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MMAI 803 Design for Good Project Paper	10 pages + 1 page Resources + 5 pages Appendix

INTRODUCTION

Education is a formalized approach of acquiring and proving the acquisition of knowledge and skills by following an institution's system. Learning, on the other hand, is a natural desire which comes from an individual's interests and curiosity. Learning is intertwined with social activities, decision making, reasoning, collaborating, and exchanging real-time responses. Thus, to increase the desire to learn, educators need to identify how students learn and how to promote learning, that is, capture their attention and keep them engaged (AI Grand Challenges for Education, 2013).

Challenges in current education system

According to UNESCO (The United Nations Educational, Scientific and Cultural Organization,) in 2018, the global average pupil-to-teacher ratio is 24:1 and 40:1 for low-income countries. Given a set of 24 to 40 diverse learning needs, learning styles and pace of understanding, this ratio makes it difficult for teachers to identify individual student's needs, mentor effectively at scale.

In addition, an instructor's ability to pitch teaching to the level of the student can help motivate the students in learning more and successfully improve their performance. To be an effective instructor, a teacher needs to be given constant feedback on the learner's understanding, strengths and weaknesses. In the current education system, this is not provided until after the completion of coursework or term, which might be too late for the teacher to re-motivate the student to enjoy learning a topic. This can often lead to higher student dropout rates or failure to even begin education.

To address these issues, we believe an intelligent system can be modelled to support individual learners so that they reflect on their achievements, predict student's requirements for extra support and attention, and help teachers plan supporting interventions.

For the remainder of our paper, we describe our definition for personalized learning, its challenges and benefits, design approach, short, medium- and long-term plans, required resources, and possible risks and their mitigation strategy.

PERSONALIZED LEARNING

What is it?

We propose a system based on Artificial Intelligence (AI) and big data analytics which offers a personalized learning experience, identifying **pace and path** of the learner and provides targeted instruction aligning to specific learners' needs and goals. When learning is supported by technology, we receive more frequent and immediate feedback throughout the learners' journey, which helps teachers build effective and active instructional strategies (AI Grand Challenges for Education, 2013).

Differentiated Pace

In a systematic education system, the teacher sets a common pace for all the students in class in terms of understanding and completion of tasks. This method does not suit to challenge 'fast' learners as they might find certain tasks easy, nor does it favour 'slower' learners as they struggle to follow challenges that are just outside of their reach. In our proposed system, we would like to identify the learner's pace and assign tasks accordingly such that we can the student desires and is challenged sufficiently, to learn the concepts they are being taught.

Differentiated Path

Differentiated path is the idea of using our system to provide a variety of methods to help students reach their learning targets. That is, assigning additional reading materials if the model identifies that the learner's way of understanding is through reading, or providing additional online resources to better reinforce concepts, fitting the specific learner in question. This customizable approach is distinct from traditional teaching methods where everyone follows a one-sized learning path, with only little regard to their strengths and weaknesses.

Why is it important?

The current environment of fixed classrooms, lectures, and static printed textbooks does not offer flexibility, or adaptation to the needs of the learners. Personalized learning based on AI techniques aims to give teachers useful information about their students' learning styles, abilities, and progress, and provide suggestions for how to customize their teaching methods to students' individual needs. Although the curriculum stays identical in the education system, our systems help teachers guide different student groups with individual requirements.

Benefits	Challenges
Assist teachers to identify learner's strengths and weaknesses by providing real-time feedback.	Educating many stakeholders involved such as students, parents, teachers, school board, Ministry of Education, etc.
Increase graduation rates by motivating students to learn through these individualized learning methods.	Poor integration of data systems, such as collection of various types of data and maintaining high data quality.
Provide equality between students by providing every learner with what they need to be successful regardless of their demographic, cultural, socio-economic background.	Time and funding required to design and develop a model that accommodates various types of students.

DESIGN APPROACH & METHODOLOGY

To design our model, we will use a user-centric approach to help us focus on what is important for the users. We believe the five-steps of this design thinking process, empathize, define, ideate, prototype, and test will help us think outside of the box and uncover new ways to meet users' needs. In this paper, we reached up to the ideation stage, but we do discuss the prototype and testing stages as well. Our approach for the five stages is as following:

1. **Empathize** - performed user survey and expert interviews to gain empathetic understanding of the problem we are trying to solve.

2. **Define** - using the information gathered in the empathy stage, the team worked on clearly stating the problem faced by the users and why it is important to solve.

3. **Ideate** - the team formulated real solutions and ideas around the problem at hand. This helped us evaluate the role AI and analytics will play within our design.

4. **Prototype** - develop an inexpensive and scaled down version of the product to help us capture the information necessary to process the design ahead.

5. **Test** - this will be an iterative process and results generated in this phase will help reveal insights that redefine our problem to better accommodate users' needs, come up with new ideas and learn more about users through continuous testing (Interactive Design Foundation, 2016).

Given the different education systems, privacy policies and diversity of learners in a classroom, we understand it is difficult for us to reach every student in the world. Therefore, we limited **the scope of our project to focus on high school students (grades 9-12) in the Ontario Public School system**. We believe high school students will benefit with our model because they are in the transition phase for big career decisions - moving on to post-secondary schooling. In addition, we believe they are more capable of adapting to new technology compared to younger age groups.
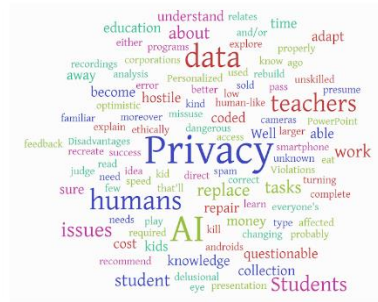
RESEARCH

For our design, we aim to use our research findings as a basis for evidence-based decision-making rather than hunch-based reasoning. We researched the current public school education system in Ontario, the processes and delivery methods that are being followed and the stakeholders involved in decision making. From our research findings we understood that there are several different delivery methods being followed in educating high school students however there still is a gap between education and learning. Given the diversity of the students in a classroom, neither teachers nor students believe that the current processes are being effective enough. In addition, we researched on the AI-based learning solutions available in the market currently that are trying to solve a similar problem. Appendix A – Research, details the results of our research findings.

INTERVIEWS & SURVEYS

To better understand the problem and to have a deeper comprehension of everything that is involved with the personalized learning experience, we conducted a survey for stakeholders. 33 teachers, 29 parents and 110 students participated from 15 different countries (Canada, USA, India, UK, Australia, Argentina, Germany, China, etc.) participated in our survey.

Also, from our survey we learned that privacy is the main concern for both parents and teachers when it comes to using AI methodologies for data collection and storage. These results are shown below (Figure 1) in the word cloud. We will be taking data privacy and security into strong consideration while designing our data repository.
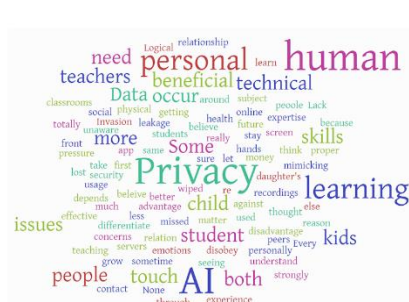
Figure 1: Word cloud of stakeholders' privacy concerns

Another important thing we learned from our survey result is the likability of different data collection tools. Use of Natural Language Processing (NLP) model to evaluate student's work is the most liked methodology while video and audio recording devices are the least liked by our stakeholders, as shown in Figure 2.
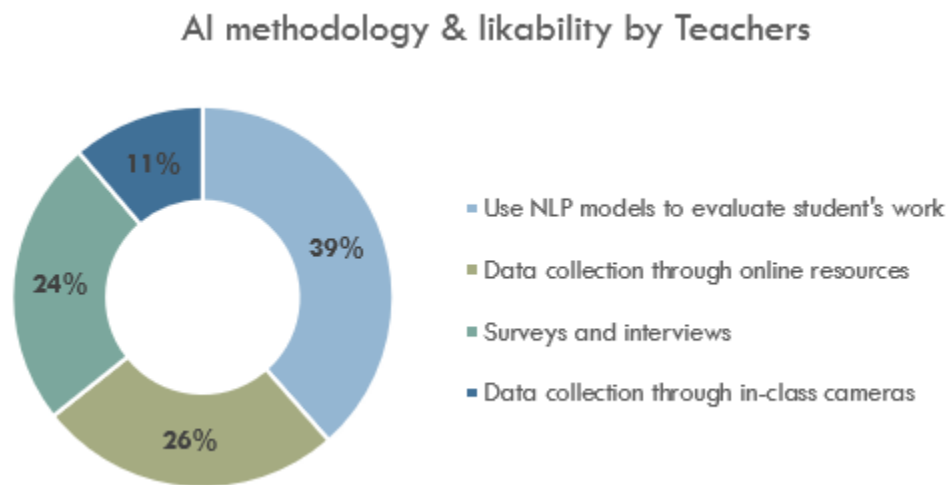
Figure 2: Teachers' likeability of AI methodologies in classroom

Based on the likeability of NLP models in our survey, we interviewed Dr. Stephen W. Thomas, faculty member at Smith School of Business, specialized in Big Data, NLP, Machine Learning, to understand how NLP can be used in the first phase of our project.

According to Dr. Thomas, NLP can be used to measure the writing style of a student through the readability matrix technique. This method provides scoring based on metrics like structure, clarity, tone, sentiments, size of vocabulary, persuasion etc. With the help of these scores we can identify the top and bottom metrics of individual students and provide necessary resources to help them perform better. In addition, we can give feedback to teachers regarding the areas they can enhance their delivery methods to better engage students.

POTENTIAL RISKS AND MITIGATION STRATEGY

Performance (Design and Learning biases)

AI models themselves can create problems when they deliver biased results. The team has identified two main biases - design bias, where the developer ingests their own biases in the AI model. Secondly, the learning bias, where the machine learning algorithms are being trained on biased data. To avoid any performance biases, we need to ensure high-quality data for training and testing of the AI models.

Security

Student's personally identifiable information (PII) data, if not securely stored, can result in a data breach. Secondly, the distortion of individual data/information leads to digital defamation. To mitigate the security risk, we need to have a security framework by giving restricted access to all the stakeholders involved.

Control

Our objective of introducing the AI personalized learning model is to ease the burden on teachers for evaluating tons of exam papers and engage with students. However, it may lead to the impression that the AI model is taking control of the teacher's role. To avoid teachers over-relying on the AI model evaluation role, the final say on the grades and evaluation process is still with the teacher. The control remains with the teachers and not with the AI model.

Ethical

A lot of data is required to train the AI model, and there are chances that student's data collected can be used for commercial purposes without the consent of the parents. To address the concern of the student's data privacy, parents will be informed about the data which is collected and how it will be used. If parents are not comfortable in sharing their child's data, they will have the option to opt-out.

Economical

A significant amount of resources (financial, technical resources, time) is required not only to deploy this technology successfully but also to maintain it. If these resources are not appropriately planned, our plan will not realize its return on investment and benefits. There are few steps we can adhere to so that we do not run into financial viability of the project. First, have a separate budgetary allocation for maintenance and new advanced technology. Secondly, invest in time to train the Teachers to make them acquainted with the AI system.

Societal

Given the impact our model brings to the education system and the stakeholders involved, it is apparent that families who are accustomed to "traditional" methods of education, i.e. human teacher-student relationships, may find it difficult to accept and can create some hurdles for our model to be successful in the long run. To make our stakeholders comfortable with the idea of personalized education, there will be seminars/sessions about the benefits of AI in education and make them aware of the risks and its mitigation plan so that they can make informed decisions about AI in education.

CURRENT MARKET DESIGNS

When it comes to evaluating and assessing student's performance using AI, a few notable AI-based market solutions currently available include **Century Tech** (AI enabled lesson planning to create individual pathways), **Bakpax** (computer vision for grading assignments), **Squirrel AI** (AI powered custom curriculum), and **Hanwang** (using cameras to take roll call and assess students' attention). Details regarding these solutions are presented in Appendix B.

The biggest distinction between above noted solutions and our proposed idea is that current applications are all focused on adaptive learning where the same content from the course is delivered using AI based on what the students know and don't know. In contrast, our focus is on creating a unique and personalized learning experience for each student where the pace and path are tailored based on their individual needs to keep them engaged. For example, we will personalize learning by not only predicting when a student is ready to learn the next topic in statistics, but also delivering the same concept in the context of baseball video to a student who enjoys sports or recommending a hands-on exercise to another.
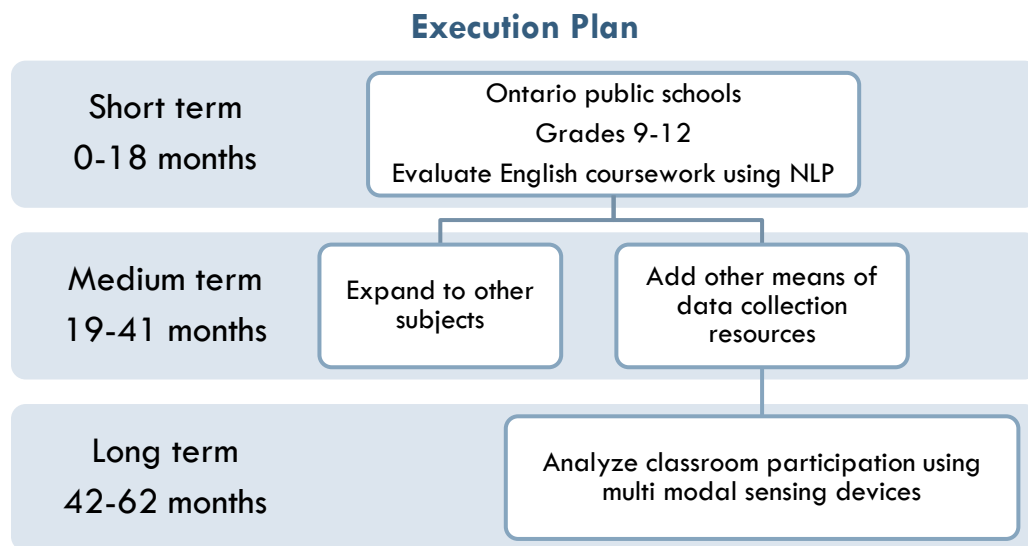
Regarding the use of cameras and facial recognition in a classroom setting, the concept is still in its early exploration phases in the education field. Comparing our proposed system to that of Hanwang's, we expect to use similar technology, but the purpose of using it is completely different. We intend on using facial recognition to track emotions with respect to success of content delivery and understanding levels. Data collected would be used to further refine the pace and the context of the educational concepts for each student.

We believe that our idea is distinct from the existing solutions to benefit both teachers and students in the long run.

PLAN OF EXECUTION

Our project plan is divided into short, medium- and long-terms such that it aligns the users' likeability noticed in surveys we conducted. These plans only apply to students who are willing to participate in the Personalized Learning experience. That is, if a student is not interested in this system, they will have the option to opt-out and continue their education in 'regular' format. To validate the impact of our project, stakeholder surveys and interviews will be conducted in every term. This will also help us understand any change in their view, trust, and likeability of AI implementation in the education system.

Execution Plan

Short term **0-18 months**	Ontario public schools Grades 9-12 Evaluate English coursework using NLP
Medium term **19-41 months**	Expand to other subjects / Add other means of data collection resources
Long term **42-62 months**	Analyze classroom participation using multi modal sensing devices

Short term

We will start the short-term as soon as we get the official project plan approved. The primary objective of this phase is to evaluate students' strengths and weaknesses in one subject - English - and provide real-time feedback to teachers such that they can accommodate students based on their needs. To achieve this, we will utilize NLP techniques to evaluate coursework including essays, book reports, and short answer responses. We chose to evaluate English coursework in this phase because it is a requirement for all grades and all levels of education (eg. applied, academic).

Medium term

Once the short-term goals are successfully achieved, we will move to the execution of our medium-term plan. The primary objective here is to expand the use of AI to evaluate additional courses taught in high schools. In order to evaluate students' performance in other subjects such as science, maths and social studies, we would need to collect additional data to train our NLP model. The team plans on utilizing 3rd party apps such as Plickers (formative assessment tool for classrooms), MasteryConnect (performance

benchmarking tool), and Nearpod (platform for pre-made interactive lessons) to assign additional work and collect data accordingly. Furthermore, part of our execution plan is to also deploy a CNN model for image processing to evaluate quantitative coursework.

Long term

Long-term will be implemented once we have achieved our milestones for short and medium-term. In this phase we will install multi-modal sensing devices, such as cameras, in classrooms to capture the teacher and students' various motions. We will process the data collected, develop facial recognition and sentiment analysis using deep neural network models to understand students' interest and focus towards the course material and delivery methods. A detailed timeline of the entire plan is presented in Appendix C.

RESOURCES REQUIRED

Stakeholders' approval - It is important for us to reach out to all the involved parties and educate them to get their approvals to implement AI in a classroom.

Sufficient Funding - It is important for us to have sufficient funding for execution of the plan including training teachers on using different tools.

Technical resources and expertise - Technical resources including team, compute power, and data storage system to build AI models and integrate different systems will be required in all phases.

Access to students' coursework - Access to students work in various subjects throughout the years of high school is very important as it is the input data during short and medium terms.

Partnership with EdTech companies - We require partnership with EdTech companies for launching their apps and accessing raw data collected by these app will be needed to utilize that data for our models.

DERAILMENT

We believe these four factors can cause potential derailment to our project plan.

Inability to meet education standards - Ontario has differentiated levels of instruction – open, applied, academic, IB, AP, etc. Not being able to meet these standards would cause issues with providing proper feedback to teachers regarding their students' needs and abilities.	**Privacy and Security Concerns -** Violation of MFIPPA and Educational Act as well as inability to satisfy stakeholders' concerns with data privacy, especially in long-term where many of them do not feel comfortable already, can cause project derailment.
Lack of Funding - Lack of sufficient funding is a major concern in all phases (short, medium, or long term). Without sufficient funding it would make project implementation difficult including hiring experts, training of teachers on utilization of models, devices and apps in the classroom.	**Poor Technology and Expertise** - lack of specialized skill set and proper technical resources can delay the deployment of our model.

SUMMARY

During our research we learned that only 65% of the students that completed elementary schooling enroll in upper secondary school. Given the diversity of the students in a classroom, neither teachers nor students believe that the current processes are effective enough. If education is a basic human right and influences human and social capital, economic and income growth, our phased approach to implement AI based models can help motivate students to learn more and successfully improve their educational outcomes. We propose a design thinking approach in developing our AI solution, starting from a user-centric approach, working to identify the learner's pace and assign tasks accordingly such that the student is challenged sufficiently. To aid educators, our personalized learning AI techniques aim to give useful information about their students' learning styles, abilities, and progress, and help customize their teaching methods to the individual needs.

In implementing our phased approach, we will work to address performance risks, biases, and stakeholders' approval, including students, teachers, community, guardians, and school administrators. The ultimate goal of our model is a further extension of the short- medium and long-term plans, to be able to implement the system in a much wider audience and, at the same time adding more functionalities to help teachers and students.

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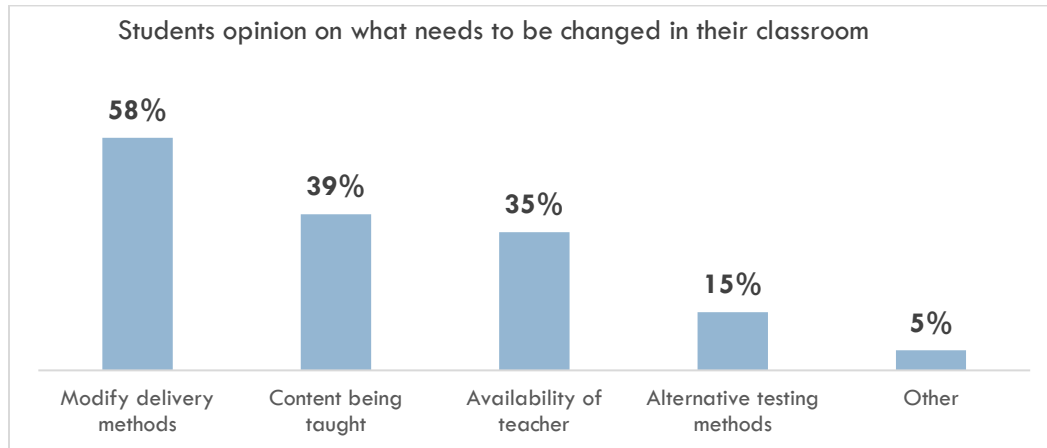https://www.gettingsmart.com/2018/11/how-teachers-and-leaders-can-promote-personalized-learning/
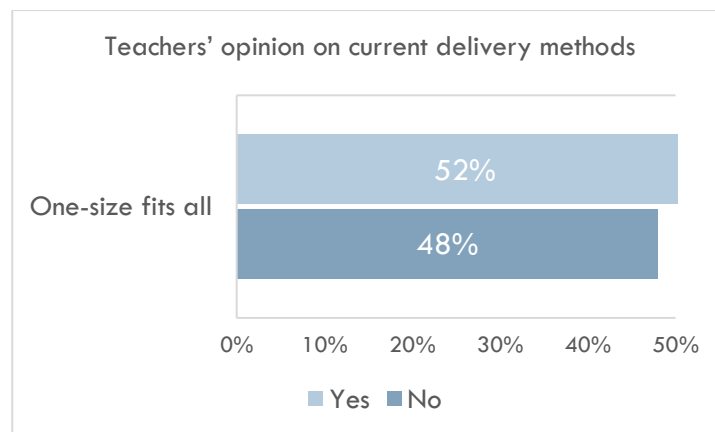
APPENDIX

A. Research findings

- Over the last 50 years, the expansion of schools and student enrollment rates has tripled including in low- and middle-income countries (The World Bank, 2018). In many high-income countries, primary and secondary education has become free of cost as it is seen as a basic human right. However, this expansion to date fails to consider that more schooling may not produce more learning.

- During our research we learned that only 65% of the students that completed elementary schooling enroll in upper secondary school (The World Bank, 2018).

- Students learn in various ways including reading books, watching videos, working in teams, etc. They learn more when they receive help from present and engaged mentors who respond quickly in ways that reflect deep understandings to the learner's background, strengths and weaknesses (AI Grand Challenges for Education, 2013).

- When students have a hard time following and understanding what is being taught in class, they tend to get distracted and lose focus. Particularly those who are disadvantaged socioeconomically or have learning disabilities (The World Bank, 2018). This can often lead to higher student drop out rates or failure to even begin education. According to a study, 90% of students with learning disabilities who repeated a grade ultimately dropped out of school (Accenture, 2018).

- It is important for teachers to receive professional training even after being placed in their roles. This will help them understand current needs and available resources to be a better instructor. The United States of America spends about $2.5 billion a year on providing professional training to the teachers in their education system (The World Bank, 2018).

    - However, in many low- and middle-income countries teachers' salary itself is considered the largest budget item in their education system, therefore, restricting the training provided to them. They take part in some professional development, but much of it is inconsistent and overly theoretical.

- As part of our research, we asked high school students to rate how often they lose focus in class on a scale of 1-5 (5 being often), and 76% of them ranked 3 or higher.

- To get more insight on why they lose focus or interest we asked their opinions on what needs to be changed in classrooms so they can learn better. 58% of the students said the current method of delivery is not motivating them and needs it to be modified. Plot below shows the results of our findings.

Students opinion on what needs to be changed in their classroom

58%	39%	35%	15%	5%
Modify delivery methods	Content being taught	Availability of teacher	Alternative testing methods	Other

- Currently in Ontario's public school system several delivery methods are used to accommodate various types of learners. However, every student is expected to do all the activities regardless of their strengths and weaknesses.

  o Some of these methods include: Black/white/smartboard instructions, textbook, novel reading, presentations – students, guest speakers, seminars, Group discussion and activities, research projects, labs, and ELearning – Khan academy, YouTube, GeoGebra.

  o Then we asked a follow up question to understand teacher's perspective if they believe that applying same delivery methods to all students works and the following plot is the resulted output.

Teachers' opinion on current delivery methods

One-size fits all

52% (Yes)
48% (No)

0% 10% 20% 30% 40% 50%

■ Yes ■ No

- The 'Municipal Freedom of Information and Protection of Privacy Act' (MFIPPA) sets out the rules that school boards and other municipal institutions must follow regarding the collection, use, retention and disclosure of personal information. In addition, The Education Act is the main law under which schools and school boards operate. It governs how education is delivered to students in Ontario's publicly funded school system. The Education Act contains a number of sections relevant to access and privacy, including rules about access to and the collection, use and disclosure of information contained in the Ontario Student Record (OSR).
  - Therefore, it is important for us to follow these laws, rules and regulations in order to move forward with the project. Any violation could cause a complete shutdown of the project.

B. Current Market Designs

1. Century Tech: A company based out of the UK which uses AI to enable data-driven lesson planning by understanding how students learn and accordingly, creates individual pathways containing micro-lessons called 'nuggets' to address gaps in knowledge.

2. Bakpax: Established in the USA, Baxpax uses computer vision to translate handwriting to text and grades an assignment within a matter of seconds. The application is able to provide insights into the collective performance of the class and where students need help.

3. Squirrel AI: Squirrel is an AI powered adaptive education provider or "AI tutor" in China. From a short diagnostic test, Squirrel is able to build a curriculum for a student outlining where they excel and what needs to be worked on. As students progress, the model updates and adjusts the curriculum accordingly.

C. Project Plan
Short term timeline

- Assuming all the schools are on board, we estimate 3-4 months (January-April) timeframe to collect past coursework data and prepare it. This data will be from students currently in grades 10-12 as they will have at least one academic year's worth full input data.
  - There are approximately 1.2 million students in Canadian Public high school system in the 2019-2020 academic year. So, if we collect 4 essays from each student, that would be

4.8 million essays plus book reports and short answer responses. That is a total of over 10 million pieces of information.

- We assume it will take us 2 months (May-Jun) to develop, train and test our initial NLP model, assuming the model works and provides reliable results.

- We would like to launch our pilot project during summer school as there will be a limited number of English courses being offered and fewer students attending school. This will give us an understanding of the model's capabilities. Using this the results from this phase, we would like to gain the trust of our stakeholders and gather feedback of user stories and functional improvements

- Finally, we will expand the model to all schools during academic year, fine tune it as needed and keep all stakeholders informed on the progress.

- Since students entering in grade 9 will not have any prior coursework that we can evaluate, we will use transfer learning to analyze their work for the first academic year.

Medium term timeline

- Firstly, the team will allocate 2 months (July-August) for collecting feedback from the stakeholders and gaining approvals for the implementation of our medium-term plan.

- After the necessary approvals are obtained, we will begin collecting data for additional subjects starting in September. At the same time, we also plan on initiating the partnership conversations with the 3rd party applications including MasteryConnect, Plickers, and Nearpod to use their platforms as supplementary data collection methods.

- As the next step, the implementation of 3rd party apps across schools along with integration of data into one central repository will begin at the start of next year in January and is expected to take 6 months till June.

- Once all the necessary raw data is collected, we will move onto the building of a CNN model for handwriting recognition and enhancing our previously built NLP model in order to prepare them both for evaluating other subjects such as social science, science and maths. The estimated timeline is 3 months from July to September.

- Our goal is to launch a pilot test of the NLP and CNN models to a select few schools starting September. After evaluating the performance, we will move to a full-scale implementation across all the schools in our purview. The team has allocated a total of 9 months to this step.

Long term timeline

- In around 42-47 months, procurement and installation of the motion-capture devices would commence.

- After about two months, data coming from the devices would be processed and analyzed. A deep neural network will be developed or trained to perform the task.

- As with any other data, a central database repository would be utilized as the data warehouse for future analysis and reference.

- After around 62 months, if all methods, steps, analysis, and results meet the standards, the program would be expanded to other schools in the area, district, and region.

- We foresee our long term plan to be around five years and onwards with deployment and implementation.