SCHOOL OF SCIENCE AND ENGINEERING

Capstone Final Report

Schooly: A Web Portal for Moroccan School Curriculum

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Acknowledgements

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals. I would like to extend my sincere thanks to all of them.

First of all, I would like to express my special thanks of gratitude to my supervisor, Dr. Naeem Nisar Sheikh, who has been a great inspiration to me. He always believed in me and was such a great listener and advisor. If ever this project come to life, his contributions would be big part of it.

Secondly, I would like to thank my parents for their support during my four years as an undergraduate. They have always encouraged me so that I can achieve my high ultimate goals.

My thanks to my dearest friends Peter Suhm and Mohamed Essedik Najd with whom I have collaborated using GitHub and notifying me about bugs if they were any or helping me in the design phase. Also, I would like to apologize for Peter for not using Laravel framework even if he tried harder. However, his first tutorials gave me enough knowledge to work with any framework now.

Abstract

Education has always been one of the most important sectors for every country. In fact, a good education system is what allow to distinguish a developed country from another one. Growing up in Morocco, I had always this idea of using my skills to address social issues and education is my target sector. For that, I have planned to develop Schooly, a web application based on gamification aiming to help Moroccan students to understand well the materials. It will provide a set of lessons, tutorials, and exercises featuring mainly the interactivity with the user.

This report intends to show the overall progress of the project and what has been done so far.

Keywords

Education, tutorials, lessons, exercises, gamification, Morocco.

Table of contents

Introduction

Schooly is a web application based on gamification aiming to help Moroccan students to understand well the materials.

It goes without saying that targeting Moroccan students is quite broad and difficult to achieve in a short amount of time. Thus, the first step to achieve the objective was to target a specific level which was in this case the third year of secondary school. Same applies for the subjects and lessons. In fact, covering each subject with its lessons is not optimal and that is why only few mathematics lessons will be the project's targets.

Once the lessons were chosen, they were broken down into sections and bounded to the related Intended Learning Outcomes (ILOs). Obviously, examples and exercises should be provided to enforce the understanding of the materials. Hence, they are considered as a module where it has to be designed appropriately.

The Schooly application should help the students to understand the materials interactively. For instance, a student might be asked to plot a point or change the 3D geometric shapes and move them using the mouse.

Concerning the different parts of the project, they were distributed over the semester, where there were weekly assignments and meetings with the supervisor. This means that each sub-objective was assigned a number of weeks depending on the needs. This includes the meetings with the supervisor in order to get the feedback and testing phase (if needed).

The minimum subset of the objectives was as follows:

- Target a specific level

- Choose a specific subject and lesson

- Break down the lessons into sections and bind them to the ILOs

- Develop the interactive sections and exercises.

- Develop an effective gamification design

- Perform an extensive and parallel testing

On the other hand, since the application is going to be gamification based, there should be a good and meaningful design in order to meet the requirements of the project. Experience Points (xp), Badges, Achievements, and all other adequate game elements were included in the project depending on the needs.

Hopefully, the application will get to be tested by real users, Moroccan students, in order to get feedback and then improve the application.

Regarding the description of the project, it is clear that its main characteristics are educational and societal. Indeed, it helps improve the level of students and therefore have an (indirect) impact on the Moroccan society. Besides, it is important to mention that the Schooly application is to be considered as a support to students and not replacing an actual teacher who knows better the materials.

In the following sections, I will list the methodology I have adopted to build the Minimum Viable Product.

Feasibility Study

As every project, it is crucial to study its feasibility in order to evaluate and analyze its potential. Schooly is no exception to this rule. In fact, at the beginning of the semester, I had to conduct an extensive investigation and research to be a support to the process of decision making on the different aspects. This section will summarize the result of the study.

First, the technological aspect is considered as the main criterion of evaluation of the capstone project. Therefore, it requires more attention choosing the right tools in order to fulfill the requirements.

With this being said, I have designed Schooly application as being a client-server architecture allowing the access from many endpoints such as mobiles, tablets, and laptops. This enforces the extendibility and accessibility features.

Also, there have been four level that were mainly exploited. The first one which is the front-end development ended up deciding on using Bootstrap, an HTML and CSS framework to build the user interface. Second, the back-end development is what constitutes the core business logic of the platform. I have decided to use Django framework built with Python implementing the MVC paradigm. The main reason behind this choice was basically the fact that I am more familiar with Python and the time constraint doesn't allow me to master another language. Data Storage is an important component in the application. In fact, there is a clear need for persistent data; therefore, I had to conduct a DBMS benchmarking to choose the right one. Again, the idea of learning a new tool had a great influence on my choice. This brought me to decide of choosing PostgreSQL since it is also recommended by the Django framework official documentation. Finally, The REST with JSON is the paradigm chosen for the data communication.

Sticking to the capstone scope and requirements, the economical aspect is not a major priority. Therefore, I did not go deeper in this feasibility study nor developing a detailed business model. However, the project has the potential to become a good reason to launch a startup and once then it will become a necessity to take into consideration the business perspective.

Methodology

The main methodology adopted to build the Schooly platform is an agile methodology called Scrum. The Agile methodology is seen as an alternative to traditional project management. The main advantages of agile methodology is that it allows the quick response to unpredictability.

Scrum is the most popular way of introducing Agility thanks to its simplicity and flexibility. It emphasizes empirical feedback, team self-management, and striving to build properly tested product increments within short iterations. Scrum is a simple set of roles, responsibilities, and meetings that never change.

Scrum has three roles: Product Owner, Scrum Master, and Team.

- **Product Owner**: he is the visionary, and represents the authority. Highly available, the product owner is responsible for continuously communication the vision and priorities to the development team.
- **Scrum Master**: He works as an intermediary between the team and the product owner. In fact, the Scrum Master does not manage the team. He works on facilitating the team to achieve its sprint goals.
- **Team**: The main characteristics of the team is that: "the team is utterly self-managing." A development team using Scrum contains around seven full dedicated members working, ideally, in one team room no distractions allowed. A typical team would include software engineers, architects, programmers, analysts, QA experts, testers, and UI designers. Again, the team is totally autonomous and responsible to achieve the goals of the sprint.

The fact that I don't work with a team didn't allow me to benefit from the full advantages of the methodology. Indeed, I was at the same time the product owner and the team. Obviously, I didn't need the Scrum master.

In general, the agile development provides direction assistance throughout the development lifecycle. The team goes through regular cadences of work, known as Sprints or iterations where at the end of which teams must present a minimum viable product increment. Moreover, the agile methodology has proven that thanks to the "inspect-and-adapt" approach reduces the costs of developments and time to ship the product. In fact, teams can develop software at the same time they're gathering requirements.

Scrum User Stories

To express the work in the backlog in Scrum, we use user stories. The format of the user story may vary from one team to another. However, all the user stories should be written from the perspective of the end user. Mike Cohn, the founder of Mountain Goat Software, and which helps companies adopt and improve their use of agile processes, has defined a template that many Scrum teams have adopted. Basically, the template identifies who is the user, what the end user wants, and why in a single and simple sentence. The template of the user story is most often written like this: "As a **[end user role]**, I want **[the desire]** so that **[the rationale]**."

Some user stories used in the development of Schooly are the followings:

- As a user, I want to register so that I can access the platform
- As a user, I want a detailed dashboard so that I can view my progress
- As a user, I want to read/review lessons
- As a user, I want to earn badges and points

In summary, user stories emphasizes on the end user's point of view. Cohn's model is so far the greatest model since it provides enough information about the story. Since the product is customer-driven, it is obvious that the developers must remain focused to reflect the desires of the end user.

System Description

The design of the platform had to go with how the Django framework works. Recalling from the DjangoCon 2008's event, James Bennett has defined some Django best practices:

- Do one thing, and do it well

- Don't be afraid of multiple apps

- Write for flexibility.

- Build to distribute.

Basically the main idea about structuring the application is to understand the difference between a project and an app. The official documentation of Django framework defines both of them as follows:

"An app is a Web application that does something – e.g., a Weblog system, a database of public records or a simple poll app. A project is a collection of configuration and apps for a particular Web site. A project can contain multiple apps. An app can be in multiple projects."

This lead into creating a new dilemma regarding the design of apps. For that, the developer should ask himself/herself few questions about the feature trying to implement:

- Should this (feature) be its own application?

- Is it completely unrelated to the app's focus?

- Is it orthogonal to whatever else I'm doing?

- Will I need similar functionality on other sites?

Once I got the philosophy behind the framework, I could design my project with ease. This resulted into the following structure:
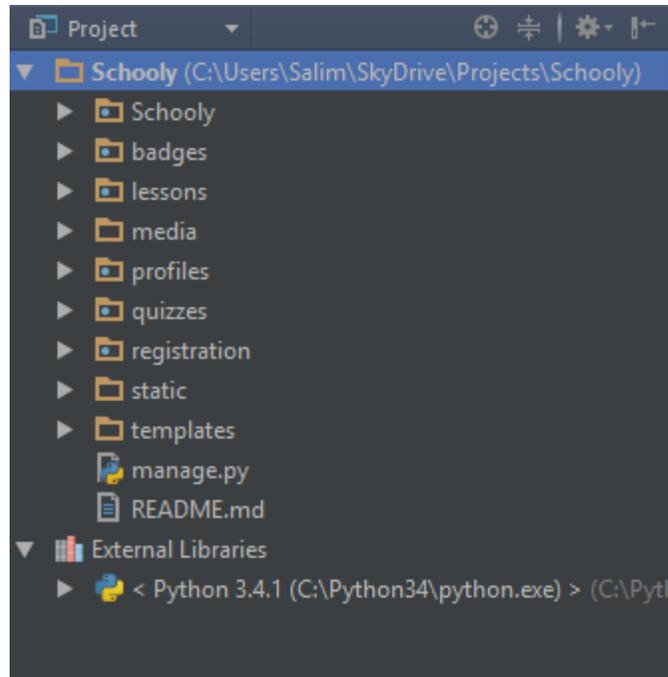
Figure 1 Schooly Project Structure

As you can notice there are about five applications interacting with each other. The

Django framework encourages the integration of reusable apps since some of them can be

integrated on other websites. This allowed me to use the registration app developed by James

Bennett himself. Therefore, you benefit from modularity, but also from high quality code written

by skilled people in the field.

Modules

Registration

The registration app is what allows the user to perform all actions related to registration and authentication. It uses the default Django User model, but, one can simply specify custom model. The application provide support for two common use cases:

- Two-phase registration which consists of initial signup followed by a confirmation email with instruction for activating the new account.
- One-phase registration, where a user signs up and is immediately active and logged in.

Notice that the app is completely flexible for those who want to customize the registration process.

Profiles

Following the Django best practices, it shows clearly that the user's profile is considered as an independent app. The first thing I have done is that I looked up some apps already available and ready to be integrated. However, all of them were not maintained and therefore created some compatibility issues. The solution was to develop my own profile app while getting inspired from the available apps.

The profiles module has a Profile model with a One-to-One relationship with the User model. Also, it includes all additional information that might be useful to the user such as city, experience points (xp), earned badges, viewed lessons, quizzes taken.

For the views, two were implemented. The first one allows the rendering of a detailed user's dashboard with all the important information. The second one is about editing the profile.

Lessons

The lessons module is what constitutes the core of the Schooly platform. It implements the Lesson model which has One-To-Many relation with each of Subject, Level, and Section models. The actual content of the lesson is going to be dispatched over the different sections. In fact, the views are going to render the HTML pages with the content of the lessons.

Quizzes

In order to demonstrate the mastery of class, the student is required to take a quiz. A set of multiple choice questions with different levels of difficulty chosen randomly. Basically, each lesson will have a set of questions in the database and each time a user decides to take a quiz, it should be generated by selecting randomly questions with different levels of difficulty.

Design dilemma: Selecting randomly from the database can be seen as an expensive operation. In fact, although the Django QuerySet API provides random ordering, the documentation mentions that the queries may be expensive and slow, depending on the database backend you're using. Therefore, I had to look for other better alternatives. The best solution was by an active developer named Peter Bengtsson who performed an experiment by comparing the normal solution provided by the official documentation and an algorithm he wrote. He wrote an article on his personal blog:

```
TIMES = 10
def using_normal_random(model):
    for i in range(TIMES):
        yield model.objects.all().order_by('?')[0].pk

t0 = time()
for i in range(TIMES):
    list(using_normal_random(SomeLargishModel))
t1 = time()
print t1-t0, "seconds"
```

Result:

```
41.8955321312 seconds
```

Figure 2 using normal random

The result shows clearly that the query takes quite a long time to execute. Also, it

consumes a lot of resources. Therefore, the solution he provided is as the following:

```
from django.db.models import Max
from random import randint
def using_max(model):
    max_ = model.objects.aggregate(Max('id'))['id__max']
    i = 0
    while i < TIMES:
        try:
            yield model.objects.get(pk=randint(1, max_)).pk
            i += 1
        except model.DoesNotExist:
            pass

t0 = time()
for i in range(TIMES):
    list(using_max(SomeLargishModel))
t1 = time()
print t1-t0, "seconds"
```

Result:

```
0.63835811615 seconds
```

Figure 3 using max

Basically, the solution is a smart move to counter the extensive SQL execution. In fact,

instead of performing on the database side, we generate randomly indexes then we retrieve rows.

But, what about the rows that have been deleted? Well if we get a random id that doesn't exist,

the loop will just try another number until it has rounded up as many as it needs. The result is 66

times better than the first method which is impressive. Therefore, I had to adapt this solution to my needs.

Another solution would be generating only one index and then have a slice of records from the database. The limitations with this is that some ids are not contiguous. Also, it will not allow us to have questions from different level of difficulty.

Badges

The badges module is what represents the gamification part, one of the key characteristics of my software. From the beginning, I have emphasized on the importance of a good gamification design, not from the implementation perspective but the pedagogical one. In fact, choosing the right elements to be implemented, and under which conditions the user deserve to earn them revealed itself to be a hard task and requires efforts. However, in order to fulfill the requirements, I have designed a basic gamification that would serve as a framework for upcoming Sprints answering a five-step questions:

1- Who is the target audience, and what is the context that surrounds the education program?

2- What does the instructor want the student to accomplish by completing the education program?

3- How can the learning program be broken down and what are the pain points?

4- What are the resources needed to gamify education?

5- What gamification elements should be applied?

Going through these five steps, would allow us to implement effectively gamification elements in learning programs and achieve different educational objectives. Once the objectives

are set, the context aims to identify the pain points. This leads to breaking down the whole

learning program into stages/milestones that will make the analysis easier. There should be a

good tracking mechanism and rules to develop levels and provide feedback on the student's

progress. It is also important to mention that the self or social elements are to be applied in order

to have a complete gamified learning program. The results are subject to change. In fact, there

should be a trial run which will allow us to compare the results with the objectives and

eventually tweak the gamification engine accordingly (Huang & Soman, 2013).

I have decided on using two game elements: badges and experience points (xp).

Badge: which allows to celebrate and recognize special user's behavior. Such as

mastering a lesson after taking a quiz, asking a question on a forum, sharing on social network,

etc.

Experience points: are considered to be a unit of measurement to quantify the user's

progress. It will allow him/her to be ranked on a Leaderboard against the different users and be a

motivation to earn more and hopefully learn more.

Results

This section will contain some screenshots of the website. Notice that the design is for the demonstration. In fact, a professional web and graphic designer would provide better visualizations for the website
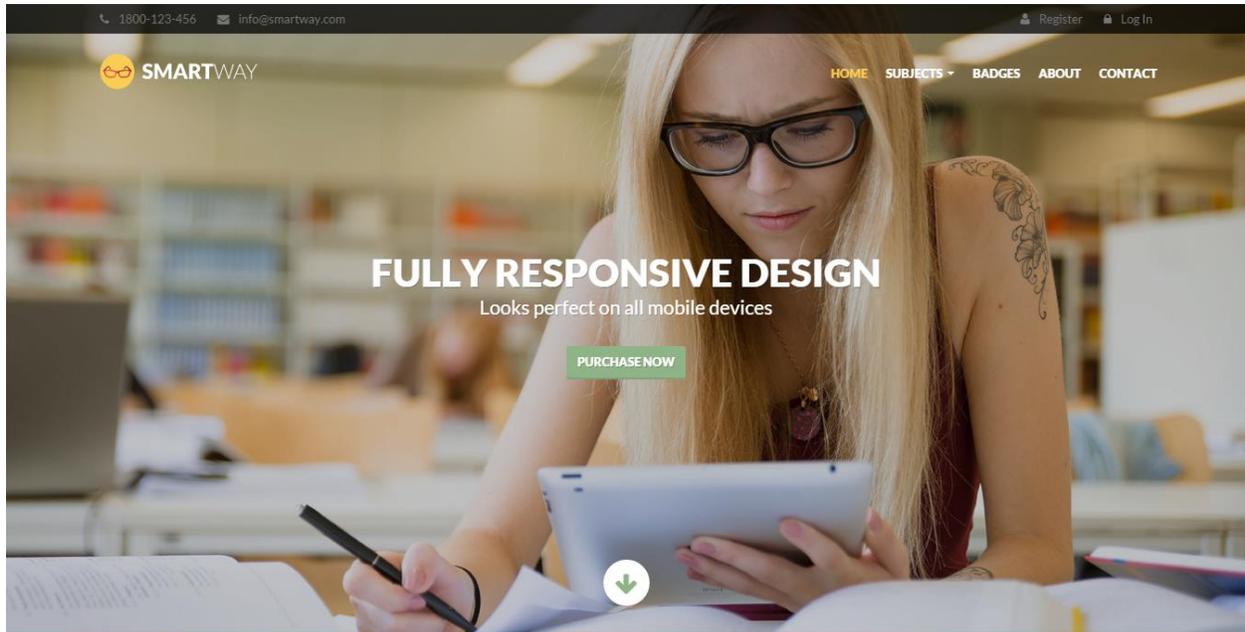

Figure 4 Homepage of the website

Figure 5 Registration Form

Please sign in

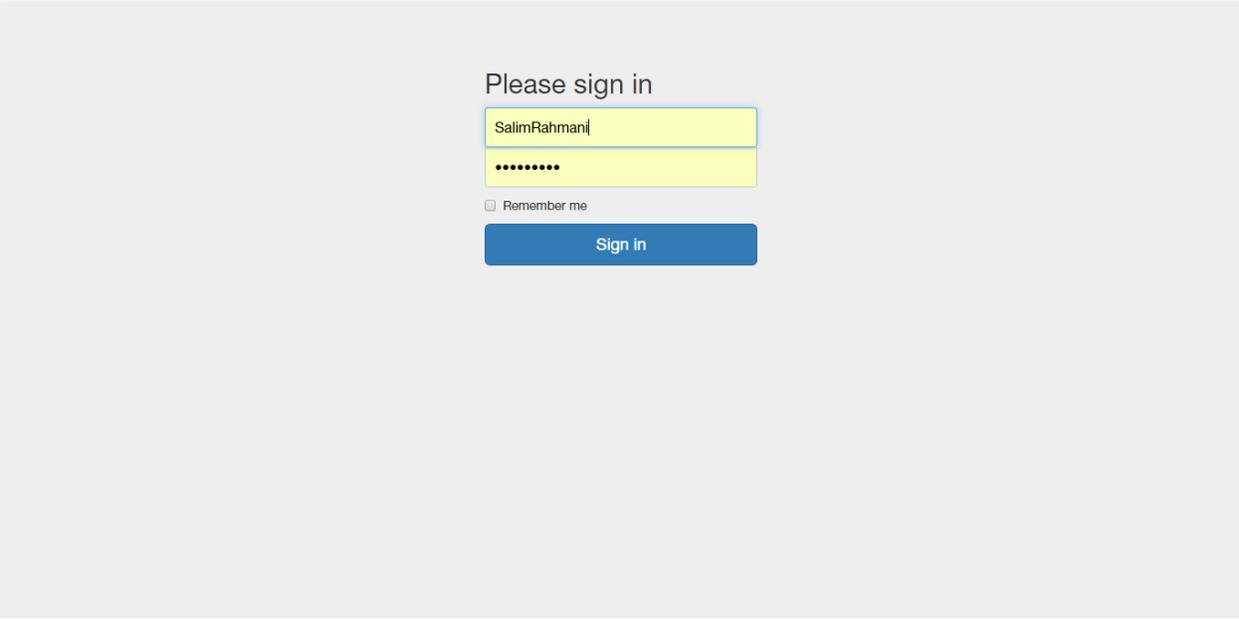SalimRahmani

••••••••

☐ Remember me

Sign in

Figure 6 Login form

PROFILES

SALIM RAHMANI

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- **Username:** SalimRahmani
- **Joined:** 04/25/2015
- **Last Seen:** 05/04/2015
- **City:** Rabat
- **XP:** 15

SALIM'S REVIEWED LESSONS

المعادلات	100%

EARNED BADGES

View All Badges

SIGN UP
Badge you earn when you sign up

FIRST 50 000 USERS
because you are one of the first 50 000 users

Figure 7 User's Dashboard

LESSONS

<div dir="rtl">

المعادلات

في هذا الدرس نعطي تعريفا للمعادلة من الدرجة الأولى بمجهول واحد و تتعرف على تقنية حل هذا النوع من المعادلات بإعتماد القواعد و الخاصيات التي تنظم حل المعادلات. في الأخير نتطرق غلى بعض المعادلات التي تؤول غلى حلها في معادلة من الدرجة الأولى بمجهول واحد

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◄ PREVIOUS LESSON TITLE   NEXT LESSON TITLE ►

TEACHER

JOHN DOE
Web Design

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Read More ›

Figure 8 Lesson's Page

المعادلات

تعاريف و قواعد

👤 John Doe   🏷 Chat, Video   💬 24

ماهي المعادلة من الدرجة الأولى بمجهول واحد ؟

تعريــف:

أعداد حقيقية x و b و a

كل متساوية على شكـل ax + b = 0 تسمى معادلة من الدرجة الأولى بمجهول واحد هو x

BACK

WRITE A COMMENT

Figure 9 Section Page

QUIZ

👤 John Doe   🏷 Chat, Video   💬 24

حل المعادلة 7 = (x/5) هو:

Answers:

- ◯ 35
- ◯ 12
- ◯ -35

العدد 1 هو حل المعادلة:

Answers:

Figure 10 Quiz

SCORE: 2

Figure 11 Quiz Score

Conclusion

This project was a chance for me to demonstrate my engineering and programming skills. Moreover, it allowed me to explore and learn new tools and get familiar with many other technologies that I didn't have the chance to do so during my last four years.

The capstone project helped me to start developing the Schooly platform that I am willing to turn it on to a real startup. Therefore, a lot of work is coming up to produce at least a minimum viable product to be shippable.

The first thing I am willing to work on is the content by developing or integrating a good management system that would allow me to write easily in Arabic, and insert mathematical equations and symbols. In fact, writing in Arabic in plain HTML is really a hard task. This explains the reason behind rendering templates with few Arabic HTML blocks and titles.

The second thing on the list is to enhance the Gamification system. Hopefully, I can collaborate with other skilled people in order to tweak the design better and optimize the output. Also, a graphic designer is required to design the suitable badges logos.

Finally, I should conduct an extensive business plan in order to define the right and suitable business model, marketing strategies, and most importantly discuss the different financing sources.

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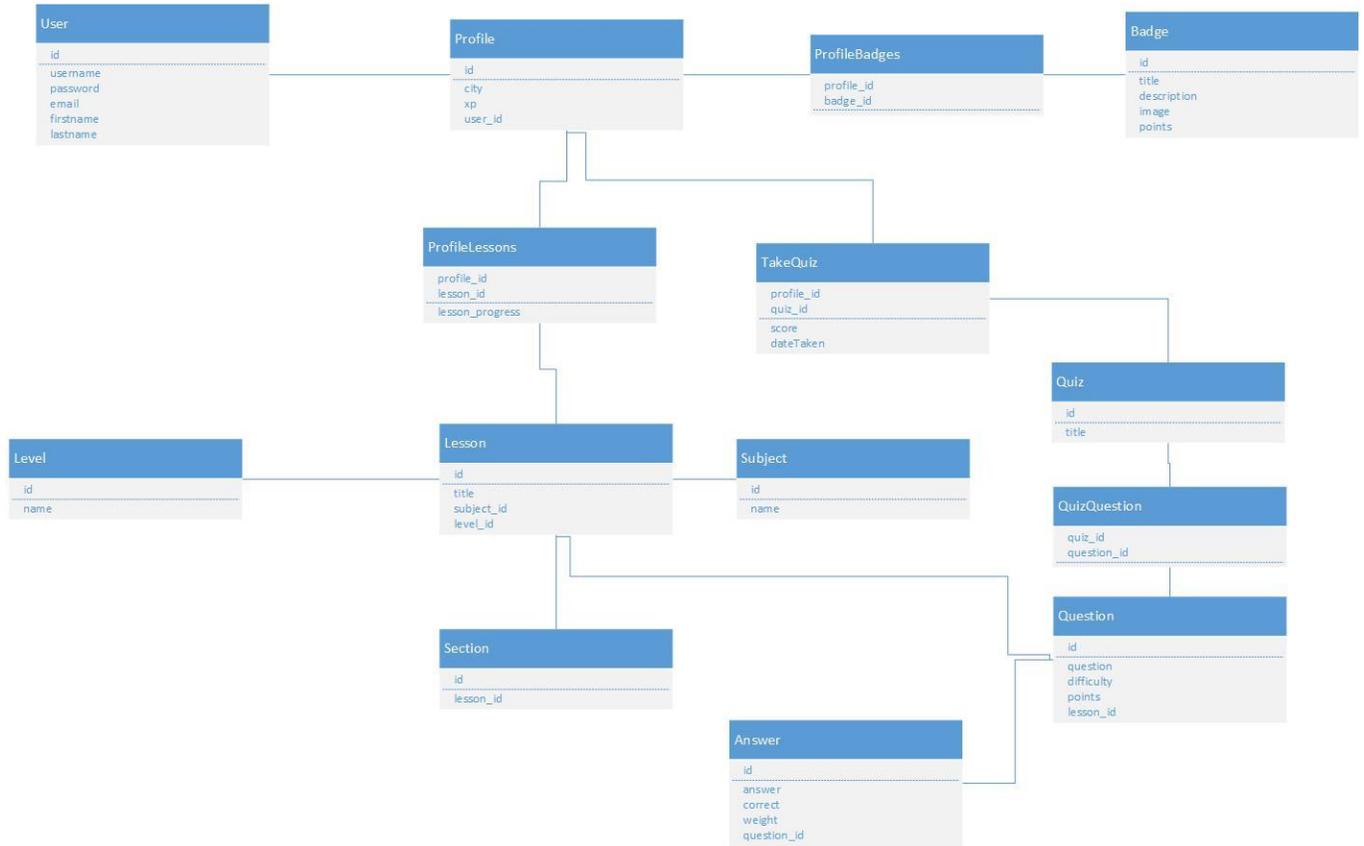
Appendix A: Entity Relationship Diagram

Figure 12 Schooly Entity Relationship Diagram

Appendix B: Steeple Analysis

Social Cultural	- Engage more students to learn with Gamification. - Providing useful information and articles to help them study - Create a social network of students reviewing their lessons
Technological	- Uses the best practices of Web Development - Good maintained framework (Django) - Enforcing the Enterprise Applications Features & Principles such as extendibility, scalability, applications reusability
Economical	- The source of financing is not defined yet. However, I am thinking of good ways of Bootstrapping. - There will be (affordable) paid plans. Students must pay to get access to the content. - Include different payment methods in order to enlarge subscribers
Environmental	- Optimize performance by minimizing resources and therefore lower the energy dissipation. Being environmentally friendly.
Political	- There is no political implications.
Legal	- The application uses mostly open source code, such as the different reusable apps. - The application will not be open sourced because of
Ethical	- The content of the lessons are written by the company and not to be taken from other places. - Quizzes are generated randomly so that students will not get the same