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The 'AI in Education' lab recommendations paper

(An English Summary)

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In September 2019 the Research, Development & Initiatives section of the Israeli ministry of education has initiated a 'lab' dealing with Artificial Intelligence and Big Data in education.

A 'lab' is an R&D project, that is usually 2-year long, which' purpose is to provide applicative knowledge and models for a systemic educational challenge that the Israeli ministry of education highlights as a priority. A 'lab' will most likely consist of selected schools, academic experts and ministry of education executives working together in a running R&D effort that combines techniques of design thinking and action research.

The 'AI in Education' (AIED) lab was established with the goal of creating a knowledge base that will serve as groundwork for the Israeli ministry of education to create a strategy regarding the use and the development of AI technologies in the educational system.

To reach this goal, the lab created a partnership that included:

- 10 selected schools, from all age groups.
- Two relevant units from the ministry – the Technology in education authority and the 'unifying databases' project.
- 5 technological and/or academic partners who either wanted to experiment with their technologies in schools, wanted to partner with schools as development environment, or provided consultation for the design of AI/Big Data systems.

The lab worked in several activity arenas, each created a partnership between educational and technology professionals. The arenas (which will be described later) performed experimentation in different aspects of the overall challenge, and through these experimentations, and through an ongoing learning process of what goes on in the world, insights were obtained.

In August 2020, at the end of year 1 of the lab's work, an interim document describing the work process, lab's insights and initial recommendations was submitted to the ministry of education.

This paper presents the main points from that document in English.

The lab's activity arenas

4 activity arenas were performed in the lab during 2019/2020 school year:

The social robot arena

A partnership between Dr. Goren Gordon, the head of the curiosity lab at Tel Aviv University, and two schools from the lab. The social robot designed by Dr. Gordon allows the facilitation of small group learning activities. The arena focused on:

- Exploring the pedagogic "positioning" of the social robot. For example: it has been assumed that the robot is best used as a "learning station" in an active and diversified classroom, and not as a "stand alone" learning experience.
- Breaking down pedagogic decisions through the designing of learning activities. For example: how should the robot address wrong answers? (decision: be authentic and say it is wrong). How should the robot address low-involvement students? (one strategy: ask them a "what is your opinion?" question), and so on.
- Design a friendly interface for teachers to design lessons with the robot – which was a joint effort of the teachers and the researchers.
- Evaluate the effectiveness of the learning process (this goal has been tempered due to covid-19 constrains; a new experiment as such will begin this year with a robot-imitating software that works through Zoom).

An evaluation & feedback system for quality of writing (NLP) development arena

A partnership with an elite technological IDF training program, in which schools and programmers-in-training from the unit went through a process of training a system with NLP algorithms to be able to evaluate 4 characteristics and qualities in an argument paper that students write. More than 1000 essays were used to train the system, and its applicative pilot is scheduled for this upcoming year.

The 'Big Data' use-cases arena

A partnership between 4 schools, a hired data-science expert and the 'unified databases' project of the ministry. The arena was dedicated to come up with needs raised by schools that existing and non-existing data applications can support. The work in this arena was mainly speculative, yet on several cases initial data-models were created.

The prominent use-cases defined in this arena were:

- Designing a '360 view' about students' progression and activity
- Identifying students' learning preferences through a combination of "test lessons" (a series of pre-designed lessons that exemplify different learning modes), student's self-report and teachers' observation.
- An ongoing learning assessment system evaluating effectiveness of intervention programs on different students and helping make better future matching decisions for intervention programs for different students.
- Early diagnosis of emotional distress based on various school parameters.

One of the major insights coming out of this arena was that the "conventional" data being gathered (attendance, grades and so on) has little value when meeting schools' deeper pedagogic needs.

The 'AI in learning' mockup arena

A technological expert has been recruited and worked with schools in developing ideas and mockups for AI-powered systems that could benefit learning processes and school needs.

The prominent ideas that were developed were:

- A "short-talk arranger" system – a systems that assigns teachers with making short 3-5-minute talks with different students throughout the week and documenting their impressions from the talk. The system is designed so that all students are "covered" and approached in a timely manner, and that teachers' impressions help create a dynamic well-being and learning climate picture of the school (and with the potential to detect students in emotional distress early, depending on the ethical decision of storing the personal student impressions of the teachers).
- "Class pulse" – a system which uses either video and/or audio to identify students' engagement levels in classroom and provide feedback to teachers about the practices that help them raise positive engagement and hider it. Upon ethical considerations the system can also provide feedback to students regarding their engagement level.
- A system that identifies violent incidents and behaviors in the making and "sends" a teacher to intervene.
- Improving English understanding and vocabulary through personalized podcast designation based on personal interests, accompanied with personalized assignments.
- A "self-awareness" and reflective app that guides students in their choise-making situations and helps them identify patterns about themselves from different choices.

For the upcoming year there are several more arenas planned, some of them might be: Chatbots that help 12-grade students prepare to their matriculation exams; a virtual environment for doing physics experiments; and more.

The basics of AI development for educational policymakers

A section dedicated to providing the basic understanding of what is involved in developing AI systems to educational policymakers. Main points and concepts:

- Artificial Intelligence – an overall concept for computer systems that are able to perform functions they were not directly and specifically programmed to do (meaning systems that can learn and improve outcome, identify patterns, make predictions and more).
- Big Data & data-science – a concept describing the field of planning the gathering, storing and processing of large amounts of data and harnessing it for new uses.
- Machine learning, Deep learning, Neural networks – are all techniques and groups of algorithms that are used in AI systems and underly the system's ability to "learn" and use constant high-level statistical processing to make more accurate predictions and outcomes.
- Structured vs. Unstructured data – structured data are usually numbers or other discrete or continuous variables. Unstructured data are more complex phenomena that is perceived by sensors, such as a picture, video or audio.
- The Training process of AI systems – usually involves "feeding" the system with "training data sets", which are matches of variables that present the system with the kinds of connections it needs to make. The more the data is complex, unstructured or demands handling plenty of variables, the larger the "training set" has to be (sometimes to the degree of hundreds of thousands and millions of exemplary matches).
- Common AI applications: predictions, advanced data mining, NLP, computerized vision, voice recognition
- AI technology is still in its ANI (Artificial Narrow Intelligence) stage, meaning it can be trained to perform very specific and well-defined tasks. AGI (artificial General Intelligence) is very far away.
- When considering the development of AI systems and the cultivation of an AIED industry echo-system, one should understand the 3 pillars of AI development:
    I. Data – plenty of it and of good quality

II. Algorithms (and programmers) – either creating a new algorithm (which demands a high skill level) or applying existing algorithms, like from Azure, Tensorflow etc.

III. A good idea and good characterization – being able to identify and characterize the needs, and concoct the proper "package" of data, algorithms and outcome design.

The current state of AIED

Existing AIED systems roughly, yet not exclusively, "fall" into the following three categories:

Enriching the learning experience	Learning analytics	Adaptive learning systems
-		
Minecraft framerspace Kidsense Semantris Quizlet Data_playground	xPro Beestar LOCO-analyst solutionpath edgecanvas schoolday	SquirrelAI Knewton TailorED Cognii Mathiau cerego 4littletrees bettermarks

There are different AI-powered systems that are designed for educational uses or are used in education (even if intended otherwise) that do not belong to the above-mentioned categories, such as:

- iTuotorGroup which matches students and private tuotors.
- A system developed by Pearson which uses NLP and can give grades to written texts
- Magisto and Autodraw that help easily create videos or drawings and are used by teachers and students.
- And more

Trends and developments that can be seen in the next few years might include:

➢ A growing use and efficiency of adaptive systems (aided by the enormous growth of available data), and the heightened inclusion of sentiment detection abilities to heighten personalized learning experiences. A system like the Chinese

"SquirrelAI" is in position to accumulate plenty of data and add new features to lead such a development.

- The growing use of adaptive computerized systems will grow the use of learning analytics systems – which in today's education fail to capture the classroom learning experience but when more learning will be done through a human-computer interface – more data will be potentially gathered.
- More AI-powered learning games & gamification, and systems that can make learning more experiential will be developed and used (for example: talking with avatars of historical figures, Minecraft-like games for learning, use of Augmented Reality learning objects and more).
- NLP systems will be better (especially in popular languages such as English, Chinese and Spanish) and be able to evaluate and provide feedback to students' assignments.
- Systems that cut down administrative chores for teachers (grading, attendance etc.) already exist and the use of them will increase as they will become cheaper.

It is worth mentioning that smaller countries with unique languages (like Israel) might have slower development of AIED systems and abilities (NLP, adaptive systems) due to the lesser economical reward for entrepreneurs and the need to establish a complete local language supporting echo-system of data.

The category of **AI-powered adaptive learning systems**, which captures major attention and resources in the AIED world, also creates a dispute for its educational value. These systems and the outlook for their development seems to have some advantages and some disadvantages.

Among the advantages:

- They are starting to outperform human teachers and self-directed learning in helping students acquire more structured skills and knowledge, such as mathematics and basic knowledge in various disciplines.
- They offer the promise of helping underachieving students to "catch up" faster.
- They offer possibilities to reach students from remote areas and also to compensate in places where there is a shortage of teachers and schools.
- In emergency situations, such as covid-19, they can serve as a valuable resource for long-distance learning and educational continuity.

Among the disadvantages:

- At least for today – many of the existing adaptive learning systems are not good enough – they suffer from a lack of quality learning objects and their adaptiveness is based on too narrow and questionable variables (mainly students' level of performance).

- They require students to spend a lot of time online and in front of a screen, which is not necessarily the best educational idea.
- They raise a lot of ethical questions regarding students' privacy and the gathering of use of data about learners.
- Adaptive systems are not suitable for developing higher order thinking skills. This educational challenge demands the presence of a mediator-teacher who can better understand the complex thinking process of the student and conduct a dialogue with him.
- A big potential downside of adaptive learning systems is that they might diminish self-directed learning skills by "expropriating" many of the executive learning functions from the student to the system (as happened to navigation skills with today's advanced GPS systems).

Looking a little further to the possibilities that are not ripe yet but could emerge in AIED, it is worth mentioning:

- Advanced curating, inquiry, research and knowledge-editing systems that can support research and inquiry-based learning
- Virtual guides and/or learning assistants. Those already exist in small scales, but its level of efficiency still doesn't allow the experience to be persuasive and natural enough. This will probably change.

AIED policies from around the world

Based on a policy paper issued by UNESCO (2019)[1] and other sources, a review of things that happen in different places is offered. Some of the more prominent ones covered are:

- **China** has set a goal of becoming a world leader in AI technology in general, and AIED takes a major place in this strategy. The AIED benefits from a policy decision that every county will invest at least 8% of its budget in EDTECH, so there is an opportunity for many entrepreneurs to supported. On top of that, the large population makes development worthwhile economically, and also allows for vast amounts of data to be collected quickly.
- **The Emirates** invested in creating and maintaining a comprehensive, personalized educational database (many parts of which would probably not be accepted by the general public in most western countries). The database allows to compare and analyze many variables, juxtaposing student performance,

[1] Pedro, F. et al. (2019). *Artificial intelligence in education: challenges and opportunities for sustainable development*. UNESCO publication. https://unesdoc.unesco.org/ark:/48223/pf0000366994 . Retrieved on October 8, 2020.

teacher performance, usage of online resources, feedback questionnaires and more.

- **Uruguay** promotes EDTECH solutions for education in remote populations and students from lower socio-economic backgrounds. Within that framework, they promote the use of adaptive learning systems, especially in math.
- **Brazil** is also active in promoting EDTECH initiatives, with an emphasis on academic level online learning resources, and in relation adopts complementing AI-powered personalized learning components.

Major obstacles in promoting AIED in Israel

- The EDTECH market in Hebrew is small, dominated by one big player and possibly not rewarding enough for entrepreneurs (some of Israeli AIED initiatives are developed in English to begin with).
- AIED systems raise many ethical issues, such as student privacy and "false positive" issues, and wrong designs might take efforts of the sort backwards due to public and legal reactions (as happened with the American "InBloom" system).
- The data infrastructures in Israel are not comprehensive enough and of proper quality (in terms of validity and reliability) to support all kinds of developments.
- Educational professionals tend to adopt new technologies slowly.
- Many AIED developments require a "child in front of screen" setting, which is still (and probably with a great deal of justice) considered as an undesired educational mainstream setting.

Recommendations for the consideration of the ministry of education

From the experience and the knowledge-gathering done in the "AI in Education" lab, four policy challenges were identified, and initial recommendations were suggested:

1. Education for a world rich with AI & Big Data

The first challenge to be considered is not necessarily related to AIED development, but to prepare students to the meaning of living in a world which is rich with AI & Big Data systems. This challenge has 2 faces:

a. Promote & update learning subjects such as math, computer-science, data-science, physics and such with AI-related content, so that a reserve of skilled people will be able to learn and be proficient in the AI-driven technology industry.
b. And even more importantly… promote educational programs that deal with critical thinking, ethics (especially with regard to technology), understanding concepts of knowledge and data, understand the scientific process and have a good-enough base of math & statistics (especially in relation to social sciences), so they will have a solid base to cope, understand, form an educated opinion and feel competent in an AI-rich world.

2. Reconsider and reinvent current policy for educational data

Based on the "unifying databases" project – initiate a strategic thinking process regarding which educational data is now and should be gathered, organized and managed, so that educational database will be much richer than it currently is and contain more data which is of clear value to teachers and schools.

The criteria by which the variables to be gathered can be considered are:

a. Deeper and richer data about educational phenomena, such as the learning process, well-being and more.
b. Data which is compliant with ethical considerations, such as avoiding collecting personal data that can be misused (for example: emotional data, personal performance predictive data and more).
c. Data which can be collected systematically and with not too big of an effort.

Among the ideas emerging from the lab's work (presented in an earlier section), there are several suggestions that could meet these criteria.

3. Cultivating an entrepreneurial AIED echo-system based on educational-technological dialogue

Under the assumption that promoting Israeli AIED development is valuable, the government should take part in incentivizing entrepreneurs to engage in it and to ensure that such initiatives are done with a proper dialogue with educational professionals, so it will meet educational needs and increase prospective usability and effectiveness.

This can be achieved through the creation of supported development frameworks (like hothouses, challenges, accelerators) that enable technology developers and educational professionals to interact, and to entrepreneurs to be able to have good conditions –

such as having partnering schools to test and refine their ideas, receive data and test early developments.

This will be one of the major functions that the lab is going to fulfill entering the 2020/2021 school year – by offering an "umbrella" for several initiatives as such, providing partnering schools and pedagogic consultation.

4. "Entering the game" – an intended endeavor for initial development

For a vibrant AIED industry to further develop in Israel (there is one existing, but still relatively small compared to the technological development potential in Israel) – the ministry of education should initiate such developments through bids. This will generate an interest and promote both the AI industry's awareness and involvement with education and understanding of educational needs, and the education system's understanding of AIED and gaining experience in characterizing and adopting it (which is what the lab is trying to do, but in a relatively small scale).

Good places to start might be such that answer needs of teachers and schools, are ethical in nature and relatively easier for development. For example:

- Buying, translating & implementing existing systems that are not overly expensive or heavy to translate and use (such as 'schoolday' that deals with school climate and students' well-being)
- Practice chatbots
- Encouraging existing Israeli systems (like 'TailorEd' and 'TribeEffect').
- Buying/developing AI-powered learning systems for improving English studies
- Developing AI-powered learning games, that are potentially cheaper to develop
- Considering adding adaptive abilities to existing Israeli online learning resources

Artificial intelligence is a technology on the rise. It disrupts and changes many industries and sectors with new possibilities. The question of its growth in the education sector is a question of time. The 'AI in Education' lab is an effort by the Israeli ministry of education to be on top of the trend and be a leader in adopting and developing this technology, in a way that is ethical and related to the real needs and potential of the education world.

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