Smartfun Academy

Building A Holistic STEM Learning Application for Kids

Bachelor Thesis

Ada Lungu

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Supervisor: Constantin Alexandru Gheorghiasa

Professional Bachelor in Web Development

KEA Kopenhagen School Of Design and Technology

Copenhagen, Denmark

Contents

1 Introduction **3**
1.1 Company Profile and Vision 3
1.2 Problem Statement 3
1.3 Competitor Analysis 5
1.4 Preliminary Work and Preparations 6

2 User Experience **8**
2.1 Target End-Users Of the Application 8
2.2 Typical Usecase for Kids 9
2.2.1 Experential Learning (Learning by doing): Projects . . . 9
2.2.2 Learning through Play: Gamification, Rankings, Achievements 10
2.2.3 Assessment Techniques: Quizzes 14
2.3 Typical Usecase For Admins 15

3 Implementation **18**
3.1 Working Environment Setup 18
3.2 Front-End 18
3.2.1 Programming Languages 19
3.2.2 UI Frameworks 19
3.3 Back-End 20
3.3.1 Programming languages 20
3.3.2 RDMS 20
3.4 Application Architecture and Design Principles 21
3.4.1 Design Principles 21
3.4.2 Client-Server Architecture 27
3.4.3 All Projects Page 27
3.4.4 Create New Project Page 28
3.4.5 Edit Project Page 28
3.4.6 Present Project Page 31

4 Future Work **33**

5 Conclusion **35**

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Chapter 1

Introduction

1.1 Company Profile and Vision

This is a project performed in collaboration with SmartFun. SmartFunis a start up whose vision is to come up with a friendly and holistic environment for children where they practice STEM (Science, Technology, Engineering, Mathematics) by means of interactive and playful methods.

They create a learning environment by providing workshops, where kids are involved in hands-on projects in coding and electronics. Children experiment with building robots, motors, electric circuits by connecting and coding these devices. They learn a lot empirically by trial and error.

Part of the solution they envision in creating a holistic learning experience is an online platform that will incorporate the know-how and learning materials of the actual workshops. We have already started to do that migration of information towards the platform. At the moment we are using the beta version of the platform as a helping tool in our workshops, until gradually it will replace the need of tutors and of traditional workshops.

Workshops constitute the perfect testing environment for our application, as we receive constant feedback by observing kids interacting with it. Using them as a testing ground for the platform assured the selection and prioritization of the developed features based on users reactions.

1.2 Problem Statement

The lack of a holistic learning experience for kids in STEM. Educational systems today still promote learning as an information transfer where students are passive learners, rather than an experiential process where learners engage in active playroles. Moreover, there is still attendancy to teach disciplines in isolation of each other.

More than other disciplines, STEM should promote experimentation at the core of learning, and interdisciplinarity as a norm. Experimental learning (Learning by doing) supports trail by error learning where kids play active roles in decision taking and problem solving. Interdisciplinarity bridges concepts viewed as independent by showing kids how disciplines are so tighly connected and rely on each other in real life instances.

It is hard to revolutionalize the educational system within its conventional boundaries, so there are more efforts directed into creating alternative solutions. Such alternative solutions are seen in the latest development of online educational platforms. Although there is a considerable number of such attempts, there is still a lack of an online platform that promotes a holistic approach for kids in STEM.

Some of these solutions, while focusing in addressing some traditional issues, end up leaving out important aspects. A common flaw is a tendancy in flipping entirely from a theoretical to a practical approach, leaving out any conceptualization. There are other good practice learning strategies that tend to be neglected. A generaly left out educational tool is assessment, which is a powerful component in a learning process. Another common challenge is providing the users with the needed tools in engaging in experimental projects.

Sharing ideas and knowledge within a community transforms learning in an active enterprise and boosts self-confidence. A holistic educational system is complete when it engage users in active participation, as they share ideas and know-how.

Apart from respecting principles of a holistic learning, we focus in shaping the learning process based on our end-users innate trademarks. And what is more naturally instrumental for kids than play? Play is the articulation of individual expresivity and creativity in kids. We want to bring learning as close as possible to the most intrinsic form of expression in children.

The long-term vision of our product is to compete with the entertainment industry for kids. Its goal is to model such an exciting experience for kids, that they learn within the realms of play.

Consequently, we have set the goals to design our platform guided by these principles:

- Interdisciplinarity
- Experimental learning: both practical and conceptual
- Users become active agents of a community

- Assessment tools
- Play (gamification)
- Integrated solution for supplying support materials

1.3 Competitor Analysis

Instructables: `http://www.instructables.com/classes/`
Instructables is a website that provides tutorials for hands-on projects in a range of disciplines. It provides well documented instructions and learning resources and it also comes up with a set of creative projects. The downsides of their concept is that their tutorials are so focused on how to build a project, that is does‘’ not enforce any conceptual understanding. The website does not implement any assessment tools.

Code Combat: `https://codecombat.com/`
Code Combat is one of games that aim teaching kids coding within the mechanics of a real game. Commands controlling the characters in the game are code-like commands, sometimes language specific (Code Combat uses Python commands), other times more generic. This is a successful model for wrapping learning in the realms of entertainment, and it uses gamification as an incentive. Kids understand the power of code commands within the virtual reality, but still lack the vision of connecting coding within a broader spectrum of STEM multidisciplinarity.

Bitsbox: `https://bitsbox.com/`
Scratch MIT: `https://scratch.mit.edu/`
Programs like Scratch or Bitsbox empower children on a higher degree, as they become themselves the creators instead of players of games. Scratch is particularly powerful for the community they build around it. Users can upload and share their creations with others, can exchange tips and comments. Scratch MIT lacks outlining the concepts it operates with. Kids understand the power of coding, but the platform does not provide conceptual basis. By contrast, Bitsbox connects modules of practice with specific coding concepts, but do not empower the users by engaging them in active participation.

EEME: `http://www.eeme.co/tour`
Creation Crate: `https://mycreationcrate.com/`
These websites have a well built system of monthly kits and learning support (tutorials), plus good integration of interdisciplinary STEM projects. Users can subscribe for getting a monthly kit and can preview the projects they gonna make. Especially My Creation Crate has a portofolio of very creative projects. What both these platforms lack is engaging the community and assessment tools.

Thimble: `https://www.thimble.io/`

Thimble's solution is the closest to our concept, bringing together a number of components left out by other competitors. One feature is the community they build through forums, chat, projects sharing and weekly project webinars. Users are encouraged to customize their projects and share them on the platform. Another differential aspect is that they complement the practice with conceptual learning. They do so by using assessment tools as part of the learning strategy. They explain concepts and insert quizzes through the projects presentation steps.

1.4 Preliminary Work and Preparations

"When you design a product, inside and out, the most important thing is to nail down the user experience. What are the screens, how do they work, what do they do. Later, you worry about how to get from here to there. There's no use arguing about what programming language to use before you've decided what your product is going to do." - Joel Spolsky (co-founder of Trello and Fog Creek Software, and CEO of Stack Overflow) [1]

I was part of a small team responsible for developing the product. It was composed of two developers and the product owner who was also the start-up CEO and the project manager. This resulted in having the developers directly involved in gathering and negociating the requirements.

I participated in the project set up from the scratch. This means I needed to narrow down the initial generic, ambigously broad ideas of the product into detailed, manageable requirements. I decided the best technique of doing so was to come up with functional specifications.

Inspired by Joel Spolsky view of functional specifications, I followed his model and took each screen, gave it a canonical name, and wrote a chapter describing it in as much detail as possible. The description focused on functionality and interaction design, rather than the exact look and layout. I have used sketch up UI mock-ups only as a tangible common baseline for discussions. Having a visual anchor is an efficient method for understanding the interaction design of the app and possible features implementation.

Having the specs, it became much easier to nail down a set of tasks and to prioritize them into a manageable backlog.

I have framed the specs around user scenarios for anticipating the end-users interactions with the platform and a better understanding of their needs. As this quote sais it well: "A human brain understands things much better if you

[1] http://www.joelonsoftware.com/articles/fog0000000036.html

can paint a vivid picture in their mind by telling a story, even if it's just a fragment of a story, because our brains have evolved to understand stories."[2]

[2]http://www.joelonsoftware.com/articles/fog0000000036.html

Chapter 2

User Experience

2.1 Target End-Users Of the Application

The main end-users of our product are children with ages between 8 and 15 years old. Part of our development strategy was a continuous testing of the platform with representatives of this group age. We have set our testing environment through the workshops in which we have been assisting as tutors. We have designed the platform iteratively based on continuous feedback from our target users. We have redesigned features in accordance with free observations of users interacting with our product and with direct feedback from them.

The other end-users group of the platform are administrators, which at the moment are represented by the tutors of the workshops. By playing both the role of a tutor and the developer of the application, I had the chance in directly testing the product usability in its real life context.

Consequently, the application has two modes for the two target groups. The profile and the needs of two types of end-users appeal for quite different presentation styles. We focused in designing a user friendly interface for the main target which are the kids, and invested less effort in polishing the administrator panel.

As a central user experience convention, we have kept a minimalistic design for the whole app, both as an aesthetic principle and as a strategy for further future graphics integration. In the next subsections of the chapter I will briefly describe what are the main features of each end-users mode.

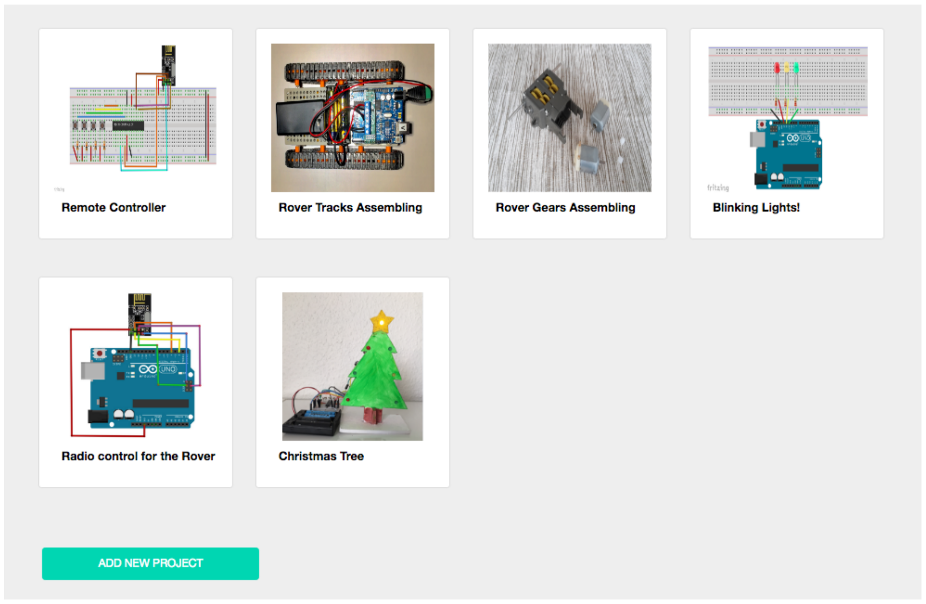


Figure 2.1: Main Projects Page - Projects Overview.

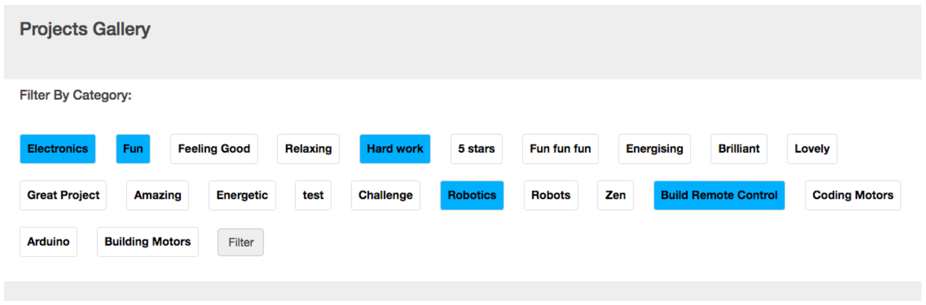
2.2 Typical Usecase for Kids

2.2.1 Experential Learning (Learning by doing): Projects

Projects Section is a central component of the learning experience on the platform. The main page of the module displays all projects to users and a searching feature for projects by labeled categories. [Figure 2.2] Projects are briefly presented by a distinctive image and their title. [Figure 2.1]

Users can create and edit a project. The editing mode is currently open to administrators of the platform for putting up and editing teaching materials related to the project: title, description, media resources, a list of needed materials. This mode supports uploading of files (pdf), images (png, jpeg) and videos. Kids can create projects as well, so that they become active contributers to the platform. To ensure appropriate content, the data submitted by kids await check-ups and approval from the administrators before getting uploaded on the website. In the end we want to create an experience where the user is also author and contributor of the platform.

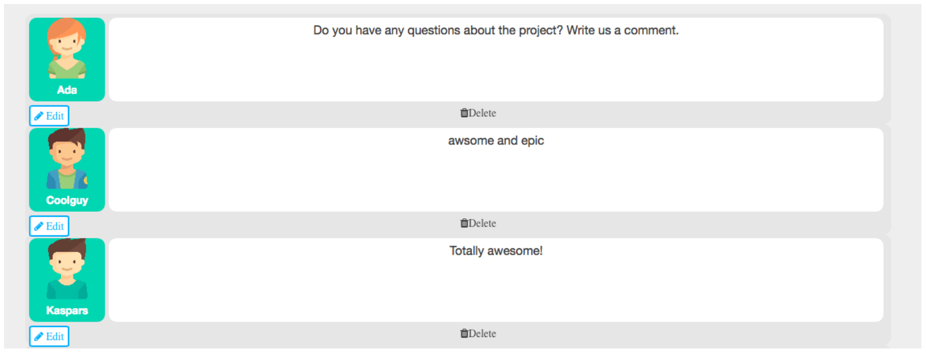
In the project presentation mode, the user finds all details about the current selected project: description, label tags, needed materials, estimated time of completion. The materials list come along with an order and purchase system. Users can check the items they already have and can add to basket for purchase the ones they need. Users can leave comments on the page, with questions or any


Projects Gallery

Filter By Category:

Electronics Fun Feeling Good Relaxing Hard work 5 stars Fun fun fun Energising Brilliant Lovely Great Project Amazing Energetic test Challenge Robotics Robots Zen Build Remote Control Coding Motors Arduino Building Motors

Figure 2.2: Filtering Category Labels for Projects.


Ada: Do you have any questions about the project? Write us a comment.

Coolguy: awsome and epic

Kaspars: Totally awesome!

Figure 2.3: Users Comments System.

information related to the project. [Figure 2.3] The page includes a stars voting system, where they can rate the project based on a few criterias: functionality, difficulty, fun. As a future feature, users will be permitted to vote only after completing the project. [Figure 2.5] Moreover, they can contribute to extending the labels decribing the project, by adding new descriptive tags. [Figure 2.4]

Each project is split in a number of steps that the user must complete, in order to get rewards such as points and achievements. The user is able to visualize the progress of steps completion on the tracking progress bar at the top of the steps view. [Figure 2.6]

2.2.2 Learning through Play: Gamification, Rankings, Achievements

The application is built around a motivational reward system. It uses gamification techniques to transform learning into an engaging and provocative activity.

The reward system is represented by achievements and a points system. Achievements have two states: locked and unlocked. They are split in cate-

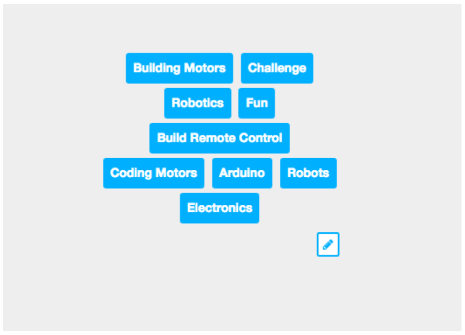


Figure 2.4: Add Labels for Project.

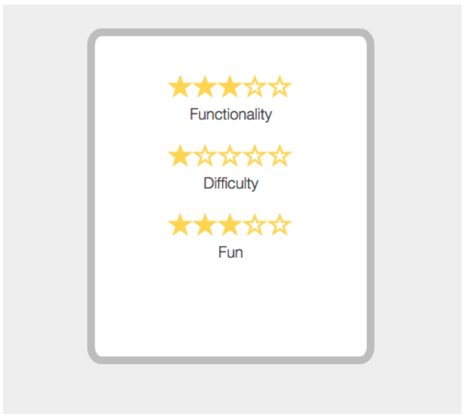


Figure 2.5: Stars Voting System.

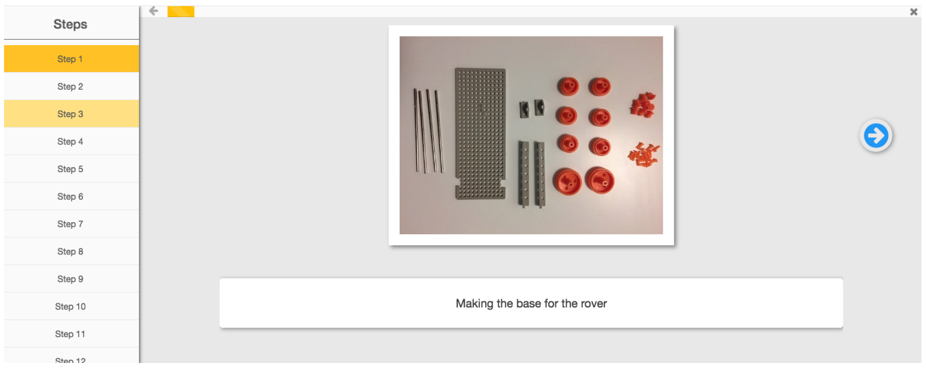
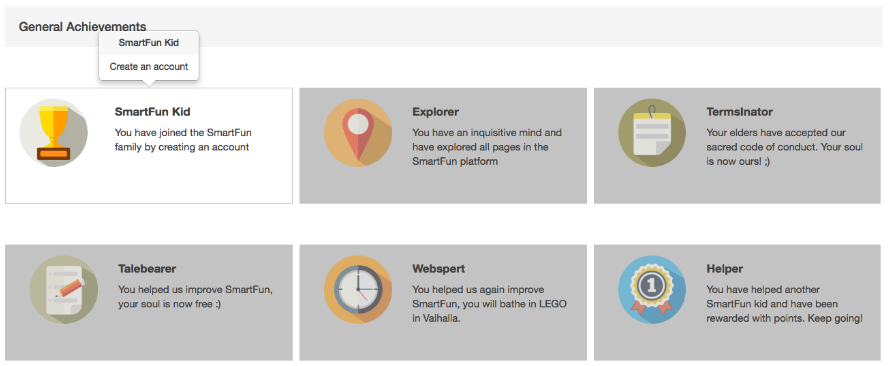


Figure 2.6: Project Steps Presentation.


General Achievements

SmartFun Kid

Create an account

SmartFun Kid
You have joined the SmartFun family by creating an account

Explorer
You have an inquisitive mind and have explored all pages in the SmartFun platform

TermsInator
Your elders have accepted our sacred code of conduct. Your soul is now ours! ;)

Talebearer
You helped us improve SmartFun, your soul is now free :)

Webspert
You helped us again improve SmartFun, you will bathe in LEGO in Valhalla.

Helper
You have helped another SmartFun kid and have been rewarded with points. Keep going!

Figure 2.7: General Achievements.

gories, each category standing for certain types of activitis and tasks that the participants can perform. Initially all achievements are locked and they can be activated only when users perform specific actions. The locked state of achievements is visually represented by a grey overlay or background (depending on the context where they are displayed). The unlocking of an achievement is marked by a pop up in notifications section on the menu. [Figure 2.9] The achievements have a general presentation page and can be found also on the user dashboard, where only a maximum of 6 achievements are displayed (always a few unlocked for challenging the user). [Figure 2.8]

In the current beta version, there are 2 functional categories of achievements: the Quiz Achievements and the General Achievements. [Figure 2.7] The achievements are closely linked to the points system, each coming with a number of points as a reward.

The points system is linked to the rankings section which enhance a competitive experience for the users. There are 3 types of rankings: *general rankings* - rank individual achievements comparing the performance of all active users; *workshop rankings* - list individual achievements between members of same workshop; *groups rankings* - evaluate collective performance per workshops based on the average points gained by their members.

We have designed the rankings in a way that stimulates both an individual and collective competitiveness. The rankings per groups targets to boost children spirit of collaboration and feeling of group adherance.

During our UX testing sessions with the kids, we have concluded that the rankings is the most popular feature of the platform, as kids kept coming back and checking the rankings page many times per session. Rankings motivates kids

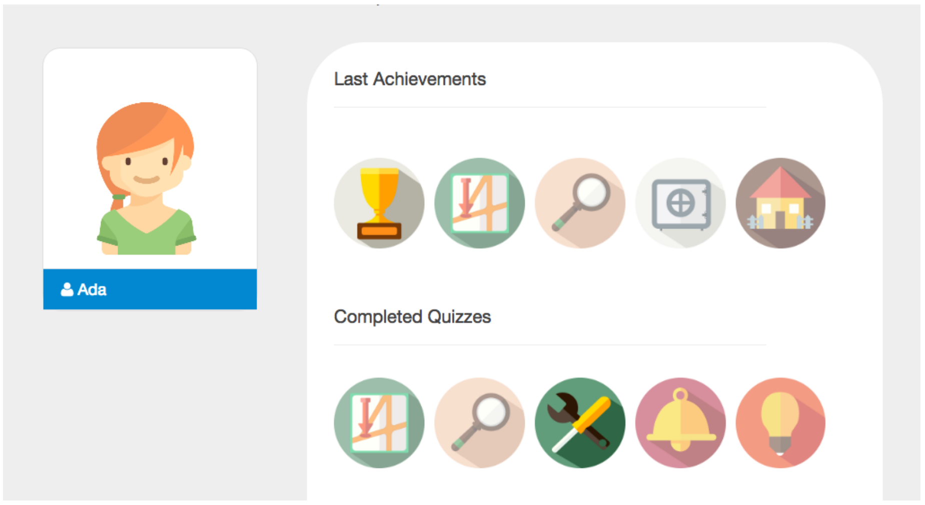
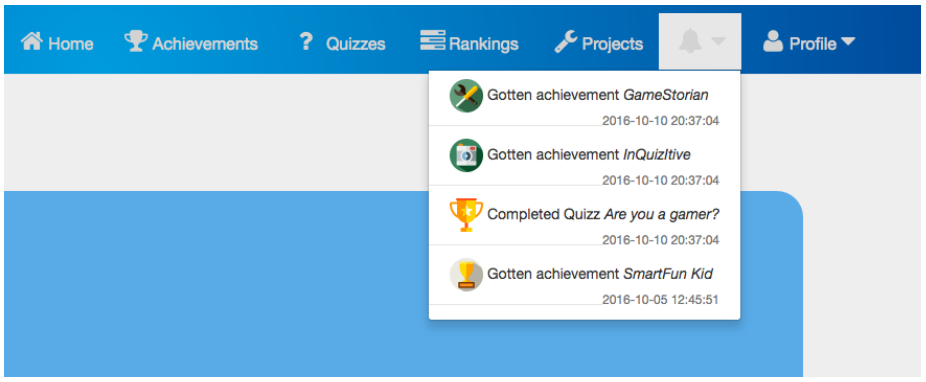
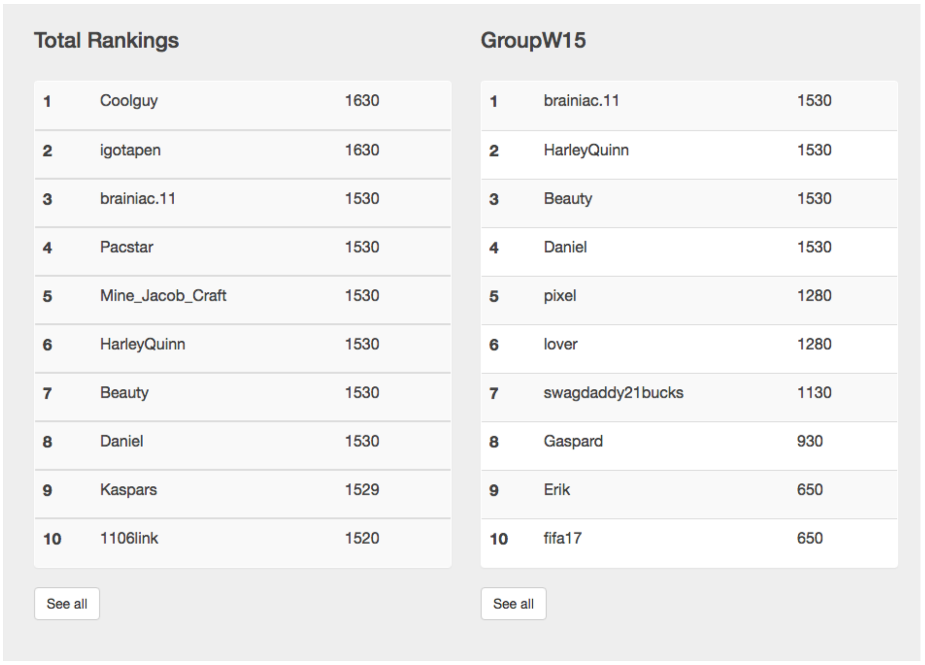


Figure 2.8: Achievements Display on Dashboard.



Gotten achievement *GameStorian*
2016-10-10 20:37:04
Gotten achievement *InQuizItive*
2016-10-10 20:37:04
Completed Quizz *Are you a gamer?*
2016-10-10 20:37:04
Gotten achievement *SmartFun Kid*
2016-10-05 12:45:51

Figure 2.9: Achievements Notifications.



Total Rankings

1	Coolguy	1630
2	igotapen	1630
3	brainiac.11	1530
4	Pacstar	1530
5	Mine_Jacob_Craft	1530
6	HarleyQuinn	1530
7	Beauty	1530
8	Daniel	1530
9	Kaspars	1529
10	1106link	1520

GroupW15

1	brainiac.11	1530
2	HarleyQuinn	1530
3	Beauty	1530
4	Daniel	1530
5	pixel	1280
6	lover	1280
7	swagdaddy21bucks	1130
8	Gaspard	930
9	Erik	650
10	fifa17	650

Figure 2.10: Ranking System.

in taking more and more quizzes and redoing quizzes for gaining more points. Based on our UX testing findings, we included a number of links to rankings on the platform: when logging in on dashboard page, after the completion of a quiz. [Figure 2.10]

A central gamification feature intended for the release version will integrate and link together the current gamification elements (achievements and points) by introducing an avatar buiding system. Users will build their avatars trading their achievements and points for items that will constitute parts or accessories of the avatar. We take into consideration adopting a monetary system represented by coins, with an equivalent of points per coin.

2.2.3 Assessment Techniques: Quizzes

The main feature of the current version that generates points and unlock achievements are quizzes. Quizzes are linked to workshop themes and to projects and assess users level of mastering a topic. After completing a quiz, users can evaluate their answers and visualize the wrong answers against the correct ones. [Figure 2.11]

Users are evaluated by the number of correct answers and by the time of quiz completion. They can redo the quiz to upgrade the completion time, but they can't update their points, which are decided by their first quiz completion.

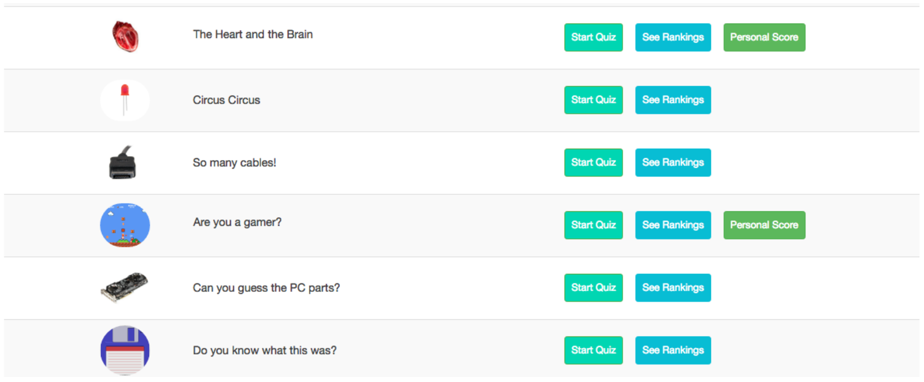


Figure 2.11: Quizzes Overview.

In a future release version, quizzes will be locked by default and will be unlocked only in a logical sequence.

2.3 Typical Usecase For Admins

We have designed the administration panel system in such a way that admins can manage most of the platform content and monitor users activity. From the admin panel, administrators can add and edit content displayed on the platform (quizzes, projects), activate or disable components (the chat system), view and manage users profiles and activity (login history, reset passwords). Each main section on the platform has a correspondent management control in the admin panel.

In the Projects Management section, the admins have an overview of all projects, can edit the display data of the projects or can delete projects from the system. Projects can be disabled or turned on, meaning admins choose which projects are currently displayed on the projects page. Project Management panel includes an users progress tracking feature, which gives admins an overview of the projects started by users and the level of completion progress.

The Quiz Management system allows adding or editing quizzes: uploading images and creating multiple choice answers, setting the correct answer. As it does in projects, the admin system allows the enabling or disabling of quizzes.

The profiles and activity of users can be monitored and managed in the User Management panel. The Login History comprises the timestamps of the users having logged in on the application. The Reset Password feature came as a result of a common problem tutors faced in the actual workshops: kids frequently forgetting their credentials. The Group Management is also linked to the real

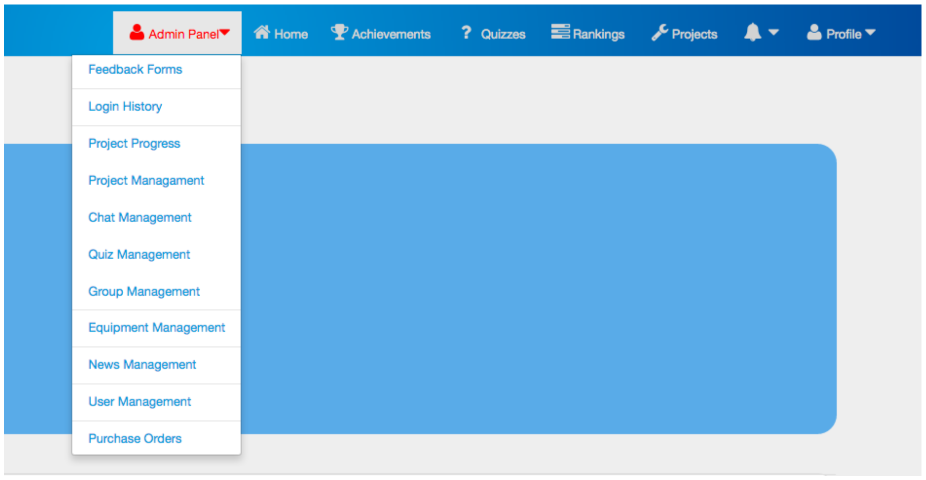
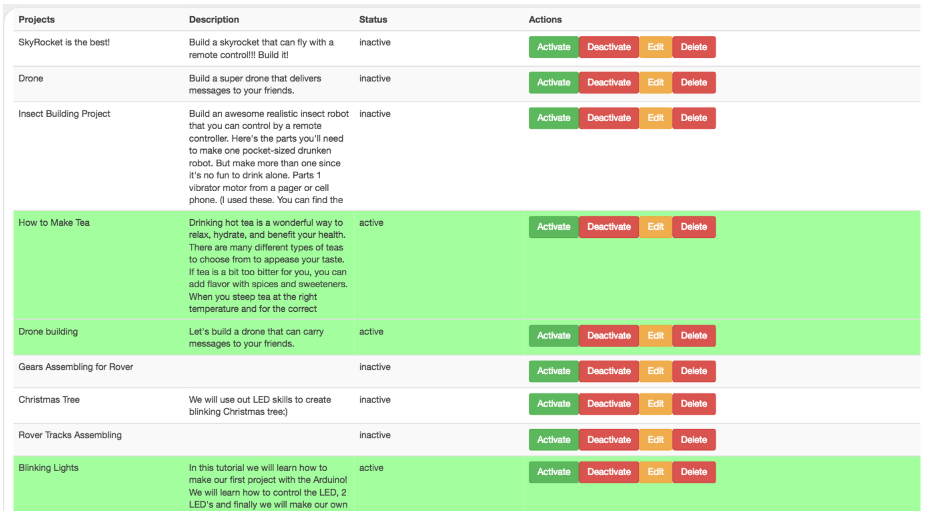


Figure 2.12: Admin Panel Menu.



Projects	Description	Status	Actions
SkyRocket is the best!	Build a skyrocket that can fly with a remote control!!! Build it!	inactive	Activate Deactivate Edit Delete
Drone	Build a super drone that delivers messages to your friends.	inactive	Activate Deactivate Edit Delete
Insect Building Project	Build an awesome realistic insect robot that you can control by a remote controller. Here's the parts you'll need to make one pocket-sized drunken robot. But make more than one since it's no fun to drink alone. Parts 1 vibrator motor from a pager or cell phone. (I used these. You can find the	inactive	Activate Deactivate Edit Delete
How to Make Tea	Drinking hot tea is a wonderful way to relax, hydrate, and benefit your health. There are many different types of teas to choose from to appease your taste. If tea is a bit too bitter for you, you can add flavor with spices and sweeteners. When you steep tea at the right temperature and for the correct	active	Activate Deactivate Edit Delete
Drone building	Let's build a drone that can carry messages to your friends.	active	Activate Deactivate Edit Delete
Gears Assembling for Rover		inactive	Activate Deactivate Edit Delete
Christmas Tree	We will use out LED skills to create blinking Christmas tree:)	inactive	Activate Deactivate Edit Delete
Rover Tracks Assembling		inactive	Activate Deactivate Edit Delete
Blinking Lights	In this tutorial we will learn how to make our first project with the Arduino! We will learn how to control the LED, 2 LED's and finally we will make our own	active	Activate Deactivate Edit Delete

Figure 2.13: Admin Panel Projects Control.

needs of the workshops. We want facilitate the tutors in changing names or adding new workshops, without the need of the developer changing entried in database.

In the Chat Control panel, tutors can disable the chat. We have designed this feature, after chatting during the workshops became a way of distracting kids from focusing on the projects and paying attention.

Chapter 3

Implementation

3.1 Working Environment Setup

We use a server host provider service (Meebox), which comes with a package that supports php development, offers access to MariaDB 10.0.27, and includes phpMyAdmin as database management tool. On top of these it provides SSH Access and SSL Management.

I have suggested Github as our Version Control System, and learned Slack as the company's favorite Communication Management Tool. We have created a separate environment for testing and for production and for this purpose we have created a database for each environment. All the local changes are tested on the test database which is on the server.

I have chosen as IDE (Integrated Development Environment) PHPStorm, which is Jetbrains product for php development. Our main team tasks management tool was Trello, where we split tasks in categories and constantly prioritized our workflow.

3.2 Front-End

We have opted for a minimalistic, simple design for our beta version, as a strategy to iteratively develop it while testing its usability with end-users. This approach also facilitates later integration of graphics. The trademarks of our front-end user interface design are: minimalist and intuitive, kids-friendly, responsive.

3.2.1 Programming Languages

On front-end I mostly use JQuery. Apart from substantially compressing the code in fewer lines, JQuery is also the most browser-friendly option. It does not need Adobe Flash plug-in to be interpreted by the browser, meaning it is readable in any browser. [1]

I use SCSS as a preprocessor programming language, to facilitate better standardization and omogenity of UI components. Jetbrains PHPStorm comes with a File Watcher, a transpiler tool for SCSS that facilitated its integration.

As a working practice I keep the mark-up language separated from Javascript as much as possible. I use small modules of Javascript code, usually having Javascript files corresponding to core UI components. I have created a dedicated layout folder, that comprises the layout elements common to all or some of the application pages.

3.2.2 UI Frameworks

The front-end framework we use is Bootstrap Twitter 3.3.6. We have settled on Boostrap after analysing pros and cons of alternative frameworks. Although frameworks like Foundation, Semantic UI, Material Design, Ulkit have some competitive features, Boostrap won by having some unbeatable advantages.

It corresponds to one of our core design principles: responsiveness. It exceeds other frameworks by its stated attention towards resposiveness and mobile-friendliness. Bootstrap is still regarded as the most popular front-end framework, with large community support and consequenlty with rich documentation and resources: articles and tutorials, third-party plug-ins and extensions, theme builders.

I also prefer Boostrap beacause of its level of specificity. Being more generic than other frameworks that tend to have higher-level specificity, its minimal style framework is easier to customise. I consider it is more practical to add up styling rules than overwriting existing ones. [2]

A good framework needs to level up constantly with the latest web technologies, especially with regards to mobile. Bootsrap does that, being constantly under active development. It also has a generous browser support.

Some of the other frameworks have some very competitive features. Semantic UI has some extra unique UI components and outperforms Boostrap as a very friendly, semantic language. Its overall structure of the framework and the

[1] http://www.javaworld.com/article/2078613/java-web-development/6-reasons-you-should-be-using-jquery.html

[2] https://www.sitepoint.com/5-most-popular-frontend-frameworks-compared/

naming conventions, in terms of clear logic and semantics of its classes has a clear vantage point. It prounds itself with a scalable and modular architecture for CSS as main property. [3]

Frameworks such as Semantic UI and Foundation also outweight others by a unique, rich pallette of UI components. YOOtheme distinguishes itself with a better GUI Customizer. It offers a flexible and powerful customization mechanism, either manually or via its GUI customizer. [4] Regarding the spectrum of browser support, Boostrap finds itself a step behind Foundation.

3.3 Back-End

3.3.1 Programming languages

I have built the application using the scripting language PHP as server-side choice. I believe it is a reliable choice, as PHP has steadily been one of the most widely used developing language for web applications. It is commonly known for its portability and it is supported by the highest number of web server hosting providers. PHP is widely backed by large programming communities and it is open source, which assures a steady development and a solid community commitment in stabilizing it.

PHP is also known for its resilience. It it portable on all major operating systems and has support on a wide range of web servers. PHP holds up both procedural and object-oriented (OOP) programming paradigms, and has compatibility with a vast collection of databases.

For relational database management system (RDMS) I have opted for MySql. PHP can use mainstream MySQLLi and also provides an abstraction layer through PDO, which I have made use of.

3.3.2 RDMS

PDO stands for PHP Data Objects. It provides a data-access abstraction layer, using a unified API, which is a lean, consistent way to access databases regardless of the database. This increases the portability of our code, if we want to change the database we operate with.

One core advantage of PDO over MySQLi lyes in its database driver support. PDO upholds around 12 different drivers, opposed to MySQLi, which supports MySQL only. This fact has implications for further software changes, as using

[3] https://www.keycdn.com/blog/front-end-frameworks/
[4] http://noeticforce.com/best-material-design-web-frameworks

PDO makes it facile to transfer to a different database. [5]

The abstraction layer PHP offers in interaction with the database through PDO optimises the program execution and maximises security measurements. The performance is boosted by the use of Prepared Statements, which allows the parsing and execution of a query only once. The queries are sent only once to the database, where they wait for the parameters. The bandwidth to the server is minimalized through the use of Binding Parameters, which are sent independently to the query waiting on the db. [6]

The second advantage of employing PDO is the layer of security it provides. It is designed to shield against one of the most invasive forms of security breaches: SQL injections. The parameters sent in the query are transmitted later than the query commands using a different protocol. They are scrunitized with security filters through these protocols. [7]

In the design of our database, we have used all types of relational raports between tables. One-to-one relationship model is predominent, followed by one-to-many pattern. The many-to-many relationship is used in merging data between tables such Members-Projects, Projects-Steps, Members-Achievements, Members-Activities, Members-Quizzes, Members-Comments. I describe the database design using the following Entity Relation Diagram. I have used a coloristic relation map to differentiate the types of dependency between tables and data. [Figure 3.1]

3.4 Application Architecture and Design Principles

I will exemplify the application architecture and the design principles used by presenting the interactions of one of the projects main modules: the Projects section. The following diagram shows the organization and dependencies between the files of the module. [Figure 3.2]

3.4.1 Design Principles

I have designed my code around few pillarstone principles: separation of concerns, DRY (Do Not Repeat Yourself) and modularity (reusable components). Separation of concern principle is commonly associated with the MVC architecture design pattern. Although I do not employ a standard MVC framework, I have structured the composition of the code by applying MVC patterns, by

[5] https://code.tutsplus.com/tutorials/pdo-vs-mysqli-which-should-you-use–net-24059
[6] http://php.net/manual/en/pdo.prepared-statements.php
[7] http://stackoverflow.com/questions/8263371/how-can-prepared-statements-protect-from-sql-injection-attacks

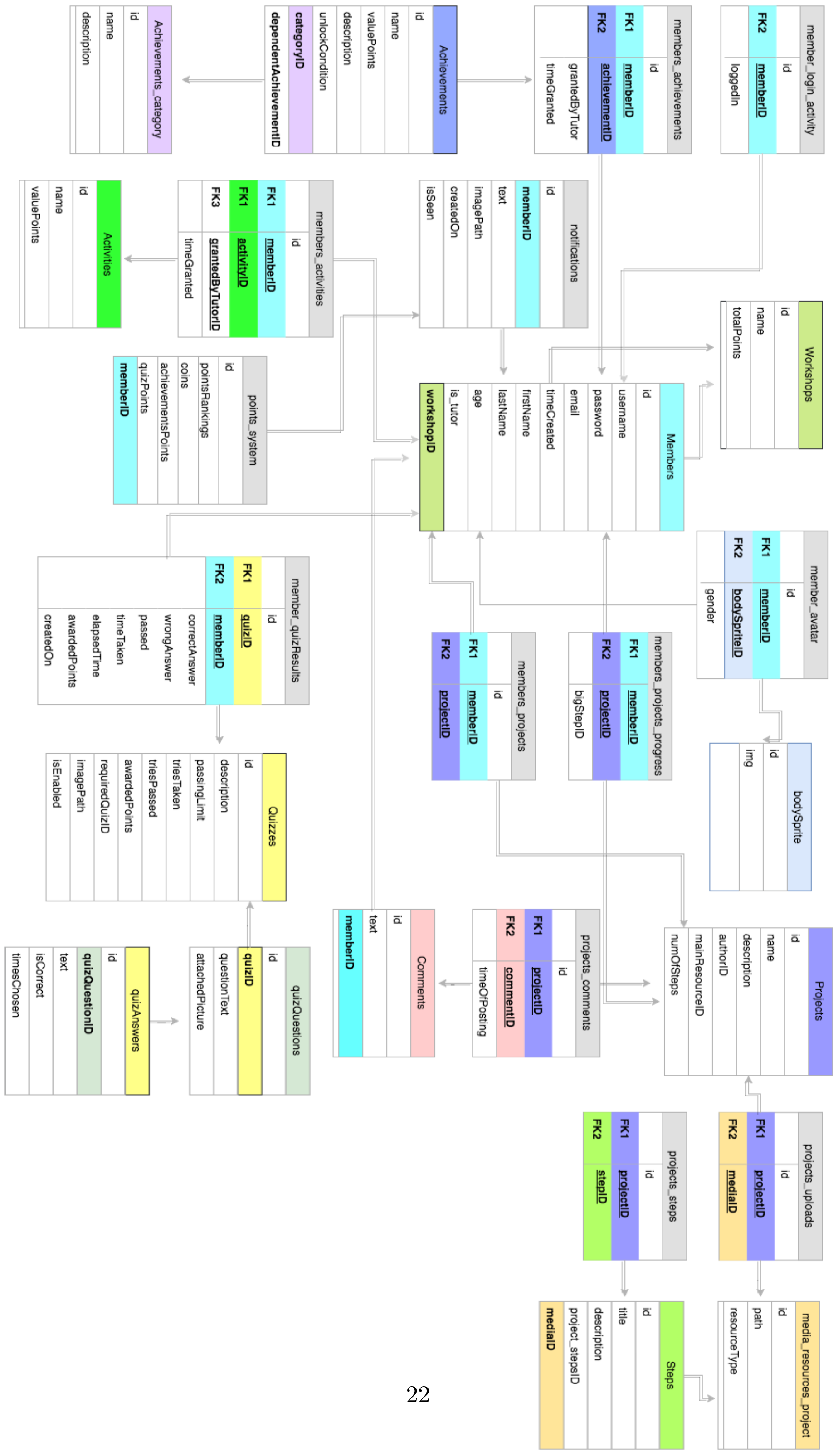


Figure 3.1: Database Entity Relation.

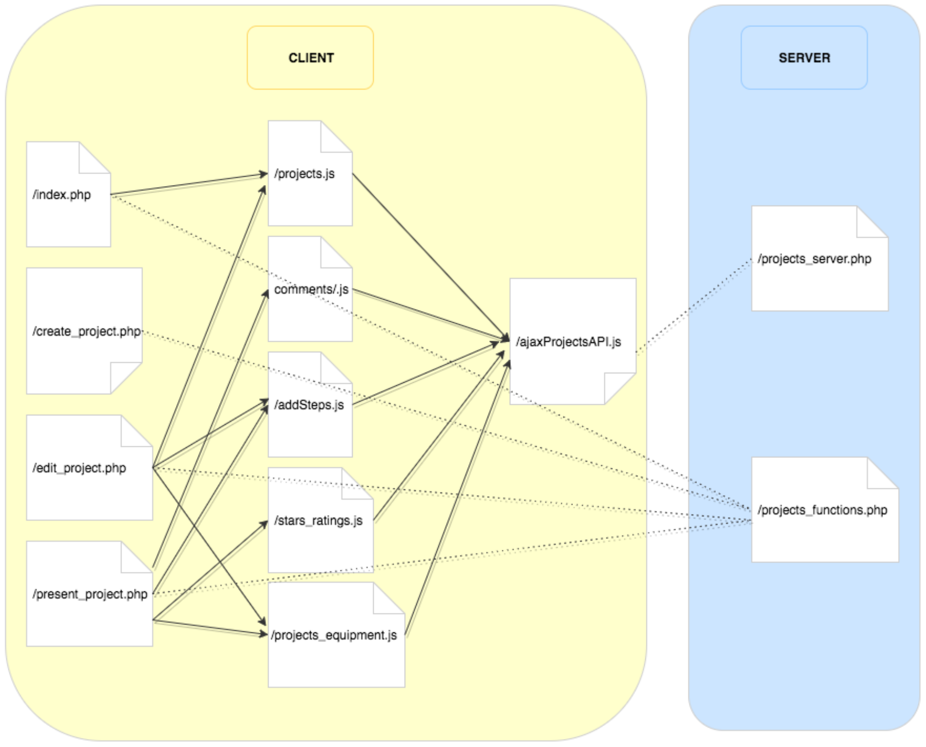


Figure 3.2: File Dependencies in Projects Module.

striving to preserve a neat separation between the business logic and the interface. [8]

On Client-side I have separated the plain presentation from functionality, by keeping the mark-up language from javascript in separate files. For readability purposes, I structured the front-end code in smaller separate files, so that major UI component are represented by distinct file.

Because I make frequent use of Ajax calls, I have decided to dedicate a separate file where I have modelled an ajax API, that defines all ajax calls functions used throughout Projects (ajaxProjectsAPI.js). Doing so, I gain readibility of the code, by having a javascript file that only deals with the actual ajax calls, and the other javascript file only displaying the data in the view. The next advantage it promotes is modularity. Having a universal ajax API for the Projects module, I centralize all the ajax calls under reusable functions, that are accessible from any file of the module and even to other modules. This way, I can use same ajax function when needed and forestall redundancy of code.

I'll describe the design of the AJAX API. It has 2 central generalized Ajax calls functions: postAjaxCall and postAjaxCallSendDictParams. postAjaxCall function sends as data only one parameter, while the other takes a dictionary for sending a couple of arguments to the server. Both functions take the following arguments: the server-side endpoint they are sending data to, the data to be sent (name of the action and parameters), and a function that will be executed (in javascript) if the ajax call has been successful. [See Figure 3.3]

All the other functions of the Ajax API are calling one of the 2 generalized functions, depending on the amount of data they send. I have payed attention at function naming conventions, as part of my clean code effort strategy, inspired by Robert C. Martin book *Clean Code* [9]. Consequently, these functions are suggestively named by the type of action they perform on the back-end, their name having in composition the name of action parameter sent as data.[See Figure 3.4]

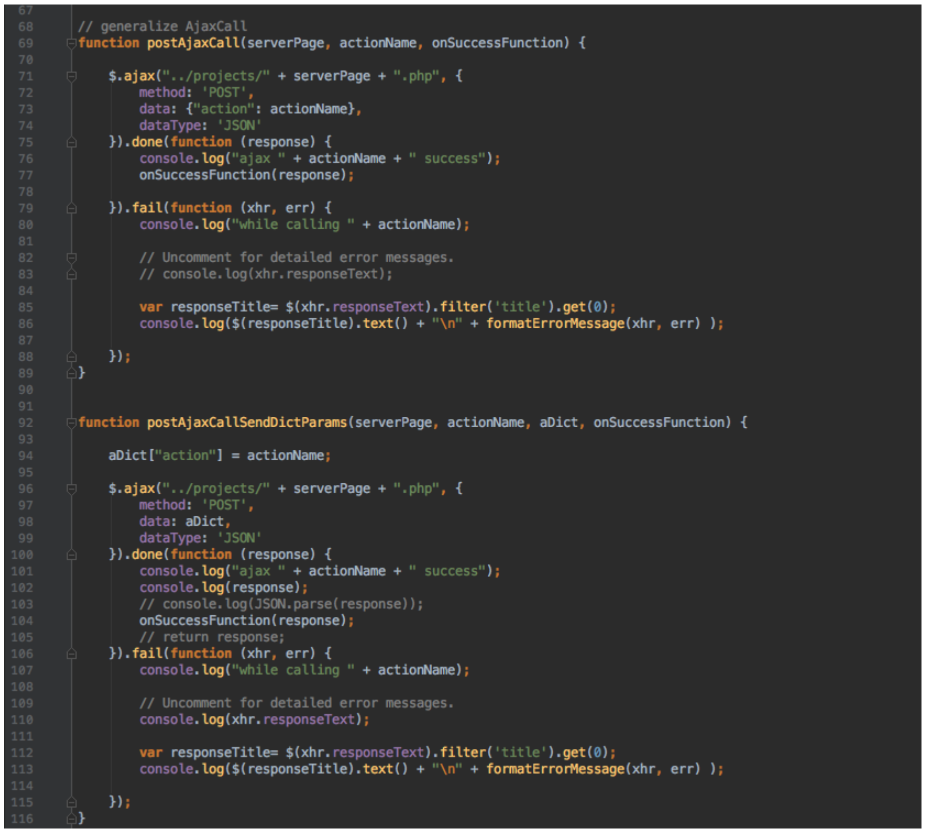
The Ajax API is for my application what the Controller is for the MVC pattern. It acts as an intermediary between the server-side(business logic) and the client-side(view). Basically, it solicits data from the server, takes the result data and transfers it to the view, without processing it in any way. [10]

Having the Ajax calls isolated, the other javascript files are left to perform the display of data. I encapsulate the display mechanism in functions. I have created distinctive functions for each display demand of data in the interface.

[8] http://www.fiftyfoureleven.com/weblog/web-development/programming-and-scripts/php-mvc-without-oop

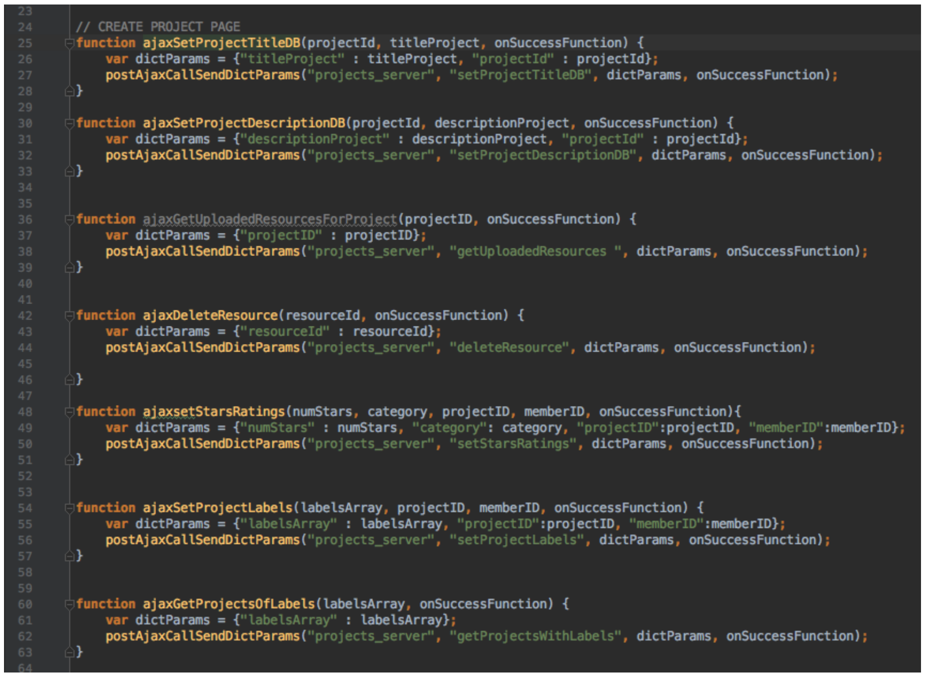
[9] Robert C. Martin. Clean Code: A Handbook of Agile Software Craftsman- ship.

[10] http://www.htmlgoodies.com/beyond/php/article.php/3912211



```
// generalize AjaxCall
function postAjaxCall(serverPage, actionName, onSuccessFunction) {

    $.ajax("../projects/" + serverPage + ".php", {
        method: 'POST',
        data: {"action": actionName},
        dataType: 'JSON'
    }).done(function (response) {
        console.log("ajax " + actionName + " success");
        onSuccessFunction(response);

    }).fail(function (xhr, err) {
        console.log("while calling " + actionName);

        // Uncomment for detailed error messages.
        // console.log(xhr.responseText);

        var responseTitle= $(xhr.responseText).filter('title').get(0);
        console.log($(responseTitle).text() + "\n" + formatErrorMessage(xhr, err) );

    });
}


function postAjaxCallSendDictParams(serverPage, actionName, aDict, onSuccessFunction) {

    aDict["action"] = actionName;

    $.ajax("../projects/" + serverPage + ".php", {
        method: 'POST',
        data: aDict,
        dataType: 'JSON'
    }).done(function (response) {
        console.log("ajax " + actionName + " success");
        console.log(response);
        // console.log(JSON.parse(response));
        onSuccessFunction(response);
        // return response;
    }).fail(function (xhr, err) {
        console.log("while calling " + actionName);

        // Uncomment for detailed error messages.
        console.log(xhr.responseText);

        var responseTitle= $(xhr.responseText).filter('title').get(0);
        console.log($(responseTitle).text() + "\n" + formatErrorMessage(xhr, err) );

    });
}
```

Figure 3.3: Generalised Ajax Calls API.



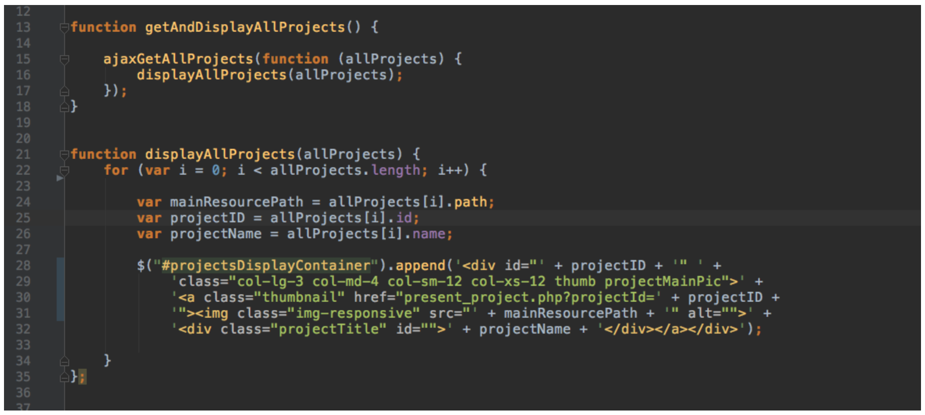
```javascript

// CREATE PROJECT PAGE
function ajaxSetProjectTitleDB(projectId, titleProject, onSuccessFunction) {
    var dictParams = {"titleProject" : titleProject, "projectId" : projectId};
    postAjaxCallSendDictParams("projects_server", "setProjectTitleDB", dictParams, onSuccessFunction);
}

function ajaxSetProjectDescriptionDB(projectId, descriptionProject, onSuccessFunction) {
    var dictParams = {"descriptionProject" : descriptionProject, "projectId" : projectId};
    postAjaxCallSendDictParams("projects_server", "setProjectDescriptionDB", dictParams, onSuccessFunction);
}


function ajaxGetUploadedResourcesForProject(projectID, onSuccessFunction) {
    var dictParams = {"projectID" : projectID};
    postAjaxCallSendDictParams("projects_server", "getUploadedResources ", dictParams, onSuccessFunction);
}


function ajaxDeleteResource(resourceId, onSuccessFunction) {
    var dictParams = {"resourceId" : resourceId};
    postAjaxCallSendDictParams("projects_server", "deleteResource", dictParams, onSuccessFunction);

}

function ajaxsetStarsRatings(numStars, category, projectID, memberID, onSuccessFunction){
    var dictParams = {"numStars" : numStars, "category": category, "projectID":projectID, "memberID":memberID};
    postAjaxCallSendDictParams("projects_server", "setStarsRatings", dictParams, onSuccessFunction);
}


function ajaxSetProjectLabels(labelsArray, projectID, memberID, onSuccessFunction) {
    var dictParams = {"labelsArray" : labelsArray, "projectID":projectID, "memberID":memberID};
    postAjaxCallSendDictParams("projects_server", "setProjectLabels", dictParams, onSuccessFunction);
}


function ajaxGetProjectsOfLabels(labelsArray, onSuccessFunction) {
    var dictParams = {"labelsArray" : labelsArray};
    postAjaxCallSendDictParams("projects_server", "getProjectsWithLabels", dictParams, onSuccessFunction);
}

```

Figure 3.4: Projects Ajax API.

By doing so, display functions can be reused by other functions and the readibility of the code is increased. Moreover, it increases modularity and it facilitates easy future changes or integration of new components in the UI. Commonly, a javascript function in the system will call one or more ajax functions and will pass it as argument a display function, like in the next snippet example [Figure 3.5].

On Server-side, I have organised the API in 2 main files: projects_functions.php and projects_server.php. In projects_server.php are all functions and the database requests/queries called through the Ajax API that are sent to the Data Server, while in projects_functions all the other functions, associated with the Web Server requests. Besides the two endpoints, I separate the back-end functions for self-contained actions in independent files, like uploading media resources in upload.php, adding the steps for the project in addSteps.php and uploading steps in upload_steps.php.

Another clean code principle I have developed while designing the application is trying to perform as much processing of data as possible on the back-end and in queries, obtaining as clear-cut data as needed in front-end (with less functionalities in javascript).



```javascript
function getAndDisplayAllProjects() {

    ajaxGetAllProjects(function (allProjects) {
        displayAllProjects(allProjects);
    });
}


function displayAllProjects(allProjects) {
    for (var i = 0; i < allProjects.length; i++) {

        var mainResourcePath = allProjects[i].path;
        var projectID = allProjects[i].id;
        var projectName = allProjects[i].name;

        $("#projectsDisplayContainer").append('<div id="' + projectID + '" ' +
            'class="col-lg-3 col-md-4 col-sm-12 col-xs-12 thumb projectMainPic">' +
            '<a class="thumbnail" href="present_project.php?projectId=' + projectID +
            '"><img class="img-responsive" src="' + mainResourcePath + '" alt="">' +
            '<div class="projectTitle" id="">' + projectName + '</div></a></div>');

    }
};
```

Figure 3.5: Javascript Function - Typical Design.

3.4.2 Client-Server Architecture

The Front-end API is represented by the functions responsible with the data display which are organised in the js files, and the ajax functions.

I make a formal distinction between functions which are both called and executed on server-side and those which are actually called on client side in javascript, by having them in 2 distinct end-points. The ones on the client are passing through the AjaxProjectsAPI and are executed in projects_server.php.The functions that are both called and executed on server are defined in projects_functions.php.

In the following subsections I will present the client-server architecture of the application by analysing the interactions derived from each page of the projects module.

3.4.3 All Projects Page

`/projects/index.php`

This page displays all existent projects and a collection of labels that users can select for filtering and searching the projects by categories.

The data of the category tags is retrieved through the getAllProjectsLabels() of the projects_functions.php endpoint, which is displayed directly in the index.php.

For the category filter tags system, I use Ajax in retrieving and displaying the projects that result in labels selection. I have prefered to dynamically update the page with the selected projects rather than refresh the page, as it was more facile to hide the unselected projects in javascript than updating the page with the previously selected labels. This way, after the filter event is triggered, only the projects section is dynamically changed, the selected labels remaining unchanged. All these interactions are described in Figure 3.6

The page also gives the user the possibility of adding a new project. The *Add New Project* button will redirect the user to the following url: `projects/edit_project.php?projectId`. In the background, the click event actually links to `projects/create_project.php`, from where the user is redirected to the edit page. I will explain the logic of this process in the *Create New Project Page* description.

3.4.4 Create New Project Page

`projects/create_project.php`

create_project.php has only a mediating and rerouting function between index.php and edit_project.php. Before saving the edited information of a newly created project, we first need an entry of the new project in the db. In create_project.php, we insert a new project in the database with no other data than its id. Then we extract the id, sending it as an argument and redirecting to `edit_project.php?projectID`. See Figure 3.7

In the end, creating a new project and editing an existing one, both happen in the edit page, as we'll subsequently see.

3.4.5 Edit Project Page

`/projects/edit_project.php/{projectID}`

The page is accessed in two situations. One instance is when the user creates a new project, case in which it receives the id of the new project through a GET protocol from the create_project.php. The other is when the project was already created and the user only expects to edit the information. This case is accessed from the present_project page. At the moment the editing of an existing project is open only to administrators. Their access to edit the project is done from the same project presentation page available to all users, through an event which is visible only the the admins of the system, as shown in Figure 3.8.

Editing projects connects to both main endpoints: the projectsDataServerAPI.php and the projectsAPI.php. The projectsAPI.php returns information about the editing project: title, description, uploaded media resouces, materials list.

The projectsDataServerAPI.php endpoint processes the edited information of the project sent to the server through the Ajax API. The Ajax functions are called by triggered events defined in projects.js, projects_equipment.js and addSteps.js files, all included in edit_project.php.

A core feature of the projects section is the presentation of the project in a succession of steps. The javascript functions of editing these steps are ini-

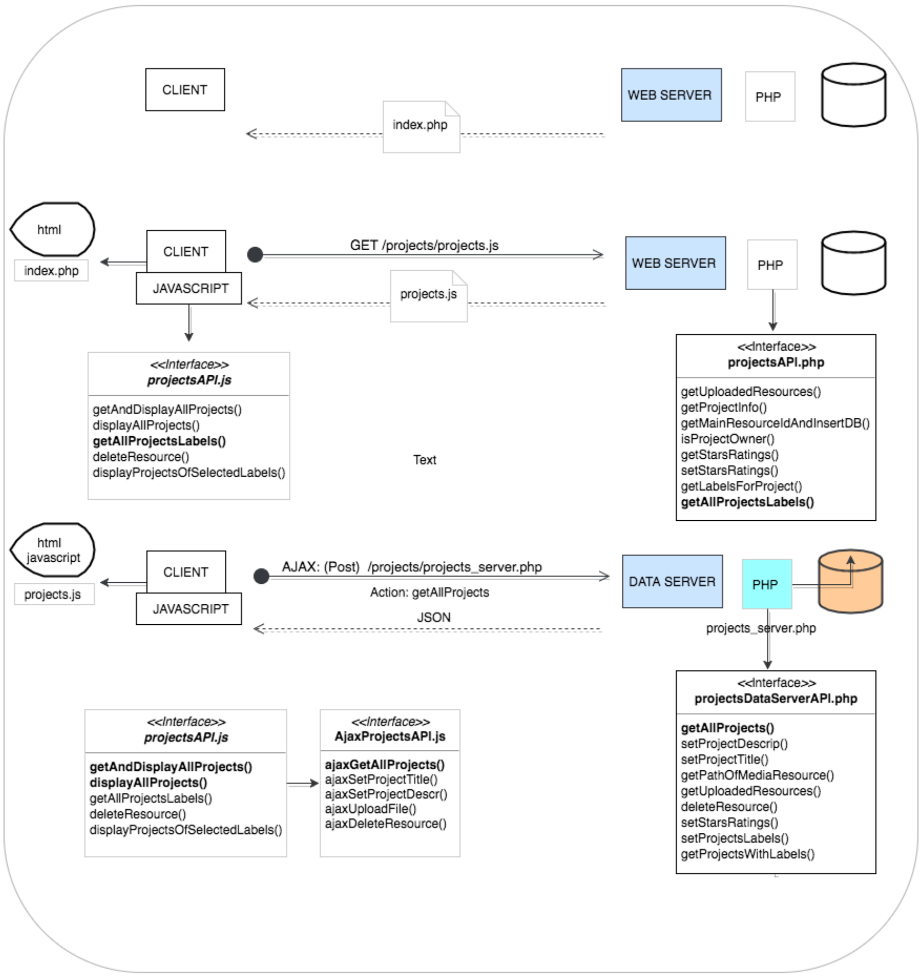
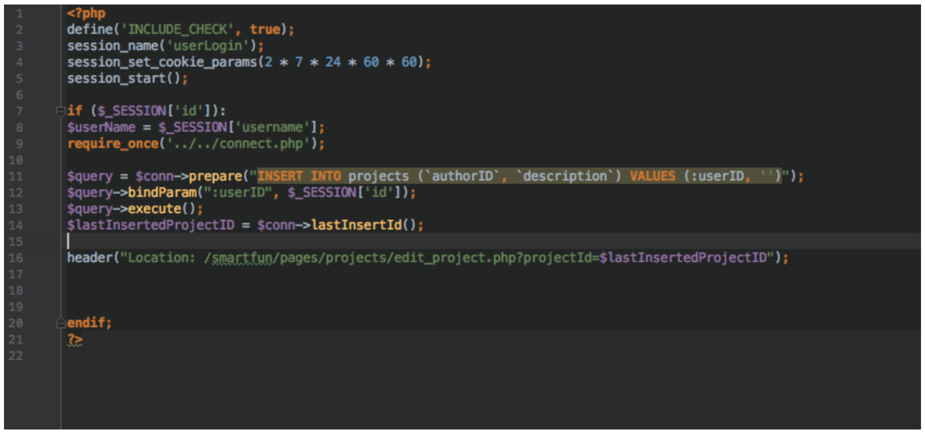
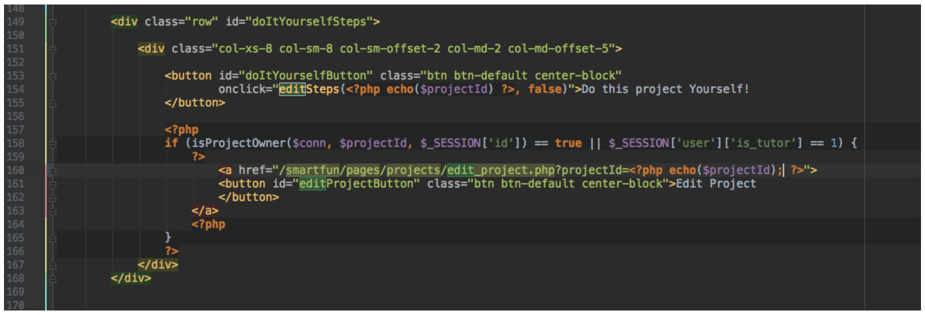


Figure 3.6: Client-Server Architecture for All Projects.



```php
<?php
define('INCLUDE_CHECK', true);
session_name('userLogin');
session_set_cookie_params(2 * 7 * 24 * 60 * 60);
session_start();

if ($_SESSION['id']):
$userName = $_SESSION['username'];
require_once('../../connect.php');

$query = $conn->prepare("INSERT INTO projects (`authorID`, `description`) VALUES (:userID, '')");
$query->bindParam(":userID", $_SESSION['id']);
$query->execute();
$lastInsertedProjectID = $conn->lastInsertId();

header("Location: /smartfun/pages/projects/edit_project.php?projectId=$lastInsertedProjectID");



endif;
?>

```

Figure 3.7: Create Project Page - Rerouting to Edit Project Page.



```html

    <div class="row" id="doItYourselfSteps">

        <div class="col-xs-8 col-sm-8 col-sm-offset-2 col-md-2 col-md-offset-5">

            <button id="doItYourselfButton" class="btn btn-default center-block"
                    onclick="editSteps(<?php echo($projectId) ?>, false)">Do this project Yourself!
            </button>

            <?php
            if (isProjectOwner($conn, $projectId, $_SESSION['id']) == true || $_SESSION['user']['is_tutor'] == 1) {
                ?>
                    <a href="/smartfun/pages/projects/edit_project.php?projectId=<?php echo($projectId); ?>">
                    <button id="editProjectButton" class="btn btn-default center-block">Edit Project
                    </button>
                </a>
                <?php
            }
            ?>
        </div>
    </div>


```

Figure 3.8: Edit Project only by Admin - Control Structure.

tialized in addSteps.js. Although it is a self-sustaining solid feature, instead of dedicating a new page for editing the steps, we opted for displaying it within the edit_project.php page, in a full-page pop-up element. The content of each step is modified dynamically inside same markup elements. Javascript functions used in addSteps.js: showStepPanel(), addStep(), deleteStep(), loadProjectProgress(), updateProgresBar().

Functions of the ajaxProjectsAPI.js that connect the editing projects front-end with the endpoint projectsDataServerAPI.php: ajaxSetProjectTitleDB, ajaxSet-ProjectDescriptDB.

3.4.6 Present Project Page

`/projects/present_project.php/{projectID}`

Gets information from web server about the requested project. Besides the project description and a carrousel with project pictures, it includes a few dynamic components the user can interact with. present_project.php include a number of javascipt files, each correspondent to one of these UI components.

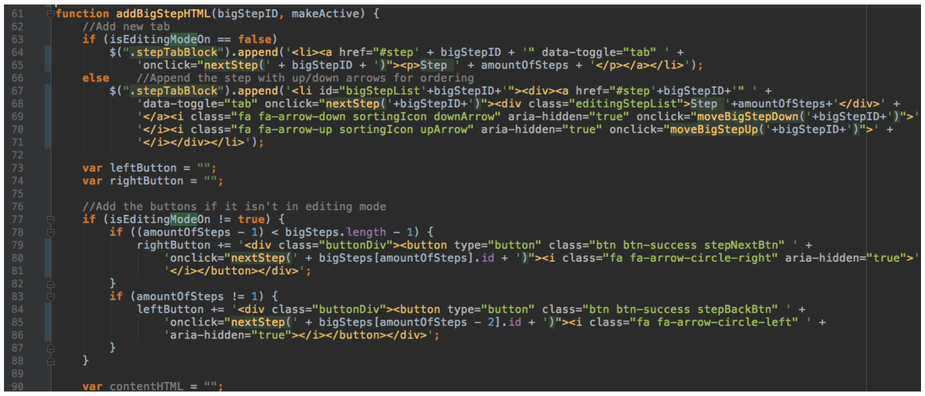
One component is the Stars Rating System, where users can evaluate the project by voting on a 5 stars scale on criterias denoting project's level of: difficulty, fun and general. In stars_ratings.js I define the functions that show interactions with the ratings system. Each criteria voted in the system is individually updated in the database through a concurrent Ajax.

Second dynamic component is Projects Labels Section, where users can participate in adding descriptive tags about the project. In the current version, users can add up any labels that are yet non-existant. We have two alternative scenarios for dealing with the obvious problems this approach raises (too many user entries, unrelevant or inapropriate label names). We consider implementing a filter of the labels as a feature in the admin panel, or alternatively we could leave the feature only for admin use.

The Project Equiments Section is the third component users can interact with. This component lists all the needed equipments for carrying out the project. Users can check the items they already possess or can send to basket items they would need and like to buy. The event handling for the equipments is encapsulated in projects_equipment.js.

Users can exchange ideas through the Comments Section, which can be monitored and managed(edited, deleted) by admins. comments.js processes the events linked to users comments.

Users can find a detailed description of how to do the project themselves in the Steps Section. Steps represent a tutorial about building the project. We use the same UI component for displaying the steps as for editing them, by using



```
function addBigStepHTML(bigStepID, makeActive) {
    //Add new tab
    if (isEditingModeOn == false)
        $(".stepTabBlock").append('<li><a href="#step' + bigStepID + '" data-toggle="tab" ' +
            'onclick="nextStep(' + bigStepID + ')"><p>Step ' + amountOfSteps + '</p></a></li>');
    else    //Append the step with up/down arrows for ordering
        $(".stepTabBlock").append('<li id="bigStepList'+bigStepID+'"><div><a href="#step'+bigStepID+'" ' +
            'data-toggle="tab" onclick="nextStep('+bigStepID+')"><div class="editingStepList">Step '+amountOfSteps+'</div>' +
            '</a><i class="fa fa-arrow-down sortingIcon downArrow" aria-hidden="true" onclick="moveBigStepDown('+bigStepID+')">'
            '</i><i class="fa fa-arrow-up sortingIcon upArrow" aria-hidden="true" onclick="moveBigStepUp('+bigStepID+')">' +
            '</i></div></li>');

    var leftButton = "";
    var rightButton = "";

    //Add the buttons if it isn't in editing mode
    if (isEditingModeOn != true) {
        if ((amountOfSteps - 1) < bigSteps.length - 1) {
            rightButton += '<div class="buttonDiv"><button type="button" class="btn btn-success stepNextBtn" ' +
                'onclick="nextStep(' + bigSteps[amountOfSteps].id + ')"><i class="fa fa-arrow-circle-right" aria-hidden="true">'
                '</i></button></div>';
        }
        if (amountOfSteps != 1) {
            leftButton += '<div class="buttonDiv"><button type="button" class="btn btn-success stepBackBtn" ' +
                'onclick="nextStep(' + bigSteps[amountOfSteps - 2].id + ')"><i class="fa fa-arrow-circle-left" ' +
                'aria-hidden="true"></i></button></div>';
        }
    }

    var contentHTML = "";
```

Figure 3.9: Present or Edit Steps - Control Structure.

control structures and javascript hide and display functions, as the following code snipet shows in Figure 3.9.

Chapter 4

Future Work

We have strategized the developement of our product by targeting the deployment of a MVP (minimum viable product). The concept of MVP means implementing the application features minimistically while testing them with the users and validating them based on their feedback. It means developing only the core features sufficient to deploy the product, or in other words ”just enough features to gather validated learning about the product and its continued development.” [1][1]

This approach minimizes the risk of developing a product which do not resonate with the target users. It also implies that the product owners must prove adaptable in directing the vision of the product based on their users feedback. ”The minimum viable product is that version of a new product a team uses to collect the maximum amount of validated learning about customers with the least effort.” [2]

We have designed our MVP by making sure we integrate core elements of each learning practice we want to explore on our platform: assessment tools, gamification strategies, users active participation. Consequently, the current version gathers a rough representation of each component we want to develop in the future.

In the following paragraphs I will present the possible future trajectories of our core application components.

A future version will include monthly subscription kits that contain all necessary items for building one or more projects on the platform. Subscribed members will receive these material kits by mail. Alternatively, users will be

[1]Eric Ries. The Lean Startup - How Today’s Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses.

[2]Eric Ries.The Lean Startup - How Today’s Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses.

able to order individual components they are missing for building a project. This requires an integrated payment system, which is under development at the moment. Currently we have a shopping cart system where users can select items they need to buy, that will later integrate the payment solutions.

One central future gamification feature is an avatar system, where users can customize their avatars as a rewarding component for their activity on the platform. For having the avatar system functional, we will need a virtual monetary system in place. The monetary system will be connected with the current points system and achievements. Points will be exchanged for coins, and users will use the coins for buying items for avatar customization. Some of the customizing items will be available to users only after gaining particular achievements.

The achievements themselves are subject to future development. A future version will develop a more complex achievement tree system, where achievements can be linked to each other and unlocked in a specific predefined sequence.

As a long-term development vision, the platform could offer a learning experience in which the user, represented by the avatar will become character in a virtual game, in which solving tasks will be part of the learning process.

Chapter 5

Conclusion

Building the current project has been a complex learning experience in my evolution as a developer and beyond. One of the greatest assets of my role in this project was being involved in all stages of product development: gathering requirements, prototyping, writing specifications, DB and UI design, UX testing, implementation. Working in a start-up meant direct and constant communication with the product owner and a tight dialogue with the whole team.

It was challenging to be a full stack developer, as I had constantly switched from crafting back-end functionalities to polishing the UI. I consider as an achievement the fact that the implementation of the current version was done entirely by me and one more developer. The greatest achievement though is the fact that I have seen the application in use by kids in workshops.

It has been reassuring to see how the platform has improved the learning experience during the workshops. It brought more structure and it increased time efficiency. Following the projects tutorials on the platform, made kids more focused and independent. Having the platform enabled them to work in their own pace, without tutors having to explain same instructions all over again. Further development of the platform will bring the workshop experience to kids at home, so more kids will have the chance of experiencing learning with STEM projects in their own age specific language: play.

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