parts of a web page)?

- o Extremely easy
- o very easy
- o Neither easy nor difficult
- o Slightly difficult
- o Moderately difficult

Q11 How clear is the wording?

- o Extremely clear
- o very clear
- o Neither clear nor unclear
- o Somewhat unclear
- o Extremely unclear