SCHOOL OF SCIENCE AND ENGINEERING

EDUCATIONAL MOBILE APPLICATION ON

ASTRONOMY

Youssef Boulaouane

Supervised by: Dr. Tajje-eddine Rachidi

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EDUCATIONAL MOBILE APPLICATION ON ASTRONOMY

Capstone Report
I, Youssef Boulaouane, affirm that I have applied ethics to the design process and in the selection of the final proposed design. And that, I have held the safety of the public to be paramount and have addressed this in the presented design wherever may be applicable.

Youssef Boulaouane

Approved by the Supervisor

Dr. T. Rachidi
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ABSTRACT

Astronomy is one of the biggest research fields in the world, and unfortunately, despite some efforts, Morocco is still behind when it comes to astronomical research. This is mainly due to the fact that there are very few, if any, astronomy classes or activities in the educational system in Morocco. The aim of this project is to develop an easy to use educational mobile application targeted towards the Moroccan youth to spread astronomical knowledge amongst them. Throughout this report, I will be going through the process of working on this project from the initial idea through the design and implementation processes, and ending with conclusions and future work.
INTRODUCTION

The education system in Morocco tends to spark a few arguments over whether it provides the students with enough information and education at an early age or not. One of the arguments that people use against the education system is the fact that it does not offer a big variety of options and materials. One the materials that would be very useful for the Moroccan youth and that is not available in most educational institutions in Morocco is Astronomy. Since I am very passionate about the topic of Astronomy, I wanted to combine it with something else that I am passionate about, which is computer science, and therefore, I decided that for my capstone, I would develop an educational mobile application on astronomy. While there are many apps that would serve the same purpose as the one I am working on for my capstone project, mine is unique in the sense that it is basic, easy to use, rich with information, and made in Morocco.

The app title will be: *AstroKnowledge*
PROJECT SCOPE

Project Overview

This project is in the form of a mobile application that will allow the users to learn more about astronomy through either taking an introductory detailed class and follow their progress throughout, get notified with astronomical pictures once every day, get notified of facts and astronomical events happening on a daily basis, or freely search a database for a celestial object they would like to learn about.

Target Audience

The targeted audience will be mainly the Moroccan youth. Especially ones familiar enough with the English language and are interested in learning about astronomy. In addition to the Moroccan youth, since the application is in English so far, it can also be targeted towards any other youth group who can read and understand English and who are interested in learning about Astronomy.

Competitors

There are actually a lot of apps similar to the one I am working on, but on the other hand, I could not find one that incubates all the functionalities I am trying to include in my application. An app that is worth mentioning is Google’s Sky Map application. This application has a feature that I would like to be able to add to my app in the future, it is able to show you a real time map of the sky wherever you point your phone towards.
To work on this project, I had to use the tools and processes I had learned in my software engineering class. Specifically, The Software Development Life Cycle. Before starting work on the project, I had to go through the planning phase first, which involved choosing the idea, and thinking about what I want to achieve and what are my goals from this project, and what good I want to bring from my project.

After having decided on the idea of an educational mobile application on the subject of astronomy, I then went on to the Analysis phase. In this phase I went in depth when it comes to
the goals and outcomes of the application. And after that, in the design phase, I went through the requirements of the application as well as the overall design of the UI. I also decided on what technologies I would like to use, and settled for using Android Studio, Java and XML files for the front end side of the application, and using Firebase as a database when needed.

Finally, after having decided on the requirements and the technologies to use in the project, I had to start the implementation process. This process took some time in the beginning to start since I was not familiar with mobile development and I had not done it before. But after a while I started getting used to the development environment and it started going smoothly.

The testing and integration of the application are steps that I still have not done yet because of the fact that there are a couple more functionalities that are still not properly working. And finally, the maintenance of the application after its deployment would be through regular updates to fix any bugs and/or to just make an overall improvement on the application.

**Feasibility Study**

**Technical Feasibility**

From a technical point of view, the project requires a study to determine which technologies to use when it comes to the development platform and database hosting platform. When it comes to the development platform, I can choose between IOS, Android, or Windows, I choose Android over the other two mainly because it is cheaper than IOS (one time $25 vs yearly $100) and even though Windows Store is cheaper, but Android is more open source and has a greater appeal within the population. On the other hand, when it comes to choosing a database management system, my options are between MySQL because of its open source nature, and Google Cloud
SQL (google databases) for their fast nature. The choice for the database is yet to be made. Other technical decisions will be made once faced based on their feasibility and pros versus cons.

**Economic Feasibility**

When it comes to the cost of the project, the development platform and tools would mainly be free. The deployment of the application on the google play store requires a one time payment of $25 plus tax which converts to around 228 MAD plus tax. For the database part, if I choose to use an open source database management system such as MySQL then it would be cost-free, on the other hand if I choose to use google databases then the cost would depend on my capacity needs. Other costs will depend on the use of other technologies.

Once deployed, the application will be available for free for the public.

**Legal Feasibility**

Concerning the legal aspect of the project, I would have to make sure not to use anything that is copyrighted without permission of the owner, nor should I use a name that is already used by another application because that would also be copyrighted.

**Scheduling Feasibility**

When it comes to scheduling the project, the most important thing at the moment is to decide on the technologies to be used and get to working on the application and achieving some proper progress.
**Project Management Plan**

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      | ● Interim Report submission |
| 8-12 | ● Design and Implementation start |
| 12-13| ● Implementation and Testing |
| 14   | ● Final Report submission and Project Defense |
| 15   | ● Updated Final Report submission |

**PROJECT REQUIREMENT SPECIFICATION**

Since I am not working on this project with a client I had to come up with my own requirements based on what I would like to achieve in this project and also based on research and looking into what other applications serving the same purpose have. Through this process, I came up with a list of functional requirements.
**Functional Requirements**

- Register for the Astronomy 101 class.
- Follow progress through the class.
- Take a quiz to unlock the next chapter.
- See the astronomical picture of the day.
- Download the image to the phone.
- See detailed information about the picture.
- Activate/Deactivate notifications for the picture of the day.
- See Astronomical fact/event of the day.
- Activate/Deactivate notifications for the fact/event of the day.
- Search for celestial objects available within the database and get information about them.

These functional requirements are also modeled in the following Use Case Diagram:
My application also has to satisfy a certain number of non functional requirements. And in the list below, I go into detail on how I achieved that.

*Non-Functional Requirements*

**Performance**
The app should run with high performance, and should be optimized and have fast processing times and responsiveness.

**Usability**
The use experience should be enjoyable through an easy to use and pleasing to the eye interactive user interface.

**Availability**
The app should ensure being available at working conditions at all times. The class material within the app should also be available at all times for the user even when they are not connected to the internet. Meaning, that the class slides should be cached locally within the user’s phone.

**Scalability**
The application should allow for scalability and growth without sacrificing the performance and reliability of the application.

**Maintenance & Extensibility**
The application should be easily maintainable and easily upgradeable with new features without any troubles.
Reliability
The application should be reliable by insuring a stable user experience without any recurring errors and bugs.

Security & Privacy
The application should protect the information that the users provide and store it securely and privately.

PROJECT DESIGN

Technology enablers
As mentioned previously, the main technologies I chose for the implementation of the application are Android Studio for the front end and the User Interface and in order to make it dynamic, Firebase was chosen as the main database management system. Some other APIs were also used to make some operations simpler during the implementation and the maintenance of the application. Google Slides APIs was used for loading the slides content of the Astronomy 101 class, the APOD NASA open API was used for the astronomical picture of the day functionality in the application. In order to talk about these technologies in depth, I will separate them to the two categories of front end and back end.

Front End
Android Studio was chosen as the main IDE because of the fact that it is the official release by Google, tailored and made specifically for developing
software for the android environment. Using this IDE would make the implementation process faster. Its simple and intuitive interface, makes it easier to develop apps even for people with no experience in the field such as myself.

Java programming language was chosen as the main programming language for this project since it is the language I am most familiar with and have used it in a big variety of projects before. I also chose it because of its cross-platform compatibility since it runs on its own JVM (Java Virtual Machine).

Finally, XML files were used for the design of the user interface. XML was also going to be used for the organization of the class material in customizable files in order to allow customizability of the application’s purpose in the future, i.e. The class material can easily be changed from astronomy to any other material.

**Back End**

When it comes to the feature of the Astronomy 101 class, I managed to get permission of Dr. Miller to use the class material of the Introduction to Astronomy class. At the beginning of the project, my supervisor, Dr. Rachidi, gave me the idea of organizing my data in XML files that are standardized and therefore would allow the app to be used for other materials.
other than astronomy in the future easily. I did take the advice and worked through weeks to organize the data from slides to XML files, but unfortunately, due to a hard drive crash, I ended up losing those files two weeks before the deadline of the capstone.

Because of what happened, I started looking for easier ways to achieve the same purpose. I ended up finding out about Google APIs. I chose to have the sets of slides on my Google drive account and use the Google Slides API to access them directly from the application. This made customizability which we were aiming at, easier while also maintaining high performance. Another advantage to using a Google developers API is that it caches the data to the user whenever they load new data, which means that after the user unlocks a certain chapter, that chapter will be cached locally on the user’s device and becomes available offline.

For the functionality of the astronomical picture of the day, with the help of Dr. Miller, I managed to land on a website run by NASA (apod.nasa.gov) which is basically the same thing I had in mind for the application, since APOD in this case stands for Astronomical Picture Of the Day. And since NASA makes all of its services and data open source, I was able to get a private API key that I could use directly from my application to access and use that service.

And finally, Firebase was used as the main database management system where needed. Firebase is a NoSQL realtime database, therefore it is fast
and reliable. It is also a Google product built into Android studio which made using it more convenient for the project. Firebase was used to store the astronomical facts and events of the day, with 365 days and each day containing one astronomical event (if any are happening) or a random fact as well as storing a list of astronomical objects along with brief descriptions of them. These facts/events are stored in JSON files. An example of the data managed using Firebase is in the screenshot below.

```json
{
    "facts": {
        "Apr22": {
            "title": "Lyrids Meteor Shower is Happening April 22, 23"
            "factText": "The Lyrids is an average shower, usually producing about 20 meteors per hour at its peak. It is produced by dust particles left behind by comet C/1861 G1 Thatcher, which was discovered in 1861. The shower runs annually from April 16-25. It peaks this year on the night of the night of the 22nd and morning of the 23rd. These meteors can sometimes produce bright dust trails that last for several seconds. The first quarter moon will set shortly after midnight, leaving dark skies for what could be a good show. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Lyra, but can appear anywhere in the sky."
        },
        "Apr23": {
            "title": "Uranus is tilted on its side"
            "factText": "Uranus appears to be a featureless blue ball upon first glance, but this gas giant of the outer solar system is pretty weird upon closer inspection. First, the planet rotates on its side for reasons scientists haven't quite figured out. The most likely explanation is that it underwent some sort of one or more titanic collisions in the ancient past. In any case, the tilt makes Uranus unique among the solar system planets."
        }
    }
}
```

Firebase also offers a bunch of other functionalities that would be useful for the application in the long run. Below, I list some of the functionalities and their usefulness to the project
**Authentication**

Firebase offers secure authentication service for the user using their email and password. The users can also log in using third party applications such as Facebook, Twitter, Google Account, or GitHub. This service can be used in the login of the users to the Astronomy 101 Class because it is much more secure than local login and it also allows for the collection of user Analytics to get an idea about user engagement.

**Cloud Messaging**

Firebase Cloud Messaging (FCM) allows for the delivery of notifications containing data to the user either because they were timed or triggered because of an event. This feature can be helpful to deliver a notification to the user containing the astronomical event/fact of the day without the user having to enter the application to check it.

**Crash Reporting**

This feature allows the developer to get notified about any crashes or bugs that happen within the application, therefore making it easier to fix them. This is very helpful during the testing phase but also in the long run in the maintenance phase by making it easier to upgrade the application to fix any bugs or errors that might be happening.

**System Architecture**

In the case of AstroKnowledge, the system architecture is a server-less architecture, which means that the application uses Firebase which is a BAAS (Backend As A Service) to do all the backend management on the server side without having to develop the application using a complicated
n-tier architecture. In the case of this application, firebase would take care of four main things. First, it will process any HTTP requests coming from the Client Tier for data from the realtime database and return requested data to the client side for display. Second, Firebase would manage all the authentication requests from the users using their email or other accounts. Third, Firebase would send any crash reports to the admin in order for the bugs to be fixed. And finally, Firebase will send notifications containing data from the realtime database based on certain timings during the day back to the client side to be displayed to the user.

Furthermore, the application will also be able to establish secure HTTPS connection to the Google APIs, specifically Google Slides API in order to retrieve any slides requested from the Client Side. And similarly, the application can also establish secure HTTPS connection to get the Astronomical Picture of the Day from NASA’s APOD open API.
This Sequence diagram shows in details the hierarchy of interactions within the application. Starting with the User who interacts with the user interface of the application AstroKnowledge, and based on what he/she wants to do, the application in its turn interacts either with the Firebase
Authentication System, Google Slides API, NASA APOD Open API, or Firebase Realtime Database, in order to execute whatever the user requested on the client side.

**The Interface**

The user can interact with the application through an intuitive User interface that will be explained through the following few screenshots.

When the user first opens the application, the first thing they see is a welcome page with the logo of the application on it. And after they click through it they are directed towards the login page of the Astronomy 101 class.
After the user logs in to their account, they can now see a list of the chapters in the class, with the classes they have unlocked through taking a quiz in bald (The quiz system is still under development, the bald chapters are just as a visual). The users can then access any of the chapters they have unlocked and go through the slides.

The users can also access any other feature of the application through a menu they can access at any time from a button at the top left corner. They can for example view the astronomical picture of the day, which they can then save to their device if they like it or view an explanation to give context to the image.
shuttle training aircraft. Taken well above the clouds, the image can be matched with similar images of the same shuttle plume taken below the clouds. Hot glowing gasses expelled by the engines are visible near the rising shuttle, as well as a long smoke plume. A shadow of the plume appears on the cloud deck, indicating the direction of the Sun. The US Space Shuttle program concluded in 2011, and Endeavour can now be visited at the California Science Center. Planned for tomorrow, however, is a different launch – that of the Transiting Exoplanet Survey Satellite (TESS) aboard a SpaceX Falcon 9 rocket.
The user can then access to see the astronomical event or fact of the day.

**AstroFact of the Day**

**Lyrids Meteor Shower is Happening April 22, 23**

The Lyrids is an average shower, usually producing about 20 meteors per hour at its peak. It is produced by dust particles left behind by comet C/1861 G1 Thatcher, which was discovered in 1861. The shower runs annually from April 16-25. It peaks this year on the night of the night of the 22nd and morning of the 23rd. These meteors can sometimes produce bright dust trails that last for several seconds. The first quarter moon will set shortly after midnight, leaving dark skies for the what could be a good show. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Lyra, but can appear anywhere in the sky.

And finally, the user can search for any astronomical object they might be interested in and get a picture of it along with a brief description, along with a “Read More” button that can redirect them to NASA’s solar system directory if they want to learn more about the object.
Mars
Planet

Mars is the fourth planet from the Sun and the second-smallest planet in the Solar System after Mercury.

Read More
STEEPLE ANALYSIS

Socio-Cultural:

The App will have an added value on the socio-cultural context since it will help spread knowledge about astronomy among the population, therefore raising their knowledge and capacities. The app will also serve as a way to introduce students into the field of astronomy, and hopefully leading them to gain more interest in the field and delve in it further later on. It will also be a way for people to practice and enhance their English skills.

Technological:

The App will take advantage of the most popular mobile operating system, android, as well as other modern technologies available on most devices used by the population. This will make the application’s technology familiar and easy to use.

Economical:

The application will be free to download and will have minimum to no economical impact.

Environmental:

The application will urge people to reduce the use of light to help them stargaze more often, therefore helping in the efforts to save energy.

Political:

The application does not include anything political and will not get involved into politics.
**Legal:**

The resources used in the development of the application were either approved or open source, therefore, not violating any legal copyrights.

**Ethical:**

The resources used as material for certain features of the application were used after getting the permission of the creator.
CONCLUSION & FUTURE WORK

The idea for this project is one that I have had for a while now, and I decided to make it my capstone project because it is an idea that combines both my passion for Astronomy as well as my passion for Computer Science. Leaving this project until my final semester was a good idea because I feel like I am now more equipped to work on this project than ever. It was a fun and rewarding learning experience, and I hope I manage to eventually deploy this project and aim it towards the Moroccan society and that it also creates a fun and rewarding learning experience.

I had big plans for this project, and I am happy to have realized a big amount of them. Although, I still feel that there is progress to be made before calling it a complete product. Some of the future work I intend on doing on the project before calling it complete includes but is not limited to:

- Finishing the implementation of the quiz system.
- Making the quizzes randomized.
- Migrating completely to Firebase Authentication.
- Find a more efficient way to implement the astronomical fact/event of the day.
- Include more celestial objects (not just solar system objects).
- Use Firebase Cloud Messaging for Notifications.
- Make the application available in other languages (i.e. French, Arabic, Amazigh).
- Finally, enhance the overall look and user experience.