

UNIVERSITY OF TWENTE.

Team-Based Learning Application

FINAL REPORT

Supervisors: Yeray del Cristo Barrios Fleitas, Karen Slotman, Alisa Veale

Aida Enache | Cristian Anghel | Denis Arva | Laurentiu Birton | Radu Basaraba

Table of Contents

1. Introduction	4
1.1 Motivation	4
1.2 Requirements	5
2. Domain Analysis	6
2.1 Introduction to the domain	6
2.2 Stakeholders	6
2.3 Clients and potential users	8
2.4 Software Environment	9
2.5 Commonalities of the UT software	9
3. System Proposal	9
3.1 Requirement Analysis	9
3.1.2 Stakeholder requirements - user stories as functional requirements	9
3.2 Planning	10
3.2.1 Management plan	10
3.2.2 Plan of action / Project schedule	12
3.3 Tools to be used	15
3.4 Usability tests	16
3.5 Conclusion	17
4. Design	17
4.1 Page flow	17
Figure 4: Activity diagram for the student and teacher	19
4.2 Design choices	19
4.2.1 Overall look & feel	19
4.2.2 Group test answer vote	19
4.2.3 Flagged questions	20
4.2.4 Group Creation	21
4.3 Interface design and prototypes	21
4.4 Database design	23
4.5 Detailed design	24
4.5.1 Teacher view	24
4.6 Prototype testing	27
5. Implementation	27
5.1 Back end	27
5.1.1 Tools and technologies	27
5.1.2 Functionalities	28

5.2 Front end	31
5.2.1 Teacher implementation	31
Complete overview of the exams	31
Creating or editing an exam	31
Complete overview of the student groups and grades	32
Statistics for every exam	32
5.2.2 Student implementation	33
Complete overview of the exams	33
Overview of the groups	34
Individual Readiness Assessment Process	34
Group Readiness Assessment Test	34
5.3 Database	35
6. Testing	36
6.1 Test Plan	36
6.2 Approach	36
6.3 Functionalities to be tested	36
6.4 Unit testing	37
6.5 Integration testing	38
6.6 Usability and reliability testing	39
6.6.1 Objectives	39
6.6.2 Detailed procedure	39
6.7 Evaluation of test results	40
7. Future planning	40
7.1 Utilization and maintenance of the system	41
7.2 Additional features	41
8. Reflection/Evaluation	44
8.1 Planning	44
8.2 Team evaluation	44
8.3 Final result	45
Bibliography	47
Appendices	48
Appendix A: Figma Prototype	48
Appendix B: TBL App Webpages	53
Appendix C: Ethics report	60

1. Introduction

The Team-Based Learning (TBL) methodology is a highly structured form of small-group learning which has gained a lot of popularity in recent years through evidence and positive results. The core of TBL is designed around collaborative work and makes students responsible for their own learning process, which enables teachers to offer quality education that is beyond memorization.

Before a TBL class, students prepare the assigned material through self-study. During a TBL session, students spend most of the time working in strategically divided, constant teams. They first take an Individual Readiness Assurance Test which consists of multiple-choice questions to show their knowledge of key concepts in the assigned pre-class materials. Afterwards, they take the exact same test together with their team, called the Group Readiness Assurance Test, which requires discussing the questions within the team and reaching a consensus on each answer. What makes this activity special is that the team receives immediate feedback on their answers, designed using Immediate Feedback Assessment Technique (IF AT cards) that allow students to scratch off the chosen answers. When the students scratch off the correct answer from the first try, they receive full points for the question, and every time they choose a wrong answer points are deducted and they have to go back to discussing until they agree on their next choice. Through the feature of having immediate feedback on the teams' work, the potential for discussion, self-evaluation and learning is maximized. Finally, the tests are followed by a mini-lecture that concludes the TBL tests, during which the teacher can elaborate on the topics and concepts that are still unclear for the students.

1.1 Motivation

For the University of Twente as an adopter of the Twente Educational Model, teams, collaboration and independence are the key elements in a study programme. These principles fit perfectly with the core of Team-Based Learning and, consequently, some teachers in the university want to apply TBL to their classes. The impediments to incorporating TBL are now the new structure of online education and the hassle of setting up such sessions, since the IF AT scratch cards would need to be ordered in advance. Therefore, a digital product on which TBL sessions can be carried would be ideal for the university. At the moment, there is no dedicated system that can hold a proper online TBL session, so the teachers have to use different workarounds of Canvas and other services in order to have simply one TBL class with the students, a process which has proven to be complicated and troublesome.

Although there are a few products on the market which offer a platform for digital TBL activities, either they are very costly, they can not be integrated into the Learning Management System (LMS) used by the University of Twente, or they have a difficult and time-consuming set up process.

Our Design Project aims to fulfill this void in the infrastructure by offering a Team-Based Learning web application in the form of a plugin for the University of Twente's LMS, Canvas.

1.2 Requirements

Firstly, we were given a list of the initial requirements of the application, just after we had been announced that we were going to work on this project. The system requirements of the TBL application are prioritized using the MoSCoW technique, so they are divided into Must, Could, Should and Would. However, the team has not received any Would-requirements, and therefore that section will be omitted. The list is as follows:

Must

- The system must be fully integrated (using LTI 1.3 standard) with Canvas, such that access to the system is primarily through Canvas user authentication & authorization
- The system must allow students to interact through digital scratch cards to offer their individual solution
- The system must allow teachers to create TBL sessions through this plugin
- The system must allow the configuration of equipment and the exchange of jobs that are carried out in a TBL session

Should

- The system should be easy to maintain and/or be written in a programming language and with a technology that the technology staff can handle
- The system should be easy to use and familiar to teachers and students in Twente.
- Session creation should be able to be done quickly and without much effort on the part of the teacher
- Teachers should get immediate feedback on the results of the students/groups
- The data handled by the system must be secure and hosted on a European server

Could

- The system could include a gamified system for obtaining points
- The system could include a communication system like a voice-chat for students to work in groups
- The system could include a system that allows teachers to configure teams based on previous statistics such as their performance. This could also be a feature that allows uploading the group configuration through an excel file
- The system could include a feature for exchanging feedback comments between students

2. Domain Analysis

In this chapter, we are going to discuss the domains associated with our application. Correctly identifying the domain will help in understanding the later development and the design choices that were made in order to satisfy all the requirements.

2.1 Introduction to the domain

The main sphere that we had to organize our research in was the TBL methodology, and how we can digitize the whole process, without changing its scope and adding additional functionalities for both the teachers and the students. The other areas of expertise that we had to take into consideration were the usability of the application, alongside data analysis and persuasive design.

2.2 Stakeholders

We will go through all the stakeholder groups in order of importance. The first, and most important group, who also proposed the project, is represented by the Centre for Educational Support (CES) department and LISA team, both working inside the University of Twente. Their primary goal is to have a system that can fit well in the present infrastructure of the University, is easy to use, and will also help the teachers with their work for the classes. By having such a system, the TBL methodology can be adopted by any teacher for nearly any subject, with minimum effort. The resulting data from this session can provide a very important insight into the progress of the students for the CES department, who are directly interested in this kind of data.

The teachers represent the second group of stakeholders, who work in close collaboration with the first group, and are of very great importance as well in the scope

of our project, as they are going to directly benefit from the implementation of this system. The organization of one TBL class will be simplified, will fit both online and physical classes, and the teachers will also have a complete overview of the students and their results.

The last group of stakeholders are the students, which will be, like the teachers, beneficiaries of the system, as they will now have the possibility to experience the TBL experience, which hopefully will have a positive impact on their learning process. There are many more advantages for the students, but we will cover them later in this paper.

A good way to better visualise the stakeholders in order of their relevance to the system, an onion diagram which contains all stakeholders (also possible ones) was created, shown in Figure 1.

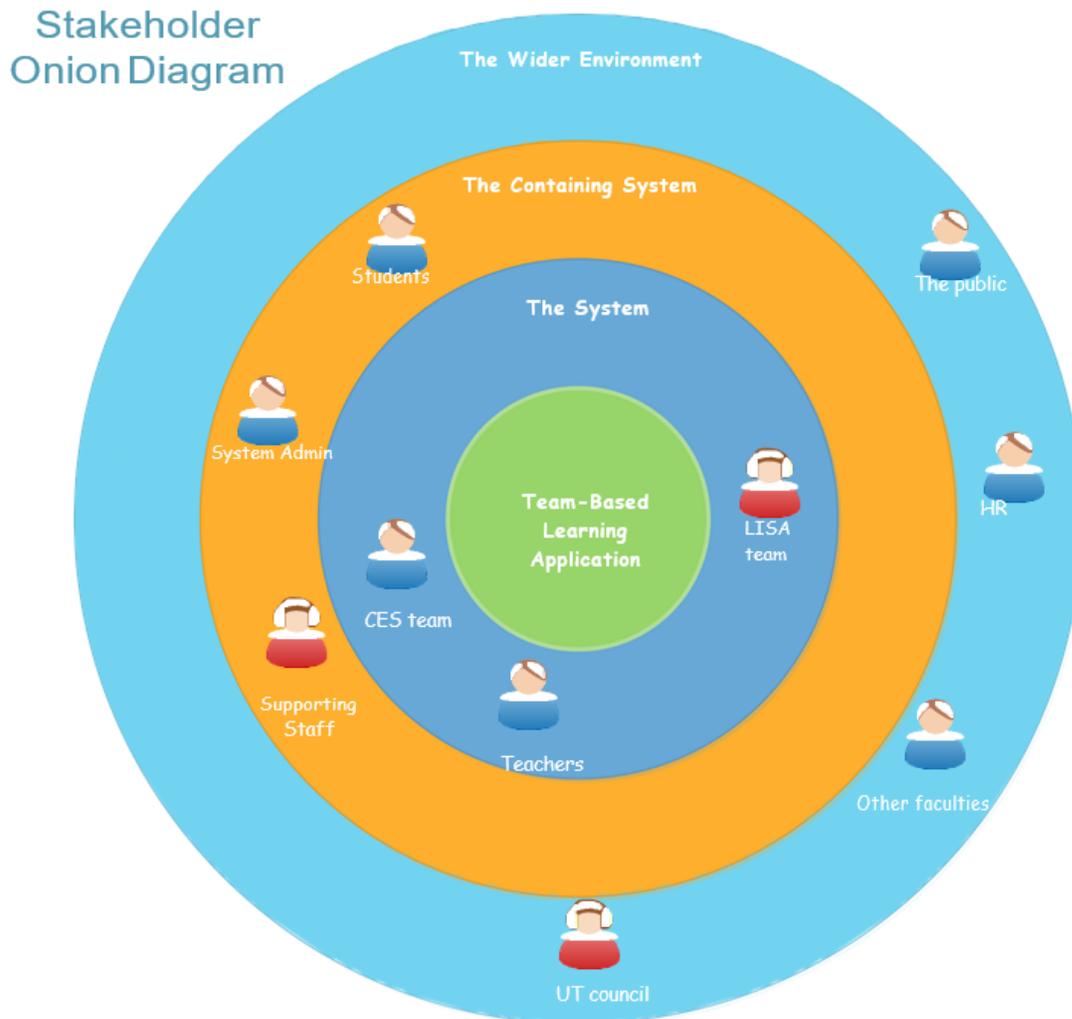


Figure 1: Stakeholder Onion Model [Alexander(2004)]

2.3 Clients and potential users

The system is developed for the parties involved in the process of TBL, more specifically, teachers and students, who are going to interact directly with the system, and the education department of the University, who are going to use the data generated by the TBL session in order to improve the current educational methods and help innovation happen in this field. As this application is an education-focused software, these groups of people will represent the only clients and potential users, but they can come from multidisciplinary levels, as there are no requirements over which students can use the software.

2.4 Software Environment

From the first meeting with our stakeholders, it became clear that we have to use the recommended tools and frameworks for software development inside the UT. This choice shaped our development process and we tried to keep as close as possible to these recommendations, so the maintainability efforts towards our application in the future to be as low as possible for the UT staff. More detailed information about the technologies used and justifications of the choices can be found in [section 3.3](#).

2.5 Commonalities of the UT software

One of the critical requirements received from the stakeholders stated that our system should be fully integrated with the web-based learning management system used by the University, more specifically, Canvas. In this way, the access would be extremely simple and steps such as registration or authentication would be done in the background, by our system. As all our clients and potential users are using other systems deployed in the University of Twente's infrastructure, our design also resembles different looks and functionalities of Canvas, so to give a more familiar feeling when the software is used.

3. System Proposal

After a careful analysis of the initial requirements and research into the domain in which this software resides, our project group came with a proposal of an application that is going to fulfill the requirements and give the stakeholders the wanted product.

3.1 Requirement Analysis

The main objective of this project is to deliver the product that our stakeholders need. As part of this, our secondary objectives are finishing in time and delivering quality work.

3.1.2 Stakeholder requirements - user stories as functional requirements

To present the stakeholder requirements, user stories are formulated. The system has three types of users: teachers, students, and administrators.

1. As a teacher, I want to be able to easily and quickly create a test on the application.
2. As a teacher, I want to be able to edit a test after its creation.
3. As a teacher, I want to be able to instantly see the grades after a test.
4. As a teacher, I want to be able to instantly see the statistics after a test.
5. As a teacher, I want to be able to manually change a grade.
6. As a teacher, I want the application to be easy to use and familiar.
7. As a student, I want to be able to interact through digital scratch cards to offer my solution.
8. As a student, I want to be able to have instant feedback after choosing an answer during the group test.
9. As a student, I want to be able to flag a question.
10. As a student, I want the application to be easy to use and familiar.
11. As an admin, I want the application to be fully integrated with Canvas through LTI1.3 standard, so that access to the system is done with Canvas authentication and authorization.
12. As an admin, I want the application to be easy to maintain and integrated with the LISA guidelines frameworks.

3.2 Planning

3.2.1 Management plan

This section presents the schedule of the proposed project, which was already given by the supervisor. The four stages are Planning, Design, Development and Closure, and the flags in the diagram represent checkpoints: meetings during which we present a new version of the project.



Figure 2: Project schedule

In order to efficiently manage the whole project, the team divided the project into several different parts and established responsible members for each of them. The division of roles and responsibilities in the group is, therefore, the following:

Back end development - Cristian Anghel, Laurentiu Birton

Front end development - Radu Basaraba, Denis Arva

Organization and communication - Aida Enache, Radu Basaraba

Research - Radu Basaraba, Denis Arva

Quality Management - Aida Enache

Application Design - Laurentiu Birton, Cristian Anghel

UI/UX Design - Aida Enache, Denis Arva

Legal matters - Laurentiu Birton

It is important to note that the assignment does not imply that only the mentioned members will work on those parts of the project. Instead, it denotes the contact persons within the group and it gives an overview of what each team member is responsible for. In order to have a smooth integration of all parts, there needs to be close

communication within the group, so it is important to have these roles to know exactly who to refer to. Moreover, we will use Trello to keep track of the task division and to see what everyone is working on at any time.

<p style="text-align: center;">S</p> <p style="text-align: center;">STRENGTHS</p>	<p style="text-align: center;">W</p> <p style="text-align: center;">WEAKNESSES</p>	<p style="text-align: center;">O</p> <p style="text-align: center;">OPPORTUNITIES</p>	<p style="text-align: center;">T</p> <p style="text-align: center;">THREATS</p>
Close collaboration within the group and with stakeholders	The time constraint: there are only 6 weeks available for the implementation	The shift from a local Canvas plugin to an independent application	Hard integration with Canvas, due to libraries that are not 100% fully functional
Committed workforce	Collaboration is online	Develop a system that will be used by the University in the future	Worse/less feedback due to the online medium
Great group culture	Small sample of user testers	Experience with different technologies and procedures	
Determined attitude of the group	Closed spectrum of resources	Get a clear idea about working on a project of this size and expectations	

3.2.2 Plan of action / Project schedule

After the overall analysis of the time management has been made, the general tasks outlined in the management plan can be divided into more specific tasks, whose completion time will be estimated. We will also group the actions based on the four stages and the closure in the end:

Planning  Design  Testing  Development  Closure 

Objective	Activity	Responsible person(s)	To be completed until (approximative deadline)
Formulate the requirements	Gather all the requirements from our stakeholders	All	End of the first week
Research the problem	Find out more about the implementation of some requirements, study other implementations that were made in the past	All	End of the first week
Initial design	Make the initial system design based on all the gathered data	Laurentiu, Cristian	End of the second week
Design prototyping	Create a prototype that will illustrate our initial design and will fulfil the most important requirements This includes also the testing that will be made on this prototype	Aida, Denis	Middle of the third week
Make the connection with	Create a back-end connection between our	Cristian, Laurentiu	Start of week 4

Canvas	application and Canvas		
Set up the database	Make all the necessary steps to set up the database that the application is going to work with	Denis	End of week 4
UI design	A visual user interface design will be made, in order to provide a model for the actual implementation	Aida	End of week 4
Visual implementation of the initial design	Create the frontend of the application	Radu, Aida, Cristian, Denis	Week 5
Link the front-end with the backend	A connection is made between these two pieces and the application can be considered functional at this point	All	Middle of week 5
Testing	Test all parts of the project that have been implemented and are functional	All	End of week 5
Reflection about the test results	Discuss the results of the testing and draw some conclusions	All	End of week 5
Discuss with the stakeholders	We present our current implementation, alongside our test results and reflections	All	Week 6
Adapt application	Make the necessary changes after we talked with our stakeholders	All, depending on what we have to do	Week 6
User testing	Test the application with student and teachers	All	Week 7
Additional features	After user testing, we implement one or more	All	Week 8

	of the suggestions received		
Finishing touches	We put everything related to the application in order and start to prepare the presentation	All	Week 9
Deliver the product	Our product is successfully delivered to our stakeholders before the deadline.	All	Week 10

One important objective, which we did not include in the table above since it is an additional feature at the moment, will be related to the front-end and to the UI/UX design of our application that will make the experience in the application “gamified”. By this, we want the students to have an immersive and easy to use experience, with elements that resemble popular aspects from video games.

3.3 Tools to be used

With this plan of action in mind, we can derive and present some of the tools that are needed in this process. As our application will be maintained after its completion by the University of Twente, we will adhere to their protocols and frameworks, so our work will not be in vain. Therefore, we can outline most of the tools to be used, grouped by category of work.

- **Back-end:**
 - Java
 - Spring Boot Framework
 - Spring Security
 - JPA / JDBC-Template
 - Maven
 - LTI1.3 standard (Advantage)

- **Front-end:**
 - Bootstrap (ng-bootstrap), Bootstrap Studio
 - Javascript
 - Angular CLI

-
- JSON
 - **Application Design:**
 - Visual Paradigm
 - **Database:**
 - phpPgAdmin
 - **Prototyping:**
 - Figma
 - Adobe Illustrator

3.4 Usability tests

The usability tests were conducted on the prototype, with the goals of uncovering problems in the design, discovering opportunities for improvement and learning about users preferences and behaviour.

To test both sides of the TBL application, students and teachers were invited for usability testing. For more genuine results, we aimed to choose participants from different backgrounds, i.e. students and teachers from different studies. Each participant received a test scenario that they had to follow under the observation of group members.

During and after the completion of the test scenario, users were free to give feedback. They were then asked questions about the general feel and intuitiveness of the application. A good insight into the user-friendliness of an application is remembering the number of clicks it took to reach a point and therefore we also asked participants whether they could state the number of times they clicked to complete a task.

Task scenario for teachers:

1. Open the description of week 4 assessment
2. Close the description of week 4 assessment
3. Create a new assessment
4. Add a question
5. Add a second question
6. Submit test
7. Check submission
8. Navigate to the results page
9. Check group 1 results

10. Navigate to the statistics page

Task scenario for students:

1. Start the individual assessment
2. Complete the individual assessment
3. Start the group assessment
4. Flag a question
5. Complete the group assessment
6. Navigate to the results page

Since the TBL Application is a Canvas plugin that will be used within the University of Twente, the interface was designed based on the current design of the existing educational tools that students and teachers are used to: *Canvas Quiz*, *Remindo*, *Canvas Groups*. Therefore, the feedback from the students was positive and they did not find anything wrong or to be improved, while the teachers wanted the grades to be displayed as they are on the *Canvas Grades* tool.

3.5 Conclusion

At the end of the planning phase, we presented our project proposal to the stakeholders, alongside a lo-fi prototype, so the design ideas can be visualised early in the project, before actually starting the design phase. The discussion was very productive for us, as our plans from the proposal were approved and we got the green light for continuing on the same idea regarding the application design. We also agreed with our supervisor to have a weekly meeting with all the team, himself, and two co-supervisors of our project, members of the CES department, Alisa and Karen, with whom we were in contact since the start of the project. In this way, we will discuss the progress made every week and we will make sure that our product is what our stakeholders really want.

4. Design

4.1 Page flow

The Team-Based Learning Application contains multiple pages that together make up the interface. The diagram presented below shows the page flow, where the arrows indicate the navigation from one page to another.

When designing the page flow, we had to think of what goes on each page and in what order they are accessed. To get good insights, we simulated the workflow of the

application from both the student and teacher perspective (shown in the activity diagram below, Figure 4).

The main structural difference between the student view and the teacher view is the navigation bar. The decision of not having a navigation bar on the top of all student pages came because of the exams. During an exam, the test itself is the focus of the students, since navigating between pages would imply an early, irreversible submission of the exam.

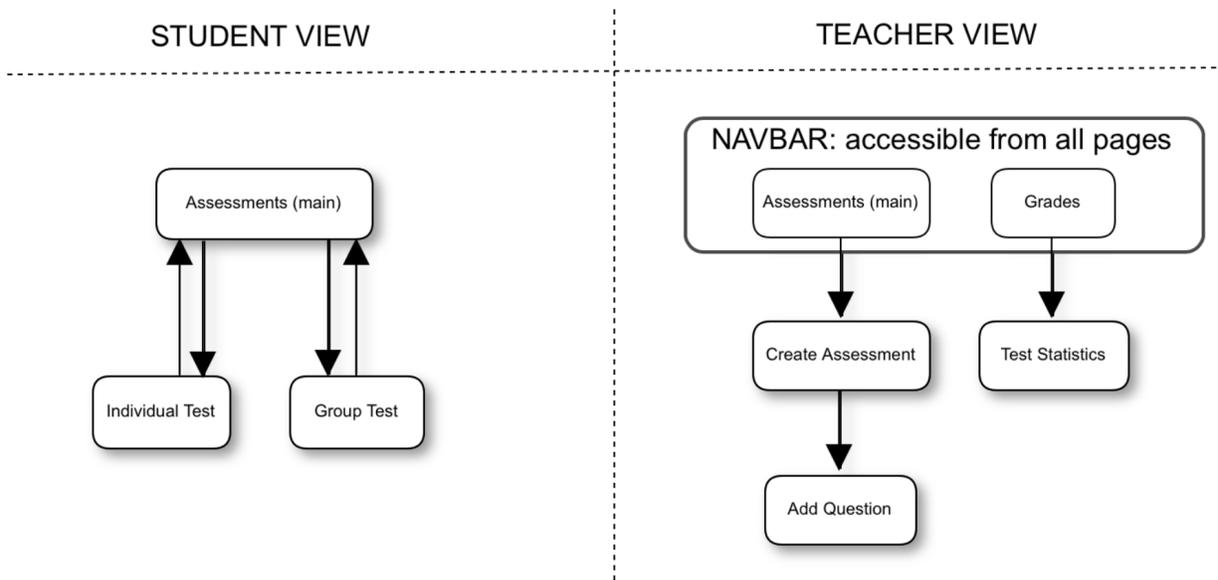


Figure 3: Page flow diagrams

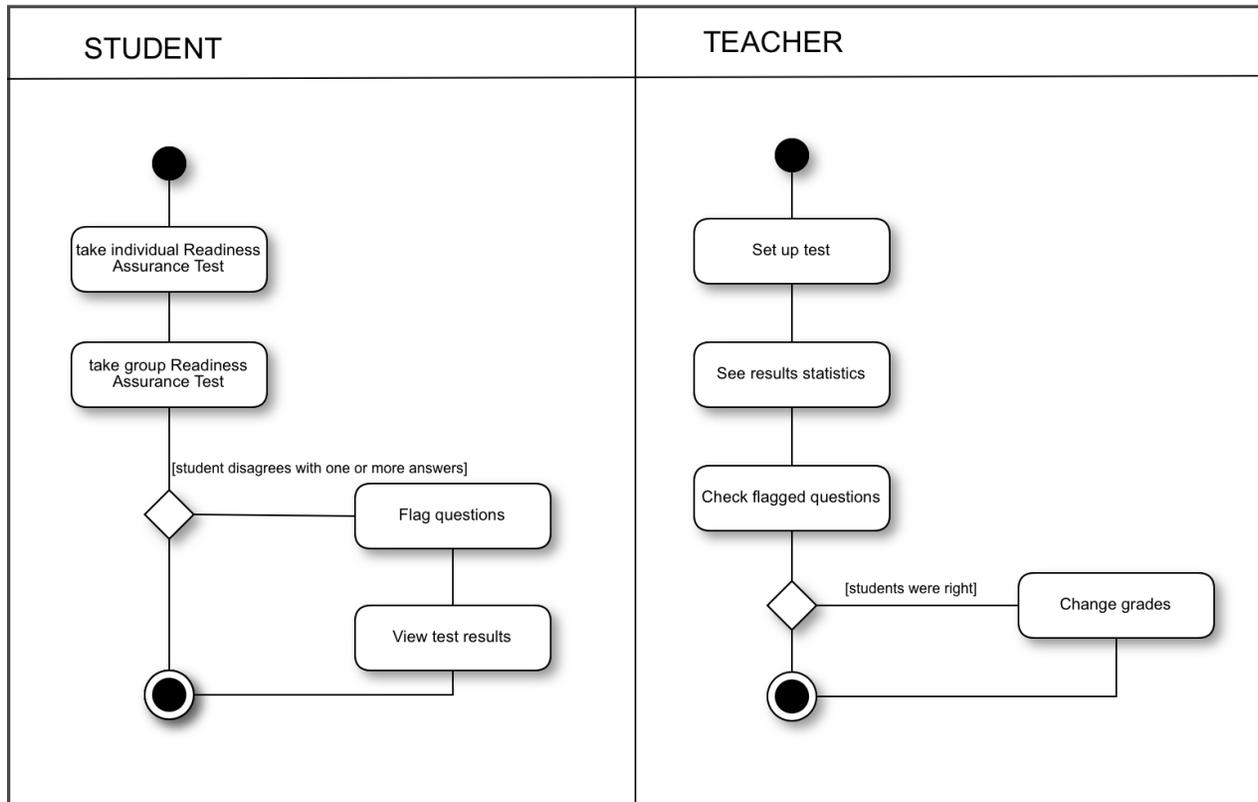


Figure 4: Activity diagram for the student and teacher

4.2 Design choices

4.2.1 Overall look & feel

From the start of the project, it was clear that the application will be used and possibly maintained by the University of Twente, which is why the look and feel, as well as the structure, need to resemble the other systems used by UT in order to ensure a smooth integration. This also guarantees that the users, students and teachers, will not have a hard time getting used to the TBL Application.

4.2.2 Group test answer vote

The design choice that took the longest time to be made was the modelling of the group assessment. *“Should there be a leader of the group who selects an answer on behalf of the team or does everyone in the group need to select an answer in order for it to be registered?”*. This question was answered only after brainstorming within the project

group and talking to the stakeholders, and the conclusion was that a voting system is more reliable than assigning the leader role to one student. Students should see in real-time which members voted for which answer, and it can only be submitted if all members voted for the same option.

It should always be the case that all members of the group vote for the same answer, because they are only supposed to vote after having discussed the question and having reached an agreement. In the case that some members vote for a different answer than the rest, or that some members do not vote at all, the group is stuck.

4.2.3 Flagged questions

In a Team-Based Learning session, after the completion of the individual test and the group test, the teacher can discuss a few questions with the class, namely the ones that most students would like an explanation for. To make this possible in a digital environment, we make use of a button called “Flag question” next to every question in the test. If students want the teacher to discuss that question at the end of the session, they press the button and get a confirmation. When the tests are over, the teacher can see the five most flagged questions in the Test Statistics section.

Since the term “flag” usually implies that something might be wrong with the question, there needs to be a clear explanation to the students that within the TBL app, flagging a question simply means they want to discuss it with the teacher rather than reporting it.



Figure 5: 'Flag question' button shown on the Student View

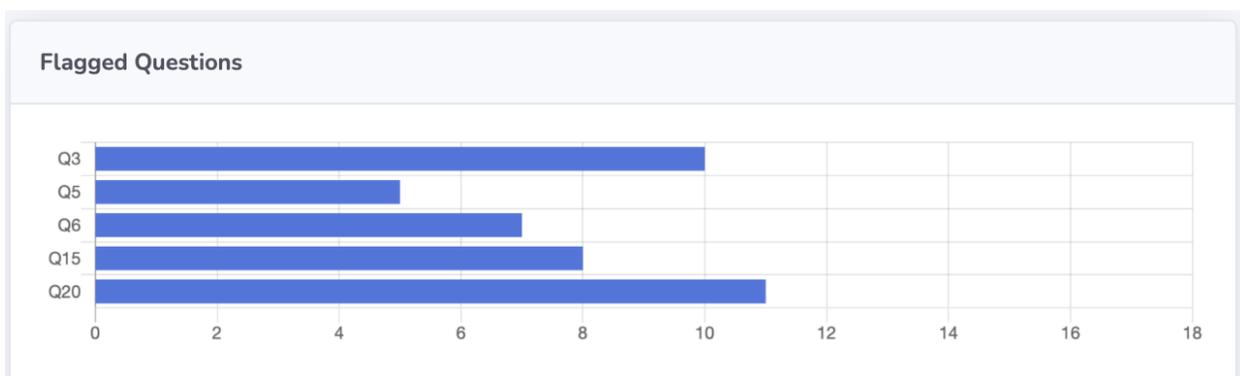


Figure 6: Top 5 flagged questions shown on the Teacher View

4.2.4 Group Creation

In a TBL session, students participate in a Readiness Assurance Process (RAP) for the first time. Specifically, they have to take an individual exam after which they join the second stage called group Readiness Assurance Test (gRAT) where students take the exam with the team.

To translate these ideas into a digital application, during the design we considered the possibility of using a Canvas API that returns all the groups in the course from which the application is accessed. However, this solution presents a spectrum of complications in its implementation because as mentioned above, this API returns the groups in a course, but there is no API available to receive a student as input and return their group. The initially proposed solution is to implement an algorithm that iterates in each group in search of the student we want to know to which group it belongs. On the other hand, an alternative solution is to create 30 groups for each course in the application database. Additionally, these groups together with their members will be displayed on the main page of the students and they will have the possibility to choose the group they need to join.

4.3 Interface design and prototypes

A high-fidelity prototype was developed for the first usability test, with the purpose of recreating the flow of the application during regular usage and seeing how different visual elements may interact in a dynamic environment. For this, we recreated the following functionalities:

- ❖ Individual exam
- ❖ Group exam with a voting system for an answer
- ❖ Create an exam
- ❖ Views of the grades, present exams and statistics

Below is a screenshot of the group exam session, emphasizing the voting system needed to register an answer as a group through the digital scratch cards.

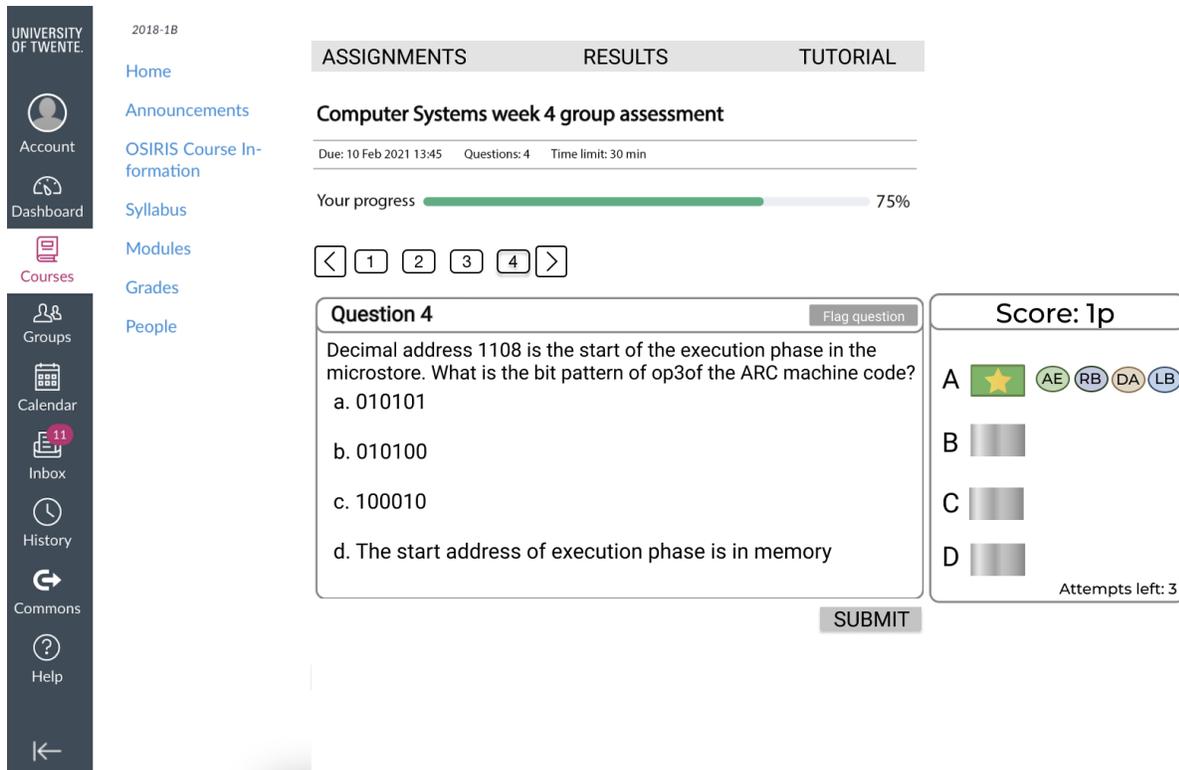


Figure 7: Figma prototype: group session screenshot

The prototype was developed using the online tool Figma and was tested after its completion with the stakeholders. A complete flow of the hi-fidelity prototype can be seen in [Appendix A](#). This prototype is made out of around 40 different screens, such as the one in fig. 7, which are linked together by some elements that will trigger the transition between them. Even though it was an arduous task to map a transition based on every element interaction of the whole set of screens, we covered most of the important actions (voting, clicking on buttons, system responses, animations) in order to give a clear idea about the actual usage of the software.

4.4 Database design

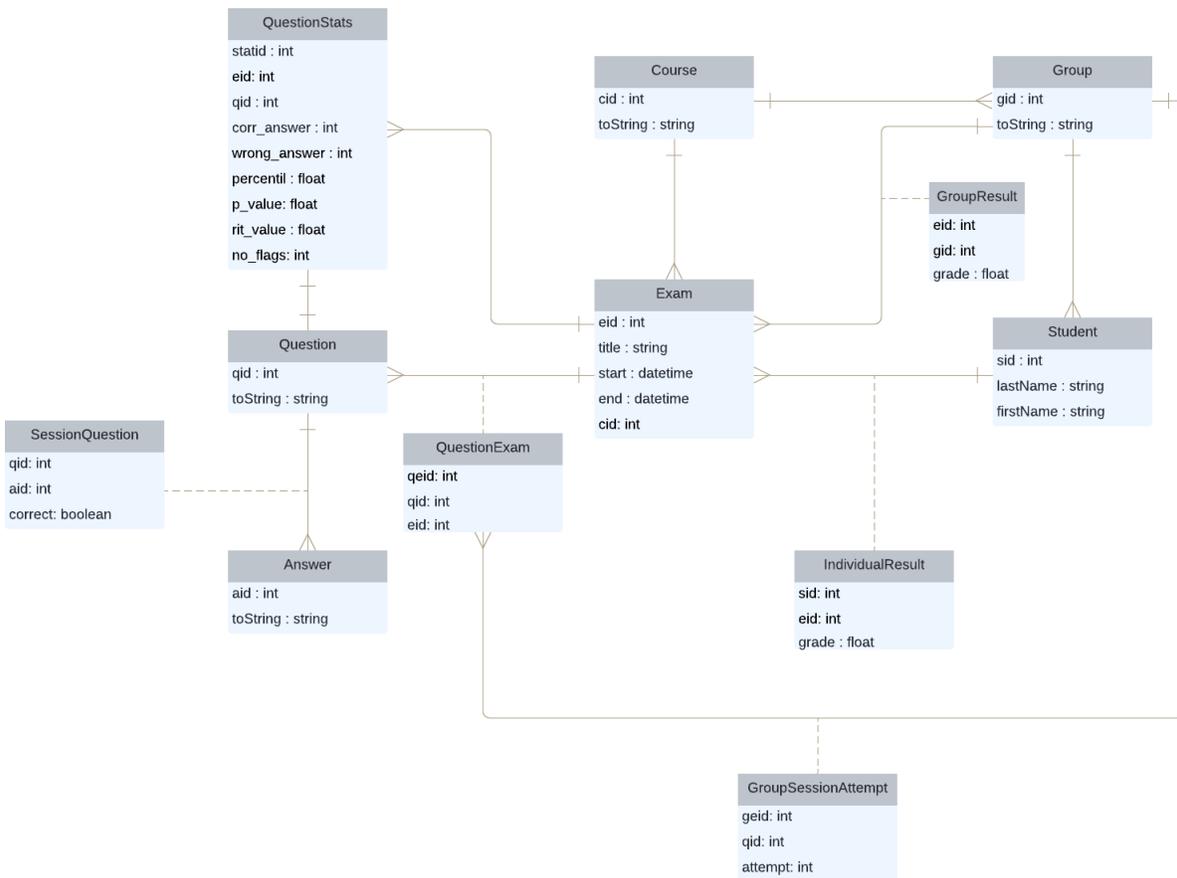


Figure 8: UML design of the application's database.

This unified modeling language (UML) diagram is built around the exam table. To understand the idea behind this figure, it is important to start with this table, which belongs to a course, and has several questions to which statistics-relevant data are linked through the QuestionStats table. The QuestionExam table can also be seen, which links an exam to several questions and the reason why this table exists is that it avoids storing information more than once, for example, if we have an exam that has the question X, and an exam from another course contains the same question, it is not desirable that it be recorded several times in the Questions table, but it will be memorized only once, and two links will be created between the question and the two exams. The same situation applies to the SessionQuestion table where a question is linked to several answers to avoid storing the same answer multiple times. For example, two distinct questions may have the same answer "none of these".

Also, in the IndividualResult table, we store the results for the Readiness Assessment Process, where a student is linked to an exam, and this link contains a field where the grade for the individual exam is stored. It also applies to the GroupResult table where a group is linked to an exam, and the link contains a field where the grade from the exam given in the group is stored.

Finally, the last table added in this diagram is GroupSessionAttempt, meant to record the attempts that a team takes on a certain question, it stores the unique id of the question, the number of attempts and the unique id of the link between the question and the exam.

4.5 Detailed design

In this section, we aim to further elaborate on the design details and choices that were taken in the course of this project and sustain them with the reasoning behind these choices.

4.5.1 Teacher view

The design of the teacher side was made such that it will offer all the required functionalities in a relatively reduced amount of pages and the general focal point was that everything is directly in front of the user. Elements present on a page have a clear purpose and subsequent indications about their functionality. The overall design is minimal, without eye-catching elements or animations, because the experience of a teacher who uses the application should be as smooth as possible and also time-efficient, as our potential users usually have very busy schedules. The overview of all exams and the creation/editing of an exam resembles the workflow and design of Canvas. In this way, the plugin will have a feel of deep integration with Canvas, easing any potential problem that can appear as a result of having little or no experience with the application. The design of the main page, which contains all the exams already created, feature light-coloured headlines that contain the title and date of an exam, with the rest of the information being present in the expandable body, which also offers the possibility to edit that particular assessment. The main inspiration was the module page of a course in Canvas, but without the body already expanded when the page is accessed, so the page is not flooded by text when the application is started. A good example of an indication about the functionality can be noticed when looking at the headline of an exam: its body is expanded by clicking on the bar itself (not necessarily clear for new users) and by clicking on the 'View' button on the right side of the bar, so a

user, however inexperienced it may be, will still be able to use any functionality of the application.

Canvas provided inspiration also for the creation of an exam. Firstly, the general settings of an exam are set, followed by the addition of the questions one by one. On this page, the introduced data is firstly formatted by fields that require it (such as the date or the time), then it remains in front of the user, who can view it and edit it in case something is wrong. When the exam is to be submitted, all fields will be checked for input and its correctness, giving an error of the particular field that does not respect the format or has no input. If everything is correct, then the exam is created and the fields are cleared. Afterwards, the exam can be edited through the edit page, which is the same as the one for adding an exam, but has all the data already in place, leaving the user to simply modify what he/she wants. All fields also have tags that indicate their purpose and suggested input format (fig 8.1).

Create new assessment

Settings

Assignment Name

Please fill in this field.

Date

Please fill in this field.

Figure 8.1 Field validation

The general overview of groups and their grades is made on the same idea as the previous pages exemplified above, only this time more simplified than in the Canvas grade book.

4.5.2 Student view

Out of the need to provide an easy-to-use platform for students, Remindo was used as an example of the front end design. This is familiar to most students due to the period we are living in, when most exams were taken online.

On the main page, there is a navigation bar that leads to the overview of the session and the results. On the general overview, the application displays all the exams that belong to the course from which the application is accessed, and from there the student has the possibility to take an individual or group exam if the time interval is corresponding to the one established by the teacher.

Regardless of whether a group Assessment Test or Individual Assessment Process page is accessed, in addition to the topic with questions and answers displayed, at the top of the page there is a bar on which is written what kind of session the student is in, meant to overcome the confusion between the two.

On a readiness assessment process page or in short, the individual session page, a question numbered from 1 to n is displayed, along with 4 answers. The student can navigate through these questions by scrolling. After all the questions have been answered, the student can press the submit button, which will redirect them to the home page and send the answers to the server who in turn will calculate the grade and store it in the database.

In the traditional version of TBL, in a group readiness assessment test, the members of the group have the printed exam that was given at the individual session, only that this exam has a part that can be scratched next to each answer. Precisely for this reason, TBL is considered an effective method of learning, because students must discuss what the correct answer is and when everyone has decided, the answer will be scratched. The answer is correct if there is a drawing under the scratch paint, usually a star, and the answer is wrong if there is no drawing.

For the digital version, we decided that the group session should be based on the design decisions taken above for the individual session, adding to the left of each answer a box to represent the digital version of a scratch. We also decided that students should vote for an answer, and if an answer received the vote from all members of the group, then a star should appear instead of the box if the answer is correct, or blank if the answer is wrong.

4.6 Prototype testing

During our weekly meeting held on week 3, the high-fidelity prototype was tested by our stakeholders. The testing had two different procedures:

1. *Testing in isolation*

One of our stakeholders received the link to the prototype and tested it following the test scenarios. Some indications were provided before, but sparsely, so we can better see how an inexperienced user with the software will interact with it. The prototyping tool also provided some help, as at any moment it is possible to see the interactive elements and get an idea of how to proceed through the screens.

2. *Testing in the presence of the team, following a pre-made list of actions to be tested*

This user testing had the purpose of also observing the user interacting with the software and closely analyzing its actions. This can give important insights about the design and the way the interactions actually happen, an aspect which is very hard to predict when developing the application, as the testing is made by the people working on the software, which know very well the structure and reasoning behind some design choices. During the testing, the general impression was fairly good, with positive feedback regarding the voting structure. On the other hand, some transitions were not quite adequate and some screens (for example, the main page of the teacher) were overwhelmed with text.

After both user tests were finished, we had a collective discussion about the results of the tests and agreed on the design and functionalities that were going to be implemented during the development phase (Section 3.4).

5. Implementation

5.1 Back end

5.1.1 Tools and technologies

As this application is intended to be used and maintained within the University of Twente, the solutions used for various aspects of the system reflect this. They are the same as the University's recommendations for software that should be maintained

in-house. As a consequence, the following tools and technologies have been used for the backend side of our system:

Programming language: Java

Application framework: Spring, mainly Spring's MVC framework

Dependency management: Maven

DBMS: phpMyAdmin

5.1.2 Functionalities

The major responsibilities of the backend are Canvas authentication and data synchronization, session management for logged-in users, delivery of web pages to clients, access to RESTful services and persistent data management.

First, it ensures operability and authentication within the Canvas environment using the LTI 1.3 standard. This technology builds upon OpenID Connect, which in turn is an identity layer on top of the OAuth 2.0 protocol. The tool offers the possibility for users to use the application using account information from their Canvas account, while logged in on Canvas. Therefore, we didn't need to implement custom authentication and login mechanism and only needed to retrieve and validate the data from Canvas, as specified in the IMS Global specifications⁷. Whenever a user needs to access our tool, Canvas sends a login request to the "login" endpoint. Then, the tool creates an authentication request and sends it to Canvas. If valid, Canvas sends back an authentication response to the tool's redirection endpoint. Next, we verify that this response was not tampered with and indeed comes from the same user that initiated the login request. If so, the user is presented with a home page respective fotoheir role.

Furthermore, session management is another important part of the backend's functionality. After a successful authentication process is completed, users will be able to stay logged in to the application for the entire duration of their Canvas browsing session. This is done using a cookie to assign an ID to each user after they have successfully authenticated. The same ID is used in the backend by the HTTP session Java implementation, which stores information in a temporary database-like structure for the duration of the user's session. A session is considered as terminated when more than 60 minutes have passed since the server last received a request from a client, at which point that particular ID and all information associated with it is deleted.

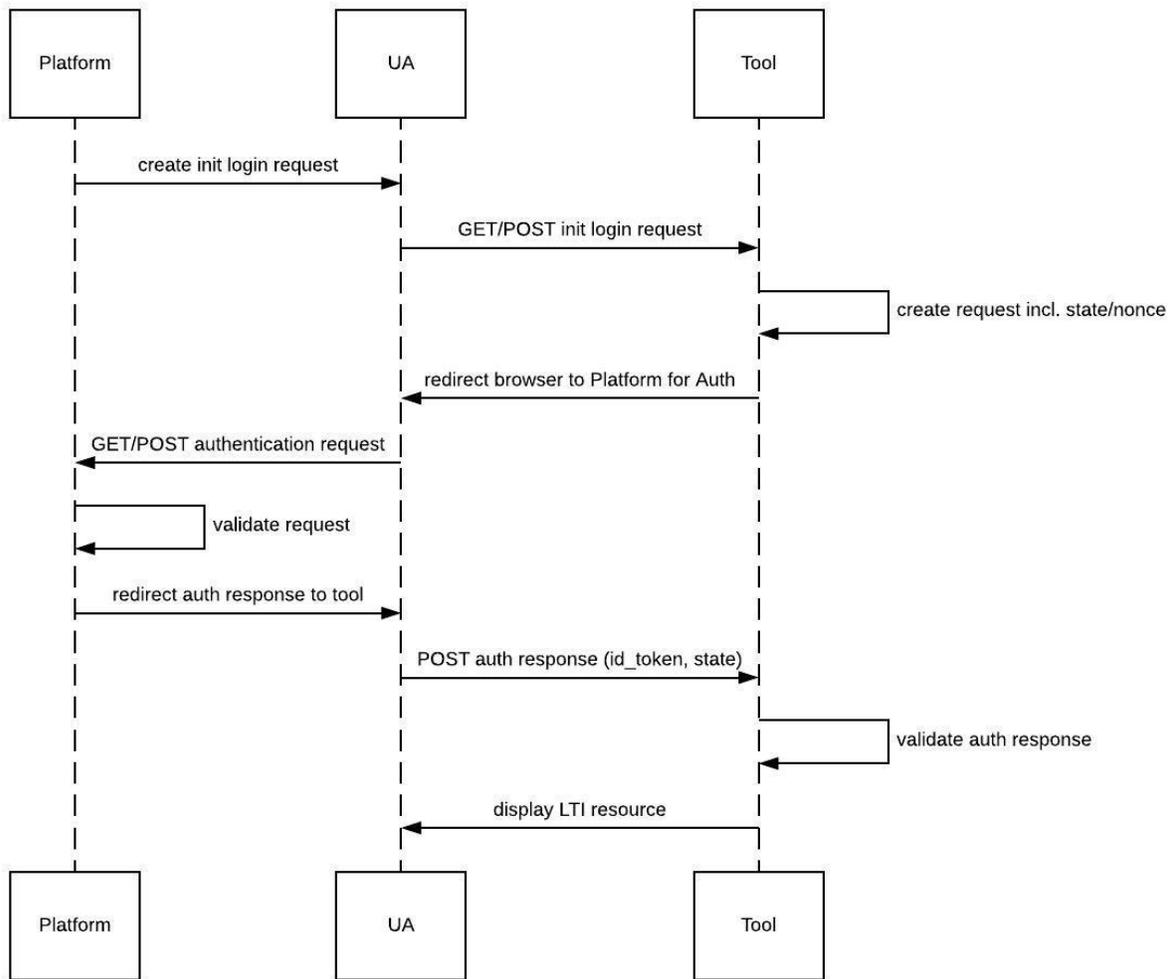


Figure 8.2 The OpenID Connect launch flow(IMS Global)

For each session, the role, university number (student or employee) and CSRF value are stored. These values will only be associated with a session if the user has gone through a successful authentication process. At the same point, a cookie is also set for the client with the same CSRF value. Afterwards, for every request coming to our application, checks are made if the user has permission to view a certain page based on the attributes associated with their session. There are 2 types of roles a user can have which determine access to pages and API resources: Student and Instructor.

One major part of the backend is the RESTful service controller. Each entity present in the database UML ([Section 4.4](#)) (e.g an exam), as well as links between base entities, such as IndividualResult, have their own separate class that is part of the RESTful

service controller. This is done in order to have a clear structure of the code and to separate distinct entities and methods apart.

Another important part of the back-end implementation is the custom repositories for each of the aforementioned entities. These repositories contain default methods for the insertion, retrieval, deletion, and update of the entries in the database, such as finding by ID, but also custom queries that allow for the selection or update of some specific entry/entries using different parameters.

The RESTful service controller and the repositories are dependent on one another, so they could be thought of in fact as belonging to the same part of the back-end, instead of splitting them into separate parts.

Another part of the back-end configuration that is as well dependent on the repositories is the message controller. This is the part that handles messages being sent between groups of students during the group exam. The sole purpose of this is to maintain the connection between the students and record attempts their group made in the database by means of the repositories.

Some of the libraries used in the back-end and their usage is described in the table below:

Library name	Description
spring-websocket	Creates a websocket that clients can connect to in order to send messages.
spring-messaging	Handles the actual sending and retrieval of messages to and from the front-end, as well as serialization and deserialization of the messages.
postgresql	Database driver that is used by <i>spring-boot-starter-data-jpa</i> in order to connect to the database.
spring-boot-starter-data-jpa	This is a library that creates methods for queries defined in the repositories.
sockjs	This library provides a websocket-like object that provides a communication channel between the front-end and web server (back-end)

5.2 Front end

The general idea around the implementation of the front end was to keep it as simple and easy to use as possible. All the necessary elements of every page are present directly in the face of the user, with very little effort expected in order to locate or identify the functionalities of the software. Moving on to the effective implementation, we used Bootstrap Studio 4 for the initial design of the pages, followed by manual additions of all the Javascript code that was required by every functionality and of the new visual elements that were added later, such as the page loader. During the development, we decided to split the front end into two parts, which were developed in parallel. In this way, the progress was accelerated, as the two parallel parts (teacher side and student side), were relatively independent one from the other, having in common only the data from the database. This was relatively easy to tackle, as we simply populated the database with tentative data, so we can have it in place for the later development of the pages. Therefore, we will cover in detail the teacher view and student view also separately, which will follow in the coming chapters.

5.2.1 Teacher implementation

The teacher interface is focused on the four main functionalities of the software related to the work of a teacher. Images with all the screens can be found in [appendix B](#). The four functionalities are the following:

- ❖ Complete overview of the exams

This can be considered as the main page of the teacher, as it appears first after the application is launched. It contains all the exams created for the particular course, with the name and date of every exam being placed in the headline and the body of the exam (questions + answers) being in the body that is expanded by either clicking the button 'View' or by clicking on the headline. The body will also contain a possibility to edit that particular exam, as a button will also be present on the right side of the screen. In this way, the overall look is pretty simple and straightforward. Through the 'create exam' button, on the right side of the exams, the user can be redirected to the page for creating an exam.

- ❖ Creating or editing an exam

Both functionalities are grouped in this category because the development and the overall look is very similar, with the only main difference being the fact that when you edit an exam all the fields are already auto-completed with the necessary data, otherwise, these are empty. The upper section of the page is reserved for the exam details, such as name, date, start and end times. The fields

contain suggestions of previous inputs and helper functions for setting the date and time in the correct format. The lower section is reserved for the questions and the answers of an exam. Every question, its four subsequent answers and an indication of the correct answer can be added through clicking on the 'Add question' button, which will trigger a popup. After a question has been added, the table will be updated, giving the user a clear overview of the data. After that, the question can be edited, removed or another question can be added until everything is there. When the exam is submitted, all the fields are checked, so there is input in the correct format in all of them, with an error being shown otherwise. If everything is in place, then the exam is created and the fields are cleared. All these functionalities are also present when editing an exam. Through this design, we wanted to maintain the workflow of creating an exam that is present on Canvas, where the general information of the exam is firstly set and then the questions are added one by one.

❖ Complete overview of the student groups and grades

On this page, the grades of the students are displayed. This has a similar design as the Canvas grade book, with all the names of the student being present on the left-hand side of the table, with their results horizontally. This includes the grades obtained at all the exams related to that particular course, both for the individual and the group exam. The grades can be edited by the teacher by simply clicking on the box that contains a grade and confirming the action, with the grade being updated in the database immediately after the 'save edits' button has been pressed. This gives a great deal of flexibility, as changes do appear in exams, especially in TBL, as students can flag questions, which can be then modified by the teacher, an action which will demand a change in the grades. One can navigate further to the statistics page by clicking the button in the top right corner.

❖ Statistics for every exam

The statistics page was designed to better visualise the important factors of a TBL exam, namely, the questions flagged, p-value of every question and the average team improvement. The improvement is calculated as the average of the grades obtained by the students that form a group at the individual exam in comparison with the grade that they obtained together at the group exam. This is especially important, as it is one of the main ways in which students improve their performance (as a result of their discussing the exam in the group) and it is very frequent to see an improvement. The users can switch easily between

exams statistics, which can be done from a drop-down menu at the top of the page. For the questions flagged, the number of flags appears in the table for every question, as well as a bar chart for the top 5 most flagged questions, indicating which questions were the most unclear.

The design of this page maintains the overall design structure and style, giving a clear overview of the most relevant statistics of every exam.

5.2.2 Student implementation

To meet one of the LISA requirements, student view was implemented in Angular CLI along with its specific CSS framework, ng-bootstrap. To better understand how this application works, it is divided into two parts: service and components.

The services implemented in the application have the role of initiating and managing a websocket connection, sending requests to the server for data such as studentID, the group to which a student belongs, the exams stored in the database for the current course. There are also services that are responsible for sending a concluded individual or group exam to servers or notifying if a student has logged out of the group session.

The components are responsible for the elements that are displayed to the users, but also to call the services when they are needed. From the determination to divide the responsibilities and to make the future maintenance of the project easier, in the current implementation 9 components were created and for example, a submit button has its own component.

Also, the solutions proposed in the project design have been largely implemented, and they are described in the following lines.

- ❖ Complete overview of the exams

As established in the design, the home page has an overview of the exams, a list in which each element has a session title and two buttons through which the user can access the desired session, individually or group.

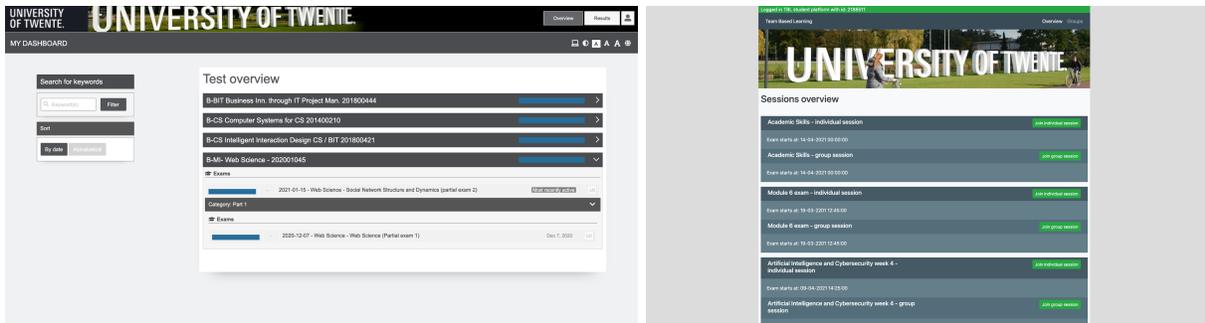


Figure 9: A comparison of the home page of Remindo (left) and the implemented home page of students in TBL (right)

❖ Overview of the groups

Based on the discussions held with the teachers, it was decided that students should have the opportunity to access the grades at individual and group sessions. However, because Canvas already has this feature, the idea was dropped during implementation and was replaced with the list of groups showing 30 groups together with their members and students can join one of the groups or change it at a time. It is important to note that such an implementation is adopted by the Canvas, and this resemblance is done intentionally, to create a familiar environment for students.

❖ Individual Readiness Assessment Process

There are no major differences from the solutions given in [section 4](#), except that all the questions together with their answers are displayed on the same page, meaning that the navigation buttons between the questions have become irrelevant. This decision was made to provide more time for other implementations that were more complicated and also, more importantly, in relation to the minimum requirements required by stakeholders.

❖ Group Readiness Assessment Test

This page of the application is similar to the individual readiness assessment test page, except that on the left side of each answer, there is a "vote" button and on the right side of each answer the initials of each student who voted for that option will appear. In order for students to receive real-time feedback with each option a student votes for, this page uses a service that initiates a websocket and deals with the transmission and reception of messages between clients. Also, if all active students in the session voted for the same answer, the button turns into a red outlined box that says incorrectly, in case the answer is wrong, or the button turns into a green outlined box that says correctly, if the answer is correct.

Moreover, stakeholders expressed a preference for a "flag question" feature, which was eventually implemented. This allows every student to report if a question is problematic in its opinion. It consists of a red button with the text "flag question" and after it has been activated, it turns into a blue button that says "question flagged", confirming the student's action.

5.3 Database

To carry out this project, the university provided a database running on phppgadmin software, ceaselessly available and reliable. This platform meets the initial requirements, which were elaborated more precisely in [section 3.3](#). In addition, all the tables and links defined by [section 4.4](#) - UML Database, which describes the database schema and the reasoning behind this design, have been fully implemented on this platform and each element registered in a table has a unique key, which is given by an auto-increment function. The database comes with a set of dummy data, which was used for development and testing purposes. Once the application is deployed all this data can be erased and teachers can start to populate the database with real exams and once there are some results on the student-side the database will be fully populated. The persistent connection to the database is established by Spring-Boot which uses the application.properties file located in the resources folder to override its default settings.

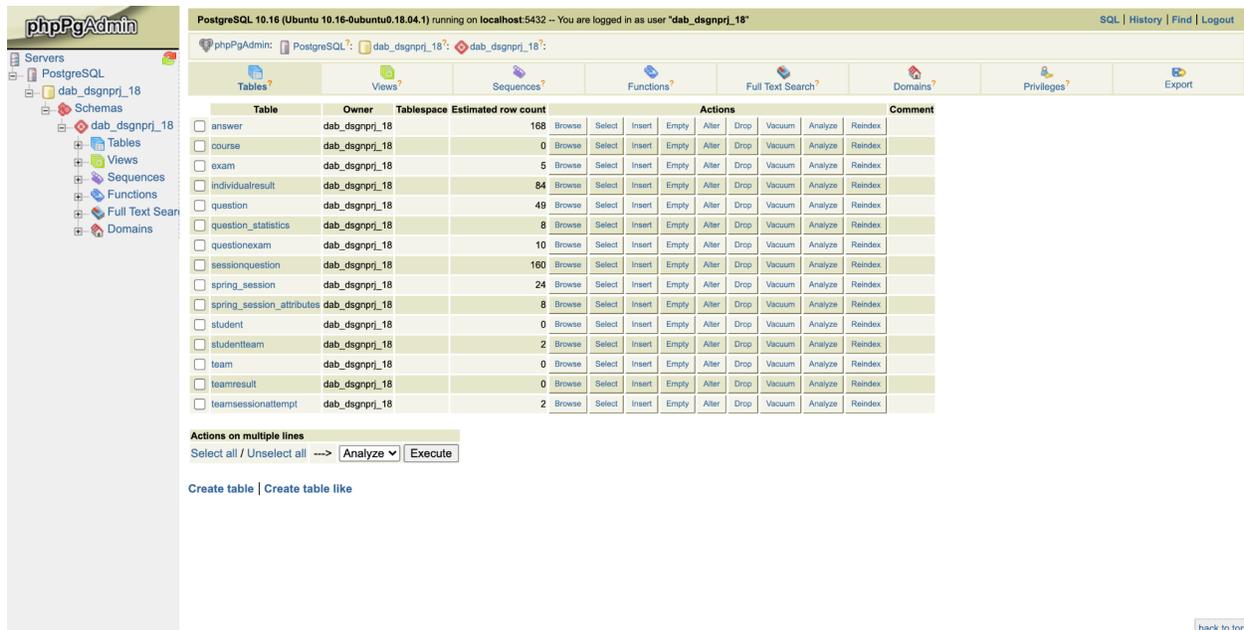


Figure 10: Implemented database for TBL application. Hosted on <https://bronto.ewi.utwente.nl/phppgadmin/>

6. Testing

Our software is in its nature a web-based application, so it is expected to have a comprehensive and far-reaching testing strategy. As the diffusion of the Internet has been massive in recent years, the testing standards for web applications have become stricter and imperative. This generates peculiarities that have to be tested carefully before deployment, to meet all the requirements of usability, reliability, interoperability and security. (Giuseppe A. Di Lucca, 2006).

6.1 Test Plan

In regard to the testing strategy applied, it has to be noted that we were not able to perform everything that we prepared in this sense, as time shortage and very busy schedules of both teachers and students towards the end of the module prevented us from putting in place a comprehensive testing plan. Nevertheless, we tested the application to the best of our capabilities, given the situation (mainly in isolation and with a relatively low number of users).

6.2 Approach

The testing approach was defined by two focal points: usability and reliability testing, in an online class with a teacher and students, and small, independent testing of the code. The first point unfortunately was not quite achieved, as the UT teachers who use TBL at their classes, with whom we were in contact, did not find any time slot that would fit all the schedules. Therefore, we couldn't conduct user testing at a larger scale (with a reasonable group of students and their teacher), but we will go through our testing plan and explain it anyway, as it can still be conducted and prove its worth in the future, should the application's development will be continued in the future. Regarding the second point, we covered most of the code through testing of different forms, which we will cover in the coming sections.

6.3 Functionalities to be tested

All the possible interactions of a user with our system represent a possible functionality (as the system does respond to the interaction in a particular way), so it is an arduous task to map all these interactions. This is why we grouped these interactions by the more important functionalities, which are considered to fulfil one of the requirements (such as exam creation). All the smaller interactions are going to be looked at when that specific functionality is tested. Therefore, we looked in general at the following:

-
- The web session and its corresponded cookies are consistent
 - Multiple users can interact with a group exam
 - The access and the data from Canvas are handled correctly
 - The two views of the application do not interfere one with another
 - A teacher can create, edit and view an exam
 - Forms are validated if correctly, otherwise an appropriate error message is shown
 - All data is transmitted and stored correctly in the database

6.4 Unit testing

Unit tests have mainly been done to test the correctness of functions providing Spring beans and utilitarian function for the program. The tested beans are used to read a JKS pair and create a JWKSet object to be used by the tool when making resource requests to Canvas. Another functionality that we were able to unit test was cookie validation.

A unit test case exists for the ExamSessionStorage class. This class is used to store details about each group's answers and members during a group exam. Because this is a rather important class, which we cannot afford to break down, we have developed some tests to check its functionality.

Basic tests include the addition of elements to the class, retrieval, and removal. After several tweaks of the class and the addition of several other tests, each method worked as intended.

Another test, although not JUnit, is in place that creates a predefined number of Threads that would access this class to perform some operations described above concurrently. This was a really helpful test to do as the first time we ran it, the class resulted in an exception.

However, since the Java-powered backend is mostly concerned with authentication Canvas users and returning resources they have access to, there's little in the way of public methods that could successfully be covered with unit tests. However, Spring provides a framework for testing the full stack of processes the program goes through when dealing with a request from a client.

6.5 Integration testing

Since a Spring controller has many functionalities, the processing of business logic, which is the part of code written by us, is only one out of the many tasks Spring performs when dealing with a request.

#	Responsibility	Description
1.	Listen to HTTP Requests	The controller should respond to certain URLs, HTTP methods and content types. The controller should parse the incoming HTTP request and create Java objects from variables in the URL, HTTP request parameters and the request body so that we can work with them in the code.
2.	Deserialize Input	The controller is the first line of defense against bad input, so it's a place where we can validate the input.
3.	Validate Input	Having parsed the input, the controller must transform the input into the model expected by the business logic and pass it on to the business logic.
4.	Call the Business Logic	The controller takes the output of the business logic and serializes it into an HTTP response.
5.	Serialize the Output	If an exception occurs somewhere on the way, the controller should translate it into a meaningful error message and HTTP status for the user.
6.	Translate Exceptions	

Figure 11: responsibilities of a Spring controller(reflectoring.io)

To test the integration of the different components working to process requests and return responses to the clients, we have used Spring's testing framework, mainly with the APIs for testing Spring MVC components.

As such, with the help of Spring testing and Mockito, we create mock requests and resources which are then passed on to the controller, which then treat them as actual HTTP requests. Mock objects imitate the functionality of objects and dependencies the controllers need to process requests and can be used to simulate different kinds of client request situations.

In this way, we were able to test how the system behaves and many situations. These include validation of the attributes assigned to a session, validation of cookies, including session-id and CSRF values, and ensuring the right responses are returned to

clients. Most importantly, we make sure only users with the right access have access to their respective resources.

6.6 Usability and reliability testing

One of the most valuable test approaches in terms of feedback received is represented by testing our application in a real environment that resembles the medium in which it will be used. This environment is represented by a group of students and their teacher having a TBL session for a certain subject. They are going to go through all the stages of a complete TBL session and share with us their feedback afterwards.

6.6.1 Objectives

Throughout this testing procedure, we wanted to primarily have an assurance that our system can properly hold a session smoothly and that our potential users feel comfortable with the overall design. By developing a web-based application, it was imperative that we tried to test into a great deal the main characteristics of this server-client architecture. These are the following:

- A reasonable number of users access the system at the same time, possibly from different locations as well.
- Access the application with a variety of hardware, operating systems, web browsers or web servers.
- The mix of components that make up the system as a whole are consistent (different programming languages, client/server computations, different models)
- The run-time of any command is executed in a reasonable time for the actual standards

The other objectives were related to the interaction between the user and the system and how we can improve it. This concerned mainly usability issues, such as difficulties in finding the desired elements, visual inconsistencies, users being stuck at any given moment and the degree of effort needed to interact with the system.

6.6.2 Detailed procedure

An environment as described in section 6.2 would provide a great number of users interacting with the system at the same time, even from different locations, as at the moment of speaking all classes are held online and with the possibility of receiving feedback from both the teachers and the students. Naturally, this would also test the functional sides of the system and, if successful, would meet the objectives set in the previous subchapter.

With the environment being set, the testing plan continues with a series of steps that simulate the workflow of the application, which were also exemplified in section 3.3.

The usability test described there is intended for prototype testing, however, the same steps apply for the final application, as the main functionalities are present in the prototype as well. The only sizable difference that would arise would be the fact that users will interact with a preponderant final version of our application, not with a prototype, so the feedback, in general, will be more concise regarding the overall design and functionality of the application. As a prototype, the feedback is more directed into what the users would want, based on the general idea that they got from testing the prototype. Normally, the feedback would be collected either as a form with different questions about the experience with the application, either by a collective discussion at the end of the session. Ideally, however, the feedback would contain both actions, as in the collective discussion, not all the participants may have the chance to speak, and the individual forms may be forgotten as time passes by after the session, which will also affect the quality of the feedback.

6.7 Evaluation of test results

As mentioned also previously, we were not able to conduct a relatively large scale testing, therefore, the analysis of the results was simplified. All the testing that has taken place was closely monitored and in most of the cases, the problems or bugs identified were located and resolved quickly. We also got some usability feedback from our stakeholders, who tested both our application and the prototype. Should a large testing session be conducted, the feedback received from the participants would have to be analysed more closely, in order to identify the key issues of the software and what our users really want. After the analysis has been completed, a plan of action has been conducted and the necessary changes were made prior to the last week of the module, which represents the closure phase of the project.

7. Future planning

In this chapter, the future plans for the Team-Based Learning Application beyond the current Design Project quartile are discussed. Initially, the Team-Based Learning Canvas plugin was designed as an ambitious project which falls into the category of Gamified Tools for Education, dealing with responsibilities beyond programming: requirements analysis, problem research, design prototyping, usability testing, documentation and deployment. The expectations of delivering an MVP during the quartile were met, and the next step is to focus on the utilization and support of the system, as well as additional features.

7.1 Utilization and maintenance of the system

Since the TBL Application project was proposed because there is a need for such a system for the university, it is expected to be hosted on a UT server and maintained by the LISA (Library, ICT Services and Archive) department. Because of this, in the development of the application, we followed the development guidelines applied by the Systems Development group within LISA.

7.2 Additional features

- Gamification:

There are several elements that could be added to enhance the gamification of the TBL application. The physical scratching is currently digitalized to a click, but it could be made into an interactive digital scratch card for a more fun experience. An important aspect of games is based on rewards, which can be incorporated into the group exam through a score box that gets updated after every answered question and (live) leaderboards showing the best performing teams.

Design-wise, the answer attempts could be displayed as “lives”(Figure 11), and each time an incorrect answer is scratched off, the team loses one life and points are subtracted. Moreover, the tests could have a gamified progress bar with checkpoints (Figure 12) to increase motivation and enhance the feeling of task completion.

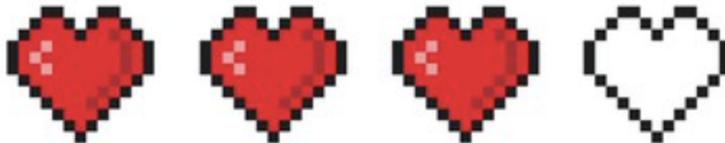


Figure 12: Heart symbols used to symbolize "health" or "lives" in video games. Source: Shutterstock



Figure 13: Video game progress bar with checkpoints. Source: Vecteezy

- **Internal communication system between students:**
As emphasized in other chapters, the TBL Application works well in both physical and online environments. In a physical session, students would sit next to each other at a table during the group assignment, but in an online session, they would have to use a third-party application for communicating in a voice channel. One of the “Could” requirements from the stakeholders was having a voice chat feature within the application.
- **Automatic configuration of teams:**
The TBL groups are meant to be strategically formed in order to ensure that the collective capacity of the team is significantly higher than the capacity of its best member. They need to be diverse (covering a wide range of skills and personal experience) and balanced (all teams should have a similar level of strengths and weaknesses). Therefore, they should not be self-formed, nor randomized. Research has shown that teacher-formed groups outperform randomized and self-formed groups (Brickell, Porter, Reynolds, & Cosgrovel, 1994). Because it can take a long time to collect the necessary information and form the groups as a teacher, especially in a large class, this could be done automatically within the TBL application. The data collection would be done at the beginning of the TBL course through a survey with Likert scale questions, after which the system creates the groups.
- **Feedback exchange between students:**
Peer evaluation is often the last practice of TBL, during which students give their group mates feedback on the team contribution. This is a highly beneficial activity, because, compared to the assessment of a teacher, the judgement from group mates can motivate a student to a greater degree (Searby and Ewers, 1997). This feature would be implemented in a new page of its own, containing quantitative and qualitative assessment forms as shown in Figure 13.

PART ONE: QUANTITATIVE ASSESSMENT (CHECK *ONLY ONE BOX* FOR EACH OF THESE 12 ITEMS)

COOPERATIVE LEARNING SKILLS:	NEVER	SOMETIMES	OFTEN	ALWAYS
Arrives on time and remains with team during activities				
Demonstrates a good balance of active listening & participation				
Asks useful or probing questions				
Shares information and personal understanding				

SELF-DIRECTED LEARNING:	NEVER	SOMETIMES	OFTEN	ALWAYS
Is well prepared for team activities				
Shows appropriate depth of knowledge				
Identifies limits of personal knowledge				
Is clear when explaining things to others				

INTERPERSONAL SKILLS:	NEVER	SOMETIMES	OFTEN	ALWAYS
Gives useful feedback to others				
Accepts useful feedback from others				
Is able to listen and understand what others are saying				
Shows respect for the opinions and feelings of others				

PART TWO: QUALITATIVE ASSESSMENT

1) What is the single most valuable contribution this person makes to your team?

2) What is the single most important thing this person could do to further your team's effectiveness?

Figure 14: Peer Evaluation Form. Source: Univ. of Tennessee Health Science Center

- **Export grades to Excel:**
Different instructors might use the TBL grades for different assessments in the end. Some might use the TBL results for bonus points to the real exams, others might compute a final TBL grade from all tests and even assign different weights to each. For this reason, a functionality to export the gradebook as a CSV file could be especially useful.
- **Image upload for test questions:**
Currently, the application only supports text questions for exams. For some courses, diagrams play an important role in the understanding and visualization of the content (e.g. Graph Theory), so it is important to allow teachers to attach images to questions.

8. Reflection/Evaluation

8.1 Planning

Throughout the module, the team followed the planning described in section 3.2. If it happened that the progress was slower than expected during one week, extra time was put in during the weekend in order to make sure there was no delay in the schedule.

Meetings with the supervisor and co-supervisors were conducted on a weekly basis, during which we discussed the progress of the project while presenting a demo of the current version, gathered feedback and explained the next steps.

For managing the task division and overview, Trello was used, which is an organizational tool that shows which member is working on what task at any given time, along with the completed tasks and the ones that still need to be done. Figure 14 illustrates a screenshot of our Trello board during the development phase of the project.

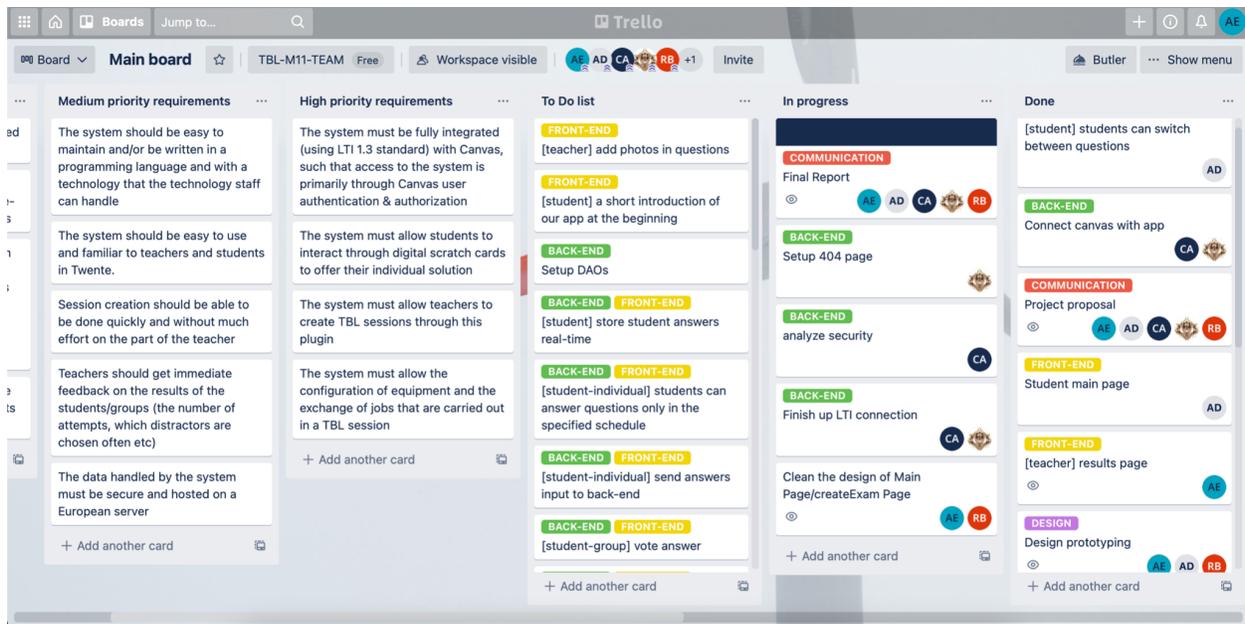


Figure 15: Trello board

8.2 Team evaluation

It can be safely stated that our group worked well together, mainly because we all knew each other before the start of this project and some of us have already worked together on other projects. As we mainly know each other's strengths and weaknesses we were able to divide the task and assign them efficiently. This made the workload to be

manageable and the cohesion in the team was consistently high throughout the whole project. Below, there is the individual reflection of each member of the team:

Radu - "I did enjoy working on this project and I feel that I learned a lot of things, mainly organizational and mental skills, as we were responsible 100% for this project, something which we did not experience yet, until now. I am also happy with the outcome and believe that our close communication with the stakeholders also played a key part in the development of the project".

Aida - "Having the opportunity to work on a real project based on a real challenge was very fulfilling. I enjoyed all phases of the project, especially the iterative usability tests which allowed us to receive feedback and improve the quality of the application week by week. I believe the strong point of the process was definitely the close communication between the team members, as well as with the supervisors."

Laurentiu - "This module was a great experience and truly felt like a culmination of the practical skills learned throughout the university. The teamwork was excellent and the chance to work with University teachers and employers was a great opportunity for experience and education. Our team had a clear task division and plan and the project went along with no major surprises or setbacks. Communication was excellent, and I would say that this team was a great example of teamwork and professionalism."

Denis - "I had a great experience in this module, by the fact that we had to make a digital product from planning to implementation, we had meetings with stakeholders to determine if everything went as planned, every member of the team is my friend, it was a pretty pleasant atmosphere. I think we all worked with pleasure and motivation, because if we deliver a well-done project, it can be used by the university in the future."

Cristian - "I had a very good time working in this team. I feel that we, as a team, have managed to coordinate and organize in such a way that a production-ready project would be delivered."

8.3 Final result

Overall, the team is pleased with the outcome of the Design Project. The project resulted in a Team-Based Learning Canvas plugin that fulfils the basic requirements, as well as some additional requirements.

Below is the list of functionalities that are included in the Team-Based Learning Application at the moment of delivery. They are based on the user stories and have been

classified by the MoSCoW prioritization technique. The features that have been implemented during the Design Project quartile are marked with a tick, while those which have not been added are marked with a cross.

	Teacher requirements	Student requirements	Admin requirements
Must	<ul style="list-style-type: none"> ✓ create and configure a test ✓ edit an existing test ✓ manually change a grade 	<ul style="list-style-type: none"> ✓ interact through digital scratch cards to offer solution ✓ receive instant feedback during the group test ✓ flag a question 	<ul style="list-style-type: none"> ✓ fully integrated with Canvas (authorization and authentication)
Should	<ul style="list-style-type: none"> ✓ easy to use and familiar user interface ✓ quickly create a test without much effort ✓ instant feedback on grades ✓ instant feedback on statistics 	<ul style="list-style-type: none"> ✓ easy to use and familiar user interface 	<ul style="list-style-type: none"> ✓ easy to maintain following the LISA development guidelines ✓ secure data handled by the system and hosted on a European server
Could	<ul style="list-style-type: none"> ✗ automatic team configuration 	<ul style="list-style-type: none"> ✗ gamification ✗ feedback exchange between group mates ✗ communication system: voice chat 	

Bibliography

Searby, M., and Ewers, T. "An Evaluation of the Use of Peer Assessment in Higher Education: A Case Study in the School of Music, Kingston University." *Assessment and Evaluation in Higher Education*, 1997, 22(4), 371–383.

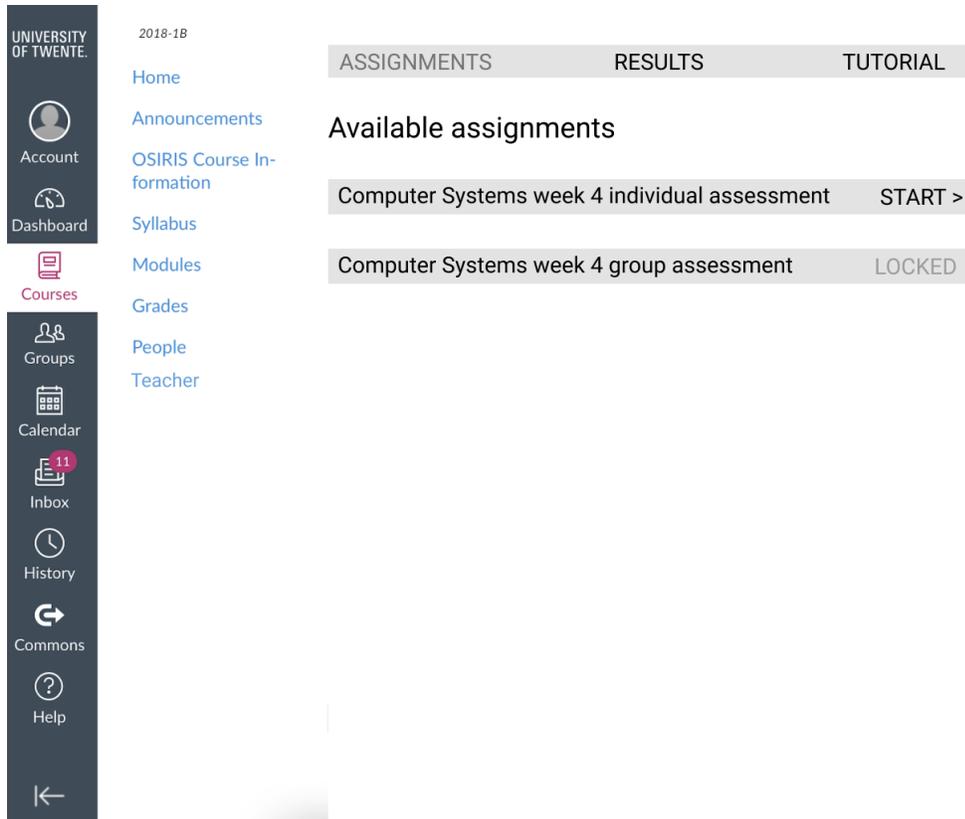
Brickell, J. L., Porter, D. B., Reynolds, M. F., & Cosgrove, R. D., (1994). Assigning Students to Groups for Engineering Design Projects: A Comparison of Five Methods. *Journal of Engineering Education*, 7, 259-262.

Giuseppe A. Di Lucca, Anna Rita Fasolino, (2006). *Testing Web-based applications: The state of the art and future trends*

Alexander, Ian. (2004). *A Better Fit - Characterising the Stakeholders..* 215-223.

Appendices

Appendix A: Figma Prototype



Student view: main page

UNIVERSITY OF TWENTE

Account

Dashboard

Courses

Groups

Calendar

Inbox 11

History

Commons

Help

- 2018-1B
- Home
 - Announcements
 - OSIRIS Course Information
 - Syllabus
 - Modules
 - Grades
 - People

ASSIGNMENTS RESULTS TUTORIAL

Computer Systems week 4 group assessment

Due: 10 Feb 2021 13:45 Questions: 4 Time limit: 30 min

Your progress  100%

< 1 2 3 4 >

Question 4

Decimal address 1108 is the start of the execution phase in the microstore. What is the bit pattern of op3of the ARC machine code?

- a. 010101
- b. 010100
- c. 100010
- d. The start address of execution phase is in memory

SUBMIT

Student view: individual exam

UNIVERSITY OF TWENTE

Account

Dashboard

Courses

Groups

Calendar

Inbox 11

History

Commons

Help

- 2018-1B
- Home
 - Announcements
 - OSIRIS Course Information
 - Syllabus
 - Modules
 - Grades
 - People

ASSIGNMENTS RESULTS TUTORIAL

Computer Systems week 4 group assessment

Due: 10 Feb 2021 13:45 Questions: 4 Time limit: 30 min

Your progress  75%

< 1 2 3 4 >

Question 4

Flag question

Decimal address 1108 is the start of the execution phase in the microstore. What is the bit pattern of op3of the ARC machine code?

- a. 010101
- b. 010100
- c. 100010
- d. The start address of execution phase is in memory

SUBMIT

Score: 1p

- A     
- B 
- C 
- D 

Attempts left: 3

Student view: group exam

UNIVERSITY OF TWENTE

2018-18

- Home
- Announcements
- OSIRIS Course Information
- Syllabus
- Modules
- Grades
- People

Account

Dashboard

Courses

Groups

Calendar

Inbox

History

Commons

Help

ASSIGNMENTS RESULTS TUTORIAL

- Computer Systems week 4 individual assessment >
- Computer Systems week 4 group assessment >
- Computer Systems week 3 individual assessment v
 - Correct answers: 5
 - Incorrect answers: 1
 - Grade: 8.3
- Computer Systems week 3 group assessment >
- Computer Systems week 2 individual assessment >
- Computer Systems week 2 group assessment >

Student view: Results Page

UNIVERSITY OF TWENTE

2018-18

- Home
- Announcements
- OSIRIS Course Information
- Syllabus
- Modules
- Grades
- People
- Student

Account

Dashboard

Courses

Groups

Calendar

Inbox

History

Commons

Help

Assessments Results

Assessments

+ New Assessment

Computer Systems week 4 assessment >

Q1: $f(A, B, C, D) = \sum m(8,9,10,12) + \sum m(0,2,13)$. What is the simplified function in sum-of-products?
 a. $A.B' + A.C'.D'$
 b. $A.B' + A.C'$
 c. $A.C' + B'.D'$
 d. none of these

Q2: What is the machine code in hex for the ARC instruction: `srl %r1, 10, %r3`?
 a. A7306A03
 b. 87306A00
 c. 8A30630A
 d. 8730600A

EDIT

- Computer Systems week 3 assessment >
- Computer Systems week 2 assessment >
- Computer Systems week 1 assessment >

Teacher view: main page (Assessments)

Teacher view: create assessment (test settings)

Teacher view: create assessment (add question)

UNIVERSITY OF TWENTE

2018-18

- Home
- Announcements
- OSIRIS Course Information
- Syllabus
- Modules
- Grades
- People
- Student

- Account
- Dashboard
- Courses
- Groups
- Calendar
- Inbox
- History
- Commons
- Help

Assessments Results

Computer Systems group 1

Correct answers: 5
Incorrect answers: 1
Grade: 8.3

Group members

Arva Denis | Grade: 10
Aida Enache | Grade: 8
Radu Basaraba | Grade: 4.9

Computer Systems group 2 | Grade: 9.0 >
Computer Systems group 3 | Grade: 7.5 >
Computer Systems group 4 | Grade: 7.6 >
Computer Systems group 5 | Grade: 8.0 >
Computer Systems group 6 | Grade: 9.0 >
Computer Systems group 7 | Grade: 5.5 >

Teacher view: grades

UNIVERSITY OF TWENTE

2018-18

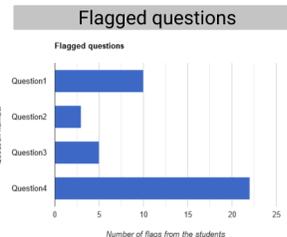
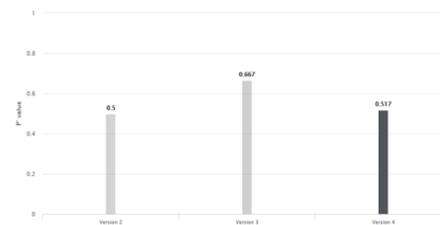
- Home
- Announcements
- OSIRIS Course Information
- Syllabus
- Modules
- Grades
- People

- Account
- Dashboard
- Courses
- Groups
- Calendar
- Inbox
- History
- Commons
- Help

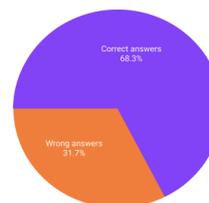
Assessments Results

Computer Systems group assessment 1 >

Q#	Description	Correct Answers	Wrong answers	%	P' value	Rit Value
1	What is the machine code in hex for the ARC instruction: srl %r1, 10, %r3?	41	19	75	0.8	0.344
2	Important timing properties of a Data Flip-Flop are: setup time (T _{su}), Hold time...	37	23	61.6	0.517	0.233
3	If (A, B, C, D) = (5, m(8,9,10, 12) * 2, m(0,2,13)). What is the simplified function in sum-of-products?	51	9	85	0.667	0.75
4	Decimal address 1108 is the start of the execution phase in the microstore. What is the pattern...	48	12	80	0.5	0.4



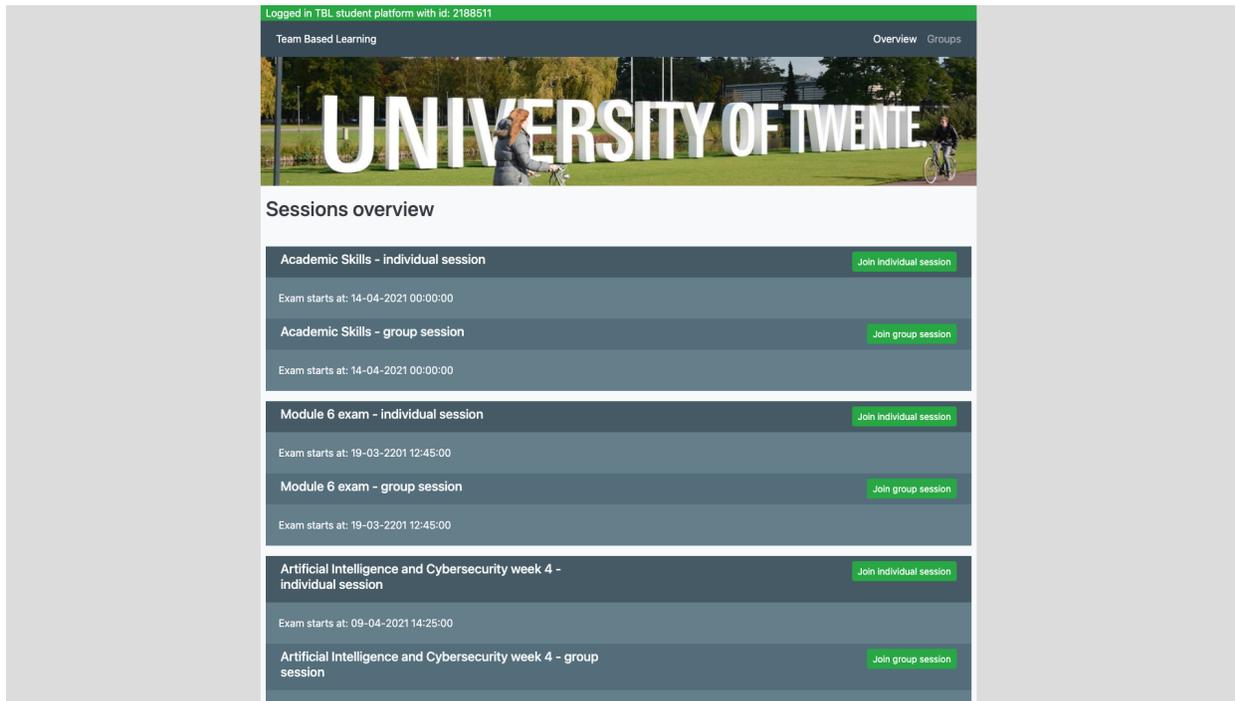
< Question 2 >



Teacher view: statistics

Appendix B: TBL App Webpages

Student view



Logged in TBL student platform with id: 2188511

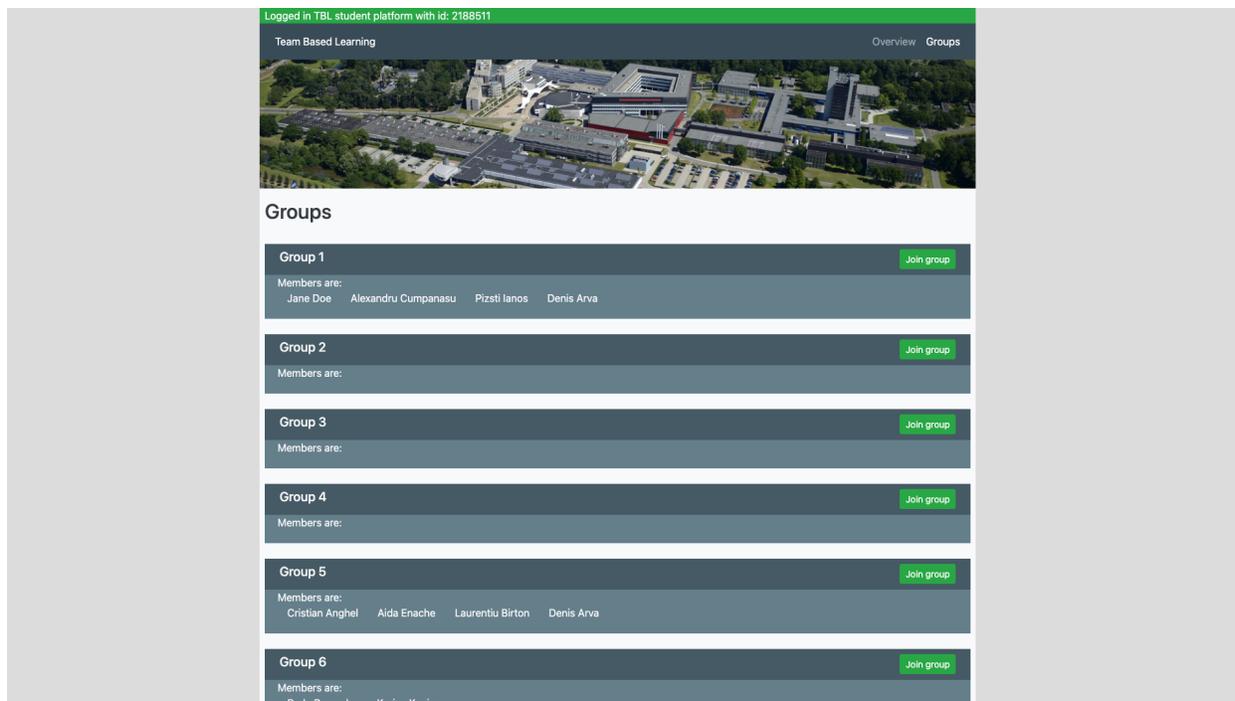
Team Based Learning Overview Groups



Sessions overview

Academic Skills - individual session	Join individual session
Exam starts at: 14-04-2021 00:00:00	
Academic Skills - group session	Join group session
Exam starts at: 14-04-2021 00:00:00	
Module 6 exam - individual session	Join individual session
Exam starts at: 19-03-2201 12:45:00	
Module 6 exam - group session	Join group session
Exam starts at: 19-03-2201 12:45:00	
Artificial Intelligence and Cybersecurity week 4 - individual session	Join individual session
Exam starts at: 09-04-2021 14:25:00	
Artificial Intelligence and Cybersecurity week 4 - group session	Join group session

Student home page



Logged in TBL student platform with id: 2188511

Team Based Learning Overview Groups



Groups

Group 1	Join group
Members are:	
Jane Doe Alexandru Cumpanasu Pizti Ianos Denis Arva	
Group 2	Join group
Members are:	
Group 3	Join group
Members are:	
Group 4	Join group
Members are:	
Group 5	Join group
Members are:	
Cristian Anghel Aida Enache Laurentiu Birton Denis Arva	
Group 6	Join group
Members are:	
Radu Basaraba Karina Koning	

Student groups view

individual session

Question 1
The search algorithm which is similar to the minimax search, but removes the branches that don't affect the final output is known as

Answers

- None of the above
- Breadth-first search
- Depth-first search
- Alpha-beta pruning

Question 2
In the TSP problem of n cities, the time taken for traversing all cities, without having prior knowledge of the length of the minimum tour will be

Answers

- $O(n!)$
- $O(n^2)$
- $O(n)$
- $O(n^2)$

Question 3
The Bayesian Network gives

Answers

- A complete description of the domain
- A complete description of the problem
- Partial Description of the domain
- None of the above

Question 4
A technique that was developed to determine whether a machine could or could not demonstrate the artificial intelligence known as the

Answers

- Logarithm
- Boolean Algebra
- Algorithm

Individual session view

individual session

Answers

- A complete description of the domain
- A complete description of the problem
- Partial Description of the domain
- None of the above

Question 4
A technique that was developed to determine whether a machine could or could not demonstrate the artificial intelligence known as the

Answers

- Logarithm
- Boolean Algebra
- Algorithm
- Turing Test

Question 5
Which algorithm is used in the Game tree to make decisions of Win/Lose?

Answers

- Algorithm Min/Max algorithm
- Greedy Search
- DFS/BFS algorithm
- Heuristic Search Algorithm

Question 6
Which of the given element improve the performance of AI agent so that it can make better decisions?

Answers

- Changing Element
- None of the above
- Performance Element
- Learning Element

Submit individual session ×

Are you sure you want to submit this session?

Make sure that you answered every question.
This operation can not be undone.

Individual session's submit warning

group session

Question 1 - Attempts: 0 Flag this question

The search algorithm which is similar to the minimax search, but removes the branches that don't affect the final output is known as

Answers

VOTE Alpha-beta pruning - votes:

VOTE Breadth-first search - votes: D.A

VOTE None of the above - votes:

VOTE Depth-first search - votes:

Question 2 - Attempts: 2 Question flagged

In the TSP problem of n cities, the time taken for traversing all cities, without having prior knowledge of the length of the minimum tour will be

Answers

CORRECT $O(n)$ - votes: A.C

VOTE $O(n^2)$ - votes:

INCORRECT $O(n/2)$ - votes:

VOTE $O(n)$ - votes:

Question 3 - Attempts: 0 Flag this question

The Bayesian Network gives

Answers

Group session view: student Denis Arva(D. A) flagged the second question and voted for the second answer of the first question.

group session

Question 1 - Attempts: 1 Flag this question

The search algorithm which is similar to the minimax search, but removes the branches that don't affect the final output is known as

Answers

VOTE Alpha-beta pruning - votes:

INCORRECT Breadth-first search - votes: D.A A.C

VOTE None of the above - votes:

VOTE Depth-first search - votes:

Question 2 - Attempts: 2 Flag this question

In the TSP problem of n cities, the time taken for traversing all cities, without having prior knowledge of the length of the minimum tour will be

Answers

CORRECT $O(n)$ - votes:

VOTE $O(n^2)$ - votes:

INCORRECT $O(n/2)$ - votes:

VOTE $O(n)$ - votes:

Question 3 - Attempts: 0 Flag this question

The Bayesian Network gives

Answers

Group session view: student Alexandru Cumpansu(A. C) also voted for the second answer and the answer is incorrect.

Teacher view

Team Based Learning Assignments Results

Assignments + Create Assignment

Academic Skills	14-04-2021 00:00-23:59	View
Module 6 exam	19-03-2201 12:45-16:31	View
Artificial Intelligence and Cybersecurity week 4	14-04-2021 14:25-15:00	View
Artificial Intelligence and Cybersecurity week 1	14-04-2021 10:00-10:45	View
Artificial Intelligence and Cybersecurity week 2	14-04-2021 10:00-10:45	View
Artificial Intelligence and Cybersecurity week 3	20-04-2021 10:00-10:45	View

Teacher view: Assignments (main page)

Team Based Learning Assignments Results

Create new assessment

Settings

Assignment Name

Date

Start Time

End time

Questions

+ Add Question

Q#	Question description	A	B	C	D	Correct

Submit

Teacher view: Create assignment

Team Based Learning

Assignments Results

Create new assessment

Settings

Assignment Name

Date dd-mm-yyyy

Start Time --:--

End time --:--

Questions

Q# Question description

Submit

Add Question ✕

Question text

Answer option A

Answer option B

Answer option C

Answer option D

Correct Answer
 Choose your option ▼

Submit Close

+ Add Question

Teacher view: Create assignment: add question

Team Based Learning

Assignments Results

Create new assessment

Settings

Assignment Name

Date dd-mm-yyyy

Start Time --:--

End time --:--

Questions

Q# Question description

Submit

Add Question ✕

Question text ⊘
Please fill in this field.

Answer option A ⊘
Please fill in this field.

Answer option B ⊘
Please fill in this field.

Answer option C ⊘
Please fill in this field.

Answer option D ⊘
Please fill in this field.

Correct Answer
 Choose your option ⊘
Please select the correct answer.

+ Add Question

Teacher view: Create assignment: add question invalid form on "submit"

Team Based Learning Assignments Results

Start Time 14:25 ⊙

End time 15:00 ⊙

Questions

[+ Add Question](#)

Q#	Question description	A	B	C	D	Correct	
1	The search algorithm which is similar to the minimax search, but removes the branches that don't affect the final output is known as	Alpha-beta pruning	Breadth-first search	None of the above	Depth-first search	A	 
2	In the TSP problem of n cities, the time taken for traversing all cities, without having prior knowledge of the length of the minimum tour will be	O(n!)	O(n ²)	O(n/2)	O(n)	A	 
3	The Bayesian Network gives	A complete description of the domain	Partial Description of the domain	None of the above	A complete description of the problem	A	 
4	A technique that was developed to determine whether a machine could or could not demonstrate the artificial intelligence known as the	Logarithm	Turing Test	Algorithm	Boolean Algebra	B	 

Teacher view: edit assignment

Team Based Learning Assignments Results

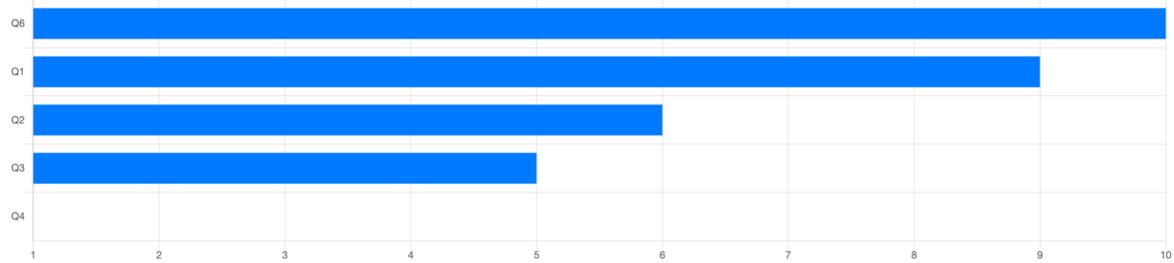
Grades overview [Save edits](#) [Statistics](#)

#	Student	Artificial Intelligence and Cybersecurity week 4 individual	Artificial Intelligence and Cybersecurity week 4 group	Academic Skills individual	Academic Skills group	Artificial Intelligence and Cybersecurity week 3 individual	Artificial Intelligence and Cybersecurity week 3 group
1	Cristian Anghel	8	8.8	8.5	9.5	7.6	8.1
2	Laurentiu Birton	1.6	8.8	6.8	9.5	7.5	8.1
3	Denis Arva	7.2	8.8	7.5	9.5	8.2	8.1
4	Radu Basaraba	7.5	-	7.9	9.2	9	7.9
5	Alexandru Cumpanasu	4.5	-	5	5	5.5	-

Teacher view: Grades

Artificial Intelligence and Cybersecurity week 4 ▾

Flagged Questions



Test statistics

#	Question	Correct Answers	Wrong Answers	%correct	Flags	P' val
1	The search algorithm which is similar to the minimax search, but removes the branches that don't affect the final output is known as	41	22	0.6507937	9	4.5555553
2	In the TSP problem of n cities, the time taken for traversing all cities, without having prior knowledge of the length of the minimum tour will be	40	23	0.63492066	6	4.4444447
3	The Bayesian Network gives	37	26	0.5873016	5	2.7777777

Teacher view: Statistics

#	Question	Correct Answers	Wrong Answers	%correct	Flags	P' val
1	The search algorithm which is similar to the minimax search, but removes the branches that don't affect the final output is known as	41	22	0.6507937	9	4.5555553
2	In the TSP problem of n cities, the time taken for traversing all cities, without having prior knowledge of the length of the minimum tour will be	40	23	0.63492066	6	4.4444447
3	The Bayesian Network gives	37	26	0.5873016	5	2.7777777
4	A technique that was developed to determine whether a machine could or could not demonstrate the artificial intelligence known as the	42	21	0.6666667	1	3.3333333
5	Which algorithm is used in the Game tree to make decisions of Win/Lose?	57	6	0.9047619	0	5
6	Which of the given element improve the performance of AI agent so that it can make better decisions?	25	38	0.3968254	10	2.7777777

Average team improvement

2.30% 

AVERAGE GROUP GRADE INCREASE COMPARED TO THE INDIVIDUAL GRADE

Teacher view: Statistics

Appendix C: Ethics report

University of Twente

Design Project Reflection Essay

Authors: Aida Enache, Cristian Anghel, Denis Arva, Laurentiu Birton, Radu Basaraba

1. Project Description

1.1 Problem Statement

The Team-Based Learning (TBL) methodology is a highly structured form of small-group learning which has gained a lot of popularity in recent years through evidence and positive results. The core of TBL is designed around collaborative work and makes students responsible for their own learning process, which enables teachers to offer quality education that is beyond memorization.

Before a TBL class, students prepare the assigned material through self-study. During a TBL session, students spend most of the time working in strategically divided, constant teams. They first take an Individual Readiness Assurance Test which consists of multiple-choice questions to show their knowledge of key concepts in the assigned pre-class materials. Afterwards, they take the exact same test together with their team, called the Group Readiness Assurance Test, which requires discussing the questions within the team and reaching a consensus on each answer. What makes this activity special is that the team receives immediate feedback on their answers, designed using Immediate Feedback Assessment Technique (IF AT) cards (Figure 1) that allow students to scratch off the chosen answers. When the students scratch off the correct answer from the first try, they receive full points for the question, and every time they choose a wrong answer points are deducted and they have to go back to discussing until they agree on their next choice. Through the feature of having immediate feedback on the teams' work, the potential for discussion, self-evaluation and learning is maximized. Finally, the tests are followed by a mini-lecture that concludes the TBL tests, during which the teacher can elaborate on the topics and concepts that are still unclear for the students.

1.2 Team-Based Learning Canvas Plugin

For the University of Twente as an adopter of the Twente Educational Model, teams, collaboration and independence are the key elements in a study programme. These principles fit perfectly with the core of Team-Based Learning and, consequently, some teachers in the university want to apply TBL to their classes. The impediments to incorporating TBL are now the new structure of online education and the hassle of setting up such sessions, since the IF AT scratch cards would need to be ordered in advance. Therefore, a digital product on which TBL sessions can be carried would be ideal for the university.

Although there are a few products on the market which offer a platform for digital TBL activities, either they are very costly, they can not be integrated into the Learning Management System (LMS) used by the University of Twente, or they have a difficult and time consuming set up process.

Our Design Project aims to offer a Team-Based Learning web application in the form of a plugin for University of Twente’s LMS, Canvas. Apart from the basic tasks carried out in a TBL session, the application has a gamified feeling, because games have extensive potential to motivate students to engage more in the learning processes (Chevtchenko 2013) ^[1]. and to enhance competitiveness between teams.

IMMEDIATE FEEDBACK ASSESSMENT TECHNIQUE (IF AT)
 Name Team # 3 Test # 1
 Subject _____ Total 23
SCRATCH OFF COVERING TO EXPOSE ANSWER

	A	B	C	D	Score
1.	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	4
2.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2
3.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	4
4.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	1
5.	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4
6.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4
7.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0
8.	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	4
9.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
10.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Figure 1. Immediate Feedback Assessment Technique (IF-AT) Card with four answer options and a scoring system as follows: 4 points for scratching the correct answer on the first try, 2 points for the second try, 1 point for the third try and 0 points for the fourth try

2. Ethical concerns

2.1 Analysis

Our top priority for this project is to deliver a valuable, working product at the end of this module to our stakeholders. They include teachers, students and employees of the University, which use or work with the Team-Based Learning system during courses. This is why we took into account all relevant ethical and social issues that may arise when using our application or after prolonged usage. In the following table, we list all these issues, alongside their context and estimated impact and relevance. The discussion and detailed analysis of the high-impact issues will follow afterwards.

Ethical concern	Context	Potential Impact	Relevance
Automation	Our design automates tasks that previously were carried out by humans.	High - some Teaching Assistant tasks are automated and the experience might be perceived as very different in comparison with the physical version of TBL	High
Persuasive design and gamification	Our application proposes an exam design whose features resemble some present in video games	High - engaging elements can raise competitiveness levels, leading to neglect of the original academic objectives	High
Privacy	The application deals with student information such as names, grades, taken courses	Low - the application is integrated in Canvas, which has a privacy policy. Neither TBL App nor Canvas shares the information further.	Medium
Relationships between students	Students work in a team during activities such as group tests; having to discuss and agree on one answer could cause conflicts	Low - this is the case for any team activity, conflicts can arise but the risk of that happening is low	Low

2.2 Automation

By definition, automation is the creation of a technological product that makes a process run with little to no human intervention. Automation is generally applied with the aim of increasing efficiency and reliability - because, unlike humans, machines do not need vacation nor breaks, and they can not have negative moods which can impact work productivity - but it has always presented ethical concerns.

Ever since the early technological advances, there has been an exponential growth in the fear that robots will take over people’s jobs and eventually conquer the world, leaving them unable to

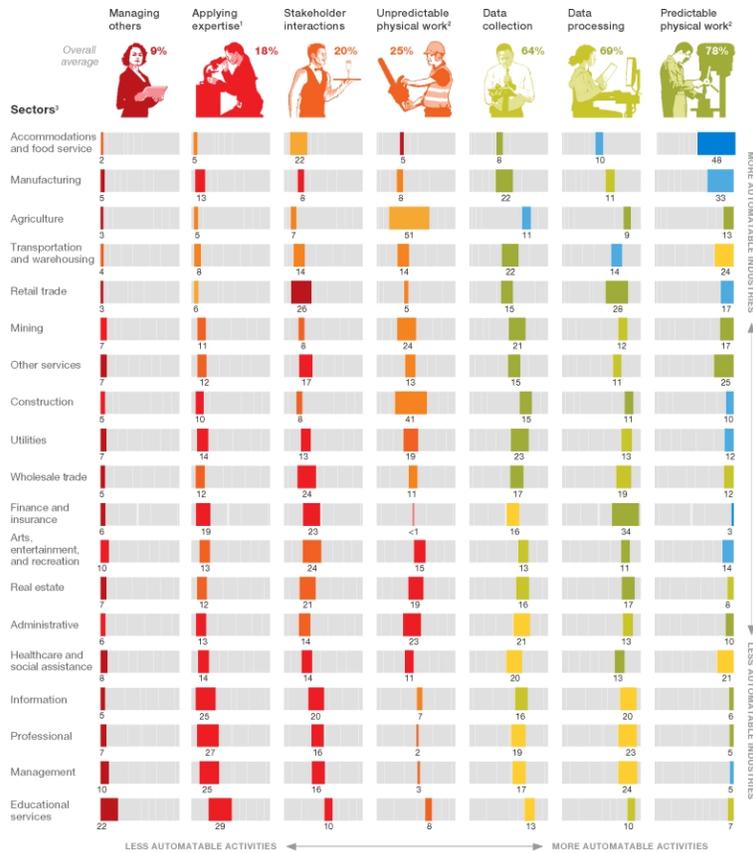
provide for themselves and their families. However, in reality, humans still play a critical role in controlling, maintaining, monitoring and configuring such software and machines, but this is mainly true for the higher-level occupations. As for the lower level occupations which can have their tasks thoroughly automated, e.g. factory assembly, industry leaders such as Elon Musk (CEO of Tesla and SpaceX) believe that automation will cause widespread unemployment that will make universal basic income necessary ^[2]. Such a compromise seems fair, because “Artificially forcing humans to work to achieve a basic standard of living holds back both human and technological potential” (Cammers-Goodwin 2019 ^[3]).

Needless to say, technological development is not impacting industries equally. A few disciplines have remained affected by automation only by a very small margin, including education. In 2016, analysts from the management consultancy McKinsey & Company conducted a study (Figure 2) analyzing and reporting the technical potential for automation in the US, in which they categorized jobs into seven industry sectors and computed a percentual automation potential for each of them. Unsurprisingly, jobs that require managing and developing humans have proved to be the most difficult to replace by technology, having an automation potential of only 9%, and educational services fall into this category.

The technical potential for automation in the US

Many types of activities in industry sectors have the technical potential to be automated, but that potential varies significantly across activities.

Technical feasibility: % of time spent on activities that can be automated by adapting currently demonstrated technology



In practice, automation will depend on more than just technical feasibility. Five factors are involved: technical feasibility; costs to automate; the relative scarcity, skills, and cost of workers who might otherwise do the activity; benefits (eg, superior performance) of automation beyond labor-cost substitution; and regulatory and social-acceptance considerations.

¹Applying expertise to decision making, planning, and creative tasks.
²Unpredictable physical work (physical activities and the operation of machinery) is performed in unpredictable environments. While in predictable physical work, the environments are predictable.

³Agriculture includes forestry, fishing, and hunting; **other services** excludes federal-, state-, and local-government services; **real estate** includes rental and leasing; **administrative** includes administrative support and government administration; **healthcare and social**

assistance includes private, state-government, and local-government hospitals; **professional** includes scientific and technical services; **educational services** includes private, state-government, and local-government schools.

McKinsey&Company

Figure 2. McKinsey & Company study on Technical Potential for Automation in the US, 2016

Our TBL Application consists of the Teacher’s View and the Student View, and both of them present some level of automation.

For the teacher, the tasks that are automated are grading, collection of feedback from students, test statistics and the distribution of tests: printing and handing in a copy of the test for each student. In this case, we can say that automation is used as an external enhancement for the teacher. It does not have the role of replacing the instructor’s job; it is meant to make their job easier and save faculty time. Instead of spending hours grading the tests, the teacher can use that time for other educational tasks such as addressing students’ questions and concerns, or providing extra materials, and therefore their agency is affected by having an increased number of actions they can pursue. Despite this, the aforementioned tasks tend to be done by teaching

assistants at the University of Twente, rather than by the teachers. In this case, we can say that automation is affecting their job by replacing some tasks and implicitly offering fewer opportunities of working hours within a course.

For the students, an exciting part of the TBL experience is automated, namely the immediate feedback process. Traditionally, scratch cards have become widely popular because they are appealing through their mysterious allure, they provide a satisfying tactile experience and the instant gratification of revealing prizes or messages can become addictive because of their gambling nature ^[4]. In our application, however, the scratching is not done in a gambling manner, because students need to answer test questions that they studied for, so they are not randomly choosing the boxes, because their grade is at stake. The scratch cards still remain mysterious and offer instant gratification, but the tactile experience is gone due to digital automation: the scratching is now done with one click.

2.3 Persuasive Design and Gamification

One of our optional requirements for this project is represented by the gamification of the TBL experience in our application. We want to achieve this until the end of the project, and, therefore, give the students that will use our plugin an interactive design, creating a new experience of the classic TBL sessions. By its definition, a Persuasive Game Design is a design aiming to create a user experienced game world to change user behaviour in the real world.

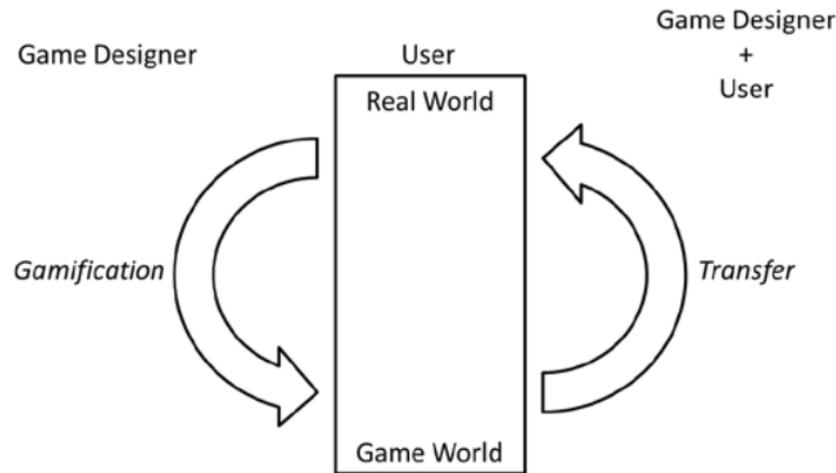


Figure. 3 Persuasive Game Design Model (Visch et al, 2013 ^[5].)

The specific part that will deal with this gamification is going to be the group exam session, where groups of four students take an exam they previously did individually. Every answer will need a discussion between the four participants, and moreover, if an answer is not the correct one, they have to continue to answer the question until they find the correct answer (or stop after the third try, as only one possible answer remains). The number of attempts for each question will be reflected in the final score they receive, based on the principle the more attempts, the lower the score. A part of the persuasive design will be represented by this aspect, as a live leaderboard

with all the groups, or a specific set of groups, depending on the teachers' choice, will appear for every group, which has the objective to make the students more focused on the task, even competitive (Apter, 2007^[6]), especially if they are doing very well in the test and have a good position in the leaderboard. These features of our design will try to engage them in both the discussion with their group, when they analyze the answers and come up with arguments, and in the way, they study the material and do the individual exam, before group one.

However, this interaction may have some unwanted effects on the general state of the students. One such issue is represented by the additional pressure put on the students' shoulders, as they will always be aware that some groups are doing very well and progress very fast, which can give a feeling of falling behind. This can result in loss of concentration, increase stress and can go as far as loss of motivation, as a result of frustration accumulated during the exam. For example, take the group that finishes in the last position in the leaderboard, as they will have to put up with this position for a big chunk of time during the exam. However, our intentions are to purely motivate the students and encourage them to work harder, and we believe that competitiveness is a natural element of a game, so our design promptly includes it.

3. Responses to the ethical concerns

In this section, we will try to go through each of the concerning points presented before and analyze what and how modifications to our software could help minimize their negative impact.

First, our application would affect the workload available to a teaching assistant (or any other employee performing similar tasks), therefore indirectly affecting their payment. Although probably the most concerning, there are little to no possibilities for us, as developers of the system, to influence this. The simple fact we are offering this software for use is already the main cause for this issue. However, structural and organizational decisions within the educational institution using the program can help mitigate some of these issues. Maybe the role of the teaching assistants could also diversify, offering replacement duties for those affected. However, this is outside the scope of our project. We could, however, at the recommendation of an institution, offer guidelines and set restraints on the use of the software, in accordance with the need of the institution.

Subsequently, the issue of the experience felt by students during a TBL session arises. On the contrary to the previous point, there is a good deal of software design choices that could help in this aspect. The physical scratching of the answer could be replaced with a mouse and sound alternative one for desktop-style systems, or touch, vibration, and sound for touchscreen capable devices. As such, scratching and all and suspense associated with it could be faithfully replicated. Moreover, elements not present in real-life scratch cards could be added, such as confetti blowing on the screen on a right answer, sad faces on wrong answers, or any other visual or audio cues that could stimulate the participant.

Another point of concern is the gamification of the group exam through a live leaderboard. While this design, as mentioned above, may have a positive impact on some of the participants, it may very well have negative effects on the rest of the participants by putting them under additional pressure. To reduce this effect, multiple alternatives can be considered. One such alternative is displaying only a few groups in the leaderboard that are doing very well instead of displaying all of them. Additionally, live scores could also be removed to further reduce this

effect. Not being aware of the score, only of the position in the leaderboard can be frustrating for the top teams who may be engaging in a competition, but seen from a different point of view it can also be stimulating in a way that encourages thorough consideration of the answers and lead as few attempts required per question as possible. There are plenty of other alternatives for the implementation of the leaderboard, but we believe that only displaying the top-performing teams, without their score is a good middle ground. On the one hand, top-performing teams are encouraged to thoroughly consider their answer, and on the other hand, lower-performing teams are not put under additional pressure due to their loss of motivation by comparing themselves to other better-performing teams.

All things considered, we believe that our project does not present significant ethical issues since the concerns are rather easy to address, as described above. To summarize, the web application collects user data that is needed to achieve the project's objective such as student identification number or individual/group session grades, however, it does not store sensitive data such as password, email address or any data that could be used for profiling algorithms. Also, the individual agency of both teachers and students are positively affected because teachers can deal with other tasks that are more important than doing iterative work that generally takes a long time, such as correcting exams. Furthermore, students have the opportunity to participate in these remote sessions, and in the times we live in, it is a potentially effective alternative to keep students and teachers safe.

References

1. Chevtchenko, A. (2013). "Gamified Education - Introducing Game Elements into the School Environment to Enhance Student Motivation and Performance"
<https://thesis.eur.nl/pub/14159/MA-thesis-A.-Chevtchenko-final-20-08-2013.pdf>
2. Weller, C. Elon Musk Doubles Down on Universal Basic Income: 'It's Going to Be Necessary', BUSINESS INSIDER (Feb. 13, 2017)
<https://www.businessinsider.com/elon-musk-universal-basic-income-2017-2>
3. Sage I. Cammers-Goodwin, "*Tech: The Curse and The Cure: Why and How Silicon Valley Should Support Economic Security*", 9 U.C. Irvine L. Rev. 1063 (2019).
<https://scholarship.law.uci.edu/ucilr/vol9/iss5/4>
4. Raposo Lima, Catarina & Castro, Liliana & Sousa, Nuno & Morgado, Pedro. (2015). SCRATCH THAT! — Two case reports of scratch-card gambling disorder. *Addictive Behaviors*. 45. 10.1016/j.addbeh.2015.01.018.
5. Visch V., vd Kooij K., Vegt N, Anderiesen H., *Persuasive Game Design: A model and its definitions* (2013)
http://gamification-research.org/wp-content/uploads/2013/03/Visch_etal.pdf
6. Apter, M. *Reversal Theory: The Dynamics of Motivation, Emotion and Personality*. Oneworld Publications, Oxford, 2007
7. <http://www.imglobal.org/spec/security/v1p0/#step-2-authentication-request>
8. <https://reflectoring.io/spring-boot-web-controller-test/>