

A Framework to Support into Computer Science Education: The Joy of Computing

by

Amjad Saad Alobaily

A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Computer Science

Auburn, Alabama
May 5, 2018

Keywords: Web based Learning, Computational Thinking, e-Learning, Curriculum, Education

Copyright 2018 by Amjad Saad Alobaily

Approved by

Dr. Cheryl D. Seals, Chair, Associate Professor of Computer Science and Software Engineering
Dr. Saad Biaz, Professor of Computer Science and Software Engineering
Dr. Dean Hendrix, Associate Professor of Computer Science and Software Engineering
Dr. Bo Liu, Assistant Professor of Computer Science and Software Engineering

ABSTRACT

The framework is web-based learning environments related to the Computer Science Principles and big ideas in computing. The National Science Foundation (NSF) and the College Board support the CS Principles. The beauty and joy of computing (BJC) coined at Berkeley was designed to enhance Advance Placement (AP) courses in high school. Students can benefit from the support this framework provide to the seven big ideas in computing.

Computer science has a shortage in the K-12 environment. Moreover, for the past ten years, alone college students planning to major in computer science have dropped by more than 70%. The CS Principles is an attempt to attract high school students to the field of computer science through animation and interaction with teaching staffs, which is designed to show potential computer science students how the discipline is invested in the idea of joy and beauty. Through the BJC we can create an online education platform to teach students by using games or videos and assess the progress of students by a quiz.

ACKNOWLEDGEMENTS

I would like to express my thanks to my advisor to Dr. Cheryl D. Seals for the continuous support, for her patience, motivation, and enthusiasm. Her support helped me in all time of writing of this thesis and research. I could not have imagined having a better advisor for my master's thesis. I would like to express my thanks towards my committee members Dr. Saad Biaz, Dr. Dean Hendrix, and Dr. Bo Liu.

I would like to thank my mom, Latifa Al-khataf, and my immediate family for all their prayers and inspiration throughout these years.

Finally, I must express my very profound gratefulness to my phenomenal wife for providing me with unfailing support and unremitting encouragement throughout my years of the process of researching and writing this thesis. This accomplishment would have been impossible without her, Thank you Neny.

Contents

ABSTRACT.....	ii
ACKNOWLEDGEMENTS.....	iii
LIST OF FIGURES	v
Chapter 1: INTRODUCTION.....	1
Chapter 2: LITERATURE REVIEW.....	4
2.1 What is the Componential thinking?.....	4
2.2 The History of Componential thinking.	4
2.3 Application of Componential thinking.	5
2.4 What is the BJC?.....	6
2.5 E – Learning.....	7
2.6 Mobile learning.....	9
Chapter 3: Method	12
3.1 Problem	12
3.2 Existing solution	14
3.3 Research Questions	14
3.4 Research Hypotheses	15
Chapter 4: SYSTEM DESIGN	16
4.1 Phase 1: Old the BJC	16
4.2 Phase 2:	19
4.3 Implementation	34
Chapter 5: Result and Analysis.....	36
5.1 Evaluation	36
5.2 Pre-questionnaire.....	36
5.3 Post-questionnaire	38
5.4 Analysis of variance (ANOVA).....	40
5.5 Post-questionnaire	41
5.6 Analysis of Evaluation	46
5.7 System test	47
5.8 Compare between old new the BJC:.....	51
Chapter 6: CONCLUSIONS AND FUTURE WORK	52
6.1 Conclusions	52
6.2 Future Work	52
Bibliography	54

LIST OF FIGURES

Figure 1: Career Interest & Project Job Opening.....	1
Figure 2: Number of graduate from 2005 to 2015.....	13
Figure 3 : Phase 1 for BJC homepage.....	17
Figure 4: Register page in phase 1.....	18
Figure 5: use case for guest who is not register in BJC.....	20
Figure 6: use case for student who is register in BJC.....	20
Figure 7: use case for teacher who is register in the BJC.....	21
Figure 8: Sequence diagram for login function.....	21
Figure 9: Sequence diagram for register function.....	22
Figure 10: Sequence diagram for do quiz function for student.....	23
Figure 11: Sequence diagram for follow up student function for teacher.....	23
Figure 12: Sequence diagram for logout function.....	24
Figure 13 : Entity relationship (ER) diagram for the BJC database system.....	25
Figure 14: homepage sketch.....	27
Figure 15: menu sketch.....	28
Figure 16: display contant of the BJC sketch.....	28
Figure 17: The BJC wireframe.....	29
Figure 18: snapshot for display contant of the BJC.....	30
Figure 19:homepage snapshot.....	30
Figure 20: menu page snapshot.....	31
Figure 21: snapshot for display content.....	31
Figure 22: login and register window.....	32
Figure 23: window for teacher.....	32
Figure 24: statues page for teacher.....	33
Figure 25: First question in pre-questionnaire.....	36
Figure 26: Third question in pre-questionnaire.....	37

Figure 27: Second question in pre-questionnaire.....	37
Figure 28: Negative feedback.	39
Figure 29: positive feedback.....	39
Figure 30: hypothesis questions 2.....	39
Figure 31: hypothesis questions 1.....	39
Figure 32: feedback from user after evaluate the BJC.....	41
Figure 33: Statistics result of survey.....	42
Figure 34: feedback about the features of the BJC phase 2.....	43
Figure 35: present result in a number for features of the BJC.....	43
Figure 36: chart for recommending the BJC.....	44
Figure 37: percentage for recommend the BJC.	44
Figure 38: Positive feedback about the BJC 1.....	45
Figure 39: Positive feedback about the BJC 2.....	45
Figure 40: Negative feedback about the BJC 2.	46
Figure 41: Negative feedback about the BJC 2.	46
Figure 42: Show the cost when find bug in different stages.....	48
Figure 43: declare file and function to test it.....	48
Figure 44: Complete the PHPUnit test.....	49
Figure 45: the result of testing and show that all test is successful	49
Figure 46: Validate the BJC website	50

Chapter 1: INTRODUCTION

How can we support the next generations have a tremendous future in technology? We must prepare for them an appropriate environment and facilities to provide a solid knowledge to achieve this goal. We must recognize that the future technology workforce will not be the same as in past years. Limited education and skills make it difficult to get jobs in a job market redefined by technology. This situation makes next generation fear the future. So, we must prepare them. The good news is that the computer science-related career field ranks as number six as the fastest growing field. In the United States, there are more than five hundred thousand unfilled technology jobs, which is expected to be about 1.7 million jobs by the end of 2019. Also, computer science-related jobs are expected to increase from 22% to 31% for next three years [1]. To prepare for these kinds of jobs that are already in demand, we must make sure students leave school with solid foundational knowledge in STEM (science, technology, engineering, math). The statistics show that students who have a solid background and good experience have a big chance for future.

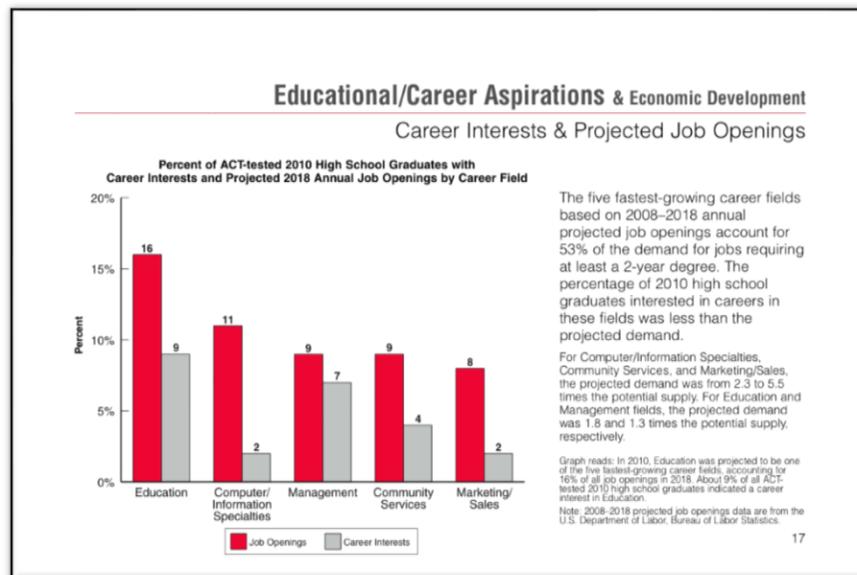


Figure 1: Career Interest & Project Job Opening

Not all students will get the opportunity to gain these skills because 30% of all schools in the nation do not offer computing courses and there were only 24 states that participated in the Advanced Placement computer science exam in 2016 [2]. The peak enrollment in computer science was in 2000; according to the Computing Research Association, there were 79,311 undergraduate student majors in computer science that year, but after that, the number dropped rapidly, and in 2007, the number of undergraduate in computer science was 46,226 [2].

The computer science community became alarmed about the shortage of trained computing practitioners. Surprisingly, in the same year, the Bureau of Labor Statistics predicted that computing would be the fastest growing sector. However, we face many barriers. For one, students had an insufficient knowledge in computing, and now are not well-prepared and lack computational thinking skills [3].

The good news is that many states are moving to fill this gap and trying to fix this situation by expanding the education for computing in K-12. For example, Chicago announced that it is planning to install computer science instruction in every public school. Furthermore, New York City Mayor Bill de Blasio declared that the city is investing \$81 million in establishing computer science instruction in every public school in the city by 2025 [3]. San Francisco and the state of Arkansas have announced they will require every public and high school to offer computer science classes.

One of the contributing factors is the BJC project - The Beauty and Joy of Computing - started in 2009, originally called CS10. The purpose of this project is to encourage K-12 to become more familiar with computing and acquire skills in computational thinking. It is a Web-based to teach the principles of ² computing by using games and videos in education. The young student that has not been exposed to introductory computing and

computations thinking exercises does not recognize or know what computing is and therefore it is our responsibility to deliver computational thinking training beautifully. In the BJC, we present the seven big ideas in computing, which are an abstraction, algorithms creativity, data, programming, and Internet also in edutainment present Algebra, functions, geometry, modeling, numbers, probabilities, and standards.

The goal of this project is to motivate students and attract them in computer science and make it easy for a teacher to achieve the principle quickly. And this project will create a web repository to make it easy to access computational thinking materials that are available anywhere and anytime.

Chapter 2: LITERATURE REVIEW

2.1 | What is the Componential thinking?

There are many of definitions of Componential thinking. Many of researchers defined it based on their perspective. Jeannette M. Wing said, “Componential thinking builds on the power and limits of computing processes, whether they are executed by a human or machine” [4]. Most of the research says Jeannette was the first person to presents this term in 2006 [5]. According to on Wing, Jeannette she defined it as follows: “Computational thinking is the thought processes involved in formulating a problem and expressing its solution(s) in such a way that a computer-human or machine—can effectively carry out.” [6]. Componential thinking will focus on how we can solve a problem, not how we can program or write a code [7]. Although, The BBC site defined it as follows: “Computational thinking enables you to work out exactly what to tell the computer to do.” [8]. For us, we can define the Componential thinking as for how we reformat issues or problems to make it easy to understand and can present it to a machine by the easy way and created a solution in steps then evaluated results. Componential thinking is a way of thinking, and it seems to skill can anyone has it or training to learn how to get these skills not exclusive to the Computer science specialist. Componential thinking contains three processes calls AAA, which are Abstraction and automation and Analysis [9]. There is a great opportunity for Componential thinking to provide support to 12-K education and creating courses that will provide activities for students to reinforce their learning of these skills and increase their opportunities for problem solving.

2.2 | The History of Componential thinking.

The development of computational thinking abilities can provide a unique way of thinking and provide general-purpose ⁴ mental tools, which remain serviceable for a

lifetime. After ten years another scientist called Minsky believed in that the programming will be more critical than the mathematics. This idea is improved and expressed by Abelson and Sussman in 1996 by said computing's procedural effect on people by how they think and decide and make their choices. The step by step process of Componential thinking develops via considering it as logical thinking or another way of think as Kugel said in 1988 [5], but Jennette M. Wing found the Componential thinking term in her paper called Componential thinking in 2006. In this paper, she presented the domination and try to simplify this term when she describes the CT by saying Componential thinking involves solving problems, designing system and understanding human behavior by drawing on the basic concept to computer science. She believed that the Componential thought is a way to solve a problem not to make humans think like computers. When we try to make a human think like a computer, we reduce the benefit of the human's mind by limited the creativity and curiosity which is not found in computers [4].

2.3 | Application of Componential thinking.

Many students who do not prefer computer science department because of the courses in this department, and the big problem when they teach programming is the students feel it is too complex. But after making the Computational Thinking as curriculum for undergraduate, it changed that they should not go to the computer, but the can deal with the complexity of it. Also, for the student who does not plan to be one of the computer science department members, the Computational Thinking gives them skills to solve a problem in other areas. Michele and Jeffrey study the effectiveness of Computational Thinking (CS0) Course on Student Analytical Skills. They notice that Computational Thinking makes a significant positive impact on the students who are studying different majors like Health Care Informatics, Electrical Engineering, and Chemistry [10]. Also based on Tim, 5 Caitlin, and James, also conduct the Computational Thinking in New Zealand, and they analyzed the effectiveness of this course in

primary school. They conducted this study on 13 teachers and gathered the data and information from them. These teachers do not have any background in computer science. They concluded that the CT is more effective than what they expected [11].

2.4 | What is the BJC?

In the United States and Canada, there is a program called Advanced placement founded by College board. This program provides a different course in the separate area, such as Computer Science. This program is taken by students who are interested in applying to school for computer science. To teach computer science for AP student, it should be easy and straightforward. The Beauty and joy of computing program provides this course to students. And the College Board approved this program in 2008, and Code.org organization also accepts this program. The BJC divides into two main parts [12]:

First: 7 Big Ideas:

1. Computing is a creative human activity.
2. Abstraction reduces information to focus on concepts relevant to understand and solve problems.
3. The creation of knowledge is facilitated by data and information.
4. Algorithms are tools for expressing solutions.
5. Programming is a creative tool that produces a computational solution.
6. Digital devices and the networks that connect to enable computational approaches to solving problems.
7. Computing allows creative in ⁶ other fields including humanities, arts,

medicine, engineering business.

Second: 6 Computational thinking practices:

1. Analyzing the effects of a computation.
2. Creating computational artifacts.
3. Using abstractions and models.
4. Artifacts and examining problems.
5. Communicating results and processes.
6. Working effectively in teams.

2.5 | E – Learning

The educational system in the United States assesses the tangible skills and competence, and some institutes give credit for who has a high level of skill. There are traditional course and online course that provide the competence-based simulation to gain these tangible skills. According to The Effect of Competence-Based Simulations on Management Skills Enhancements in E-Learning Courses paper provide experience to collect set of 12 management skills from online learners attending a course. It includes both competence-based computer simulation and those that did not have a simulation. They applied this experiment on 253 responses, and the result show all 12 skills had higher increase than those that did not. The goal of this study is to find an answer this question: what is the effect of computer simulation and competency-based projects on management skills enhancement in an online course? They had developed a study to collect the set of 7 12 management skills using a 36-item instrument from online courses which means three items for each skill. They include computer

simulations compared with a control group of those did not experience simulation. The control group includes one course in project management and one course in management information system. The experimental group includes two courses in project management and management information system and then they collect the data for two years. Also, they give each group survey at the beginning of the course and the end. For the control group, they provide him traditional e-learning like weekly discussion board assignments, quizzes, papers, and the final exam. But in the experimental group include online simulation via WileyPLUS (<https://www.wileyplus.com/>) of an SAP. They develop a website to assess the 12 management skills for each group. After they collect the survey both groups with two different survey, pre-test and post-test, they figure after analyzing the data. They find that the means and standard deviations scores for the pre-test of the control and experimental groups, and the post-test of the control and experimental groups, that the mean increases of the two groups.. In conclusion, they investigate the role of computer simulation and competency-based project on 12 management skills during the online course, and they applied this experiment on two groups then they compare the result. It shows that there is no significant difference between two groups in the pre-test. But they find a significant difference in post-test. Also, some skills that are not tested but may in future work be tested for cybersecurity skills and research and analysis skills [13].

There is another paper called What type of learning style leads to online participation in the mixed-mode e-learning environment? A study of software usage instruction written by Eugenia, Sheng, Travis, talks about the impact of various methods of learning on the online education. This study works in a different scenario. One of them for a student who works online with extended time and student who does not usually work online for learning and they need help to get used to e-learning. This ⁸ study covered 220 students. They took

different courses like Access, Excel, Visual basic each course can take it in three weeks. About 66% of teaching based on online and the rest of this course do its classroom. The content of the course is online like the lecture, slides, and videos. Also, they used the discussion board to let the students discuss with each other and send questions. Furthermore, they use the online environment to do quizzes. In this study, they found 70% of students in the quizzes have a sensual learning style. These students always used the online longer time. Also, the background of knowledge for each student affects this study. The rest of students found that they learned by conjectural style, and found the online course is not suitable for these students which they demand on the conjectural. So, the classroom is better way for these students. This paper mentions that in the future work we must study the relationship between learning style and the subject [14].

2.6 | Mobile learning

This paper discusses using the mobile learning system to facilitate foreign language learning and assessment processes. The purpose of this paper is to use mobile learning as a tool for learning a foreign language. They implement tools to use it in Germany called Terminkalender. This tool uses paper. It applied to making students interact with each other by arranging activities using different language. They implement two apps on mobile. First one for a teacher and another one for the student. Both applications linked to one server, and the teacher version is used by an instructor for defining the content. The contents will be activities which the students will complete. The teacher explains it and gives its name and how many students can participate in this activity and where this activity will be happening and when. After that, the teacher will upload the content to ⁹ the server, and he/she will divide the students

randomly or based on their language level. After uploading the activity on the server, the student can see it and subscribe to this activity based on their schedule. Also, the student application allows them to chat with each other and negotiate. Also, they provided features to let the parents track the progress. While the student interacts with each other, the teacher can analyze their interaction. The researchers test their application on students from the University of Cadiz, and they choose six students to try this application after they used the app. The system can analyze each performance for each student and export it in CVS file. The teachers can see for each student how many words they use, how much misspelling, and how is the interaction with other students. Also, it shows which words are repeated. In conclusion, they implement the tools for arranging activities and make a student learn a new language by interacting with each other. The system allows the teacher to analyze the performance of the students. Also, there is some problem they found, like when the teacher uses the app for the first time it will be challenging. Also, the system can accept only small group. It cannot deal with large students. Also, the students can use the application for other purpose or use another language when they contact with each other [15].

On another hand, there is a study for effect the mobile learning on society which is “A Theory of Learning for the Mobile Age.” The author examined different mobile device we can use for learning, for example, PC, laptop, smartphone, tablet, smartwatch, etc. This study considers the mode of use and the age of mobility of people, knowledge, and the technologies. He found that the mobile learning can support the teaching in general, but we can replace it as an alternative method to learn with traditional learning as the e-book and the traditional book. It could be support for the education, but we cannot use it alone.

Chapter 3: Method

3.1 | Problem

The education sector is the biggest sector of all, and it will be in the top five industries in 2020. Based on the Bureau of Labor Statistics the best average of salary will be \$78,730 for the Technology field. So, obviously in the future, there will be high demand for the technology, but the big problem is we do not prepare the next generation for the future. In the STEM (science, technology, engineering, and mathematics), the computer science is the only field that has decreased from 25% to 19% [16]. Based on what the White House says on its website, “an essential ingredient of economic growth and job creation.” Why are not we teaching kids how to create it? If we are looking at what we have these days most of the education focus is on learning how to type or use the basics of Microsoft office. Also, in school, there are elective courses related to computer science. According to Cameron Wilson, “It is often marginalized in a couple of different ways.” He added that “It is mostly because it is a relatively new field being taught in an education system that is slow to change. While policy-makers do understand how big of a role technology will play in students’ lives.” In Wilson’s opinion, they do not always recognize the difference between teaching kids how to use technology and how to create it.

On the other hand, there is a problem with finding qualified teachers. As reported by the Bureau of Labor Statistics the average salary for high school teachers is \$56,760, and the average for a software developer is \$92,080. A consequence of this is that we have two results either we will not get a teacher with computer science background or teacher with a weak background in technology which will affect the outcome of kids learning.

12

Although, the salary of the developers is very high, but surprisingly the

number of people who graduate from computer science was flat for a decade. In 2005, about 54,000 students graduate in computer science after ten years the number of student graduate from the same degree was 55,000 which means it is not significantly different, and we have seen the number of graduate students from each school increasing, but in computer science, there has been no difference [16].

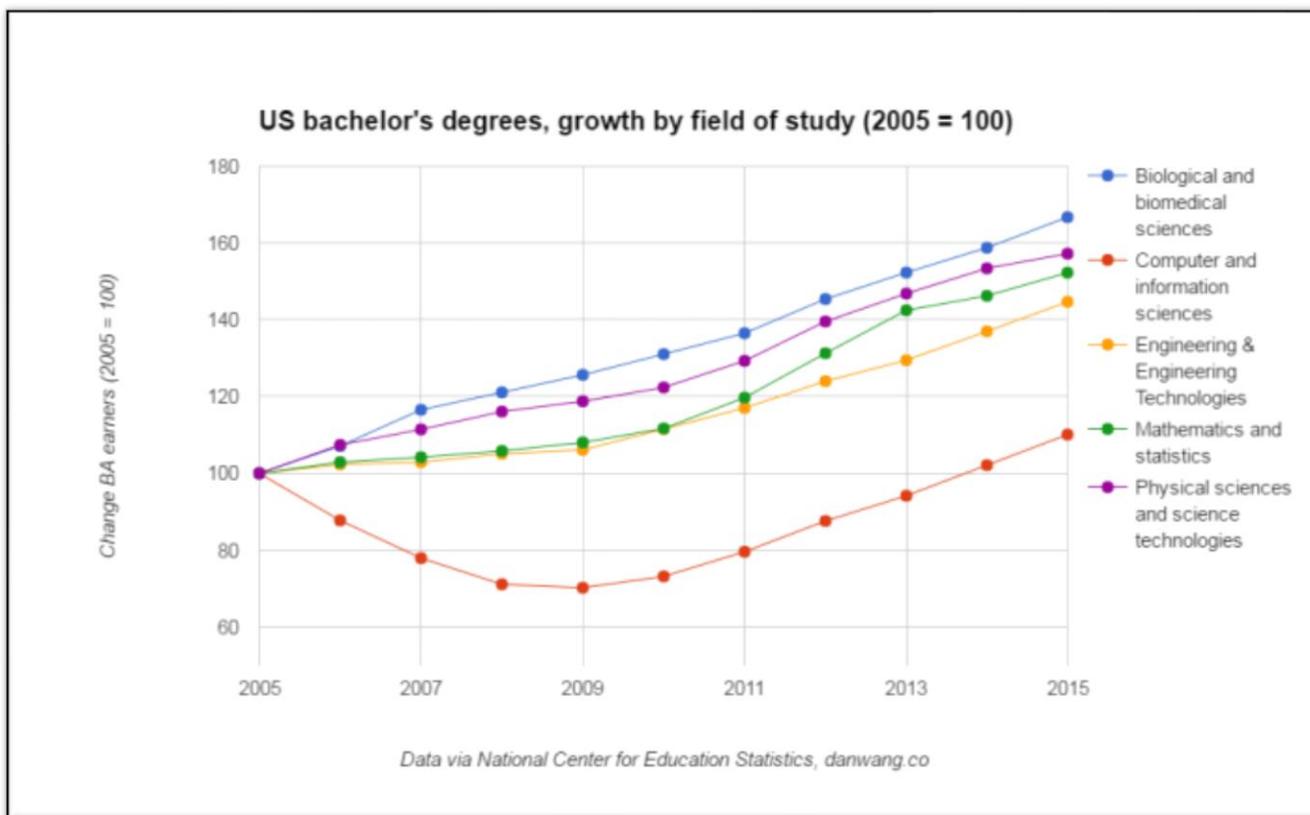


Figure 2: Number of graduate from 2005 to 2015.

Moreover, there is an only small number of useful courses in computer science, but it is not common. Part of the issue is focusing only on Java programming. According to Jan Cuny of the National Science Foundation, “Many kids come to high school without any experience in computer science, especially in lower 13 resource schools, they are not ready to take a year-long course in Java.” [17].

Even though the students will accept the programming in Java, this course is offered only to 10% of American high schools. According to College Board, only 14,517 students took the AP computer science test, compared to over 109,609 students that took the AP statistics test.

3.2 | Existing solution

The founders of the BJC think that computer programming can be one of the most satisfying activities. It can be most enjoyable, but we can call it tough enjoyable. It is like playing a game of skills like chess, but without challenging aspect. And with a beautiful result better than programming itself. The most important cause to study computer science for kids not for the fit nerd students, but for a show the joy and beauty in this field. There is some concept in computer science ugly in a different area but in the BJC try to represent it simple way and cover it with the beauty and joy. The divide computer science in 7 big ideas each idea represents one face computing [18].

3.3 | Research Questions

At the beginning, we investigated existing solutions and collected information to enhance student exploration of computer science and finding methods and activities to attract them to gain skills in computing. We also wanted to create an application that will support students learning the 7 big ideas of computing and edutainment. The main suggestion was to make the beauty and joy environment much easier to use for learning computing. My major research questions are:

1. Can we make a web repository and framework to encourage a student to explore and scrutinize and reinforce computer science and computational thinking?
2. Is the BJC attracting students to ¹⁴ the computing with?

3. Can we build a website with animation, video and games to make education more joyful?

3.4 | Research Hypotheses

Deriving from these questions, we aim to build a website which will focus on students to increase their motivation and increase their exploration of computing ideas. The ease of use and the beauty and joy website is the main point of entry for these activities and lessons. This website shows features to help the student learn more about computer science. The result and analysis of this study will be shown in chapter 5 with the feedback of users who use the BJC web repository and our plan is to test the following hypothesis:

- **Ease of Use:**

The BJC design is intended to be easy to use.

- **Effective feedback:**

The BJC provides an effective feedback to the user.

- **Aesthetically Pleasing:**

The design and layout of the BJC is intended to be aesthetically pleasing.

- **Satisfaction:**

The design of the BJC is intended to satisfy users.

- **Enjoys Learning:**

The satisfaction with provided features to find the BJC with enjoys learning.

Chapter 4: SYSTEM DESIGN

4.1 | Phase 1: Old the BJC

We will present the details about the phase one of the BJC, which was released on Dec 5th, 2013 and describe the design, requirements, and present the pros and cons.

4.1.1: Design and Requirements:

The phase one of the BJC has been designed to be like the tiled grid display used by Windows 8, which is called metro. Also, it is divided to 4 types of requirement which is functional, interface, data, security. For functional requirement there is 4 points:

- Should be a gateway for users to find information about computing.
- It will provide lectures and games to enhance a user's knowledge of a particular aspect of computing.
- It will provide a safe, reliable medium for simulated learning of computing ideals.
- It will make the materials on computing easily accessible for the students.

And for interface requirement there are two points:

- The information should be easily visible for the user to make their selection.
- The information should be shown in a rotational manner that shows brief descriptions of what the lecture/ game is about.

For data requirement:

- Games and videos should be related to the topic on that page

For security requirements:

- To access the full web ¹⁶ site, users will need to create an account

- A user is defined as a Teacher, Parent, or student
- The homepage can be viewed without becoming a registered user

In the below snap of the main page of the phase one of the BJC.

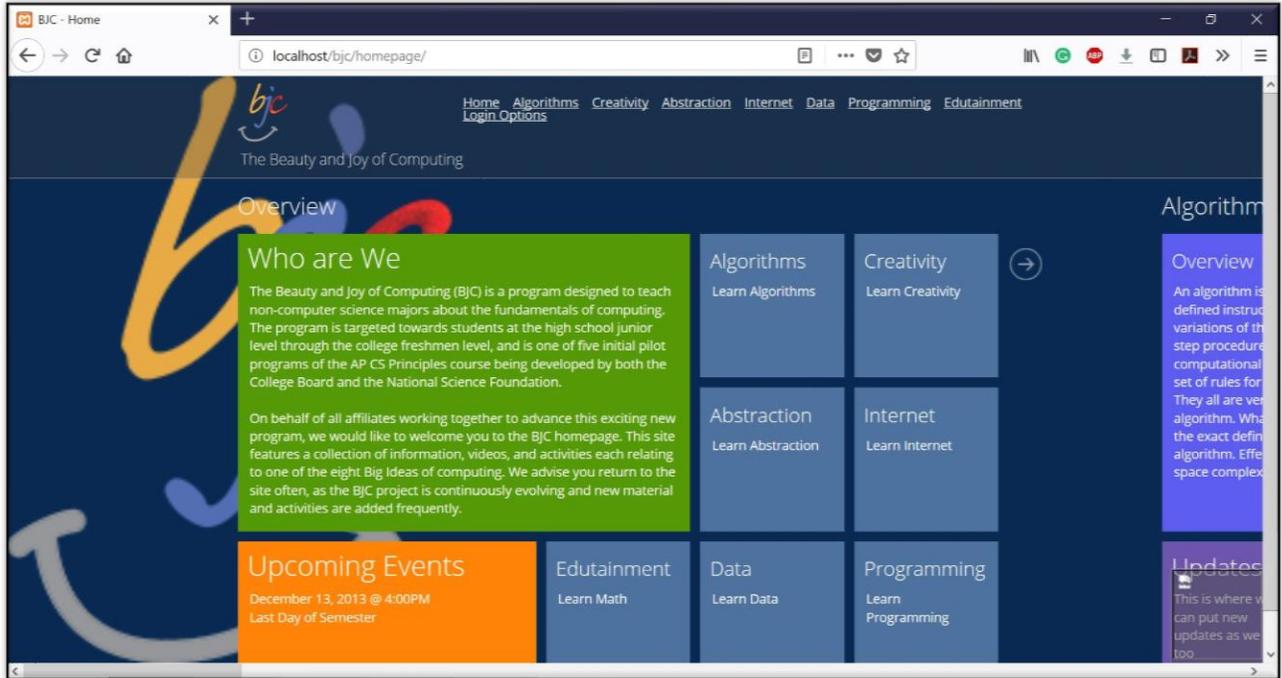


Figure 3 : Phase 1 for BJC homepage.

o **Development:**

In this phase they use different languages to build this website. They use HTML to represent the layout and the static content, and they use PHP to interact with a server for log in and log out service, and they used CSS to present the style of the web site as windows 8.

o **Result:**

In general, the website was developed with good statue but there are some pros and cons. For the pros, each section has a different color, the layout and the alignment for the whole website is beautiful. But for the cons, there are some links that do not work. Also, the color for the background for any component was generated by the system,

sometimes it gives color that cannot read the content because It is so light and there is not contrast between the font color and the background color. Also, there is no separation between the computing and edutainment category, which means it represents the edutainment as part of computing, but it is not true. It should make segregation between them. Also, the phase one of the BJC provided some games, lessons, quizzes, and videos. The issue here is most of them are hosting from outside, which means that it will be difficult to control if any of these hosting stops suddenly for any reason or they change their domain. Also, the teacher cannot track any student if he did any quizzes or watched any videos because there is no interaction between the BJC system and other system. Also, most of the lessons and quizzes are provided as a PDF file or word file. And some of them host by another server which means It is vulnerable. Because if the owner of the host can change the content of the PDF file and affect the device of students. Also, t is less interactive between the system and the users. The only interaction is in the login and logout. Also, the design of login and logout system is totally different which means it looks like another system because it has a different style. Below, shows the page of the registration.

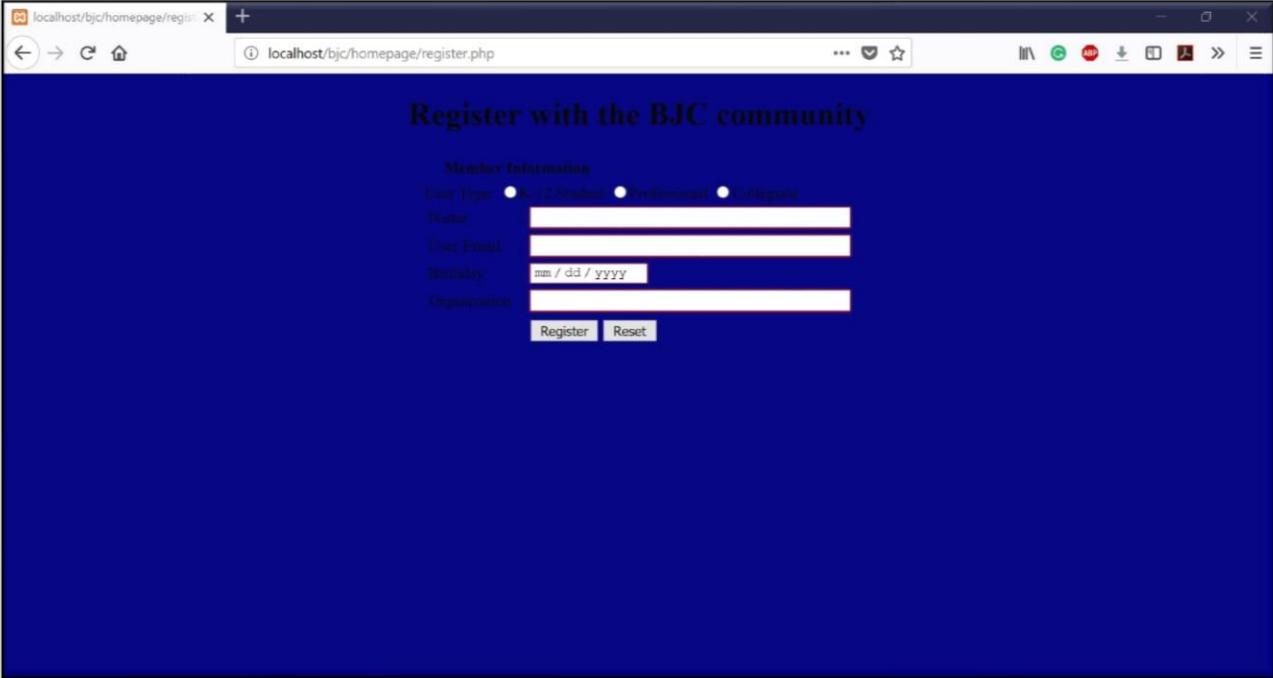


Figure 4: Register page in phase 1.

4.2 | Phase 2:

4.2.1: What is update needed to?

The most important thing we need to update is the hosting of all of the content in the same server to make sure there is no shortage to access or denial of service to any materials. Also, we changed the design because the BJS phase one resembles windows 8. This style has been deprecated and no longer in use. It is a dated method of design and we will change it to a new style and provide menu buttons to easily access any content in an easy way.

Additionally, we considered the problem with the color and font and made sure It is readable. Also, we separated two parts of the BJC, edutainment and computing. Furthermore, we added a page for each teacher to track all students who did the quizzes and who did not. Moreover, we added quizzes in some files different to PDF, in order to make them more interactive and fun with the system. And for the login and logout and for registration, we made all systems have the same design.

4.2.2: Functional Requirement Modified

- Providing descriptions, lessons, quizzes, games, and videos to build up the skills of students in each area of computing or edutainment.
- Making all content easy to access for students.
- Make sure all teachers follow up with all students.
- Make interactive quizzes for 19 students.

- Host all content to make sure all the control is in the same server.

- o Use case:

- Use case for guest:

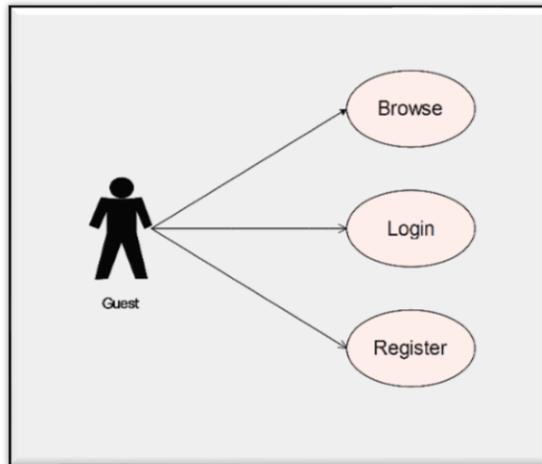


Figure 5: use case for guest who is not register in BJC.

- Use case for Student:

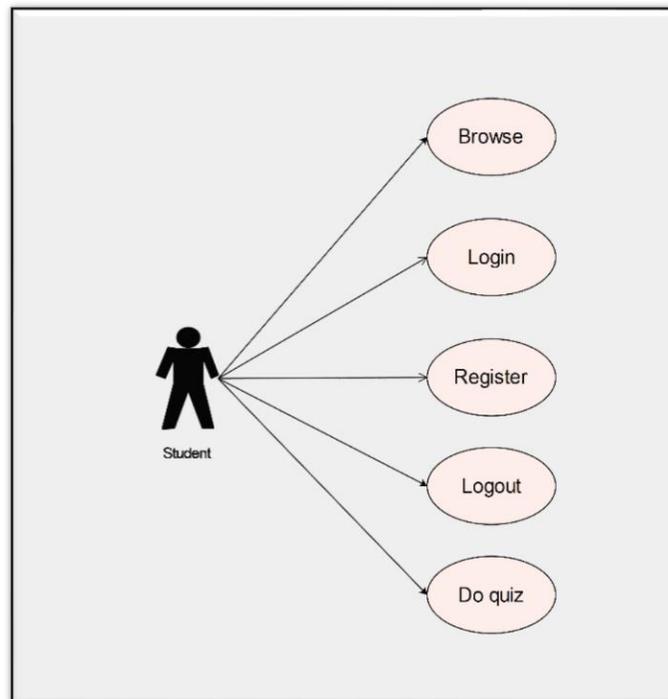


Figure 6: use case for student who is register in BJC.

- Use case for Teacher:

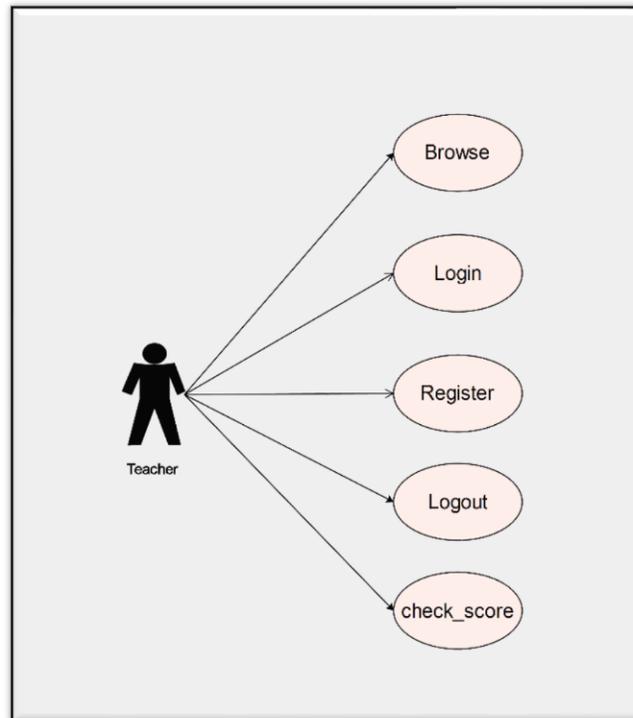


Figure 7: use case for teacher who is register in the BJC.

- o Sequence Diagram:

- Login:

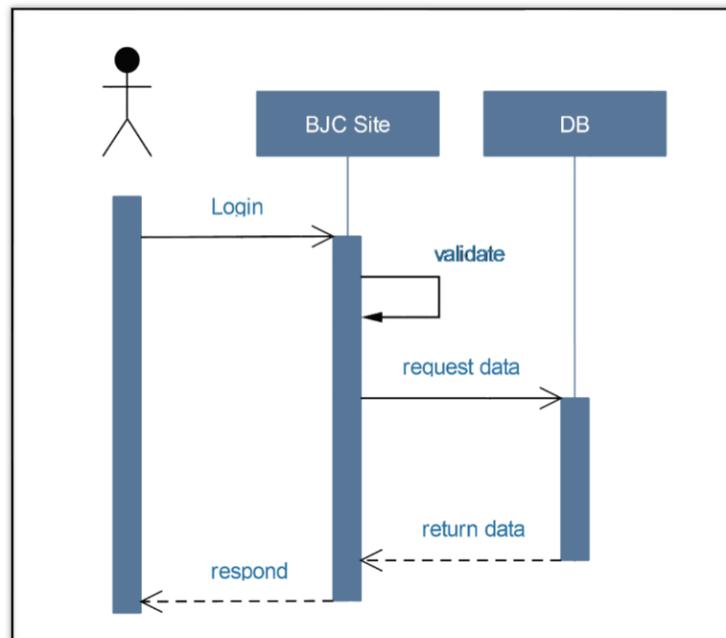


Figure 8: Sequence diagram for login function.

- Registration:

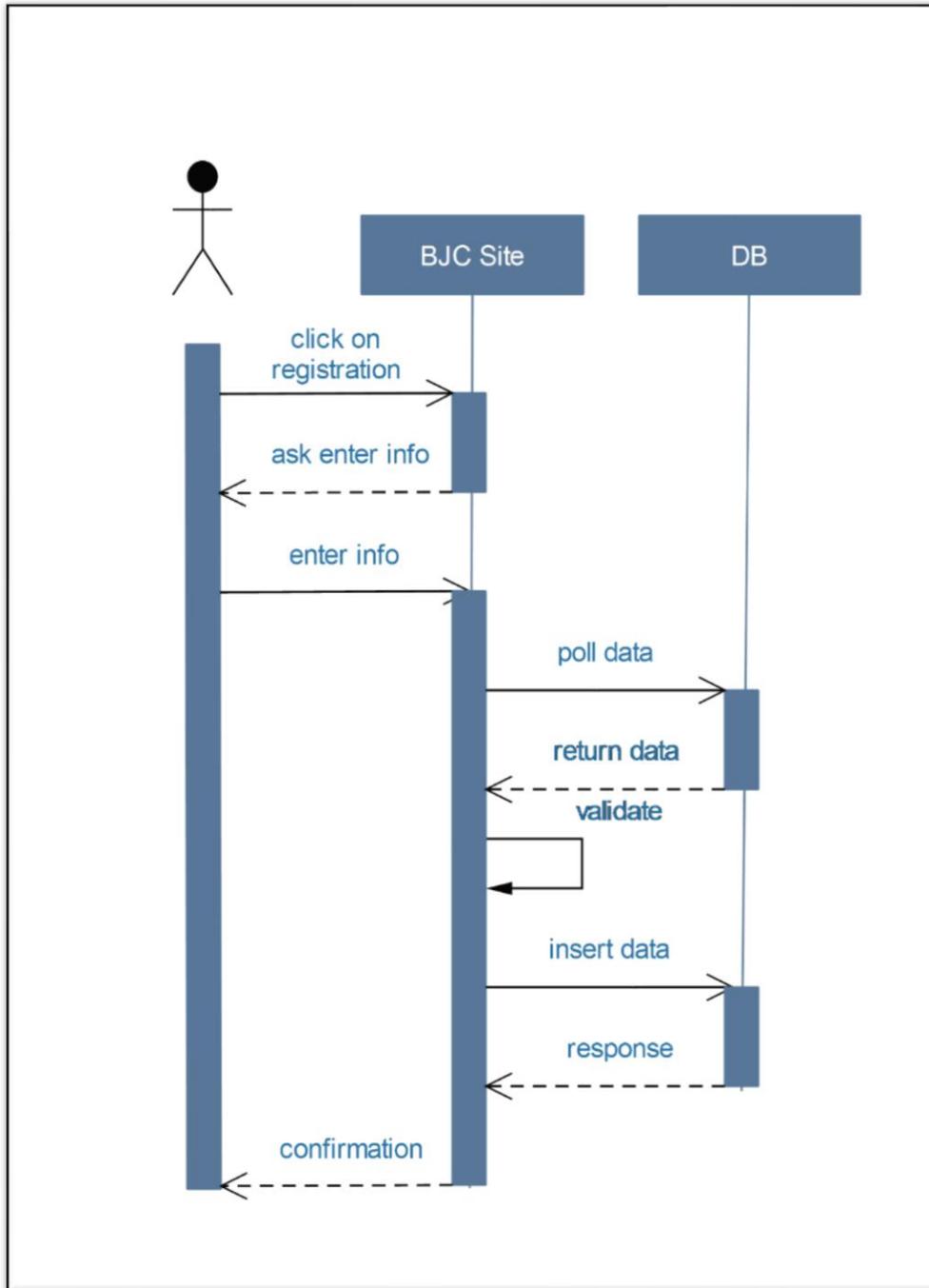


Figure 9: Sequence diagram for register function.

- Do quiz:

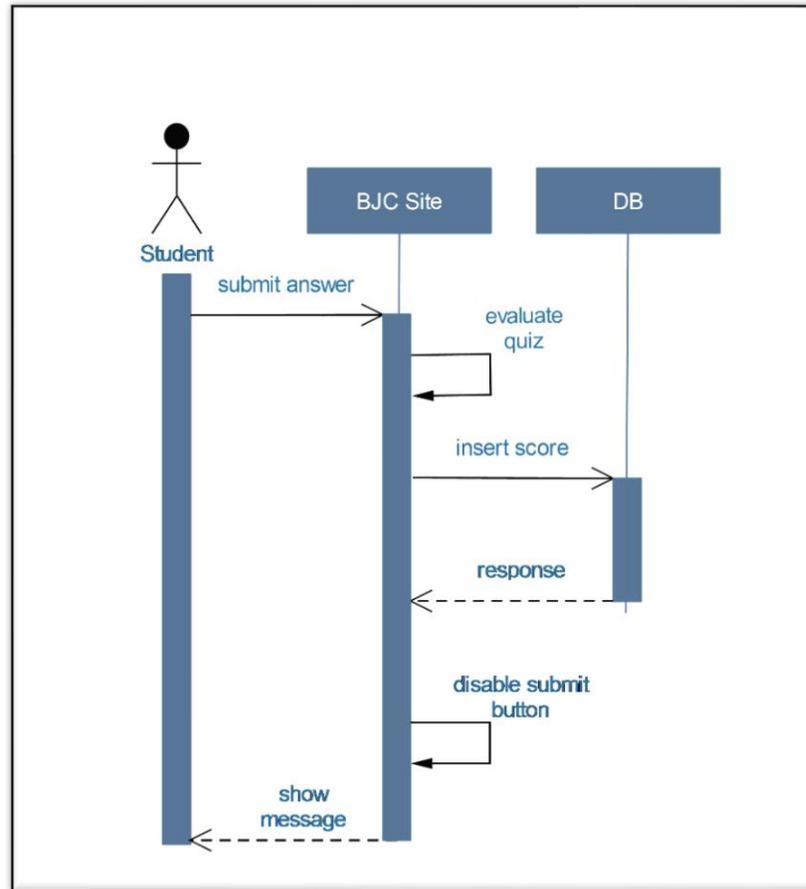


Figure 10: Sequence diagram for do quiz function for student.

- Follow up Student:

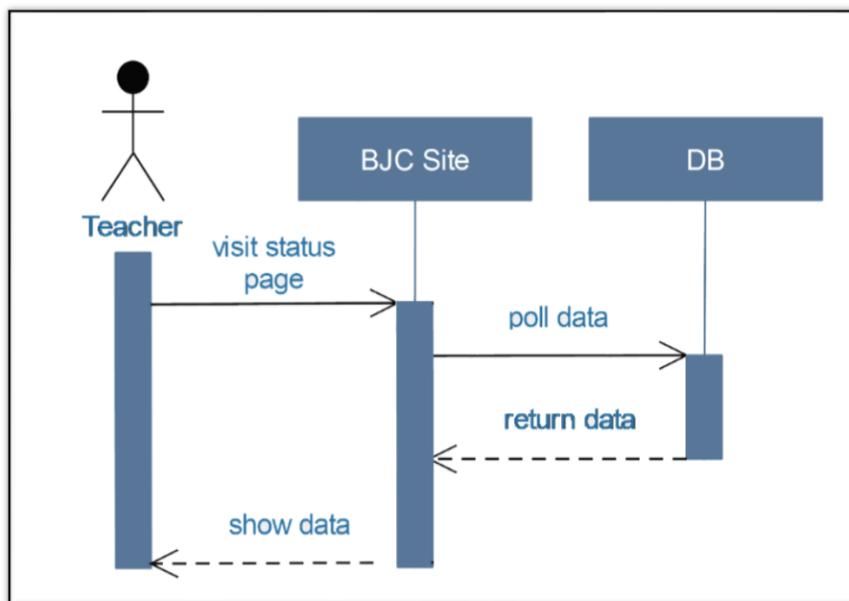


Figure 11: Sequence diagram for follow up student function for teacher.

- Logout:

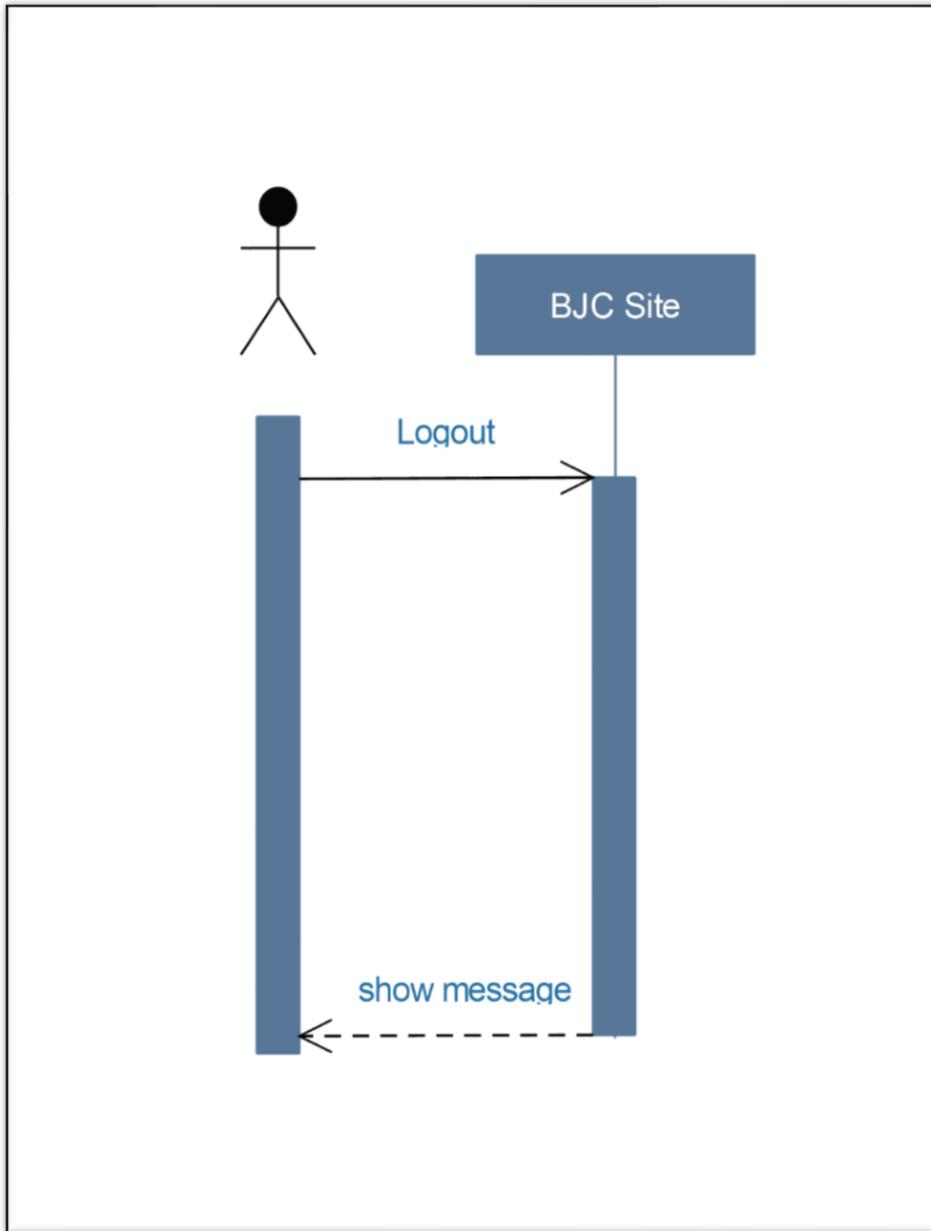


Figure 12: Sequence diagram for logout function.

○ ER Diagram:

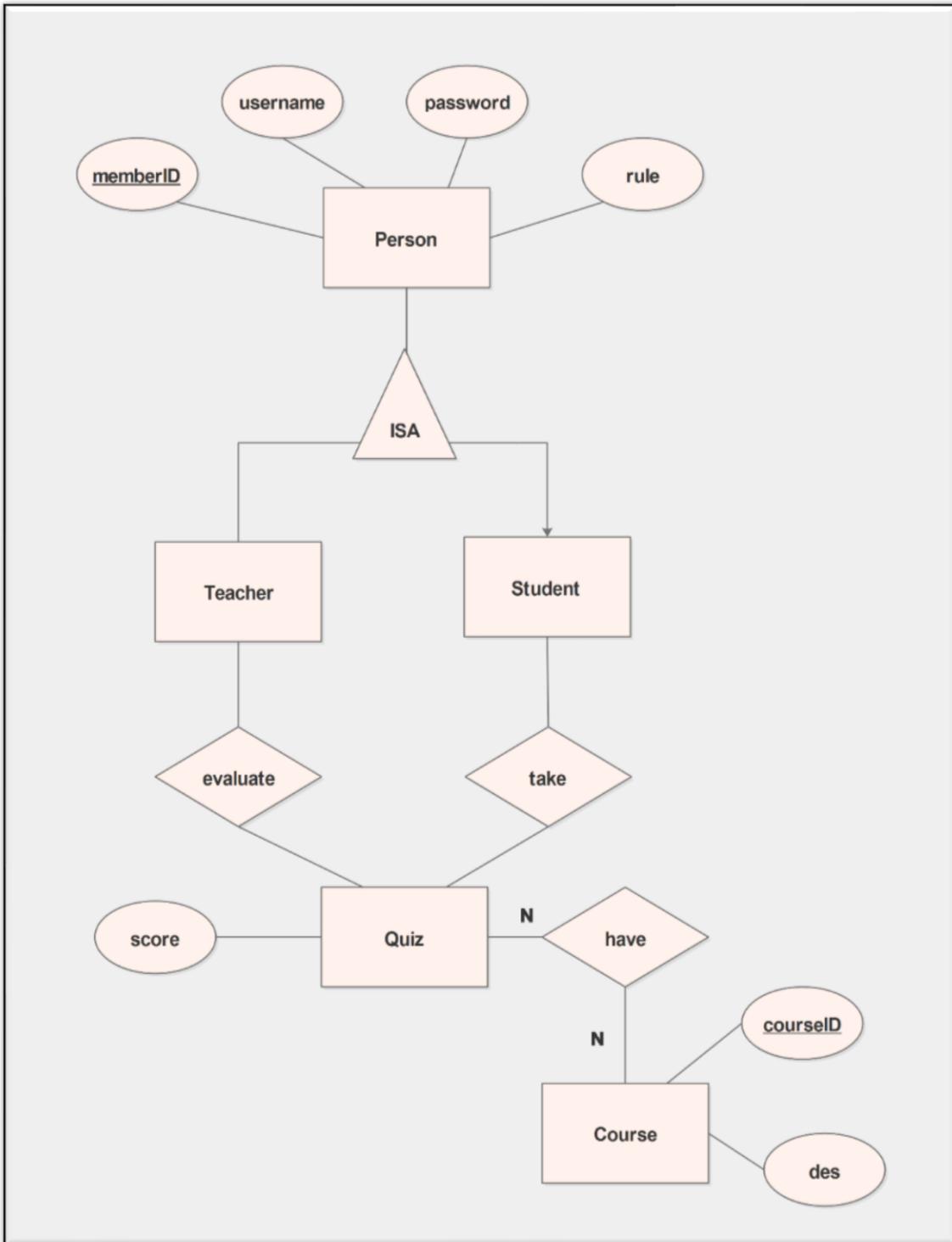


Figure 13 : Entity relationship (ER) diagram for the BJC database system.

4.2.3: Web Design Principles

We focused on the most effective web design principles in 2017 to present the BJC with aesthetically pleasing to attractive users. According to Peep Laja, who is a founder of CXL which is designing and marketing company, visual hierarchy one of the critical key to attracting the user, which is building a website with precisely which is the essential button, and which is the less of that. So, drive of this concept we design our web by creating a menu button. Also, another principle is Hick's Law Which is: "every additional choice increases the time required to take a decision." In our web we design the main page to show only three options, login, choose computing, or edutainment. By showing less option, the users will be easier to use the web. Moreover, we used White space and clear design principle, but not in the whole site just in the display show when we need to show content to users. This principle enhances the simplicity, based on a study by Google in August 2012 called: "The role of visual complexity and prototypicality regarding the first impression of websites: Working towards understanding aesthetic judgments," they concluded that simple websites are scientifically better [19]. Another principle is Fitt's Law, which stipulates that the time required to move to a target area. In our design, we make the menu button in the middle to achieve this principle [20].

- **Design**

- **Sketch:**

We drew several sketches for the new design of the BJC, but we decided to get these, which have a menu button, to make it easy to access the whole website in a short time.

Main page:

26

In the main page, shows two

options for the user to choose if he wants to

explore the edutainment or computing.

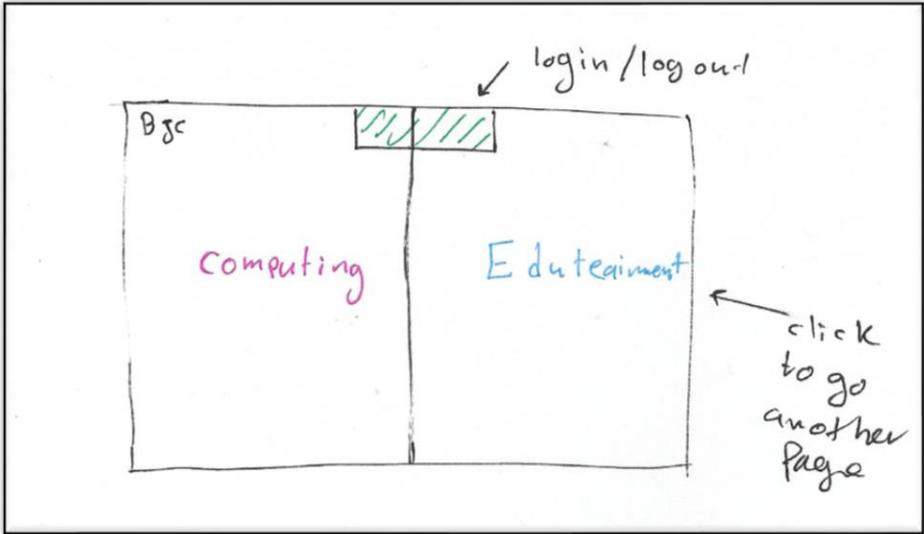


Figure 14: homepage sketch.

- Menu page:

This sketch shows the menu after clicking the button. It is showing the 6 big ideas for computing and 7 big ideas of edutainment.

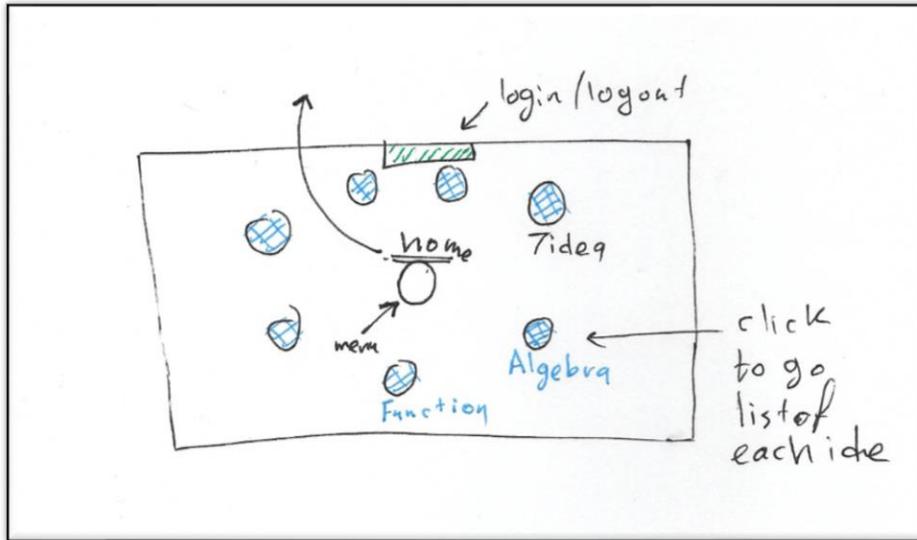


Figure 15: menu sketch.

This sketch is showing the content of each idea when the user clicks on it, and in the top it shows the tap for login – logout service.

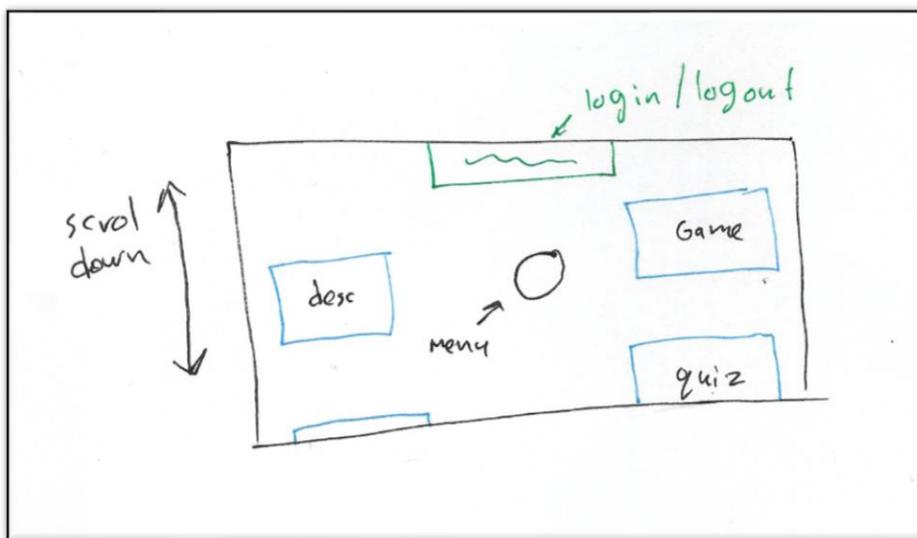


Figure 16: display content of the BJC sketch.

- Wireframe:

This is the main page that shows the logo in the top right of the page and shows two options for the user, in the left side is computing and the right side is edutainment. Once the users click the edutainment, they will go to the menu page.

The menu page shows the menu button when you click on it, it will show the 7 big ideas and the users can choose any one of them. Once you click any of the idea buttons, you will move to its details.

The description page shows the details for each idea. Its show the description, games, quizzes, videos, and lessons.

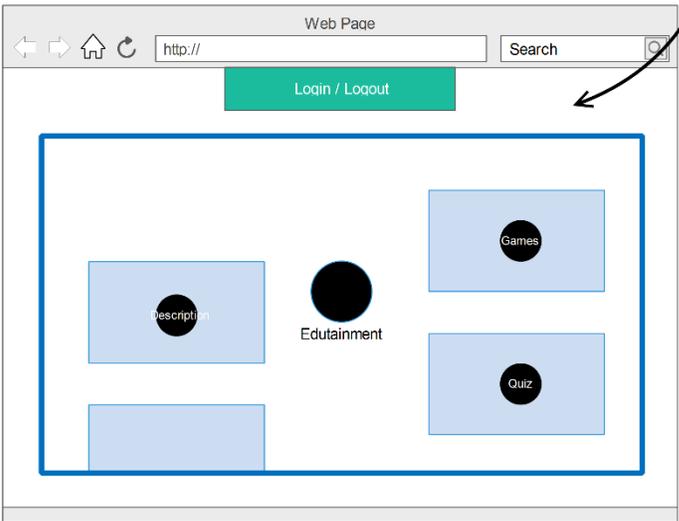
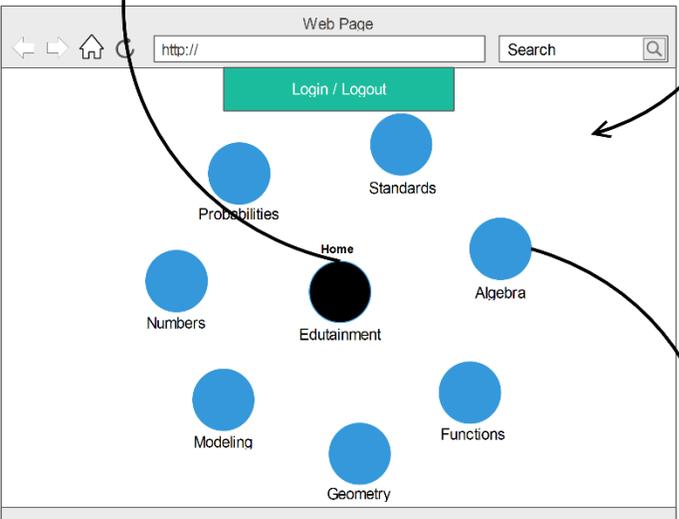
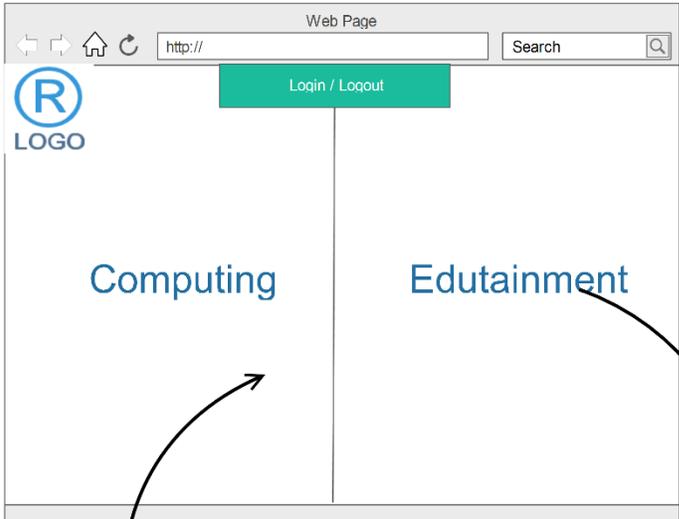


Figure 17: The BJC wireframe.

- Prototype:

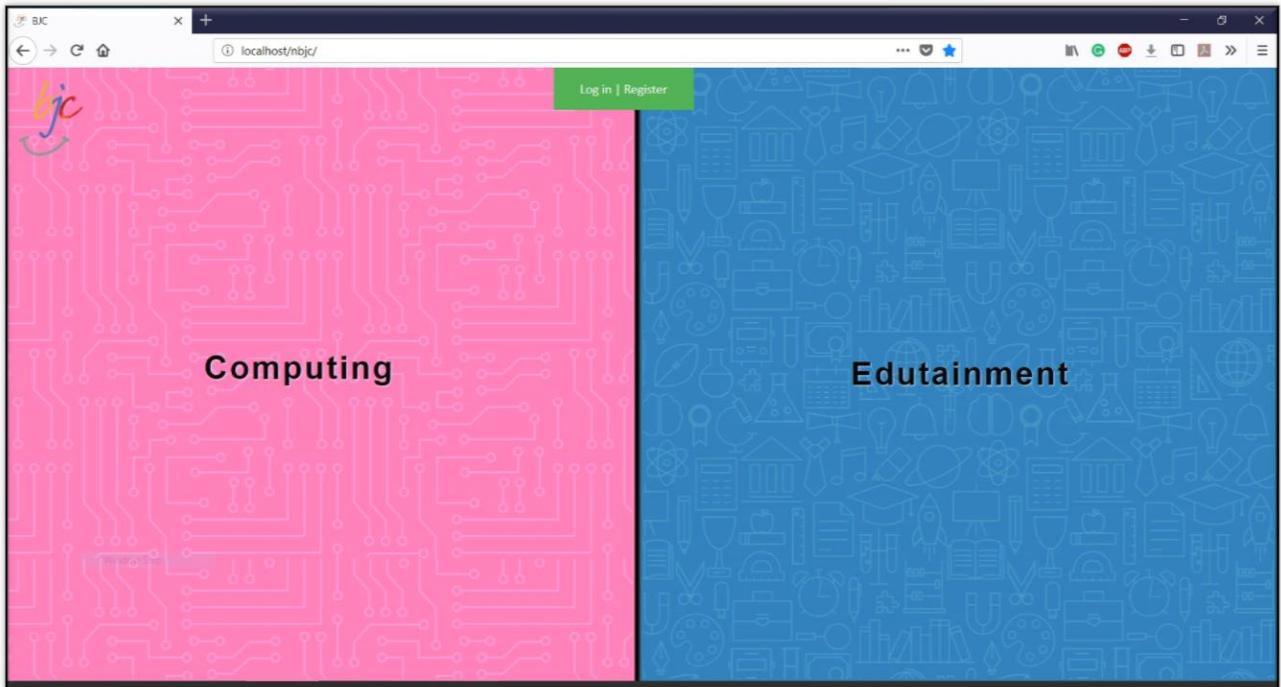


Figure 19:homepage snapshot.

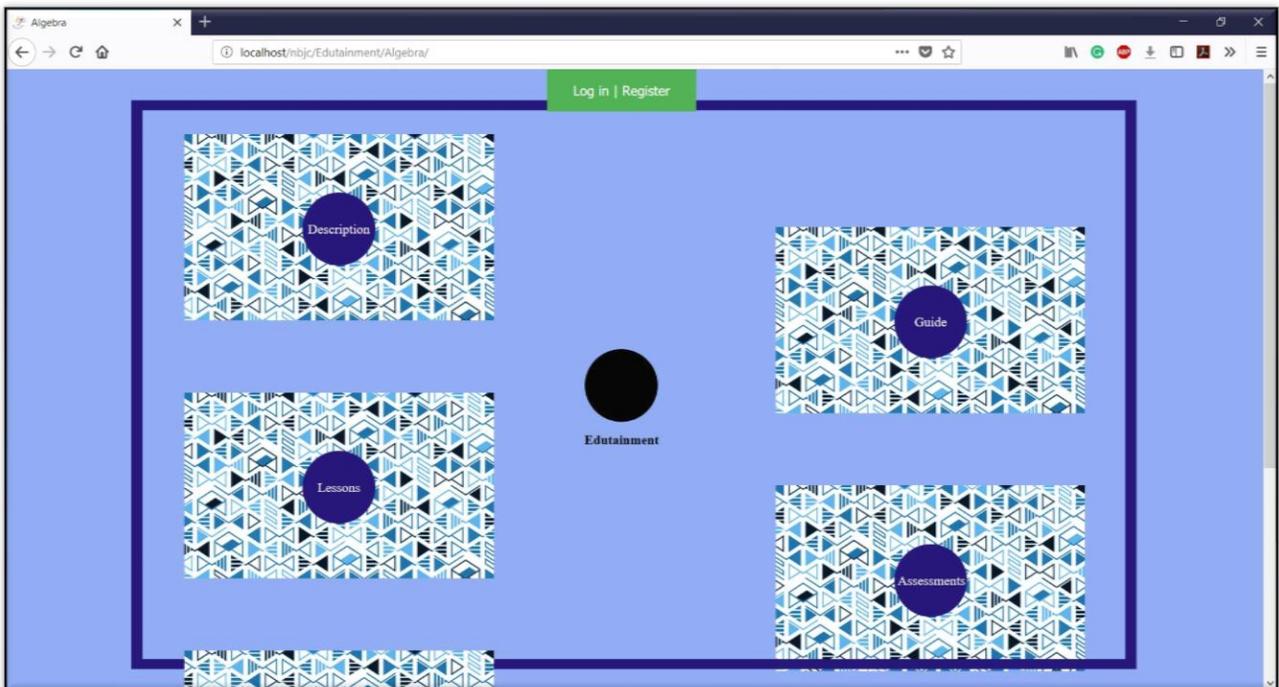


Figure 18: snapshot for display content of the BJC.

After clicking on the menu button, it will show the different fields:

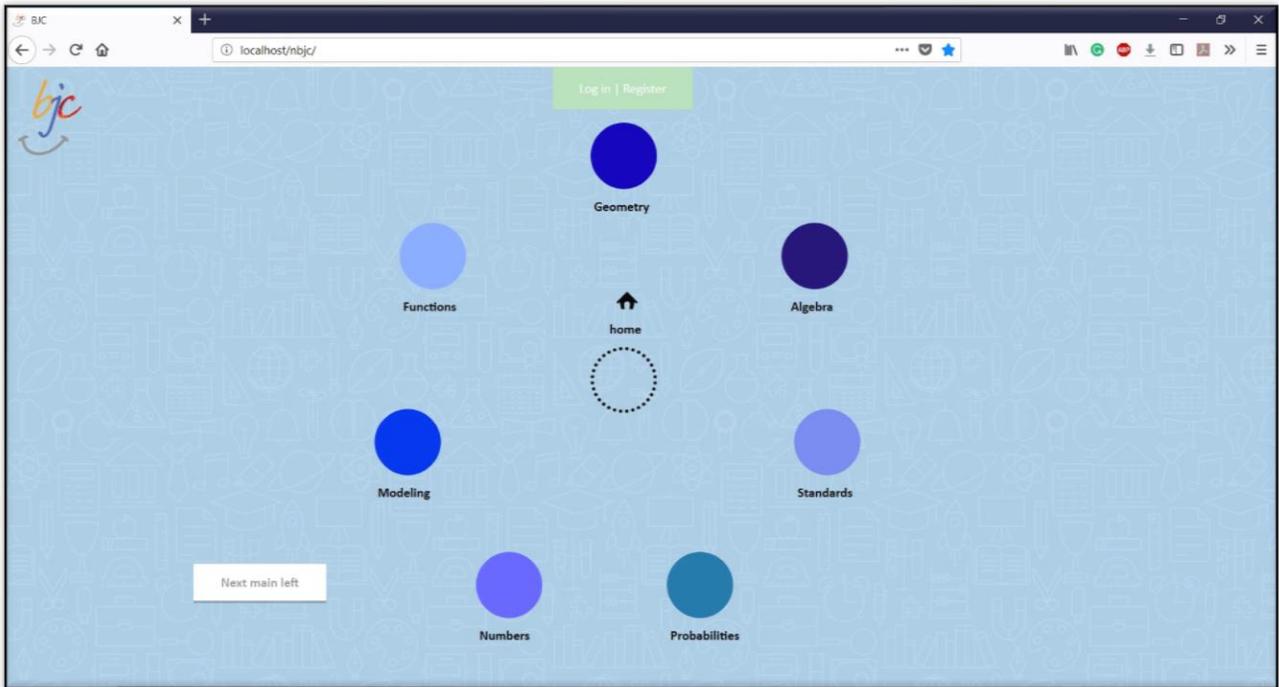


Figure 20: menu page snapshot.

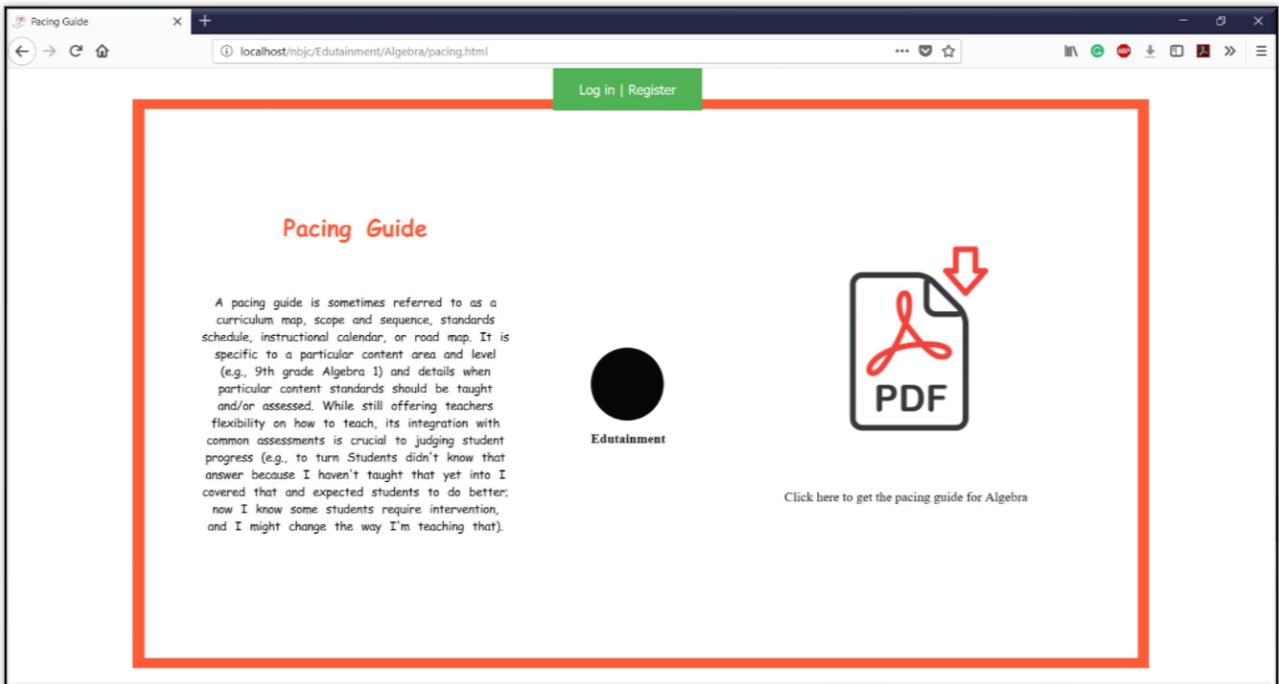


Figure 21: snapshot for display content.

Below is a window for login and registration:

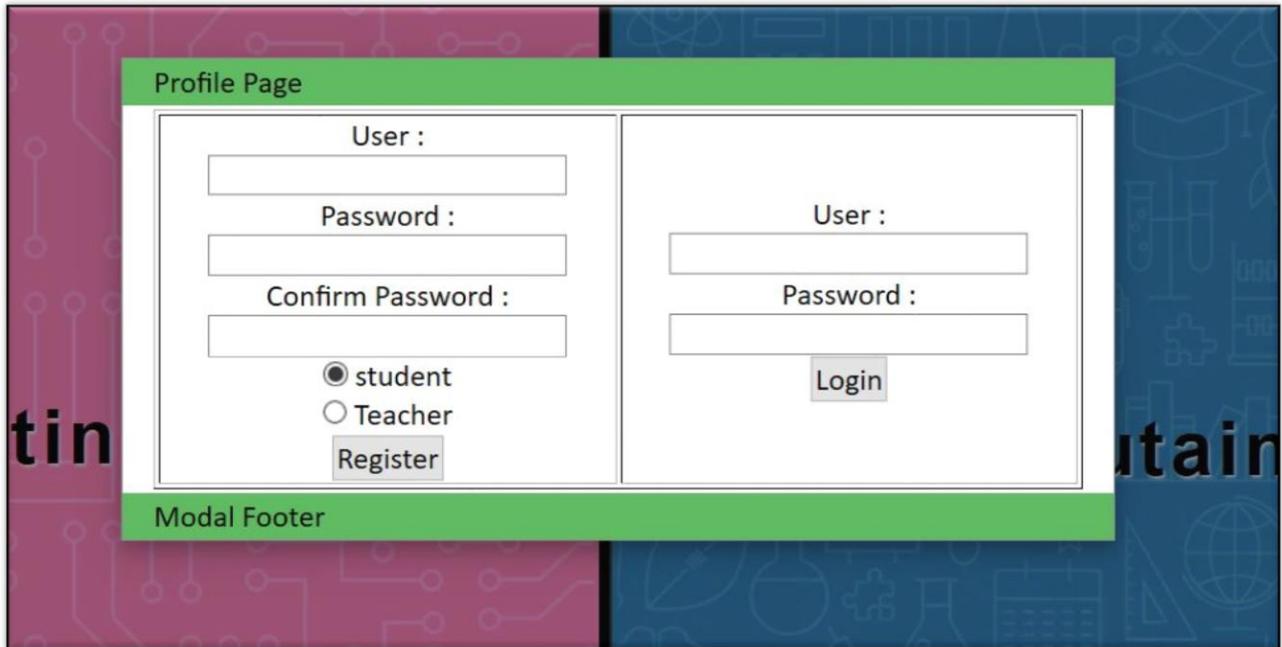


Figure 22: login and register window.

After login for teacher, there are two options, logout and status of students:

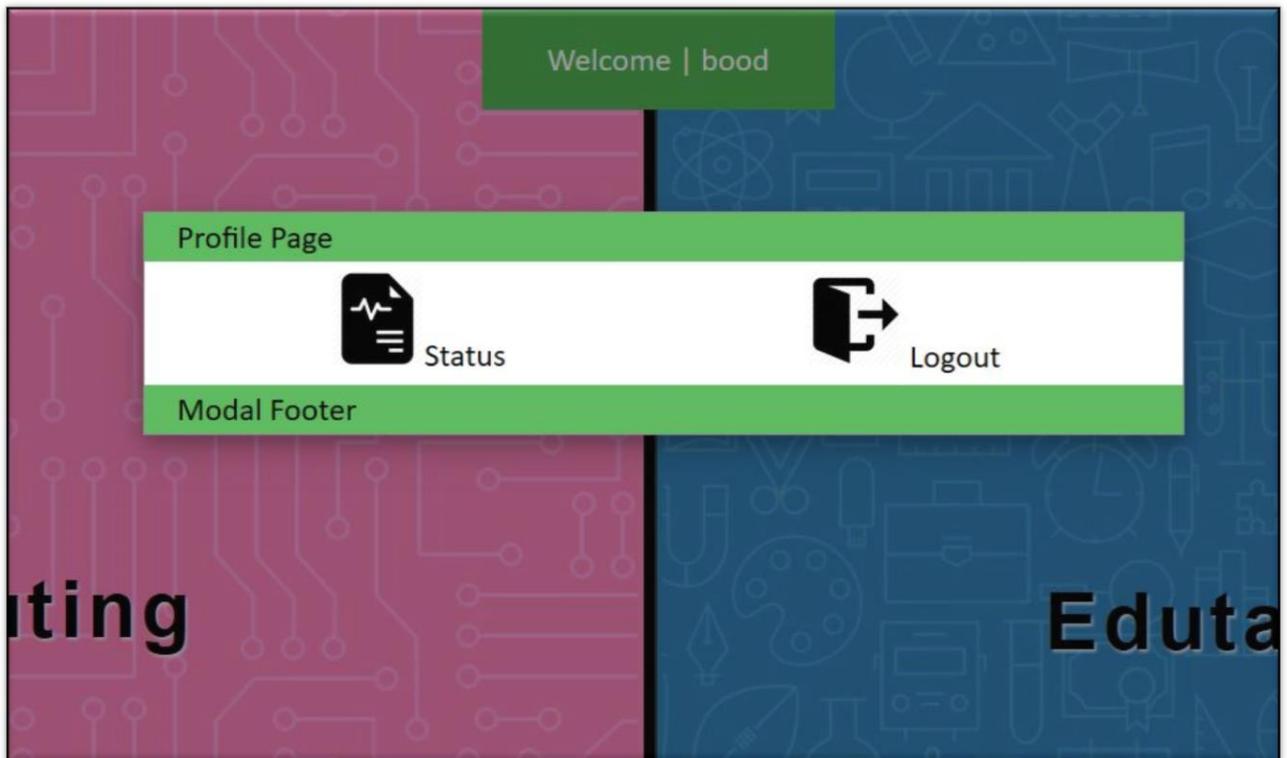


Figure 23: window for teacher.

Below, the teachers can follow the progress of the students:

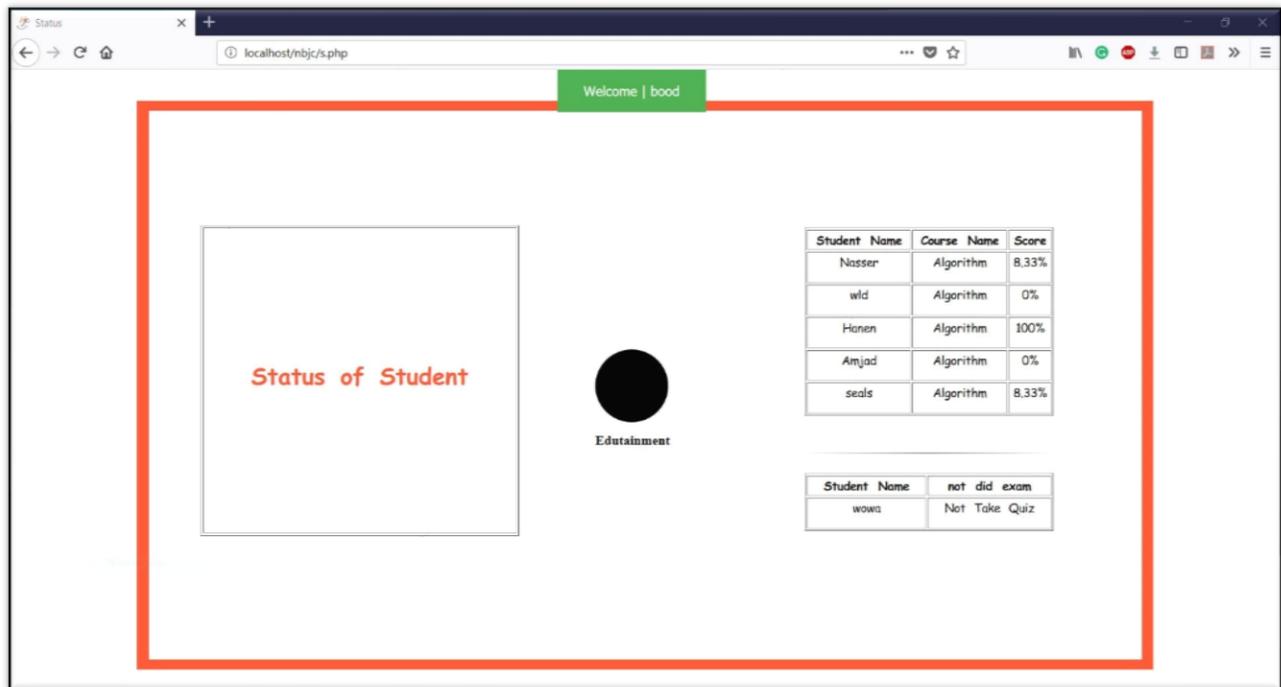


Figure 24: statues page for teacher.

4.3 | Implementation

The BJC web repository is structured as a combination of tools. We rebuilt the website from scratch and the total lines for this project is 12635 lines in 119 coding files. This the BJC project contains two parts. First, is the frontend, and we used HTML, PHP, JavaScript, CSS, and the backend, we used PHP, JSON, and SQL. Some of these tools we used as layout and some of them we used as a function work in the background to make the website easy to use. Mainly, on this website we use the menu button, because the previous version used the Metro layout. It was simulating windows 8. But in the new version, we use the menu button, and you can access any web page faster than what we have in the previous one.

4.3.1: Tools and Technologies:

For the Frontend, we use HTML (Hypertext Markup Language), which is famous language to build and create websites and it is a static language and it is not a dynamic method of design. HTML was created in 1993 by W3C & WHATWG and the new version is 5.2, which released in Dec 14, 2017. Most of the files in this project used HTML because most of the requirement is showing the student the content of the courses without interaction, the total number of files using HTML is 97 files [21]. Also, we used CSS (Cascading Style Sheets) for styling the layout of the site. It is a style sheet language and was created in 1996 by Håkon Wium Lie and Bert Bos. We used different features to animate the website, also we use the hover and active feature to make the layout dynamic with users. We used 13 files of CSS for the whole project in 498 lines [22]. Also, we used PHP to interact with users and servers. PHP is a language designed for web application in the server side. It was founded in 1995 by Rasmus Lerdorf. The last version of PHP is 7.2.4 which 34 released in Mar 28, 2018. In 12 files, we used PHP with HTML to make connections with the server and webpage. Also, we used JavaScript

to make the html page interactive with users and use it to animate the object in the website to make it easier and more fun for users. JavaScript released in 1995, the same year of PHP. It was designed by Brendan Eich [23]. And the last version of JavaScript is ECMAScript2017, founded in June 2017. Under JavaScript, there is another library found from JavaScript like jQuery and Ajax and both of these libraries are included in the project [24]. Also, we use JSON to store the data for the website, which means we can change the content just by changing the JSON file. We read the file using JavaScript. JSON refers to JavaScript Object Notation. The first release for JSON was in early 2000, and Douglas Crockford was the first one who specified JSON [25]. Moreover, we used SQL to poll data from the database we defined it in the host server. SQL means Structured Query Language. It was designed by Donald D. Chamberlin, and first appeared for SQL in 1977 [26].

Chapter 5: Result and Analysis

In this section, we will show the results and analyze if the BJC website achieves the requirements. It will be determined by questionnaires and evaluations. We will determine if we achieve the requirement from the result and details of each questionnaire.

5.1 | Evaluation

The evaluation is arranged to be executed in the way that the reason to build the application to be satisfied, and the expectation is that the BJC web repository will achieve required specifications. We want to make sure that the site meets a requirement of usability and a student can use it efficiently and we will analyze their experience with the website.

5.2 | Pre-questionnaire

The pre- questionnaire significant questions are:

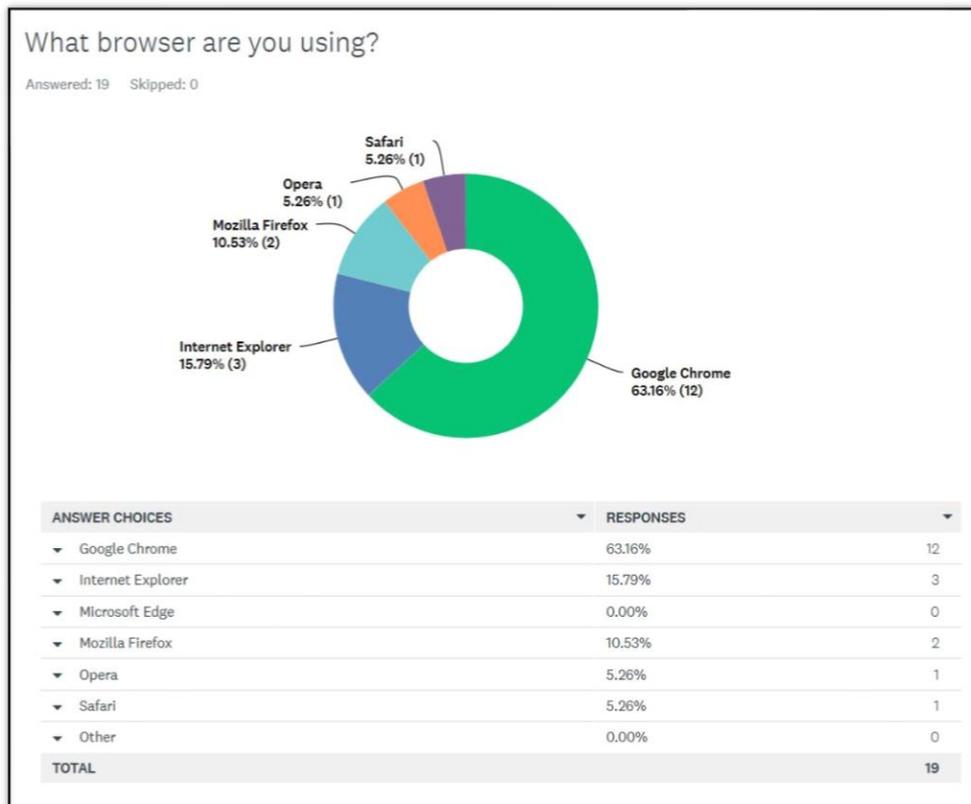


Figure 25: First question in pre-questionnaire.

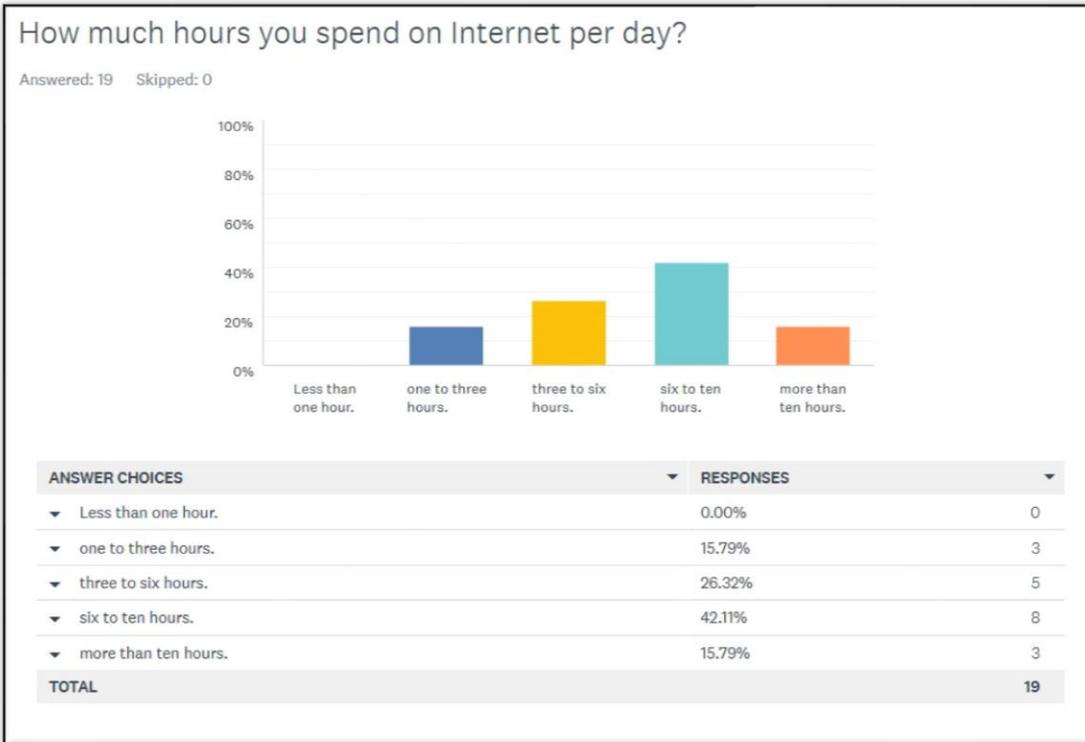


Figure 27: Second question in pre-questionnaire.

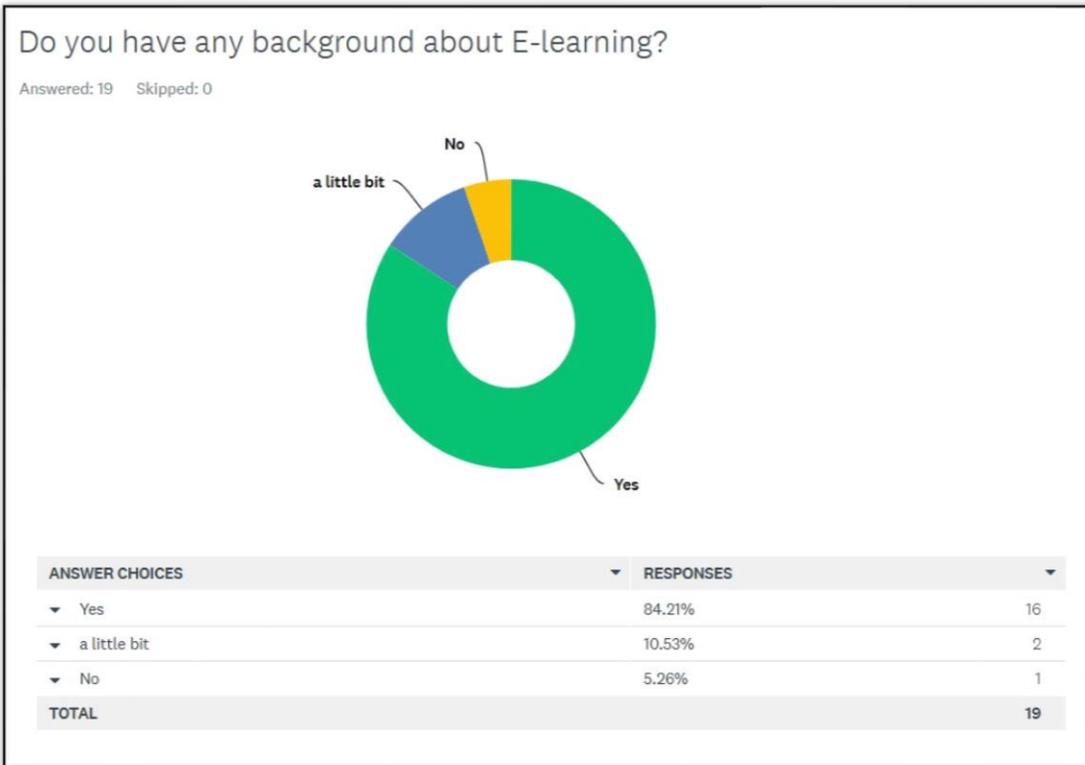


Figure 26: Third question in pre-questionnaire.

5.3 | Post-questionnaire

1. Please evaluate the following aspect of BJC site: 

	Strongly Agree	Agree	Neutral	Disagree	Strongly Agree
The homepage is attractive	<input type="radio"/>				
the typography is attractive	<input type="radio"/>				
It is easy to find my way around the site.	<input type="radio"/>				
It is easy to remember where to find things.	<input type="radio"/>				
It is straightforward to perform tasks	<input type="radio"/>				
It is easy to navigate back and forth through different case studies.	<input type="radio"/>				
The overall application is easy to use.	<input type="radio"/>				
the application is appropriate for a mobile	<input type="radio"/>				
people with limited computer experience can use the BJC site.	<input type="radio"/>				
Based on this experience, I will use BJC in the future.	<input type="radio"/>				

2. Please rate BJC site with respect to following aspects: 

	Strongly Agree	Agree	Neutral	Disagree	Strongly Agree
Flexibility	<input type="radio"/>				
User Experience	<input type="radio"/>				
Easy to Understand	<input type="radio"/>				
Joyful	<input type="radio"/>				

Figure 31: hypothesis questions 1.

3. Overall, I would recommend using BJC site to others: 

Yes

No

Figure 30: hypothesis questions 2.

4. please list the most positive aspect of BJC site you observed



Figure 29: positive feedback.

5. please list the most negative aspect of BJC site you observed



Figure 28: Negative feedback.

5.4 | Analysis of variance (ANOVA)

We will use ANOVA, which is statistics model to analyze the data from the results of students when they took specific task list in phase one and phase two of BJC and detect if there is significant different in their score, the scenario will be:

- 1) Register as new user.
- 2) Go to computing section.
- 3) Choose Algorithm category.
- 4) Take binary lesson.
- 5) Take the assessment of binary lesson.
- 6) logout of the system.

The result of students:

Students	Phase One	Phase Two
S1	12	11
S2	9	10
S3	12	12
S4	11	10
S5	10	12
S6	8	11
S7	10	8
S8	1	3
S9	5	7
S10	11	11
S11	12	10
S12	4	9

The ANOVA result:

SUMMARY						
Groups	Count	Sum	Average	Variance		
Phase One	12	105	8.75	12.93181818		
Phase Two	12	114	9.5	6.454545455		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.375	1	3.375	0.348182884	0.561156061	4.300949502
Within Groups	213.25	22	9.693181818			
Total	216.625	23	40			

5.5 | Post-questionnaire

○ Results of Post questionnaire

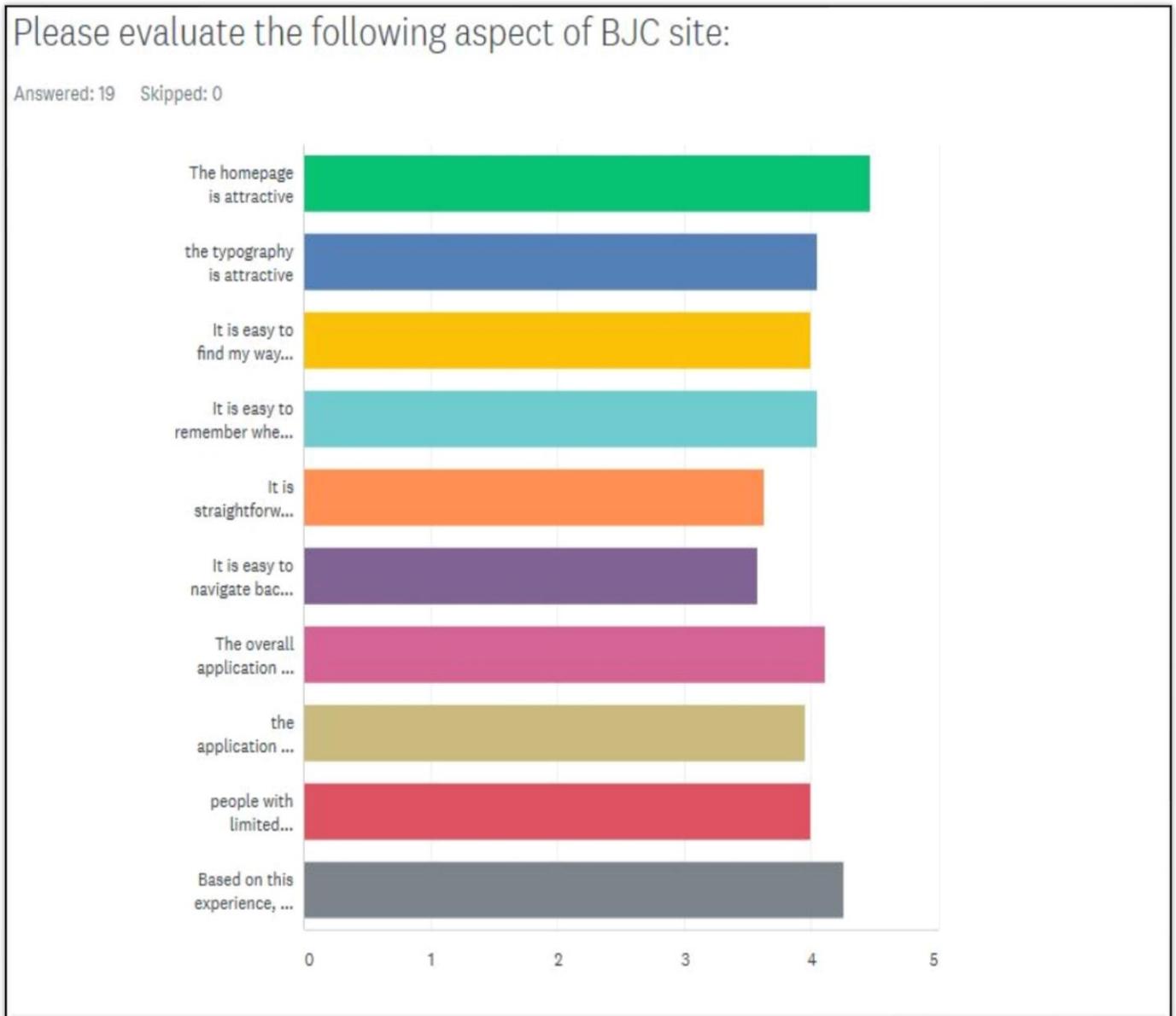


Figure 32: feedback from user after evaluate the BJC.

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY AGREE	TOTAL	WEIGHTED AVERAGE
▼ The homepage is attractive	73.68% 14	15.79% 3	0.00% 0	5.26% 1	5.26% 1	19	4.47
▼ the typography is attractive	36.84% 7	42.11% 8	10.53% 2	10.53% 2	0.00% 0	19	4.05
▼ It is easy to find my way around the site.	36.84% 7	36.84% 7	15.79% 3	10.53% 2	0.00% 0	19	4.00
▼ It is easy to remember where to find things.	42.11% 8	31.58% 6	15.79% 3	10.53% 2	0.00% 0	19	4.05
▼ It is straightforward to perform tasks	31.58% 6	15.79% 3	42.11% 8	5.26% 1	5.26% 1	19	3.63
▼ It is easy to navigate back and forth through different case studies.	26.32% 5	42.11% 8	5.26% 1	15.79% 3	10.53% 2	19	3.58
▼ The overall application is easy to use.	47.37% 9	21.05% 4	26.32% 5	5.26% 1	0.00% 0	19	4.11
▼ the application is appropriate for a mobile	42.11% 8	26.32% 5	15.79% 3	15.79% 3	0.00% 0	19	3.95
▼ people with limited computer experience can use the BJC site.	47.37% 9	21.05% 4	21.05% 4	5.26% 1	5.26% 1	19	4.00
▼ Based on this experience, I will use BJC in the future.	52.63% 10	26.32% 5	15.79% 3	5.26% 1	0.00% 0	19	4.26

Figure 33: Statistics result of survey.

About 82% of students find that the BJC web repository is easy to use. Deriving from this result, we seek to prove hypotheses number one that students find the BJC easy to use.

Q2

Please rate BJC site with respect to following aspects:

Answered: 19 Skipped: 0

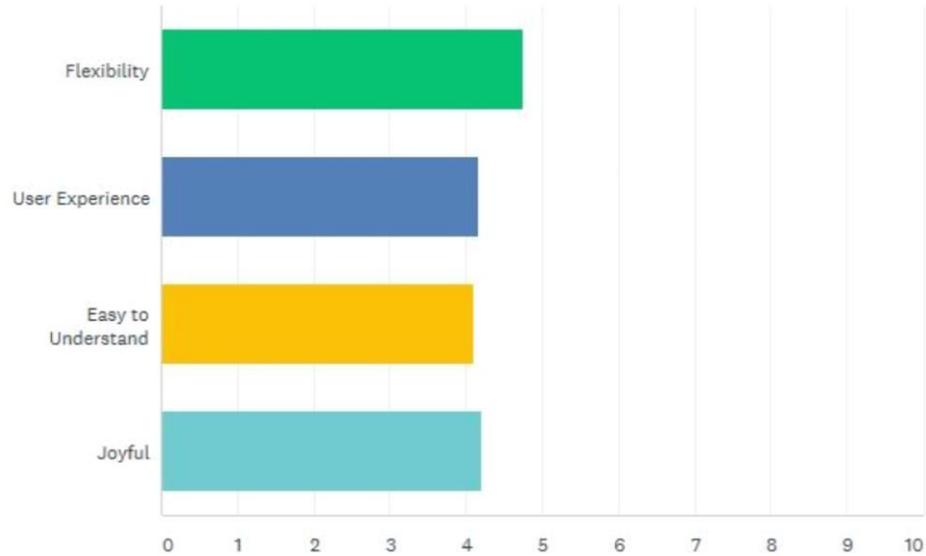


Figure 34: feedback about the features of the BJC phase 2.

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY AGREE	TOTAL	WEIGHTED AVERAGE
Flexibility	78.95% 15	15.79% 3	5.26% 1	0.00% 0	0.00% 0	19	4.74
User Experience	38.89% 7	44.44% 8	11.11% 2	5.56% 1	0.00% 0	18	4.17
Easy to Understand	52.63% 10	15.79% 3	26.32% 5	0.00% 0	5.26% 1	19	4.11
Joyful	52.63% 10	26.32% 5	10.53% 2	10.53% 2	0.00% 0	19	4.21

Figure 35: present result in a number for features of the BJC.

Hypotheses 2 and 4 are being supported by the above survey results as 84.2% of students feel that the BJC attracted them to explore computer science.

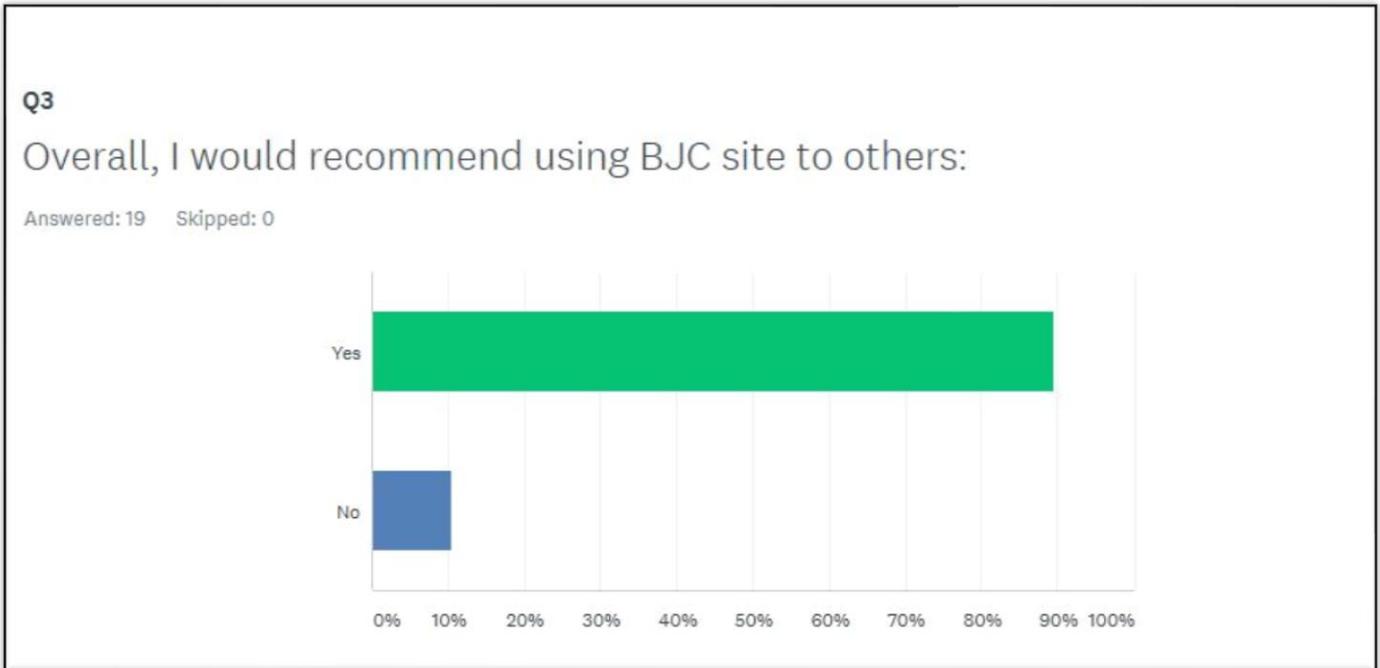


Figure 36: chart for recommending the BJC.

ANSWER CHOICES	RESPONSES
Yes	89.47% 17
No	10.53% 2
TOTAL	19

Figure 37: percentage for recommend the BJC.

Hypotheses 3 is supported by the above survey results as 89.47% of students reported that they will recommend the BJC to others.

Positive opinion:

amazing web site 4/9/2018
the arrangment is good 4/9/2018
nothing 4/9/2018
I like the orgnize of the website 4/9/2018
It's positive the games 4/9/2018

Figure 38: Positive feedback about the BJC 1.

I don't like the site it's complecated 4/9/2018
it's pretty 4/9/2018
I like the site and there is many feature 4/9/2018
I like the games 4/9/2018
The animation is great the website I like it 4/9/2018

Figure 39: Positive feedback about the BJC 2.

Negative opinion:

Showing 19 responses
4/9/2018
no thing
4/9/2018
nothing
4/9/2018
need to add more elements
4/9/2018
Nothing
4/9/2018
it's confuse I can't understand it
4/9/2018

Figure 415: Negative feedback about the BJC 2.

you need to make this website more easer
I like eevey thing
sounds good
need more feature for students
need more feature for students

Figure 406: Negative feedback about the BJC 2.

5.6 | Analysis of Evaluation

We collect the feedback to evaluate the usability of the BJC web repository. The participants in the questionnaire were expert users with a good background in system design and evaluation. They participate in assessing the BJC via a Survey Monkey questionnaire to evaluate the system in effectiveness and satisfaction. However, the sample was small size, and the findings are based on a convenience sample also findings from this study might not represent the K-12 students. We used Likert-style questions and scales for the format of the questionnaire. Most of the Participants reveal that “The homepage is attractive,” “The typography is attractive.” and about 82.2% of the participants report that the BJC web repository had ease of use. And approximately 85.2% of users show in the survey that they will use it in the future.

5.7 | System test

5.7.1: PHPUnit Test:

PHPUnit test is a programmer-oriented testing framework. The last version is PHPUnit 7.0, and it is compatible with PHP 7.0. It recommends working with the latest version. PHPUnit was developed by Sebastian Bergmann on March 15, 2004, and the last version was released on Apr 06, 2018 [27].

The main goal for PHPUnit is finding mistakes and bugs in a code. PHPUnit used assertions function to verify what we expected from the system. Writing PHPUnit test cause more workload, but it helps to find the bug and reduce repairing time for the system.

If we do not conduct PHPUnit test during the implementation, maybe we will face the bugs once the BJC site is in a production environment. Which could cause a problem and affect the whole system. Furthermore, we will need more effort and it 47 will consume more time, and it is costly to fix this problem later on. According to the National Institute of Standards and Technology (NIST), the cost to repair

a bug in a production environment will cost 30 times compared more with a coding phase which cost five times as much. Moreover, in some cases, the cost of bugs cannot be treated because they could cause consequence problems [28].

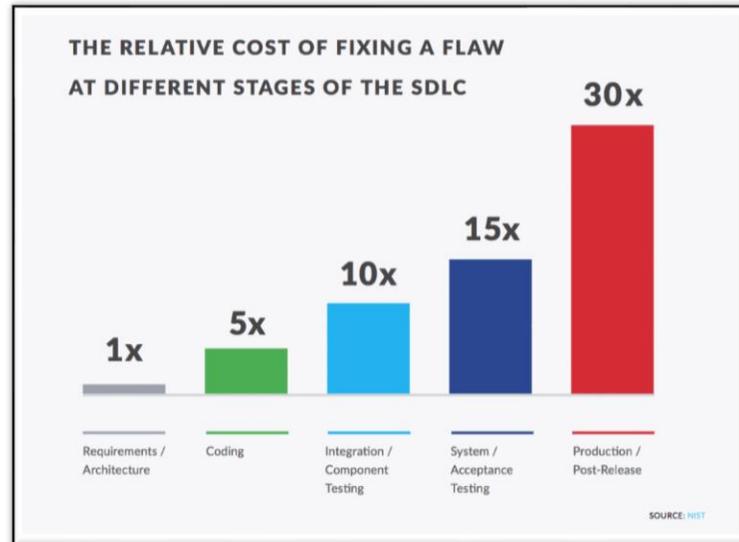


Figure 42: Show the cost when find bug in different stages.

All test classes go into a ClassTest which inherits from PHPUnit\Framework\TestCase, and for standardization we named each method starting with the word ‘test’. Inside the methods we used assertions function such as assertsame(), and we used it to match an expected value to test it [29].

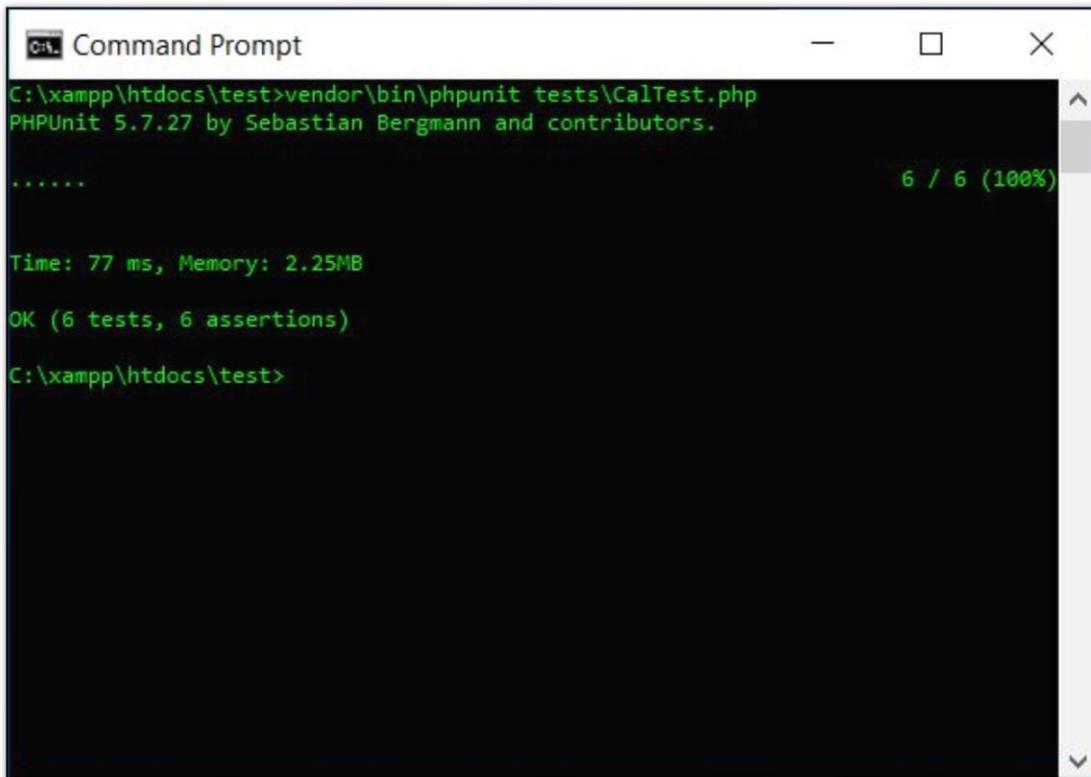
We used PHPUnit to test functions we built in the BJC system and tested if we got expected results. And I will present below the test file which we have to end the name of this file with ‘Test’:

```
1 <?php
2 include_once("calculator.php");
3 use PHPUnit\Framework\TestCase;
4
5 class CalTest extends TestCase
6 {
7     public function testCalclator_sumarray()
8     {
9         $scal = new calculator ;
10        $testarray = [1,2,3,4,5];
11        $result = $scal->sumarray ($testarray);
12        $this->assertSame(15, $result);
13    }
14    // -----
```

Figure 43: declare file and function to test it.

```
28 // -----
29 public function testCalclator_compaer()
30 {
31     $scal = new calclator ;
32     $result = $scal->compaer (1995,1986);
33     $this->assertSame(true, $result);
34 }
35 // -----
36 public function testCalclator_equal_number()
37 {
38     $scal = new calclator ;
39     $result = $scal->equal_number (22,22);
40     $this->assertSame(true, $result);
41 }
42 // -----
43 public function testCalclator_mult()
44 {
45     $scal = new calclator ;
46     $result = $scal->mult (20,15);
47     $this->assertSame(300, $result);
48 }
49 }
50 -?>
```

Figure 44: Complete the PHPUnit test



```
Command Prompt
C:\xampp\htdocs\test>vendor\bin\phpunit tests\CalTest.php
PHPUnit 5.7.27 by Sebastian Bergmann and contributors.

.....                                     6 / 6 (100%)

Time: 77 ms, Memory: 2.25MB

OK (6 tests, 6 assertions)
C:\xampp\htdocs\test>
```

Figure 45: the result of testing and show that all test is successful

5.7.2: Validate the code:

Gerald Oskoboiny started the HTML validation as a project and called it Gentler HTML Validator. In 1994, Dan Connolly and Mark Gaither launched the first online service for validating code [30]. In 2008, The WC3 released the HTML validator here (<https://validator.w3.org>), there are many benefits to validating code: We used the validation as debugging tools, for a proof quality of the system, to make maintenance easy for the web page and help to teach a good practice to writing valid code [31]. We used the WC3 validator to check our system and fix any warnings and errors which we found and made the code without any mistake.

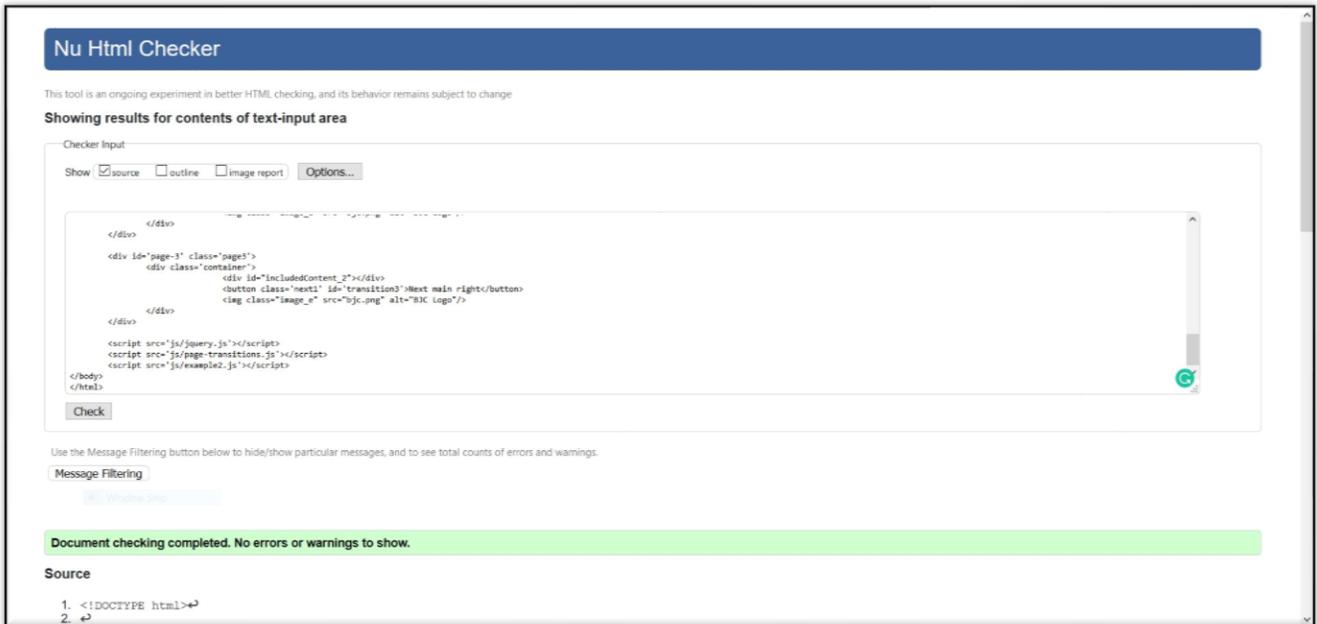


Figure 46: Validate the BJC website

5.8 | Compare between old new the BJC:

In this section we will compare between the BJC phase one and phase two in different perspectives to show the growth in new one, and what we avoid in new version. The table in below, showing the distinction:

Perspectives	The BJC – phase one	The BJC – phase two
Web Design Principles	Designed in Metro style which resembled Windows 8, which was developed in 2012.	Based on updated web design principles. We use one menu button, and the user just clicks to explore the whole website. Animation is provided to increase interest adding beauty and joy value. This one-page design is more modern than phase one.
Security	Most of the content is uploaded to a different server, which is a security problem. This could affect students' device by adding malicious files.	The whole content and material uploaded to the same server of the BJC. This reduces the opportunity for improper access to system content. Security and access control is improved with user interface and content located in same server.
Easy to access	By using the metro and cards with color change each time, it may confuse the user with poor visibility of icons, which may cause problems with navigation.	By using one button, you can access the whole website in one click which helps users to explore the BJC easily.
Aesthetics	The pages have different colors that are changed by the system randomly. Sometimes the system chooses a light color, and the original font has a white color, so, it causes difficulty to read the content.	We use more interaction and animation by JavaScript to add more beauty in the BJC and to make users more enthusiastic for attract them to learn the computer science principles and computational thinking skills.
Interactive	In this version most of the quizzes are based on downloadable files so there is no interaction between the system and the students.	We built quizzes inside the BJC to support student interaction with BJC curriculum to encourage their use and to give them quick reinforcing feedback.

Chapter 6: CONCLUSIONS AND FUTURE WORK

6.1 | Conclusions

The BJC web repository aims to help students get involved in the computer science community and attract them to explore the fun in computing. It assists students to gain skills in computational thinking and has excellent knowledge of the seven big ideas. The main goal of the BJC web repository is to provide education and information by covering it with beauty and joy. Furthermore, it is trying to fill the gap of the shortage of the information on computer science in our high schools. It will be valuable if you spread it among high school students. By contributing to these kinds of applications, we can help the future of the next generation by preparing an excellent framework to support computational thinking in computer science education and adding joy to fabulous technical life.

6.2 | Future Work

To enhance the BJC web repository, we need to improve the lesson section to make it dynamic and better than what we already have in this version by using more than files. Furthermore, we need to focus on increasing the content in the BJC web repository. Also, make students continue the site by sharing ideas between each other and commenting to make the environment more interactive and build it as a community for people interested in computer science. Also, in the content of quizzes, we need to create more and make the students compete. Moreover, the AP released new curriculum for Computer Science in middle of March, and it will be better to map this curriculum in ⁵² our framework in future. Furthermore, we

need to add system admin view to upload and create new content. On another hand, we suggest focusing on the future on the shortage of females who are interested in computer science. It is noticed that women engage less in computer science compared with males. In 1985, about 35% of computer science majors were women, but in 2014 this number dropped to be only 18% of computer science majors were women. It is a critical point, and we focus on it by researching this issue [32].

Bibliography

- [1] "Computer and Information Technology Occupations : Occupational Outlook Handbook: ;," 30 1

- [2] M. Snapp, "Being 'future ready' — computer science education as a launching pad to a promising

- [3] M. desJardins, "The real reason U.S. students lag behind in computer science," *Fortune*, 22 10 2015.

2018].

63

63

- [5] M. Tedre and P. J. Denning, "The Long Quest for Computational Thinking," pp. 120-129, 24-27 11

2016.

67

67

[6] "Computational thinking," wikipedia.org, 13 3 2018. [Online]. Available:

[7] U.S. Department of Education NCES, "AMERICA'S High School Graduates," U.S. Department of

[8] "Introduction to computational thinking," BBC, [Online]. Available:

- [13] Y. Levy and M. M. Ramim, "The Effect of Competence-Based Simulations on Management Skills Enhancements in E-Learning Courses," pp. 34-41, 10-11 2 2015.
- [14] E. Y. W. L. S. & H. T. K. Huang, "What type of learning style leads to online participation in the mixed-mode," *Computers & Education*, pp. 338-349, 2012.
- [15] A. B. J.-L. I.-M. J.-M. D. a. O. K. Manuel Palomo-Duarte, "A collaborative mobile learning system to facilitate foreign language learning and assessment processes," pp. 567-572, 2-4 11 2016.
- [16] National Center for Education Statistics, "Bachelor's degrees conferred by postsecondary institutions, by field of study: Selected years, 1970-71 through 2014-15," 2016. [Online]. Available: https://nces.ed.gov/programs/digest/d16/tables/dt16_322.10.asp?current=yes. [Accessed 12 4 2018].
- [17] K. Wagstaff, "Can We Fix Computer Science Education in America?," Techland, 16 7 2012. [Online]. Available: <http://techland.time.com/2012/07/16/can-we-fix-computer-science-education-in-america/>. [Accessed 12 4 2018].
- [18] "The Beauty and Joy of Computing," Berkeley, [Online]. Available: <https://bjc.berkeley.edu/>. [Accessed 12 4 2018].
- [19] E. E. P. M. S. K. O. J. A. B.-A. Alexandre N. Tuch, "The role of visual complexity and prototypicality first impression of websites: Working towards understanding aesthetic judgments," *Web design, First impression, Visual complexity, Prototypicality*, 12 8 2012.
- [20] P. Laja, "8 Effective Web Design Principles You Should Know," CXL, 8 2 2018. [Online]. Available: <https://conversionxl.com/blog/universal-web-design-principles/>. [Accessed 17 3 2018].
- [21] "HTML," Wikipedia, [Online]. Available: <https://en.wikipedia.org/wiki/HTML>. [Accessed 12 4 2018].
- [22] "Cascading Style Sheets," Wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/Cascading_Style_Sheets. [Accessed 12 4 2018].
- [23] "PHP," Wikipedia, [Online]. Available: <https://en.wikipedia.org/wiki/PHP>. [Accessed 12 4 2018].
- [24] "JavaScript," Wikipedia, [Online]. Available: <https://en.wikipedia.org/wiki/JavaScript>. [Accessed 12 4 2018].
- [25] "JSON," Wikipedia, [Online]. Available: <https://en.wikipedia.org/wiki/JSON>. [Accessed 12 4 2018].
- [26] "SQL," Wikipedia, [Online]. Available: <https://en.wikipedia.org/wiki/SQL>. [Accessed 12 4 2018].
- [27] PHPUnit, "PHPUnit Manual," 6 4 2018. [Online]. Available: <https://phpunit.readthedocs.io/en/7.1/index.html>. [Accessed 15 4 2018].
- [28] N. I. o. S. a. Technology, "The relative cost of fixing bug," [Online]. Available: <https://www.nist.gov/>. [Accessed 15 4 2018].
- [29] Codecourse, "Unit testing with PHPUnit," 24 1 2017. [Online]. Available: <https://www.codecourse.com/lessons/unit-testing-with-php-unit>. [Accessed 16 4 2018].
- [30] "W3C Markup Validation Service," Wikipedia, 31 12 2017. [Online]. Available: https://en.wikipedia.org/wiki/W3C_Markup_Validation_Service. [Accessed 16 4 2018].
- [31] "Why Validate?," w3, 2013. [Online]. Available: <https://validator.w3.org/docs/why.html>. [Accessed 15 4 2018].
- [32] S. Behrens, "Man, computer science needs more women," Usatoday, 8 3 2017. [Online]. Available: <http://college.usatoday.com/2017/03/08/man-computer-science-needs-more-women/>. [Accessed 18 4 2018].