Adaptive Learning Platform

Tailored support to help students achieve better performance in mathematics via online platform

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Resumo

A aprendizagem personalizada sempre foi objeto de procura, pois os pais com recursos financeiros tendem a colocar filhos em explicação, no entanto nem sempre há tempo para tirar todas as dúvidas e com a capacidade atual da tecnologia existente é possível proporcionar aprendizagem personalizada ou adaptada às necessidades de cada aluno.

Neste projecto é apresentado uma possível solução de aprendizagem personalizada por via da análise textual das respostas aberta a perguntas colocadas a alunos de ensino secundário, sendo que validamos o seu funcionamento, por via de uma plataforma web criada para o mesmo efeito, assim como também validamos a existência desta funcionalidade com plataformas de EdTech mais usadas atualmente e com a análise dos resultados de utilização por alunos reais de forma a percepcionar o impacto no processo de aprendizagem.

Todo este desenvolvimento foi feito baseado nas entrevistas efetuadas a diretores de escolas, professores, alunos e pais.

**Palavras-Chave:** Aprendizagem Personalizada, Análise Textual, Plataforma Web, EdTech, Ensino Secundário, Exames Nacionais.
Abstract

Personalized learning has always been a demanded object, parents with financial resources tend to put their kids in tutoring classes, meanwhile there is not enough time to take all doubts and with the current technological existing capabilities it is possible to offer personalized learning or adaptive learning to each student necessity.

In this project is presented a possible adaptive learning solution through textual analysis of open answers to questions that are made for high school students, and we validated its proper functionality, through a web platform specifically developed for this, and also we compared this feature existence in major EdTech platforms and with analysis of the usage results by real students in a way to get awareness of the impact in the learning process.

All this development was made based on interviews done to high school directors, professors, students and parents.

Keywords: Personalized Education, Text Analysis, Web Platform, EdTech, High School, National Exams.
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List of Acronyms

AI   Artificial Intelligence
ITS  Intelligent Tutoring System
LMS  Learning Management System
PLE  Personal Learning System
EdTech  Educational Technology
USA  United States of America
URSS  Union of Soviet Socialist Republic
LMS  Learning Record Store
EMIS  Education Management Information Systems
TMS  Training Management Systems
LRS  Learning Record Store
IN+  CENTRE FOR INNOVATION, TECHNOLOGY AND POLICY RESEARCH
FCT  Foundation for Science and Technology
MIT  Massachusetts Institute of Technology
MOOCs  Massive open online courses
SATs  Scholastic Assessment Test
SMART  specific measurable attainable relevant and timely
DSRM  Design Science Research Methodology
IS   Information Systems
K-12  grades are kindergarten (K) and the 1st through the 12th grade (1-12).
VR   Virtual Reality
AR   Augmented Reality
NASA  National Aeronautics and Space Administration
R&D  Research and Development
DVD  Digital Versatile Disc (or Digital Video Disc)
AHS  Adaptive Hypermedia Systems
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>CSCL</td>
<td>Computer Supported Collaborative Learning</td>
</tr>
<tr>
<td>LSA</td>
<td>Latent semantic analysis</td>
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<tr>
<td>SQL</td>
<td>Structured Query Language</td>
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<tr>
<td>TBE</td>
<td>Tech Based Entrepreneurship</td>
</tr>
<tr>
<td>EMT</td>
<td>Expectation and Misconception Tailoring</td>
</tr>
<tr>
<td>VPC</td>
<td>Virtual Private Cloud</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>SSH</td>
<td>Secure Shell</td>
</tr>
<tr>
<td>vCPU</td>
<td>Virtual Central Processing Unit</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>DNS</td>
<td>Domain Name System</td>
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<tr>
<td>ETL</td>
<td>Extract, Transform, Load</td>
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1. Introduction

Personally, education is a subject that matters to me a lot, I have been able to participate in challenges like Olympiads and received awards throughout my academic journey. I have been lucky but also hard worker to be invited to a biomedical group even during my high school years and in university receive two research scholarships, one from FCT and other from IN+ in an MIT Portugal Project.

If today I can solve problems that occur in my daily life that is only possible to education, my education became along the way more unique as I started to acknowledge that the more knowledge I possessed the more I could do. The more situations I could be part of and solve existing problems and learn how others older than me could do it.

Along the way I learned too with persons younger than me, not putting myself old, but the world is changing so fast that are things that teenagers know it better in terms of usage and me and older persons can use strategy and trends to make something useful out of that new concept that is showed occasionally.

I started this project in 2015 October, one month later my grandmother died, I did it as promise to create an income stream good enough to make possible for me to visit her one day. Unfortunately, she left too early, seven months later I was selected for a research scholarship form an MIT Portugal project that provided me enough income to do several visits, and three years later after many iterations I was capable to show to the Prime Minister of Portugal (my country), that project, that has also become my master thesis.

Due to enjoying business and having a lot of sensibility of the difficulties that a student has while preparing for tests or simply acquiring knowledge and understanding associated reasonings I kept on going with this project with the aim of making it a business from it. In the next subchapter I will mention the overall motivations, even though the most important I have already mentioned.

Education has been a common thing in Humanity it was the key for survival, learning and teaching proper ways to hunt, to make fire, to cure diseases, to navigate using the stars, it was remarkable to the Humanity evolution. Education also provided ways to logically think and create awareness of ourselves as human beings, but also created awareness that the Human being is only satisfied when has something unique for himself or herself.

Education become systematized in processes so the evolution could be faster but elements in society saw logically that as a threat and during many years, education was provided at a minimum level and certain practices were forbidden.

The focus was to provide education in a small quantity that would let people do the regular tasks, keep big part of the society occupied and a small part to manage the society. But the world became smaller with the Portuguese Discoveries, and even smaller with mobility solutions like cars, airplanes and ships.
The knowledge went and still goes to many areas that can empower Humanity, like Genetics, Astronomy and Aerospace, Humanity still a baby in a baby crib called Earth, but it is starting to learn how to give the first steps out of the baby crib.

With the globalization of the wars more scientific knowledge became required not only to fulfill the society needs but to ensures its equal survival. Now we have more than ever easier access to information, due to the digital world, we can easily search for anything and have a brief understanding of what it is at least.

Anyway, anything that is too much leads for a little effect. By this I mean, the more information exists the harder it is to be able to narrow it down, to master a specific field and focus, then subjects become interconnected and without a proper guidance it can be very frustrating learning certain concepts that can be in area of math, linguistics, philosophy. This is a pattern seen not only in schools but also at work.[1]

This is a similar situation that we currently find at schools, teachers have several subjects to teach and very little time to acknowledge the proper understanding acquired by the students. Meanwhile I see that in not a distant future education will be personalized and professors will be focused on teaching, but a huge support at home or while solving exercises will appear from ITS (Intelligent Tutoring Systems) able to recognize students difficulties, understand when the student is not motivated in class and be able to pass class information for the student again, without any extra effort from the professor.

In terms of economical factor school has been a money consumer that only provides results in long term, but there is a possibility that schools will reinvent themselves and become money producers, which will make a huge impact in economy and societies.

We must be aware of social media, and digital marketing, the trend is to be aware of what everyone is doing, and the goal is to do something remarkable that adds value to the society. The focus to create better prepared workforce will make students to learn a subject and how it applies, there is a tendency to make schooling more professionalized.

In terms of technology there has been good evolution, per example, smart boards, computers in classrooms, Moodle and MOOCs (Massive Open Online Courses) are helping students in classes and autodidacts to learn specific subjects.

In this project thesis, as we will see further on, there is a functionality that can empower the learning process by assess knowledge through open answer questions, so we can get more accurate data about the knowledge a student possesses.

In the next chapters we will address more specifically the Problem (section 2) providing a wider perspective of the schooling system and systematize by pointing out based on facts the main problems that we identified and attempt to solve in this project, although there are two problems pointed out, they are both interconnected as we will show; besides we will describe in the Related Work (section 3) the Educational Technology state in terms of industry and companies working on it, also we will look to the adaptive learning scientific panorama, the state of the art in this specific field of Intelligent Tutoring
Systems and to features analysis, to finalize the related work we take a close look to a very interesting work done in the psychology field, more precisely in the Learning Theory area; then we show our Proposal (section 4) and how it solves the presented problems previously mentioned; in the Evaluation (section 5) we define the metrics we will be more focused on to evaluate our solution and how we will perform the evaluation; to finalize we disclosure the Conclusion (section 6) what we want to ensure and main key features that provides a plausible differentiation to the existing solutions in this field that the HeadExam situates, besides we present the extra development that can be done for this project. In the end we can find the References (section 7) where along the document when we rely on external source, we mark it and put the information about it in this section.

1.1. Motivation

To arrive to this thesis, I passed through a certain point that motivated me more along the way. My connection to the EdTech world started when I was doing a course called Operative Systems in bachelor, a course in which the instructor didn't provide solutions of tests, that lead to a less productive study process and also to fail that course.

The solution to pass that course and help other colleagues of mine was by going to tutoring classes (extra) and solve the tests with the instructor, validate the correctness of the answers. After that I decided to create a simple mobile app that I published on Google Play. The concept was very simple, question and answer. The exercises were sorted by the date of the test so the student had a easier work in navigation.

In terms of architecture of the solution I only used a json file with the answers all there and the app would just get the json file, parse and display everything in a list. In the beginning there was a screenshot of the question from the exam, but due to the instructor not allowing I decided to change with 9gag images related to study.

In the following images you can see how the app looked like, more info can be found in the play store page: https://play.google.com/store/apps/details?id=com.dtanque.rtfa
Figure 2 – First Version of the mobile app that lead to the development of HeadExam

It was to be that simple android app for that course only, but it started to appear very positive feedback and so I expanded to other courses that I already had done. Besides students with iPhone were seeking for the app too, due to the fact that a license for iOS development costs 90$ yearly and that I didn’t have an iPhone neither had ever developed an iOS app, I decided to launch a website with the already existing solved tests, a simple website in PHP and MySQL that would show the question and the respective answer.

Meanwhile buying a domain and buy a web server to host the website had yearly costs so due to that I decided to monetize, but not with AdSense ads, I wanted something more tailored to my audience so I looked for restaurants near TagusPark, and got my first “client” paying me a certain amount to be on the app exclusively.

Later on I got an attack to the website, SQL injection and that made me realize that I would need more technical skills, and so I applied to an IN+ Research Scholarship to work on a MIT Portugal project, that provided the technical basis to create more robust solutions, real platforms, near to the state of the art, using the same technologies used by big tech companies. I got accepted and during the scholarship the idea of HeadExam started to gain form.

It was not scalable to solve every test from all courses from my own college, so I decided to give a step back, and found high school. There are fewer courses, looked for my high school course, Sciences and
Technology, but fast found out National Exams. Took more attention when noticed that college admission exams is a procedure that happens worldwide.

Talking with people with the same mindset and having the Tech-Based Entrepreneurship course at college (where we learned Lean Startup procedures), made me realize that I needed to validate my project, my new version would end up being called as HeadExam. In March, 2017, I started interviewing high school directors, math teachers, students and parents. I decided to go for mathematics, because it is easier to test in only one subject at first instance and due to my background and the higher sensibility in solving mathematical problems, also mathematics has normally a worse performance than other courses in National Exams.

The interviews not only made me understand the hardships which students have while studying, but also the things that students are paying more attention, what matters the most to them personally, per example high school final trip, the national exams (college admission exams), and life after high school. I started understanding some patterns, consequences in short and long term that schooling generates in the society and stood more deeply connected to the theme.

The way I saw that was more helpful for the student was to have a 24/7 professor watching closely what the student was doing, where was making mistakes and analyse them, that's when I discover adaptive learning and found some platforms that were providing it, mainly through multiple choice questions, due to SATs, but in Portugal there are open answer questions in the exams and so I decided to make adaptive learning on open answers, and developed a text analysis algorithm just for that. By going to schools and showing I received very good and fruitful feedback that lead me to do thesis on this project.

In my research I noticed that many EdTech solutions focus on displaying data for the student and the assessment lacks on ways to validate if the student really knows and understands the subject learned, because quizzes or multiple choices can be made randomly until gets the right answer. Going through open answers enables to see what the reasoning of the student is, thus forward more detail can be acquired to properly evaluate the student knowledge.

Besides through my research and interviews I noticed that there are several types of students and personality plays an important role, so technology in my view must systematize technologically the process of learning and assessment but to personalize to a point that tracks the performance of the student, but also identifies the type of student that is solving the exercises, if it is motivated or not, if it in a proper environment (socially and so on) to learn and practice or not.

By analysing students with good and bad performance, and correlating to top level professionals, I notice that what makes success in general, not only in studying, but in everything in life is the persistency and regular training, but also it is understandable that we do not work well if we are not motivated. The schooling system now-a-days is focused in formatting the mind to certain thought processes, to fit the conformity. Meanwhile the student if not motivated, without any sense of improvement, it starts to drift around, talking in classes, entertaining themselves with something more motivating than trying to learn something that he/she does not understand.
For the student the motivation must start with a vision, a long-term goal, like when we dream about a
great lifestyle, it is something bigger, better and brighter than our current state. But that first step only
gives you the first attempt. Then it is required a sense of improvement, a sense of evolution, because
as in our personal lives once we taste a bit of success we believe more, and we work more, so the
learning process for the student must be personalized, tailored to the needs of the student, to show
them they are not stuck.

Once the student gets used to the process, with the training, the student understands what happened
wrong, so tries again, until gets it right. The student should enter in a mindset in which despite the
difficulty of that exercise the student knows that it is solvable, and it just requires more effort. Finally,
there is a point in which the student trained so much that has the sensibility/intuition to solve new
exercises, due to the practices/reasoning and the learning acquired by the student.

With this path as motivation I decided to do my master thesis on this project and my proposal is a
personalized learning platform that is focused on helping the students understanding the points in which
they show difficulties while solving exercises and train them to achieve the total correctness on the
exercise, with core focus on passing the reasoning required to solve an exercise, besides this is not a
closed system, teachers are also involved, so it is important to provide them inputs, show students’
performance to better manage the classroom in terms of revisions, and teach more carefully certain
subjects.

1.2. Context

To further contextualize, in Portugal, students have the “Exames Nacionais” (in English, National
Exams), that are the college admission exams that occur in the end of high school and those exams
evaluate specific courses, there is exams of Mathematics, Portuguese, Biology and Geology, Physics
and Chemistry and many others. That is the entrance to college, and it is based on the average of the
three years of high school, with 50% impact and the remain 50% is based on the result on the exams,
with that final value it is the entrance grade for college plus some colleges ask for a minimum above of
9.5 on each exam.

So, the vision for the student is to obtain a good grade on the exam, it is the first goal to be able to enter
in college. But it is not sustainable, because the student when enters in “study mode” and faces
difficulties over and over it tends to lower the goals. Here is a point in which the motivation must wider
the students’ perception of reality, understand somehow that it is not only an exam, but the posture, the
habit, the regular attitude toward facing challenges, it is easier to lower the goals than keep them and
increase the work effort to achieve the goal. Mainly the students must have SMART (specific,
measurable, achievable, relevant, and timed) goals merged with discipline and focus.

With the platform developed the thesis aims to evaluate its technology and functionality. By doing a
comparison we want to validate that it is a unique tool for adaptive learning. For that we will make a list
of major EdTech platforms and validate, by comparison, if they do adaptive learning, more precisely, in
the same way we do, that means by text-analysis. Besides a technical description will be made based on the architecture and the overall algorithm created.

1.3. Problem

The problem that was identify was that professors, currently do not possess the proper tools to assess in useful time each student difficulties. To provide a more contextualized scenario, in conducted interviews for this thesis it was validated that professors tend to have classrooms from 20 to 30 students, being 30 students, the maximum accepted for a classroom size.

Another point validated was that the professor only possesses awareness of each student difficulties on tests, before that the student has difficulties and due to the size of the classroom it is not possible for the professor to provide a personalized teaching, because in other hand the professor has to follow the curricular plan and have to keep teaching subjects so in the end of the schooling year the professor has taught all the subjects.

In another way what we found out was that some ITSs are appearing and started to be used, but there is a core function in which they do not assess. In other words, most of the assessment procedures used in ITSs are multiples choice exercises, true or false, and some short answer questions, in which it is required to follow a strict pattern, per example providing only the result, like a number, or a word.

1.4. Hypothesis

Our hypothesis is that through open answer questions we can provide a more effective personalized learning than the students currently possess. The current difficulty that may occur is in understanding what the student is saying in the answer and make a proper evaluation.

We believe that through the development of a system that displays questions to students based on Portuguese National Exams, more precisely mathematic exam, and those questions receive free form answer, using mathematic formulas as well as simple written text we can provide a more personalized to the student by using a text analysis algorithm that attempts to understand the student answer and correlate with specific criteria that is defined as pretended to be evaluated.

1.5. Objectives

The objectives of this project are:

- Develop an algorithm that improves the assessment system based on text analysis that evaluates student open answers, free form;
- Implement a platform that makes use of the algorithm and tracks student difficulties in the answer provided by the student;
- Understand the dynamics associated with the schooling systems and its main elements, High School Directors, Professors, Students and Parents;
- Validate if this solution possesses anything equal in its performance, in other words, that receives a question and an answer and can identify what the steps were done wrong;
- Compare this solution with the state of the art, in academic but also in current, major, EdTech companies.

1.6. Research Method

As Research Methodology we applied DSRM (Design Science Research Methodology), this framework is commonly used in Information Systems (IS) research. The goal of DSRM is to develop an artefact through iterations, those iterations have seven steps, such as, problem identification and motivation, define the objectives of the solution, design and development, demonstration, evaluation and communication. Subjects that further on we will detail.

For this thesis we did one iteration and it can be schematized outlined in the following chart:

![Figure 3 – DSRM scheme](image)

1.7. DSRM iteration

This iteration is procedure defined in the Design Science Research Methodology (DSRM), based on the research methodology applied in Information Technology (IT) field. These methodologies provide specific rules to assess and develop research projects. The core focus of DSRM is to build artifacts that improve the functional performance of processes in which the artifact is located.

Seven major guidelines for a design science research are, (1) design as an artifact, this means, design a viable artifact that can be a construct, model, method, or instantiation; (2) problem relevance, develop technology based solution to real existing problems; (3) design evaluation, existence of metrics well defined to evaluate the developed artifact, utility/benefits, quality, efficacy and efficiency; (4) research
contributions, provide clear and factual contribution in which the artifact is applied; (5) research rigor, application of rigorous methods for development and evaluation of the artifact; (6) design as a search process, effective artifact must utilize available means to reach the desired ends as well as satisfying the laws in the problem environment; (7) communication of research, design research must be presented both to technology-oriented as well as management-oriented audiences. [2][3]

In the following subchapters we show how this project was developed fulfilling the premises of DSRM.

1.7.1. Intro

Schools are having troubles with the traditional schooling system, students have more distractions than ever and self-development is a harder process for the young individual, besides the number of students in a classroom is too big for only one professor to be able to track every student difficulties, the educational sector is also becoming part of the digital transformation and the evolution is moving towards personalized education, the objective of this work is to present a solution to track student difficulties via open answers and by acquiring those we can display to the student and the professor.

1.7.2. Objective-centered Approach

The objective of this project is to provide better tools to the professors so they can assess the difficulties of each student. For this it was conducted a set of interviews in some schools and understand the existing dynamics in the schooling ecosystem starting from headmaster, professors, students and parents.

1.7.3. Problem identification and Motivation

There are too many students in a classroom for only one professor to be able to acknowledge every student difficulty, as a student passed to the same difficulty.

1.7.4. Objectives of the solution

The objectives of the solution are to provide a tool for professors to be able to validate each student difficulties, provide personalized support for students and pass that information to professors. All of this made via open answer questions.

1.7.5. Design and Development

What we propose is a platform that lets the student to write answers, free form, and notify them which mistakes they have made, if any, and by capturing those we can pass it to the professor. The part we are focused on is analyzing what the student writes as answer and its evaluation.
1.7.6. Demonstration

The platform developed showed to detect the steps missed in the answers, and providing that information to the student, being able to correlate with the associated subject and let the platform to select more exercises to do in those subjects.

1.7.7. Evaluation

The evaluation will be based on a testing of the platform by real students in which they have a demo at school and then at home they are free to use it to solve exercises and get instant feedback, our goal here is to validate that the students get a personalized learning, so when the student is not writing the correct answer they can check where they failed and understand how to solve the exercise, the reasoning associated.

1.7.8. Communication

This project was presented in Web Summit by application and selection to the Alpha program, besides many previous events of pitching there was a possibility of presenting the project to the Portuguese Prime Minister itself as we can see in the following image.

![Figure 4 – Presenting the solution to the Prime Minister of Portugal at Web Summit 2018](image)

1.7.9. Contribution

The solution proposed provide a new way to correct open answers, free-form, and correlate with associated subjects. Thus, forward it helps the students to faster and more efficiently identify existing
difficulties and understand the related reasoning to solve the problem as well as professors that can use that data too for better class preparation.
2. Problem

In this section we will get an overview about the associated problematics. The education sector has many dynamics, we will provide a wider perspective with focus on the educational industry in a macro perspective and do a drill down into the education ecosystem based on the facts obtained at the Portuguese educational ecosystem. For more details, but in a brief way there’s the summary in which is detail a little more than in this paragraph.

2.1. Context

The educational sector has been from decades a sector that together with health are economic consumers. Very little focus is provided by the governments worldwide because the impact is in long term and does not provide power for elections neither to provide positive impact in the pools in short term, besides students from K-12 do not vote so it is a part easily ignored.

Meanwhile is good to question the economic impact of having individuals with more human capital, besides economic impact, societal and political impact. We live in strange times that somehow, we forget the past and by not learning the mistakes of the last century we may end up doing it again.

In our research we found interesting conclusions that “if every state was lifted to the achievement level of the top-performing state would amount to an aggregate $76 trillion for the United States”. Some study can be done by Europe, or better by each country based on the top-performing schools, and try to do some benchmarking.

We know from a couple of decades ago the impact of good schooling has in earnings we can look to the Mincer’s earnings function:

\[
\ln w = f(s, x) = \ln \omega_0 + \rho s + \beta_1 x + \beta_2 x^2
\]

Variables have the following meanings: \( \omega \) is earnings (the intercept \( \omega_0 \) is the earnings of someone with no education and no experience); \( s \) is the years of schooling; \( x \) is years of potential labour market experience. The parameters \( \rho \), and \( \beta_1 \) and \( \beta_2 \) can be interpreted as the returns to schooling and experience, respectively.

Another point to take in account is that the society is in change, the digital transformation has been providing numerous ways to make our lives better more specifically in providing new sources of income defining a brand new philosophy of economics, the digital economy let us create store and sell online without having a physical store, creating brands just via social media, create channels without owning a television company, making trading more possible to common citizen.

As in the beginnings of the XIX century a new layer, called the Bourgeoisie, in the society appeared due to the evolution of the feudal system in pair with the industrial revolution. This is happening again having
in account the capability and resources required to generate wealth have low entry barriers, and just necessitate a proper knowledge acquisition and have good habits and discipline.

This may seem out of context, but one growing paradigm is that students are being able to generate through digital platforms, such as Youtube, Instagram, Shopify, and many others to learn the usage basics and by practice become real professionals and make more money in monthly perspective than parents yearly. This is not just a seen from a couple years ago when some very intelligent kid would develop an app and received millions by selling it, we are talking about online shops, Youtube channels, Instagram accounts, etc…. That doesn’t require much expertise, just some curiosity, tech savvy to search how to do things and discipline to keep going.

How can the educational system beat this, how the players in the ecosystem beat this? Well this is not the thesis problem but a contextual problematic that we must have in account. We are living in a time where more people understand that wealth comes not from a regular job anymore, and the teenagers are lazier and want direct path to a better living. They see that what matters in terms of surviving is money and so they focus more on that, those that accomplish such are not many, but enough to make motivate other teens to shift their attention.

Why teens are more tuned to these projects? That happens not only because of the focus on other income sources to make money, but also, and with big impact the sense of evolution. Per example, having more followers on Instagram, having more views on Youtube, they are normally focused on the income, at least in an initial stage, money becomes a focus when they get enough traction that make parents and other elements say that they will not be able to make a living from it, so they go further, improve their results on those platforms and start taking it as a business, besides now-a-days there are agencies ready to partner with Instagrammers and Youtubers with a certain level of followers and interaction and help making it a business. Just like the managers of musicians or football players, there are already for Youtubers, Instagrammers, Gamers, etc….

What we can take from this insight is that there are notions of improvement, growth, evolution and helps the teenager to stay motivated and keep on going. Later, there’s a personalized support for those teenagers to make their project, a business with professional and tailored support to the teen and its audience.

This point of personalized support and sense of improvement are very important in business as it is in education, the education must be seen by every player, since from government to schools, as an investment. When a person starts working is making an exchange time for money, in school its money for knowledge, but also time. It should not be a surprise if school transform themselves and adapt to the digital economy and generate a disruption in the ecosystem.

The schools can teach the learnings required for the students, via the transversal subjects, but also train them to the business mindset, to the technological world where it is needed to know how to search on the web, how to edit images and videos, how to develop software, how to use math to simplify processes in day-to-day life, how to think logically and how to be emotionally strong, resilient, motivated, persistent.
Those competences are becoming more and more important in very competitive world, because the
digital world despite not cutting the physical distance, made us more connected and easier to compare
with each other. We can easily launch a business, online store, from Portugal to sell clothes in Canada
and USA, also someone in per example Singapore or India can create a web design business and sell
cheaper websites for businesses in Portugal. There are no boundaries in the market it is not regulated
right now that helps grow the global competition between persons worldwide.

2.2. Personalized Education

With this we can identify the main problem that we aim to solve in this thesis.

Problem: Professors with current tools cannot have a real-time insight of each student
difficulties, thus forward students cannot have a proper improvement strategy.

Due to this lack of personalized education parents normally seek private tutors for their children, which
is only achievable for those who have financial resources for such. Meanwhile for a student that is not
understanding the subjects, this creates a pressure of “having to rise up the grades”, “having to study
more”, which does not help, neither motivates the student, until gets pointed out where is the error and
how to do it properly.

And here students face the second problem, students enter in a loop of awareness of self-imposed
system, that success, recognition and approval in society is based on the performance on a test and
that, in my opinion is wrong and has tremendous impact in adult life because can develop a path of
personal trusting issues and believing in themselves, students enter in a loop of thinking in which they
perceive that they are only good if they have good grades, which is very wrong, and can have impact in
adult life, lack of trust. Besides those who don’t conform with such end up going through alternative
paths, some may be good, others may be bad.

Now with the proper motivation and mindset, by tuning the dreams, motivations, desires of the student
and connect with learning subject in tiny amounts of knowledge everyone can achieve mastery in the
learning process and learn anything, this belief was also defended by Jerome Brunner work I will
describe later.

In sum, the problem is:

- Professors with current tools cannot have a real-time insight of each student difficulties, thus
  forward students cannot have a proper improvement strategy.
2.3. Summary

In current times professors do not have the proper tools to track every student difficulty in a classroom, professors normally have classes with 30 students and have the obligation to teach every subject in the curricular plan so the students can do the national exams. As in older times new educational approaches were used and due to technological advancements not only the demand of new skills from future workforce but also technology has made possible to create ITS, Intelligent Tutoring System.
3. Related Work

In this section we will get an overview about the related work done towards improving the quality of the education via personalized learning. Since the last decades lot has been in many perspectives, whether in educational technology, whether in educational psychology, whether in educational reforms. Here I try to gather most of them with more focus in the technological aspect, due to the nature of my thesis. For more details, but in a brief way there’s the summary in which is detail a little more than in this paragraph.

3.1. Context

I remember back when I was in primary school the impact that was to have lectures with a computer that would explain us how the solar system was organized and the details of each planet. When I was already in 9th grade we were having classes about technology, how to use power point, word, excel, and many other programs.

There was the Moodle area that we could access just for that course some course material. Later in my 12th grade I remember using Youtube channels to solve national exams and review some topics repeatedly.

It was in college that start to see homework that was done online in the college platform, also the appearance of a MOOC in which we could review subjects given at the classrooms. Meanwhile it is important to notice that MOOC with videos about topics doesn’t substitute the primordial concept of the classroom, because the classroom is to give a lecture and some teachers see it as a place to work upon the videos previously watch. That is counterproductive because it makes the student to spend two times more the time in that subject, one at home, other at the lecture, and the other remain times that are for other classes, homework and studying for tests, and there are other courses to study too.

In overall many changes have been made in the educational sector, and some of them I experienced myself, some more productive than others. Meanwhile none were adapted to me personally, not focused to help me improve my study process. The educational platforms were more content providers than active supporters in the learning process.

During my research in a world-wide perspective I discover many Intelligent Tutoring Systems, Learning Management Systems and Personal Learning Environments. Some MOOCs already have exercises built-in, so the student can train and get a more tailored and personalized support.

Nonetheless in terms of massive usage and something more guided for the national exams I have not came across to one. One possible enough to solve not only multiple-choice questions, but also written answers (free-form) and free for the students at least.

Anyway there are some steps made in that sense, but besides adaptive learning other concepts of technology usage for learning is being developed, per example using Virtual Reality (VR) and
Augmented Reality (AR), this makes the lectures more easy to understand mainly in complex topics that have dynamics difficult to imagine at a first glance and a conceptual view helps a lot. Some examples are used in classes to see wild animals and their structure, but also in Medicine in anatomy to understand where each specific bone locates.

3.2. Education Industry

Education comes from early times of Humanity, when adults would pass the knowledge to the young how to hunt, how to understand the weather, how to make fire, rituals and many other subjects… We see more rigorous processes in the education through Egypt, Plato Academy, Catholic Churches, and many other entities in which the passage of knowledge was systematized, because there was the notion that to avoid repeating mistakes a registration of historical aspects, observations and reasonings were recorded.

Through time has been an adaptation to the society and to the needs of each era. With the change of society and to democratized western world education became more available. Recent centuries show us the potential impact of education and scientific research to propel economic powers and to make the world a better place to live.

We can denote some major facts, like the Portuguese Diaspora, some may say that was a random luck and adventure, but we knew in that time what we were doing, some of the best mathematicians and astronomers, majorly Jesuits, were in Lisbon. We had good knowledge of the seas and the skies, navigate by the stars, that knowledge with bravery made it possible to discover the maritime path from Portugal to India and that made Portugal the first global empire, with huge economic impact.

We can see also the impact of the atomic bomb, no one at that time had one, neither those who have knew the impact that could generate. But ended a war, provide fear to some and power to others. But time flies, and knowledge is just an infinite marathon that anyone can surpass by being humble and persistent.

Unfortunately, we see major focus in warlike research and knowledge, but if there is something to learn from Portuguese Discoveries is that real power does not come from fighting and competition but through innovation and creation or discovery of new worlds. There is a lot to discover and work on the genetic world, astronomy world and underwater city constructions.

The evolution of educational system has been based on societal circumstances, but also since 1950s there has been evolution in the aspect of psychology addressed to the learning process and the development of technology useful for this sector. The digital transformation is occurring, and many fields have been changing in which education is and more will be part of.
3.2.1. Past Perspective

The delivery of knowledge in a systematic way has been done over the last 150 to 200 years, some countries only 50 years ago. Before that schooling was able only for priests, bureaucrats and specialists [7].

It all started with the development of writing systems, patronization of way of communicating made possible to pass knowledge from generations. In the Middle Ages the monasteries of the Roman Catholic Church were the centers of education and literacy in Europe, only after 15th century modern systems of education start appearing through derivation of schools of High Middle Ages, which kept the primary purpose of training the clergy.

At the beginning it was paid but in 1179 the church opened free education for the poor, every cathedral should assign a master to teach boys too poor to pay the regular fee [8] teaching at least the literary skills. Private, independent schools reappeared in medieval Europe, meanwhile also religious, and had a curriculum based around the trivium and lesser extent quadrivium.

Trivium is a lower division of the seven liberal arts, that contains grammar, dialectic and rhetoric. The other remaining four of the liberal arts, which are known as the quadrivium, are arithmetic, geometry, music theory and astronomy. In comparison to current days they are literature, philosophy, mathematics, social and physical sciences.

And after many reforms and adaptations only in the 19th century start to appear an elementary education in reading, writing and arithmetic, partly due to the fact of politicians believe that education was needed for orderly political behavior, per example the view of Herbart was that a system of pedagogy would “produce more soldiers and more obedient citizens”.

It only started to appear a regular educational system in the 50s, but the content of the learnings haven’t change much, normally learnings would go to a primary education stage and to access the secondary education only those with economic resources could access.

Meanwhile at October, 1957, occurred the famous “Sputnik Shock”, it generated a crisis also know as “Sputnik crisis”, in which the western nations demonstrated public fear by perceiving the technological gap between United States and Soviet Union caused by the launch of Sputnik 1, the world’s first artificial satellite. The impact didn’t stay just through the creation of NASA but to do a major reform in the educational area to prepare properly the future generation in terms of mathematics, physics, biology and others, the proportion was that Soviet Union was producing two to three times more scientists than United States [9].

Substantial federal investments were made in R&D, education and national security [10]. This had tremendous impact on the society majorly in this entrepreneurial layer well known of iconic personalities such as Steve Jobs, Alan Kay and many other entrepreneurs that were starting to grasp and creating the basis of the next century technology.
Steve Jobs wanted computers in schools, so students could learn better, more efficiently. Alan Kay had his early motivation of tech for schools with his friend, Jerome Brunner, a learning theorist, both were at that time inspired by the Italian physician and educator Maria Montessori, all this info is based on e-mails that I personally exchanged with Sir Alan Kay.

Maria Montessori had huge impact in education, one of the greatest contributions was the Montessori method, it is focused on young children and attempts to develop a child’s own initiative and natural abilities, mainly through practical play. With this method children would discover their own pace to learn [11].

Despite the huge will of improving more the educational sector, through the usage of technology, after putting man on the moon, those investments decreased substantially in the educational field, and the technology, had to go to where the money was. And since education since then has been seen again more and more as a consumer and not a producer, in economic terms.

3.2.2. Present Perspective

Currently we see almost globally a form of compulsory education, a minimum period in which is required for all people and is imposed by government. Good to denote the difference between compulsory attendance, in which parents are obliged to send their children to a certain school, in some countries that happen, but compulsory education holds two paradigms, schooling and homeschooling.

Over the last decades has been a substantial decrease of illiteracy and due to the accelerating pace of change in the evolution of economy and technology, the education has adapted to prepare students for the workforce.

There is a notion of the skills required to succeed in the 21st century, many of those skills are associated with deeper learning, analytic reasoning, complex problem solving and teamwork. Deeper learning is a growing movement that emphasizes the ability to apply knowledge to real-world situations and to solve new problems [12].

The current educational systems structures majorly in schooling system, in which students learn from the teacher. The function of this element, teacher, is to guides the students through several subjects. Being able to capture difficulties of the students inside the classroom and to help better understanding, due to technological advancements there are resources which students can use to consolidate their knowledge, like Wikipedia (an online library helping research more effectively and efficiently), or MOOCs that provide online videos of lessons about specific subjects.

The classes in schools have extracurricular activities, also provided by private entities, that are not schools, and are able to teach other subjects like music, languages, sports, etc.… There are practical classes with experiments like the case of chemistry, physics, biology and geology.

For higher education still exists Universities that provide knowledge more near to the state of the art, requiring more dense and complex learnings, and leading to research, to the world of innovation. Of course, innovation can be achieved along the way, more now, in this era we live in than anywhere else
in the past. We can conduct experiments, the possibilities increase even more in the field of technology, or the combination of with other areas, this makes possible to avoid go to higher education to create science, it is possible to create science without the Academia, but it is harder to systematize without it. University provides more robust and disciplined process of researching and understand the common language used in science.

In over all the education starts by teaching how to read, talk, count, understand the basic elements of communication, then it starts to elaborate and disclosure concepts and elements about the surrounding world in terms of space and time, what do we have surrounding us, nature, and what happened before us, history. Then start to be taught social consciousness and understand the process why the student goes to school, most of all is to learn, but one important, key detail, is to recognize the person itself besides the surroundings, this is not explicitly done that is why I see many students going to college courses without any driving reason, without sensibility about what they are saying.

Until the student enters in high school, they are showed what the world has to offer, and they must find the paths they enjoy more, some people enjoy more writing, and story-telling, other enjoy more music, or painting, other enjoy more discipline and rules to regulate their day to day. It is important to notice the personality traits people show to better comprehend the area to study and later to work on.

There is a lack of self-consciousness in students and a lack of promotion of it in schools, which normally leads to trusting issues and make, per example, bullying possible, it is very important to have a coaching support to show the student what he does best, what is the best detail, trait, feature a person possess, that will create a balanced dynamic in which no one is seen as superior.

Meanwhile schooling has become a industry of mass production, because more in the public sector we see classes getting bigger as well the curricular plans, this has some impacts, like how can a teacher be aware of the difficulties of each student in a classroom, or how long does it take a student to discover by itself where he made a mistake in an exercise, how failure affects each students and how that student affects the classroom and the teacher performance. Those question we will see further on in this chapter because we are tackling in this paragraph the problem of the thesis, the problem we are attempting to solve, and which impact may solve some problematics.

Another detail that is growing in the Education is the offer of distractions students have. Since the beginning of this decade became a common thing student having smartphones or even smartwatches. This can generate health issues, more precisely in sleep pattern, that makes students be tired next at the classroom. But also makes cheating more advanced, a student copy via smartwatches and block them to simulate a digital one, this clearly destroys the evaluation and the learning process. The extensive consume of media content makes the student provide lesser time to discover itself in terms of human development, cultural and philanthropic hobbies.
3.2.3. Future Needs

As previously mentioned, “many of those skills [21st century skills] are associated with deeper learning, analytic reasoning, complex problem solving and teamwork”, we found an interesting article from the World Economic Forum in which they mention the top ten skill for 2020:

1. Complex Problem solving
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with Others
6. Emotional Intelligence
7. Judgement and Decision Making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

This will be required because many of the current jobs which are based on repetitive tasks will be delegated to robots. Per example, driving will be autonomous, call centers will have bots receiving calls just as equal a normal person, supermarket cashier will be done by machines or even automatic, like with Amazon Go [13].

Such evolution will generate changes in the schooling methods, curricular plans, and so on… And here no one knows what we could end up to, go back to the seven liberal arts, go into more artistic and creative industries in which humans are the creative thinkers and machines are the workers. But despite the evolution one thing is for certain, as everything has becoming more personalized and so education will, to better fit the student based on their will, interests and skill with related industries.

It is highly probable that the future brings new business that we haven’t even grasp, by merging two or three functions in current times. Per example, a web designer, currently, has better performance, offers a more complete and lower cost structure if it also knows how to write content, how to take photos and edit them, and many other details. Because like mentioned previously now-a-days teenagers can generate income sources through a Youtube channel, but it is not only about recording video and publishing. There is a process to write the script, train it, record the video, edit the video, schedule publication, publish properly on several social networks, promote it consecutively during a period,

Despite the personalization and even the possibility of a self-sufficient educational system, I mean a family can provide its own teaching to their kids without going due to technology, a technologically improved homeschooling, I think this trend will not become a normality due to the needs of socialization, even if there is a new baby boom generation where families have four kids or more. I think schooling will keep being a trend but with new dynamics, schools will be able to generate income and even turn themselves into a perspective of a 5, 10 or 12 years, long-term investment, in which the student, after
learning how to read and write, learns the fundamentals of digital economy and so starts themselves being a producer.

This must not be misunderstood with child labor, the dynamics here is for the student to find points in which is good at and be able to make his work profitable, imagine a painting, a music, a vlog, a book, schools have a marketplace, and professionals capable to help in the specific area and the student while studying makes money. Money which stays frozen until finishing high school or achieving adulthood, per example, avoiding in that sense to lose interest in school and being explored by any element of the ecosystem. Besides it would gamify the whole educational process, not to follow the money but instead really understand how knowledge can make money by direct appliance. I’m a believer, and we have seen teenagers creating mobile apps, I don’t think they are outliers, they are consequence of a set of actions taken.

Anyone can create something from early age if it is properly raised and naturally interested in a subject.

3.3. Education Ecosystem

Much of the panorama has already been mentioned we now will focus on the key players of the ecosystem, what are their contributions and difficulties they find in daily activity. The focus is how to improve the quality of teaching by discovering what is blocking. This info was obtained through interviews at schools, mainly Escola Secundária Aquilo Ribeiro in Oeiras, Agrupamento Filipa de Lencastre in Lisbon, Escola Secundária Maria Amália Vaz de Carvalho in Lisbon, and professors from other schools that I end up meeting through friends and other contacts.

3.3.1. High School Directors

There are many dynamics concerning High School Directors, many problematics like autonomy, but I will focus on the goal of the High School Director.

A High School Director wants to have more students in its school, independently of being public or private, to achieve that goal it can diversify the offer, per example, with professional courses, in which students do the High School, in a “hands on” approach so they can be more technically prepared, meanwhile it doesn’t provide preparation for exams thus neither for college.

Another strategy used by schools to acquire more students it is to provide better teaching, providing extra hours, for tutoring classes, or doing mixed classes, per example, Physics classes have also present the Mathematics professor to help with any doubt that occur based on the mathematical reasoning.

3.3.2. Professors

Professors are one of the core elements of the schooling environment, being the other one the Students, the professor have the main role of teaching the students through classes. Classes are scheduled by the Education Ministry which provides the main topics to focus in each subject.
Meanwhile professors need to adapt that schedule to their classes, and besides giving the lecture, should train with students exercises to get the insight that they are understanding the class.

An issue that raises is that the students normally are not focused in the lecture that makes the student to lose the reasoning required to progress. Meanwhile the professor is normally one in a classroom of 30 students maximum, even if in average it is 20, it is humanly impossible to track every student.

Another fact is that the professors have despite the entire classroom understands everything or not to keep going with the schedule mentioned before, provided by the Education Ministry, that schedule contemplates the Curricular Plan for that grade (10th grade, 11th grade and 12th grade curricular plan) and every professor is obliged to give it.

This creates a pression in the professor in which the professor must keep going giving new subjects, which translates in a perspective of quantity and not quality in learning. Additionally, professors have to make tests and evaluate them, besides National exams.

3.3.3. Students

Students mostly in the 12th grade, where my interviews were built upon, show major focus, in early moment of the 12th grade, on the final trip. This final trip is a week in which students go normally to Spain without parents.

They imagine the concept of a week of being limitless without parents and able to do anything, which normally brings tragic consequences. Meanwhile after that trip they are more concerned about the National Exams and their future whether in personal or professional aspect.

In terms of classes a student is normally concerned about grades, because of the pressure of parents, school itself, the classroom, and so on. But their focus is to be part of the community the normally deal with, as any human being, they also like to connect with other persons and make themselves useful.

This leads the students sometimes to find things they are good at, some show off by telling jokes, others by gaming skills, some type of sport, normally soccer is something that students do a lot, and some show off through that, others by playing some musical instrument.

Then it is the classroom environment, even without technologies students would write messages on a paper and pass to each other. Now-a-days with wi-fi in school or students with smartphones connected to the internet if they get bored with class they start looking to the smartphone, scrolling the Instagram feed or sending messages through Messenger.

In the evaluations another issue may raise, per example, they can use smartwatches and block them in case of emergency to avoid the professor to see the cheats created, this goes against the purpose of evaluation and the learning process.

But it is very important to identify why students do this, why can’t they pay attention to the class? The point is very simple actually since the student doesn’t understand a subject it leads to frustration in to understanding the following subjects. Students tend to think that everyone knows already everything.
and because of being shy to be “the only one not understanding” they tend to stay quiet. Turns then to a point in which they get bored and start looking for other things that are more pleasant to them like using the smartphone and talk with other colleagues.

3.3.4. Parents

Parents always want the best to their kids, and some have a more old-school view, based on rules passed by their parents, others have a view more focused on the kid desire and try to satisfy always, this enters in the subject of parenting which I will not extend.

Meanwhile their concern is based on the student performance and they want the best teaching possible so their children can learn better and have better jobs. Non the less in some cases parents support also hobbies and other works.

This normally occurs because schooling system from 40 to 20 years ago changed a lot and some subjects become a bit difficult and due to the lack of training in those subjects they can’t help so much, some mentioned that a detailed analysis of the children difficulty and suggestion to help the student to study would be beneficial, because most of the time the performance of the student is influence by their habits, by their lack of self-discipline and here parents can help just by being close to them, doing a 15 minutes review about the topics studied.

3.4. EdTech

To provide a wider picture it is good to start through EdTech. EdTech that stands for Educational Technology is the usage of technology to facilitate human learning and improve human cognitive performance. It is the fusion of technology capability with educational theory, per example interactive boards, media content, mobile or web applications, instructional material, et cetera…

Figure 6 – Educational Technology evolution
The appearance of the first personal computers that lead schools to started having computers at classrooms. In the ‘90s appeared scientific calculators that would help to faster calculations, also the rise of DVD to learn from other multimedia types like video. In the 2000s, the new millennium brought the possibility of students having desktops at classes, a program that worked interestingly well in Portugal and even exported the model to other countries.

Meanwhile is now-a-days that we see the rise of AI and multiplicity of devices that can keep us connected and share information easily and rapidly. Today anyone can go to YouTube and learn a subject, also tools as Kahoot with a strategy of gamification works in college or even in events to understand the level of knowledge the audience has about a certain subject.

The EdTech is here and starting to boom, mainly the trend will go towards better supportive tools to acknowledge the state in which the student is or help the communication between to humans. But not far will be the time where the machine helps the human to learn new concepts.

Currently EdTech provides many systems, Learning Management Systems (LMS), used for student and curriculum management, also there is Education Management Information System (EMIS), also there is a part focused on logistics, per example, Training Management Systems (TMS), Learning Record Store (LRS) used for storage learning data and its analysis.

3.4.1. Educational Platforms

Following the DSRM for the thesis we found that Educational Technology is having a tremendous growth, the skills required now-a-days are constantly changing with the rising of the digital and technological world.

There are several EdTech niches in this industry, that will be mapped, the EdTech industry and its niches, additionally we will map the location of the solution that we propose, which areas are we tackling. For that we will use an image obtained from CB Insights.

In the following image we can see the EdTech Market Map in which the companies are organized in specific niches:

Figure 7 – EdTech Market Map
Our solution is in the Test Prep niche, more precisely in the University Admission Exams Prep, but also has presence in other areas such as we can see in the following image, with blue dots.

![EdTech Market Map](image_url)

Figure 8 – EdTech Market Map with the niches our solution locates

And as we can see here, there are many platforms, we will do a more narrowed selection of those that we will analyze later on, in the Evaluation chapter, in which we will describe them, and details their assessment features and then compare with our proposed solution.

### 3.4.2. Features Chart

Firstly we will start by analyzing the some key features the analyzed platforms possess, our focus in this analysis is majorly in the assessment part having in account that the thesis focus on the open answer (free-form) that we will compare with the same platforms and validate if they have or not a feature as this one.

<table>
<thead>
<tr>
<th>Platform Name</th>
<th>Videos</th>
<th>Assignments</th>
<th>Peer Grading</th>
<th>Instant Feedback (Quizzes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coursera</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Lynda</td>
<td>✔</td>
<td>✔</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td>Udemy</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td>Udacity</td>
<td>✔</td>
<td>✔</td>
<td>✗</td>
<td>✔</td>
</tr>
</tbody>
</table>
For this project we only focused the development of HeadExam in its core differentiative feature, text analysis to correct students answer, but it is easily possible to add videos whether embedded from Youtube or inserted in the platform, the major work would be to setup multimedia server to store that data, it was not done due to time and associated costs. Study material has the same justification it is not complex to have such in the platform but for this thesis it was not added.

### Table 1 – Features Chart

<table>
<thead>
<tr>
<th>Platform Name</th>
<th>Videos</th>
<th>Assignments</th>
<th>Peer Grading</th>
<th>Instant Feedback</th>
<th>Open Answer (free form)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coursera</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>Lynda</td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
<td>✔️</td>
<td>✗</td>
</tr>
</tbody>
</table>
### 3.4.4. Algorithms

In terms of approach to help students to better performance we do adaptive learning, and in this field we have competition, per example, Knewton, that has solutions of this type, they collect the user performance on exercises displayed and based on the result they define/characterize the skills the user has or need to improve. Mainly this is the idea of adaptive learning, in terms of “adapting” the “learning” to student difficulties.

<table>
<thead>
<tr>
<th></th>
<th>Udemy</th>
<th>Udacity</th>
<th>Khan Academy</th>
<th>Iversity</th>
<th>Skillshare</th>
<th>edX</th>
<th>Alison</th>
<th>Open Yale Course</th>
<th>Knewton</th>
<th>Cerego</th>
<th>Realizelt</th>
<th>Fishtree</th>
<th>Magoosh</th>
</tr>
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<tr>
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<td>✓</td>
<td>✓</td>
<td>×</td>
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<td>✓</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 2 – Comparison Chart
In terms of scientific research, the adaptive learning is the result of improvement of three main areas: Intelligent Tutoring System (ITS), Adaptive Hypermedia Systems (AHS) and Computer Supported Collaborative Learning (CSCL) systems.

One solution that we have seen is Alfanet, despite using machine learning it is guided for building a user model but does not mention in what they rely to evaluate the knowledge of the students, mention activities but do not specify if it is multiple choice questions, open answer, quizzes or others.

In another article, we found an evaluation based on meta-analysis of some ITS solutions, the type of existing ITS’ using student modelling approaches as model-tracing, probabilistic modelling, reconstructive bug modelling and constraint-based modelling.

- Expectation and Misconception Tailoring

This one resort to tutorial dialogues using natural language, for example, AutoTutor, this one defines the student knowledge based on the matching the student answer with text passages that represent the expected learning goals, the matching is performed by a statistical method called latent semantic analysis (LSA).

- Model Tracing

In here the skill to be learned is modelled by a set of production rules, those consist of operations and conditions under which they are triggered. What happens is when a rule is activated part of the problem is solved, so as far as we perceived, it mimics the reality, for example, if I light up a lighter the consequence is fire will appear. So as the student passes certain checkpoints a model-tracing process is mapped, but if an error is inserted then the student receives feedback.

We found this very interesting approach for mathematics due to the fact of enabling the student to solve in any way a mathematic exercise what matters is the result to be correct, meanwhile in our case due to our project being based on National Exams there are rules that the Portuguese Ministry of Education have to avoid students from using knowledge from superior education, because their focus is to evaluate based on the learnings obtained during the high school and using the taught methodologies not shortcuts.

- Constraint-Based Modeling

This is also an interesting approach, in which is defined a constraint and if no constraint is passed over it means that is on the good track, It is important in here to shift outside of mathematical exercises, for example, using the example on the paper, imagine that we want to cook a pot roast, the temperature has to be always under 120° Celsius, if that rule is not passed we are on the right track.

It may be not so useful for the mathematics part in our case but in an overall learning perspective with gamification, having a correlation with performance and student grading average to enter in college it can be defined a lower level that notifies the student to study, for example, the student has an average
of 18.2 but last week s/he didn’t train and the performance correlation shows a decrease to 17.9 a prompt is displayed, mail sent, something that gets back the student to keep the study routine.

- Bayesian Network Modeling

Bayesian networks are normally used to handle systems with multiple variables it can be used to implement many different types of students’ models and include aspects of CBM and knowledge tracing (Bayesian procedure that is used in Model Tracing).

3.5. Learning Theories

I started doing more researching in the psychological and scientific research, after personally exchanging emails, with Mr. Alan Kay, that started in April 2017. Due to Mr. Alan Kay I started reading the works of Mr. Jerome Bruner which contribution for the education methods and processes were very interesting, the name of Jerome Brunner came due to the connection of this project with education and due to Mr. Alan Kay and Mr. Jerome Brunner being friends and both interested in the education industry.

Bruner had different stages in relation to Theory of Education, in his early years he defended that cultural transmission was a crucial mission to schools. That is because it is more natural for the learner to acquire knowledge based on the reality that surrounds and during the growth expand the perception of reality and thus forward the knowledge.

Most of the early Bruner’s thinking toward education were affected by the Progressive Education that raised due to 1957, the Sputnik Shock. Later around 80s he agrees with Mr. Dewey’s point of view in with “all education proceeds by the participation of the individual in the social consciousness of the race”. That is very interesting because once a person perceives a reality and sticks to it stays more available to acquire knowledge willingly, we can notice on the fact that kids easily try to learn how to play a game, or play football, do vlog, dance, etc…

Bruner defended that education becomes “disciplined understanding”, notice that in Bruner’s perspective understanding is more important than performance, it is not enough to have/retain information, but to understand it and be capable of managing it in order to expand and deepen knowledge more efficiently and go beyond what is simply given.

This perspective of Jerome Brunner made me look more deeply into the subject of learning theories, and found three main perspectives: behaviorism, cognitivism and constructivism.

3.5.1. Behaviorism

Is a theoretical framework developed in the early 20th century based on the animal learning experiments made by Ivan Pavlov, Edward Thorndike, Edward C. Tolman, Clark L. Hull and B.F. Skinner. It was used by many psychologists to develop theories about human learning.
Behaviorism combines elements of philosophy, methodology and psychology theory. It assumes that all behaviors are either reflexes produced by a response to a certain stimulus or a consequence of that individual’s history, including precisely reinforcement and punishment.

Edward Thorndike pioneered the law of effect, in which reinforcements could be used to strengthen the behavior of the subject. Later on John B. Watson lead us to the Methodological behaviorism which states that only public events can be objectively observed ignoring private events[^14], B. F. Skinner theorized Radical behaviorism in which defends that processes within the organism should be acknowledged, particularly the presence of private events (such as thoughts and feelings).

This interesting to notice because the human being can react in a methodological way, and build upon it the layer of radical way. The existence of an introspective perspective makes the person to solidify its thinking and personality, top athletes normally use a radical behaviorism they mold their thoughts around achieving a goal and training more and more for it, the same happens as well for top performing students.

### 3.5.2. Cognitivism

This perspective retains the empirical framework of behaviorism but goes beyond behavior by explaining how human memory works to promote learning. It refers to learning as “all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered and used” by the human mind[^15].

Cognitive concepts of working memory have been facilitated through research and technology in the computer science, the topics more researched are cognitive load (refers to the effort being used in the working memory), information processing (change of the information in a form detectable by an observer) and media psychology (interaction of human behavior and media and technology).

### 3.5.3. Constructivism

A philosophical viewpoint about the nature of knowledge, in which is located the theory of cognitive development created by Piaget, that focus on the nature and development of human intelligence, it defends that cognitive development is a progressive reorganization of mental process which results from biological maturation and environmental experience.

Educators that use constructivism focus more in an active learning approach in which the learner is centered in problem-based learning where real-world problems are stated and students have to develop critical thinking skills.

* These perspectives converge in the philosophy of the platform, which aims to be more than a tool for students to have better performance in college admission exams but also to help them to perceive a wider reality that provides them more freedom and lets them find their zone where talent meets hard work in a self-motivated way, instead of walking in a self-imposed path.
Due to the education become “disciplined understanding” this leads to his famous spiral curriculum and discovery learning. Spiral learning is a cognitive theory advanced by Bruner in 1960: “We begin with the hypothesis that any subject can be taught in some intellectually honest form to any child at any stage of development”. Discovery Learning is a method of inquiry-based instruction, it defends that is best for learners to discover facts and relationships for themselves.

### 3.6. Summary

The educational technology industry has changed in the last few years, they all tend to teach a specific subject or a set of knowledge in an easier way. In terms of adaptive learning the common approach has been through multiple choice answers, but can be misleading in terms of properly evaluating. So new approaches based on text analysis algorithms can be obtained. We also provided an overview about the educational ecosystem in terms of understanding what matters the most to the key elements of the schooling ecosystem, High School Directors, Professors, Students and Parents. All this complemented with educational theories that were very fruitful for the interviews taken and thus the development of this solution.
4. Proposal

In this section we will show our solution, we aim to solve the problems mentioned above. We will justify our approach, why we focused in the free form open answer, explain it in terms of development, how it was made, designed and current architecture. Demonstrate its usage flow and mention the benefits to the players of this ecosystem. For more details, but in a brief way there’s the summary in which is detail a little more than in this paragraph.

4.1. Context

This project as it is being approached in the thesis started to be developed some time before the thesis itself. I was in a research scholarship for a MIT Portugal project in which I learned how to develop Ruby on Rails web apps, work with SQL Server and Talend.

This technical knowledge lead me to develop a better solution, because at that time I was only thinking in providing solved answer to students but that would not be very beneficial, in terms of not fully testing if the student understood the subject or not.

Then the idea of correct the student answer came. I started to focus on National Exams, because already had seen a scalability problem in terms of doing that solution for the universities, so I decided to focus on High School, more precisely college admission exams, because they are few courses and the solutions are provided by the Education Ministry.

In the first version that I developed I was focused initially on the formula, input, processing and output, in a mathematical way, easy for the student to understand. After doing it I decided to show to high school directors, professors and students, mainly because at that time I was doing TBE (Tech Based Entrepreneurship) course and one of the points studied was customer validation.

To validate and further develop this proposal I did interviews at schools, mainly Escola Secundária Aquilo Ribeiro in Oeiras, Agrupamento Filipa de Lencastre in Lisbon and Escola Secundária Maria Amália Vaz de Carvalho in Lisbon too. My first approach never was to show immediately the platform developed, initially I would try to understand the dynamics of the school.

With the High School Director I would try to identify what were the major challenges they had while improving school performance, for better teaching performance and student performance. Then with teachers I tried to acknowledge the tasks they have to do as professors, per example, giving lecture, being aware of the difficulties of the students, correcting tests, preparing classes, making students more appealed to the classes. Through the students I would try to identify their focus, motivation, and correlate with the performance that each one had.

This info provided me information along the way that not only helped me to develop this platform for mathematics but to also expand to other courses. The dynamic normally is this, students in Mathematics like the fact of having a final result but many ways to get it, having exercises, many, to train. Other
courses lack on this logical path and lacks on exercises to train, and solutions with a step by step reasoning, adding more benefit to the platform.

A crucial point that I validate was that students lack personalized support during their study, and having one helps saving time and being more motivated to study/train more. With this my focus must spot mistakes that the student makes and show the student that mistake and how it is done correctly. By this learn by doing process, when a student sees a new exercise it becomes more prepared to it.

The platform could be focused on the multiple choice only, but that point would make the platform trivial and there are ways to trick multiple choice questions, per example through brute force, and that takes the core goal of evaluation. With open answers (free form) that exist in Portuguese National Exams, I found it particularly helpful to track the student difficulties step by step.

And through text and writing pattern on keyboard many other things can be collected, that per example can lead us to the sentiment analysis and so on. Meanwhile for this thesis we don’t go too far on this.

4.2. **HeadExam**

The platform was implemented this way with multiple choice and open answer because it is the same type of exercises that are used on National Exams. Besides with writing answers, free form, evolves more reasoning and it is trackable the steps written by the student, enabling deeper detail.

Additionally, it is observable how limited in terms of effectiveness because students can use process of elimination or brute force that trivializes the process of figuring out the answer, negating the benefit of learning the actual reasoning of the problem. Besides open answer questions found in research mainly based on very short input and specifically formatted.

The motivational part was inserted when the student gets bored it is necessary to re-acquire the attention and due to that we have motivational videos that give motives for the student to persist. The motivational is provided by showing famous personalities that fight through hardships, showing the student a wider view of what effort looks like.

It is possible that in future versions we make a close loop cycle in which the student after solving an exercise and if it is showed any mistake on the answer the student must repeat starting from the point where first mistake was made and keep on this loop until the student successfully solves the exercise.

4.2.1. **Implementation**

The ITS platform is developed in Ruby on Rails, and it is deployed on a Private Cloud available for any student, available 24/7. The implementation had four main phases, initially the front-end, define how it would look in first instance (because the goal was having a working prototype), then the back-end, design and think a bit forward what features will be need, not only about the data, but in reverse engineering perspective it was asked questions like what information is useful for the user and then what data is required to obtain that information.
With the prototype done it was migration phase and putting it online on a cloud server required some research, something that after some effort it was well accomplished. To faster add content and validate users I added a back-office to the platform, so it is manageable anywhere that a pc and internet exist. Since then was feature development, inform students via meetings at school, social media interaction, high school directors and teachers passing of information.

Our approach towards adaptive learning is: we show an open answer question and what we do is we receive the answer and we text-analyse it, in an approach more near the EMT (Expectation and Misconception Tailoring) and Model Tracing, because we base ourselves on the criteria from the Educational ministry, but also ensure two factors the writing easiness for the user and ensuring that the student answer makes sense (each phrase inserted).

For such we use a syntactic analysis that posses many models of an answer making it possible to evaluate the student answer, by correlation with the criteria defined.

### 4.2.2. Platform Architecture

The project in terms of architecture attempts to follow a structured path whether in terms of development and production. For the development it has a bitbucket repository, so I can develop from my pcs and save the code. There is a master branch where the production lies and the bitbucket repository is synchronized with the VPC setup in a droplet in Digital Ocean.

There are other branches that is used just to save important things occasionally, my backups I like to save in physical devices, just as a precaution. The platform was done in Ruby On Rails, and the goal in terms of development was to be easy to develop, but also to fast deploy and let users test online from anywhere in the world.

For achieving such the setup is, image: Ubuntu 16.04.4 x64, size: 2vCPUs, 4GB/25GB Disk. Then had to setup everything in the server to be able to run Ruby on Rails and also to deploy. For that the steps taken were: created an SSH user, installed ruby, bundler, postgres, apache, passenger and Capistrano and synchronized with the Bitbucket repository. Also, setup the DNS configuration so the droplet used (that has a specific IP address) can be used under an already existing domain, in this case is app.headexam.eu. And created a back-office so I can easily check data.
4.2.3. Algorithm Explanation

In this project the core differentiation is the text analysis algorithm created to provide instant feedback to students in open answers questions. It was followed the concept described early on in Expectation and Misconception Tailoring and Model Tracing in certain points.

The first approach I took was via Model Tracing, I was just validating formulas that were required to show in order to accept as correct the answer, the formula was provided by the criteria given by the Education Ministry. Then after some tests with real students some wrote the formulas, but others preferred writing sentences. Since my goal in Future Work is to have a platform that goes beyond of Mathematics, I decided to improve the algorithm.

For that I created an abstraction of, Concept, Verb, Value. This let me breakdown the problem to easier pieces. The following scheme shows the logic behind this algorithm.

```
Answer

Steps _ X

Version _ Y

Sequence _ Z <Concept, Verb, Value>

...

...
```

Figure 10 – Conceptual Drawing of the Algorithm
Each question has 1 or more answers. Inside the answer can have 1 or more steps, with a quotation associated so it is possible to grade the step as it is done in the exams. Each step has a version, per example can be a mathematical formula version or a text version, as we can see in the following images:

Treino de Geometria - Exame de Matemática A (Ano de 2017)

2. Na Figura 2, está representado, num referencial o.n. Oxyz, o prisma quadrangular regular \( [OPQRSTUV] \)

Sabe-se que:
- a face \( [OPQR] \) está contida no plano \( xOy \)
- o vértice \( Q \) pertence ao eixo \( Oy \) e o vértice \( T \) pertence ao eixo \( Oz \)
- o plano \( STU \) tem equação \( z = 3 \)

2.1. Seja \( T' \) o simétrico do ponto \( T \), relativamente à origem do referencial.

E escreva uma equação da superfície esférica de diâmetro \( [TT'] \)

Figure 11 – Screenshot of a question in the platform

In the picture above we can see a presentation of a national exam in which there is an association with specific keys subjects, that based on the student performance those subjects can be retargeted.

Figure 12 – Answer in mathematical form

Here we the Answer area with a toolbox that later on we will describe it more, here our main challenge was to receive mathematical formulas but also plain text describing a specific thought process.

Figure 13 – Evaluation of the answer in mathematical form
The image above has an evaluation that pinpoints the steps that were missed, and as we will see further on there’s a complete solution of the exercise.

Figure 14 – Answer in text form

As I mentioned previously here we do the same answer but in a written form, plain text, and try to understand the input provided and correlate with the criteria that we defined based on the national exams criteria, but that criteria can be adapted specifically to a certain step.

Figure 15 – Evaluation of the answer in text form

And as expected the platforms shows in the image above that it also understands the answer when it is provided in the written plain text form.

Besides more precisely in text version there’s a sequence of say the answer in a proper way, and for that we have the sequence. This enables to catch a context that is correct only if it is in the right order. This simple approach but effective lets the platform to be sure when it is right the student is totally correct, but lacks on catching the other correct options, in first instance.

To solve that problem what I pretend to do as Future Work is to use an ETL that after an instructor adds a possible answer the ETL will analyse and validate other possible correct answers and loads the database with versions or sequences, never adds new steps because that part comes from the criteria defined in this case by the ministry, besides answer is singular, the end result is always the same meanwhile the versions and sequences may differ, there’s always many forms to solve an exercise.

In the end what we have is the more users answer the bigger the tree of possible forms to solve an exercise appear.
4.2.4. Solution Usage

The solution created for this thesis contemplates only one subject, Math, but due to the improvement of the algorithm created it can be used for majorly all of subjects, excepting Descriptive Geometry because of the drawings and subjects that tend to go more to essay perspective, per example philosophy in which creativity can play a big role and with current technology it is hard to evaluate that part.

Best use is given when students pick up a subject from a specific course, by solving the exercise the student can receive instant feedback, and catch the steps missed. Each step is individually from the previous ones, but grade is given just for the step written correctly, unless the question, in the criteria has the possibility of just receiving the final answer as correct, which normally in National Exams are very few.

This data can be passed to other elements of the education ecosystem, those immediately direct to the student, professors and parents, and providing them extra data. Per example, for the parent can display possible tutors for that subject or even books, for professors it is possible to work the entire classroom, data, and provide an insight about which are the subjects students are failing.

Also, it is possible for the High School Director to get insights, based on the average of students’ performance, teachers are graded, and this info is given to the High School Director, with this data can per example track which professor, based on subject is better, and promote a different lecture. A scenario is there are two mathematic teachers and one has students with very good performance in Calculus and average performance in Probabilities and the other teacher has better performance in Probabilities and lesser in Calculus. Here it can be beneficial for the students to swap the teachers and they teach the subject they have better performance to the class with lower performance that same subject.
This provides more interactivity; more features were already thought but due to the time limitation and focus on the thesis it is more mentioned the differentiative aspect of text analysis algorithm being a distinctive feature based on our analysis as we will see further on in the Evaluation part. Meanwhile here is a screenshot of what can this feature, developed in the last three years, can enable to build.

Anyway, some of the ideas move towards use of gamification to compare school classes grades, not comparing students, but classes, schools and districts. Also having features for students to communicate with each with the perspective of supporting one another and due to that limitation would be based in time restriction, per example, voice call/video call would have a 5 to 10 minutes possibility and maximum of 2 calls per day.

Also providing the possibility for students and teachers to create their own exercises that can be shared to their students privately and sell for students outside of class. In addition to this there can exist other type of content, like image, summaries, or any other multimedia type of data that can provide knowledge to the students and students can sell it in a marketplace inside of the platform.

4.2.5. Screenshots

Here we can see the overall platform and the

- Platform Website

![Figure 17 – HomePage of the website](image)

Due to the presence on Web Summit and going to schools doing interviews we did a website in Wordpress to easily present the concept of the platform.

This website can be seen at [www.headexam.eu](http://www.headexam.eu)
To provide a more contextualize to the reality of web apps it was developed in Ruby on Rails this platform, as previously mentioned, and it was created a page for register and login, having in account that initially the user can register but not immediately used the platform that requires acceptance from mem as we will see further on.

- Homepage

This is a demo/static data page, to provide a possible scenario of a dashboard providing the student, this is the student perspective, in which it is possible to see the performance such as overall exercises done and correct exercises, also main four metrics, like exercises done, those with good performance,
those needing improvement and how much remaining to achieve a good level of performance. Besides there is a To-Do list to help the study log every task needed to do.

- Question

**Figure 20 – Example of an exercise**

As mentioned before this is a question, here is another one and again it is based on the national exams, provided by the Education Ministry as well as the criteria to evaluate it.

**Figure 21 – Answer area to reply the presented question**

In here we can see the area specifically to reply the question, to solve the exercise, and there is a toolbox that we will be able to see in the next image.
In here we see a toolbox because the answers in mathematical form require to be inserted in LaTex format, but the students don’t need to know LaTex, with this toolbox they can use the same style of write formulas on calculators and generate the code that then they copy and paste to the answer area.

As previously mentioned there is a part in which the answer submitted by the student is evaluated and then its result is presented, with missed steps, total score and a complete solution of the exercise, so the student can understand the reasoning, it is a solution proposed but that possess more detail in terms of the logic behind each step. When the student gets the answer totally right the solution is not displayed.
- Backoffice

In here we can see the back-office and this tool helps me to manage users and content, as I mentioned before the user after register doesn’t have immediate permission to use the platform it requires my permission, so I can enter in the back-office and the activation bit I set true and then it is possible to use.

Here is an overview of the back-office with all the entities necessary. And I can click and edit, add, remove, import and export with no big effort.

- Bitbucket
In order to develop and avoid losing my code and keep versions not just in the server, I used since early on BitBucket.

- Digital Ocean

Additionally, I used Digital Ocean, after many tries to exit Heroku and move to a more robust solution I tried Amazon AWS, and created inside a Virtual Private Cloud multiple subnets for public and private subnets, so I could have in private the databases and public just the web server. Setup EC2 and the NAT gateway to start having communication to the internet, but got scared with costs, fortunately found out digital ocean that was a easier transition and still can use Capistrano gem from rails to commit the new version of the platform and previously to that send that same version to the Bitbucket.
Figure 28 – Payments done for Digital Ocean, in order to have the platform online and able to run tests anywhere and anytime I had to early on setup the Droplet and upload the Rails project.

And yes, already nearly 2 years running on the Digital Ocean so I could go to schools and present the platform at their facilities using their computers and everyone could interact instead of taking my laptop and just being possible for only one student to test. The only limitation here was the concurrent users, if there was too many the price would spike, but fortunately in average as been 30€ per month.

4.3. Limitations

As we can observe the platform was made from scratch, implied technical knowledge to setup the digital ocean droplet, setup the database and webserver to hold the rails apache. In terms of the approach to correct the student answer and being able to provide feedback we develop a system of semantic analysis in which is deeply based on provide models, as we can observe in the Figure 10 there is one question and one answer, but inside the answer there exist many steps and each step is a point the student must pass to validate the student knowledge, now the student can pass through that step by many possibilities of what I call sequences.

Those sequences are finite, and are inserted by me or the professor (thinking in production phase), and that takes time, just to give a perspective, it takes in average 75 hours to insert an entire exam, but there are always answers that are correct but not accepted, which we will see in the Future Work how to tackle this problem. So the solution presented provides, if the result is correct it is because it really is, and if it is wrong it may be possible that the answer provided by the student is right but it hasn’t been added yet to the system as a possible correct answer, we will see this in detail in our tests of the platform with real students in which there were occasion in which they would insert correct answers but yet not accepted as correct.
4.4. Summary

The proposal presented is a platform that makes of a totally developed from scratch algorithm of text analysis that makes possible to track the answer provided by the student and correlate with criteria. If the student misses one step of the criteria can get that info and have a full display of the correct answer. The development followed the DSRM.
5. Evaluation

In this section we will conduct an app testing done with real students by presenting at school letting one student try to solve an exercise and then making able for any student to go online and try the platform at home by their own. For more details, but in a brief way there's the summary in which is detail a little more than in this paragraph.

5.1. Context

We have seen the problem we attempt to solve, the related work done in this area and the solution we provide. Following the DSRM there’s an evaluation phase and as we mentioned previously it was better to put in a chapter, so we could do the evaluation and do a deeper analysis of what already exists in the market.

For the evaluation we decided to compare our solution with the already existing EdTech platforms and verify that there is no platform that assesses the student via open answer (free form) with instant feedback.

For this evaluation the platforms analyzed are Coursera, Lynda, Udemy, Udacity, Khan Academy, Iversity, Skillshare, edX, Alison, Open Yale Course, Knewton, Cerego, Realizelt, Fishtree, Magoos.

5.1.1. Coursera

Coursera is an online learning platform founded in 2012 by computer science professors from Stanford University, Andrew Ng and Daphne Koller. Coursera provide a several range of subjects, such as engineering, humanities, medicine, biology, social sciences, mathematics, business, digital marketing, data science and many others more. The courses normally have a duration of four to ten weeks, with 60 to 120 minutes of video lectures per week. The courses normally provide quizzes, weekly exercises, peer-graded assignments and in some cases a final project/exam.[16]

They provide assignments with questions, being most of them based on multiple choice questions or short text box answers (input boxes), which are submitted and immediately graded at the same time. There is also essays and those are graded through peer review, with the final score being equal to the average of the all review scores.[17]

5.1.2. Lynda

Lynda or formerly known as LinkedIn Learning is also a MOOC founded in 1995, as online support for the books and classes of Lynda Weinman and in 2002 started offering online courses. Later one in 2015 was acquired by LinkedIn and in 2016 LinkedIn was acquired by Microsoft and in 2017 Lynda was finally merged and renamed as LinkedIn Learning.
This platform provides video courses taught by industry experts in areas such as software, creativity and business. They provide assignments such as quizzes and others that require submitting the assignment and wait for feedback. [18] [19] [20]

5.1.3. Udemy

Udemy is an online learning platform, unlike academic MOOC here, at Udemy, content is not driven by the traditional collegiate coursework, Udemy uses content from online content creators that sell those contents for profit. Udemy lets the instructors to create courses using video, powerpoint presentations, PDFs, audio, zip files and live classes, besides there are discussion boards in which it is possible the interaction from the instructor with the users online.

They provide assignments but are review and evaluated later on, the evaluation can be performed by a peer or an instructor. [21][22]

5.1.4. Udacity

Udacity is also a for-profit educational organization founded at June 2011 by Sebastian Thrun, David Stavens and Mike Sokolsky. They provide courses that are based in several comprised units in video lectures and they have integrated quizzes to help students understand the given concepts and reinforce ideas, as a method also to follow their model “learning by doing”. It possesses assignments mainly quizzes that provide instant feedback. [23]

5.1.5. Khan Academy

Khan Academy is a non-profit educational organization, created in 2008 by Salman Khan, that provides short lessons in form of Youtube videos, the website provides supplementary tools for a more personalized experience to track progress and practice exercises, to assess the student knowledge, those are mainly quizzes with instant feedback, and materials for educators. [24][25][26]

5.1.6. Iversity

Iversity is an online educational platform, based in Germany, launched in 2013 by Jonas Liepman and Hannes Klöpper, specializing in providing online courses and lectures in higher education, their courses have lecture videos, animatios, graphics, simulations and written material. Instructors can interact with students through discussion forums and also evaluate them through quizzes to get feedback on the learning progress.

Besides they have exams that can be taken on-site, online as “proctored-exam” that is graded by the instructor or if the student prefers can do it in form of a final project that has to be handed to the instructor. [27]
5.1.7. Skillshare

Skillshare is an online learning community, launched in 2010 by Michael Karnjanaprakorn and Malcom Ong, for people who want to learn from educational videos, main courses that are offered are creative arts, design, entrepreneurship, lifestyle and technology. They provide assignments which are corrected by the instructor. [28][29][30]

5.1.8. edX

The edX is a MOOC itself offering courses, but also a MOOC provider, created by Massachusetts Institute of Technology and Harvard University in May of 2012. The MOOC Técnico was built using the edX framework. edX hosts online university-level courses in a wide range of disciplines.

edX courses consist of weekly learning sequences, each learning sequence is composed of short videos interspersed with interactive learning exercises that are displayed immediately after the video lesson being given. They have also assignments and use peer assessment/review, thus the feedback is not instantaneous. [31][32]

5.1.9. Alison

Alison is a free online education platform, founded in 2007 by social entrepreneur Mike Feerick, it offers thousands of courses with certification. They have assessment tool mainly through exercises such as multiple-choice questions providing instant feedback. [33]

5.1.10. Open Yale Courses

Open Yale Courses is an educational project from Yale University in which is possible to share full video and course materials from its undergraduate courses, besides provides quizzes for each session, that also has videos and readings. [34][35]

5.1.11. Knewton

Knewton is a company focused on adaptive learning systems that has developed a platform to personalize educational content as well as courseware for higher education concentrated in the fields of science, technology, engineering and mathematics. Their adaptive learning system is based on multiple choice questions that provides instant feedback. [36][37][38]

5.1.12. Cerego

Cerego is an adaptive learning platform that bases itself in the principles of neuroscience and cognitive science, founded in 2000. It patented scientific method of spaced rehearsal as the basis for memory retention, they focused in using in other areas such as creating facebook apps (Smart.fm), also solutions for the nursing and healthcare stydents, they use quizzes. [39]
5.1.13. **RealizeIt**

RealizeIt is an adaptive learning platform that provides assessment that is later used to determine learning paths and generate predictive analytics. It tracks time to complete learning exercises (quizzes), performance and learning style preferences. [40][41]

5.1.14. **Fishtree**

Fishtree is an educational technology company that provides a dynamic, web-based platform enabling personalized learning at scale for K12 and Higher Education, it has assignments such as quizzes which results are provided immediately.[42][43]

5.1.15. **Magoosh**

Magoosh is an online test preparation company that teaches students through video lessons, practice questions and online email support, in terms of assignments it has quizzes with instant feedback. [44][45][46]

5.2. **Testing the solution**

To test the solution, we conduct in classroom a 15-minute session of presentation and demonstration. The sessions were made in mathematical classes for high school students, the project went this way because mathematics is easier for me to solve and also showed to be a major course in which students take lower grades and high school students, more precisely 12th grade because in that year there is the National Exam of Mathematic.

The approach to conduct this experiment was to talk with the high school director and a mathematics professor, ask if it is possible to show the platform to the students, let one student experiment it, reply to some questions and let students use the platform again at home by being free and available 24/7.

In this 15-minute presentation, I would make some questions about the school, what do they do when they have doubts, if they ask the teacher, ask to the smartest classmate, ask their private tutor if existed or used any application or so. Then I would invite a student to test the platform by solving an exercise, without class support, by inserting the answer they would receive a result and if it was completely correct I would show the same exercise but giving a wrong answer to show the feedback of the steps missed and collect feedback from the students about if it was useful that information or not and get an overall appreciation of the platform if they would use it or not.

The tests were conducted this way because the costs of having many concurrent users wouldn’t be possible for me to hold them, in average monthly have been paying 30€, having 3 users concurrently which if I had 30 students concurrently the bill would be too much for me.

As we can see in the appendix A there are 22 users registered in which 17 are valid, and they registered at home because in class was only possible to present and demo with one student the platform. From
those 17, there were 9 students that used the platform at home without my support we will see in next sub chapter the results of it.

### 5.3. Validation

Before the demos at students in their mathematical class I presented the platform to high school directors and mathematics professors, and talked about the project and the goal I aim to accomplish. The feedback based on the idea was well received and there was a lot of interest shared by the professors in the idea presented, in classes I demoed the project and we are able to see in class that students would solve the exercise and may solve it wrong but due to the feedback provided by the platform they were able to pinpoint where the mistake occurred.

Furthermore we can see on appendix B exercises solved by students on their own, I mean, without my supervision, and results are interesting, meanwhile it’s good to have in mind that the number of students is little but as mentioned previously I didn’t have resources to go more times to schools and financial resources to hold a classroom to solve the exercises or even an exam at the same time, but anyway despite the small number of students testing the solution it’s possible to see some achievement of our goal with this project.

We see that there are students that solve the exercise at first attempt, and others that don’t get it at first time but understand on the next attempt. This can be interpreted as the students recognize what is missing, the usability of the application is not so hard, at least for this set of students, and that there may exist correct answers that are corrected as wrong, see appendix B, id 7, in which it is correct the answer but the model wasn’t added to the system at that time.

Meanwhile by correlating each step with a specific subject the professor can get that information as well as the student answer and prepare better classes. With this we can start a path to research furthermore about the usage of open answer questions to track the points in which the student is having troubles and by pointing to those missed or wrong steps we can provide a more efficient learning comparing to the current learning process they use currently.

#### 5.3.1. Indicators

- How many students solved correct at first attempt the exercise?
  - From 9 valid students (appendix B, user ids: 3,9,13,14,5,15,19,18,22), 4 solve the exercise at first attempt.

- How many students solved correctly after first failed attempt?
  - There were 3 students (appendix B, user ids: 3,14 and 15), failed the exercise at first attempt but made it correct in the second attempt
• How many students retried after failing?
  o There were 5 students (appendix B, user ids: 3, 14, 5, 15 and 22), that failed the exercise and 3 students retried, and all that retried got a correct answer, and there were 2 that didn’t try more.

• How many improved results after failing?
  o Those that retried got the answer correct, 3 students in this case as showed in the previous question.

• How many valid students registered?
  o The platform has 22 users registered but only 18 are valid, the others are not valid because it’s my personal account, professor, friend, and an unknown user that hasn’t been accepted to the platform (Appendix A, id: 20)

5.4. Summary

We can see that many EdTech platforms offer learning options with existing assessment tools meanwhile none has showed open answer approach as we present in this project, besides with our evaluation based on demos at school and letting students register and login the website we can see that there students trying to use the platform, some of them were able to solve the exercise at first attempt and the interaction with the answer area wasn’t too hard, some that failed the exercise retried and those that retried successfully replied in the second attempt, we can assess in this very limited scale that somehow that the 5 students that failed, 3 students were successfully helped leading them to correctly reply the question.
6. Conclusion

This project has showed that personalized learning is becoming a trend, a tool more and more desired by schools, but also for colleges and EdTech learning platforms, because the students want to save time in studying by more efficiently and effectively processes, and this can be achieved.

The aim of this thesis has been to create such tool that enable a more efficient way to prepare the students for national exams, by providing the right information, in time, for students and professors, the goal was to ensure that this approach has not been yet taken by the major EdTech platforms as we saw in the comparison charts.

It is possible to verify that through open answer questions as developed can display the steps that the student has missed and help the student to understand how to solve an exercise. Besides that, this individual info and instant feedback can be passed for the professors so they can understand previous to tests.

This system here presented is a prototype with some limitations, meanwhile it proved its way to start a correction model that can be useful for students and professors. Despite the limitations it was possible to see that the platform indicates student improvement, at least in a small scale.

6.1. Lessons Learned

It was a long path to achieve this point and lessons learned were several, pointing out some of the most important we have:

- Feedback from school’s ecosystem elements was positive, high school directors found it a very useful tool to manage classes, track results of students and predict grades on tests but also on exams;
- Students save time in trying to get someone to explain why they answer wrong an open answer question and how to make it properly;
- Professors found it useful too because it saves time from correcting student answers and have a better perception of what difficulties student have and thus, they can manage better classes;
- Parents also found it useful because it helps to track their children difficulties and help before tests.
- At Web Summit is was seen good feedback too from people that were parents, which had their kids at high school and found the platform useful to help students and train faster for exams;
- Also, some government entities were interested in having such platform to the public schools; additionally, investors were seeking to test it in other countries (because this project was focused in Portugal National Exams, but the algorithm can be applied to any time of answer);
- Besides there was interest too in bringing to corporate learning trainings, so students could train easily without instructor support;
We also learned that personalized learning is being more approached but through multiple choice and true or false questions the evaluation can be altered so the efficiency of it may be affected, in other hand with open answer in which the student has to write the reasoning it becomes more easy to understand the knowledge base of the student and guide the student properly to acquire better results;

6.2. Limitations

For this project there were several limitations but I personally am proud of what was achieved here, my main limitation was time, availability to talk with more schools and develop more features for faster question insertion that can be done, but in 2017 September started working and it became very hard to be able to develop more, anyway some improvements were made, like the design, and migrating the platform for Digital Ocean Droplet so the platform can be use anywhere in the world and easily demonstrated.

Anyway, limitations of this project are:

- The platform can correct answers, when it says that is right is completely right, anyway there can be false negatives, this means, the answer is right and is considered wrong. This happens because there are infinite ways to answer a problem but it is followed certain (specific) evaluation criteria even though there are possibilities to answer in a non-initially defined in first instance. In future work we tell how to solve this problem;

- The data in platform, due to having little time and few financial resources, the number of questions was small, and the number of users to test it was small, because the costs of usage can sky rocket and in average it has been costing 30€/month. Anyway, the goal of this project has been to demonstrate that it can correct student answers and that this feature doesn’t exist in other EdTech platform, at least in the major platforms that we analysed.

6.3. Future Work

There is lots of space to grow this project, mainly making it a business but in terms of this project another thing that could be done and to make this platform more robust and solve the problem of False Negatives is to make use of ETL (Extraction, Transform and Loading) tool, so in case a student asks for review the professor can accept that answer as correct and the ETL will add that possible answer as another possible one. This will make that with time with more the students answers the platform can identify more possible ways to solve that exercise.

In terms of making a project to sell it would require the development of the professor area, high school director area, administrative area, parents’ area. So, after this (that has more specific details later like handling payments, communication between users, etc…) it is possible to make it commercialized, being that my mid-term goal.
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## Appendixes

### Appendix A – Users table

Spreadsheet with the users registered in the platform and those who are valid students are highlighted.

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<th>Remember created at</th>
<th>Sign</th>
<th>Current</th>
<th>Last sig</th>
<th>Created at</th>
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### Appendix B – Answers table

Spreadsheet with the answers given in the platform and those who are valid answers are highlighted.

Due to the short period of time in class the student would use my login, I know which answer is from the student by date and time of the visit to schools.
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