

Education in the Digital Era

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Preface: In 1991, Gidi Shenholz and his partner Tzachi Zloter left their jobs in the Israeli military industry in the field of electronic warfare and founded a start-up company called Pegasus Technologies Ltd. They used technological principles and ideas from the military field in which they were involved, and developed an ultra-sonic tracking system that follows the movement of bodies in a small space. The tiny tracking system was incorporated into the digital pen system that they brought to the market in the early 2000. A pen that looks and feels like a regular pen, writes with an ink refill like a regular pen on paper or a notebook, but while writing everything written is transmitted to the computer wirelessly because the system actually followed the movement of the tip of the pen.

The use of the digital pen was mainly intended for the banking market, medicine and education systems. The company decided to focus on the Chinese and Japanese market since using the keyboard for typing on a computer is more complicated there, as they have 2000-5000 different characters. Therefore, it seemed that writing with a pen that converts the letter to a Word document in combination with handwriting recognition software was an ideal solution for the needs of that market.

My involvement in the Pegasus Company began around 1992 when I made a documentary about Israeli start-up companies for the Israeli television, Channel 1 program "Mabat Sheni" ("Second View").

In 2010 the company was acquired by a Chinese company Yifang Digital. Pegasus was the first high-tech company in Israel to be acquired by a Chinese company. The Chinese Company focused on developing additional products based on the existing technology and used their market channels in the Far East, Europe and the USA for sales. I started working in the Yifang company offices in the marketing department and was mainly involved in marketing, exhibitions and PR.

My work at Yifang in those years exposed me to the evolvment and quick growth of the education market following the integration of technologies into it, which led to a real revolution in the field of teaching and remote teaching. In this article I will review those developments and changes in methodology in the education arena due to the integration of advanced technologies in the education systems.

Brief History

In the first part of this article I will review the changes in the education systems and methodology following the technology innovations in the last 30-40 years.

Till late 80's of the previous century teachers were giving lectures in classrooms in front of certain number of pupils, using prepared notes, writing with a chalk on a blackboard, sometimes using a projector with transparencies and hanging maps on the walls. At the end of each lecture the blackboard was wiped out, used chalks were thrown to the garbage tray and the classroom was ready for next lesson. Homework was done by using books for theory and for exercises and the pupils were writing in their notebooks with ink pens and pencils.

The evolution was slow at those times and the first small change was the replacement of the chalks and blackboards (later implied that chalks might have caused cancer) with whiteboards and markers. This was still an analogue change which was more users friendly rather than bringing any significant change to the methods and the education systems.

The main change happened in the late 80s and early 90s when two things occurred. Firstly were the digital revolution and the use of computers, or to be more specific "the PC". The second one was the internet revolution which enabled quick and easy communication between distant computerized units. This change also enabled quick and easy access to data and information data base.

Classrooms started to accommodate digital whiteboards which later evolved into big displays and next step was displays with touch screens. This enabled an easy way to display content, text or formulas and by touching or annotating on the screen, to "write" on existing texts, add notes etc.

This also has caused a clear change in the methodology of how the teacher has prepared his lectures. He could have prepared a preset texts or presentations or formulas or drawings. Then he could present them in the classrooms and teach the lecture while everything was displayed on the screen. There was no need to write the content anymore on the board.

The fact that everything was digitized and supported by computerized systems enabled to save all the information of a specific lecture in a predefined space in a server of the school. The space was dedicated to this

specific lesson, and hence this information was now easily shared between all pupils for future use, clarifications etc.

From the students view point, the drop of prices of laptops and their increased computation power enabled students to have laptops (or PCs) due to their affordable prices. So the laptop or PC became a standard and essential tool in learning. In parallel the speed of typing increased and many students were using “blind” typing which enabled them to attend a lesson or lecture and type the summary simultaneously while listening to the teacher.

The phenomena of wide spread typing speed and the “blind typing” capabilities of the younger generation raised a question whether the traditional writing with ink pen and paper will be needed at all in the future or maybe shortly it will disappear. Bill Gates stated more than once, that although all the above innovations and the new capabilities of the computerized platforms really challenge the traditional writing, in his opinion it will never disappear.¹ The importance of taking notes with pens and paper was broadly discussed in many forums, channels and professional literature. See for example the essay by Claudia Hammond (BBC) or Bryan Kerr essay and Ran Walker on this subject.^{2,3,4} In this article I shall focus only on the advantages to the education systems using handwriting and not on the other aspects of writing with pen on paper which includes creativity, feeling the “human touch” of pen on paper, activating other parts of the brain, etc.

One may ask himself on which grounds Bill Gates has stated his declarations about handwriting with pen and paper, while his own company (Microsoft) at the same time has aggressively pushed to the markets the features of handwriting capturing on screens, with touch screens and using a plastic stylus. Seemingly it contradicted those statements.

The use of touch screens in all computerized platforms which included laptops, tablets and smartphones was widely spread in the first decade of the 2000s. In parallel high performance handwriting recognition software applications were presented to the market and together with the touch screens it seemed to be a winning solution. These enabled to write directly on the screens with a stylus and then convert into typed letters in the computers in Word document or similar applications.

But this was not enough and there was a clear need for writing with pens with ink refill or pens on pads which were connected to the computerized platforms. And this was exactly what Bill Gates (and others) meant when he said that statement.

So how the handwriting written with pen and ink would be captured and transferred to the computerized systems?

This challenge pushed many of the leading companies in the computers industry to find the solution for this need.

In China and Japan there was already an existing solution of this type from the late 80s. In China and Japan having 2000-5000 letters the typing on a keyboard was a challenge and not simple. As a solution they were using a small plastic pad (about 7X7 cm) and a small plastic stylus. The individual was writing a single character on the pad and with handwriting recognition software this character was identified and printed on the screen – as if he was typing using his keyboard. This was a limited solution which served a very specific need. But they did not take it to the next level of full text recognition etc. It served a very specific need due to their complex Alpha Beit system.

As mentioned above the handwriting through screen using touch screens technologies was implemented in most computerized platforms such as laptops, tablets (MS OS, iOS, Android) and smartphones. The efforts towards introducing new solutions for input device from using an ink pen materialized in early 2000s when not a few companies in the industry have presented to the market input devices which enabled writing with pens or stylus on paper or on pads. The three technologies which captured significant market share were: electromagnetic pads, ultrasonic digital pens and optical pens. The last two were using pen with ink refills.

Some information about those technologies:

First is Wacom from Japan which is using an electromagnetic technology. Their pen input system comprises of an electromagnetic pad and a pen (plastic refill) which incorporates a coil. While the pen is hovering above the pad or writing on it the movement is captured and hence sent to the PC to get the right image or handwriting.

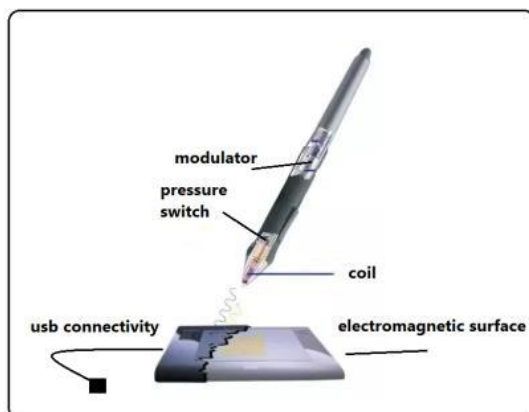


Image 1: Electromagnetic solution

The second technology for digital input device is ultrasonic digital pen. Companies such as Sieko Inc. , Pentel , Hitachi Technologies, Ricoh (all from Japan), Pegasus Technologies and EPOS from Israel and some others introduced this solution.

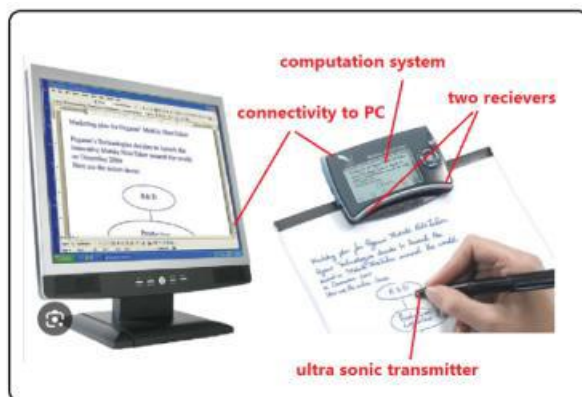


Image 2: Ultrasonic solution

The system comprises of a small unit which clips to the paper on top of the page that includes a powerful tracking system which tracks the movements of the tip of the writing pen (with ink refill). The pen transmits ultrasonic signals while writing. By calculations of triangulation the exact positing of the tip of the pen the writing is tracked and detected and hence the PC captures the image which is drawn on the paper or the written text.

The third technology was presented by Anoto (Sweden) and is based on optical pen with ink refill which is writing on a special paper and while writing the handwritten information is digitized and sent wirelessly to the computer or smartphone etc.



Image 3: miniature camera solution

Handwriting Recognition or Character Recognition (CR)

The other complementary feature which was developed and was available in the market since early 2000s was the handwriting recognition. The engine of the Handwriting Recognition (CR) application was integrated into most of the operating system such as MS OS, Apple OS and Android.

In addition, stand alone applications of Handwriting Recognition with high accuracy of conversion were available. Companies such as Vision Objects from France or Abbyy from Russia introduced their stand alone solution at that time.

The Handwriting Recognition enabled the conversion of text written freely on pads, screen or paper into text and to export it to a Word document as shown in the next example:

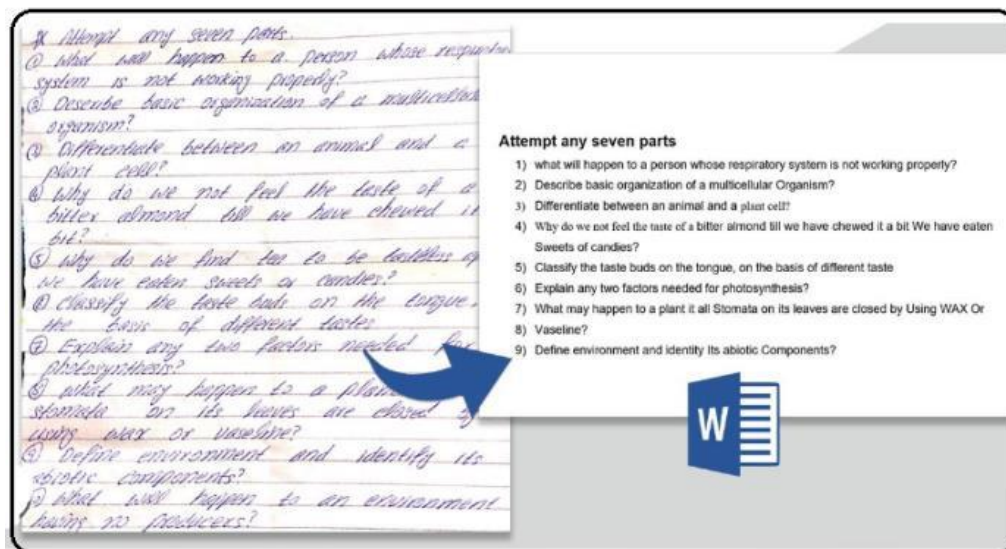


Image 4: Conversion of text

Then, the applications were farther developed to identify and convert drawings (such as triangles, squares etc) and formulas such as $\sin \alpha \pm \sin \beta = 2\sin \frac{1}{2}(\alpha \pm \beta) \cos \frac{1}{2}(\alpha \mp \beta)$ and integrating it into documents. This has created a very strong tool which supported the traditional handwriting on paper or pads.

These two powerful tools of digitizers and Handwriting Recognition applications drove the market of handwriting with pen as legitimate and essential input tools to computerized systems. At that time it was considered as equivalent as the mouse or keyboard for specific applications. This had created a computerized environment which supported full sharing and collaboration using video, voice (which were in use before) together with family of digitizers as input devices for handwriting and powerful communication.

This led to the next level of solutions which were presented mainly (but not only) to the education market and these were the integrated total solutions. Solutions that enabled multiple users in an education environment such as classrooms to share the same information, collaborate through virtual mutual pages, store information for future use, and communicate in the same space wirelessly or from remote places at the same time. In recent years applications such as Zoom and Teams (of Microsoft) drove the market forward to those areas.

In the early 2000's and especially in the 2010's years the total system solutions integrating and using all the above features and capabilities were developed and supported many fields including the education field on which I'll focus and elaborate in the following part of the article. The explanations will be based mainly on examples of different scenarios in the education market and how they were implemented.

Teaching the Alpha Beir for young pupils

One of the challenges of the teacher when teaching the Alpha Beir is not only to remember and to know how to draw the letter, but also to write it in the right way

For example the letter "H" is written in the following order:

First stroke "I"

Second stroke " | "

Third stroke " . "

And the result is "H"

But there are pupils who write it in a different order while the result is the same:

“|” and “-“ and then “|” and the result is again “H”

Or as shown in the following drawing referring to how to write the letter “A”

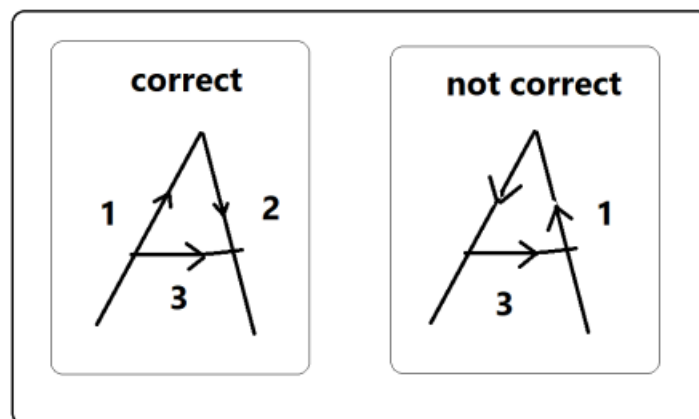


Image 5: writing the “A” letter

In these two examples the final result is the same and the teacher cannot know that de facto the letter was not written correctly. If the student was using a digital pen or other electronic digitizer, the teacher may run the digitized page with letters or words and watch it as an MP4 file so he can see exactly how each and every letter was drawn and then may give the right feedback to the pupil.

This happens many times with many other letters and is common for example when left handed pupils are writing.

Integrated Systems and Solutions

As mentioned before, in this era where internet, information sharing, meetings, collaboration are available and accessible remotely from almost everywhere - the tool of on-line and real time digitizing handwriting is crucial. It is the third dimension of the human collaboration: video, voice and handwriting. In the education field it is a must. Few types of solutions will be demonstrated in the following paragraphs.

Needless to mention that following the COVID-19 pandemic period (years 2020-2022) the communication between people in general and specifically the new remote teaching tools and platforms were dramatically changed. It is reasonable to assess that part or most of these new platforms will continue to serve us in the future.

In the next paragraphs I'll explain and bring few examples about different scenarios in the education environment where the integrated concept is implemented.

Classroom – Students Taking Notes

This scenario is small scale case of one classroom and students each taking notes for them. It is a stand-alone / non-interactive system.

Using the digital pen in a classroom enables each student to take his notes and store them in a simple and well organized manner for future use. It is true that when having a laptop it is possible to type the information of a lecture. This is relevant when attending a lecture in the humanistic sciences (history, literature, psychology etc). But when one attends a lesson in math, physics, chemistry etc., it is impossible to type the lecture (formulas, drawings, molecule structure). Handwriting is crucial for taking notes in this type of lectures. In addition, it is needless to mention, that when learning a language, the Alpha Beit writing, it is crucial to use a pen.

After taking notes in a lecture the student may save those pages of notes in a specific digital “copy book” for future reading or use. He may copy and paste part of them into Word document or any other MS Office app.

Interactive Classroom

This solution turns the classroom into a full interactive digital environment enabling all students and teachers to share any information or comment or annotate on the relevant pages.

Each one of the participants has a laptop/PC with a touch screen and/or with a writing tablet or digital pen and paper. This includes the teacher who is also the “master” of the system. In the front of the classroom there is a big screen. All components of the system are communicating via WiFi (a BT connectivity is also possible).

The teacher explains for example a problem in geometry and draws on his paper the problem and explains and marks everything. This automatically will appear on all screens of the students and on the big classroom screen. Now, if one of the students has a question or is asked by the teacher anything, the control is temporarily transferred to him by the teacher, hence enabling him to annotate or draw anything on the existing drawing and or answer the question or ask about a non clear issue while writing on the drawing in front of him – while everybody can watch it on their own screen. Then, the teacher takes control and answers whether verbally or by drawing and all this information is shared between all participants all the time.

Classroom with Remote Teaching – All Students Connected

This is a less complex system. The teacher is in a remote site with a laptop and digital pen/tablet and the students which are situated in a remote site have a big screen in the classroom and as well PC/laptops with digital tablets or digital pens.

By using the internet, video, voice and digital writing capabilities the teaching covers all aspects of teaching including interactions between each and every of the students in a classroom and the “remote” teacher. The information of the lecture might be stored in the cloud for future use by each and every student.

In this case, using the internet, the remote teaching is important to narrow the gaps of education level between all parts of the country. Best teachers/professors may teach remotely any classroom without the need to travel to those remote sites.

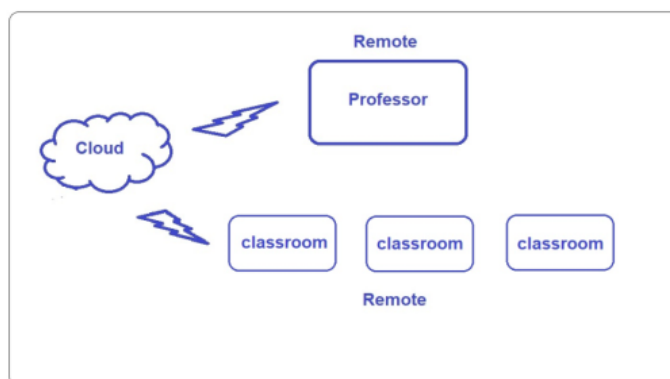


Image 6: Remote teaching

One-On-One Teaching – Private Lessons

Using the digital pen or pad with the remote capabilities it is useful to have private lessons when the teacher interacts remotely with the student who is in another location.

For example the teacher may explain a specific problem in calculus. The student remotely can follow the explanations, and see in real-time the formulas and steps of solving the problem. Then, if the student has a question, he may, on line, on the shared “virtual page”, mark or point on the non clear issue to get a clarification.

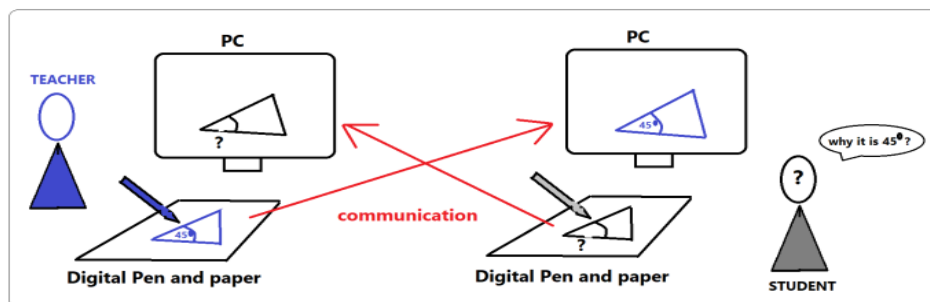


Image 7: Remote private lesson

Remote Exams or Homework

This is a unique feature which enables on line and simultaneous exams for as many students as required. At the end of the test the teacher may check the exams, mark, correct or comment on each page or line, and send back the final exam with scores and notes to the student. This is a distinctive method from doing on line an “American Exam” where a student has to choose 1 of X answers. This method supports both writing in an exam and corrections done by the professor.

The same method and system support refers to homework given to the students where they write the answers, upload into the server of the lecture and the professor may check and comment and share back the checked homework.

Third Countries and Remote Isolated areas – Education Solutions

The challenge of improving education and implementing new methods and technologies is much larger in the third world and underdeveloped countries. Especially in remote and rural isolated provinces where there is almost no infrastructure such as electricity, computers etc. There the need for better education system including the exposure to the all innovations of technology and access to the internet world is evident and clear.

There are different solutions for improving the education systems in such areas. I’ll bring one example to demonstrate how it might work.

The education system and infrastructure functions as described in the remote classroom paragraph where the teacher is in a remote site and the students are in another location. As in third world countries in remote provinces many times there is no appropriate classroom nor electricity - the solution contain all supporting elements to enable a full functioning system to be operative.

The classroom is a special container which is stationary or a mobile one. It has a room for 10-20 students as shown hereunder



Image 8: Classrooms with solar panels

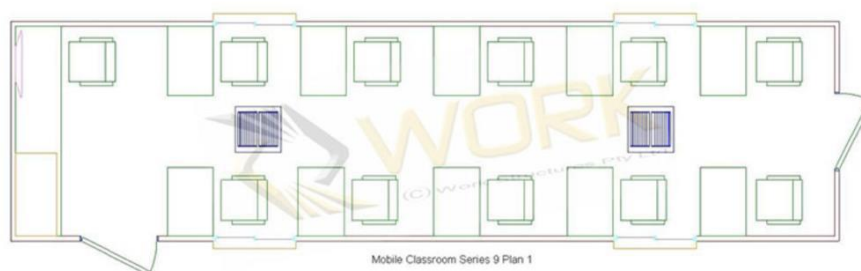


Image 9: Classroom structure

The classroom contains 10-20 stations of PCs and tablets or digital pens for writing and a teacher position in the front of the class. This position includes also a big screen, in some cases it might have a touch screen capabilities. Above the screen a camera is located. All stations are connected or by LAN or wirelessly to a router and a server with a communication link to the air. The teacher might be physically in the classroom or he may give the lecture from a remote site.

The classroom is connected to a generator and has also an air-conditioning unit. In some cases solar panels covers the roof of the container/classroom to enable power saving and an alternative source for power.

If there is a communication channel to this site, which may include cellular network coverage, then the classroom is equipped with a router and connected to this communication access point. Otherwise, it may have

satellite antenna which enables the data communication with the remote site where the teacher is situated and a continuous access to the internet.

UNICEF and many international entities are involved in many projects of this type in third world countries such as Zambia, Afghanistan, Uganda, Ghana, Papua and many more. The focus is on basic teaching of children in low grades where mathematics, language and being exposed to the internet world are crucial and having these platforms enables to bring the teaching not only to central parts of third world countries, as mostly happens, but as mentioned above also to remote and rural provinces.^{5,6,7}

As we have seen in this article the evolution and the actual revolution in the education field following all the technological means and innovations led to new concepts, new approaches and methodology of how teaching and studying should be. It may be done in front of a classroom, remotely, information may be shared easily and quickly, collaboration became simple, the use of video and voice supported all remote teaching. Having said all that we have to pay attention that some of the traditional habits of the human being such as using pen and paper will survive all these changes as in certain areas (math, physics etc.) it is a must.

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