Intelligent Schools: A Solution to Education Stagnation?

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Abstract. Throughout the last decades, the education sector across the world demonstrated stable results, even with large incentives and investments, the Intelligent School concept is an innovative education model that brings the most promising ideas as a way to modernize education and disrupt such stability, through ingenious additions in architecture, interior design, education methods, education system, education technology and education policies, including both extant and new ideas. Some education institutions and ministries around the globe already display innovative practices, however, none attempted to apply innovation at all levels and on a larger scale, therefore, the Intelligent School concept is also a way of promoting such institutions and incentivizing innovation at such gaps. As a combination of sustainability, technology and inclusion, such a concept is a way to reinvent education and decrease the education sector neglect.

Keywords. Education, Technology, Sustainability, Innovation, Education Technologies, Education Policies, Creativity

1. Introduction

As indicated by Bolden & Tymms throughout the last decades education has displayed relatively stable results, despite large investments and reforms, various governmental initiatives across the globe demonstrated ineffective strategies, hence, a distinct approach seems necessary for such a context, we shouldn't be satisfied with quick conclusions, education reforms should be executed gradually and skeptically, even if it takes longer periods [1]. As a potential solution, the Intelligent School concept is proposed in this article, fundamentally, such a concept refers to a set of innovative education practices that includes ingenious ideas on architecture and interior design, education methods, education system, education technologies, and education policies, in an initiative to bring the latest modernizations and to reach a state-of-the-art education.

2. Methodology

2.1 Architecture and Interior Design

Regarding the architectural and interior design project of school facilities, many basic and new concepts must be included to reach a state-of-the-art building. Firstly, it's crucial to be attentive to some basic elements, such as lighting, noise, temperature, and air quality. In terms of lighting, natural daylight should be something widely present in various areas of the building, however, there is an adequate level of illumination, excessive daylight may lead to visual discomfort and temperature increase [2]. According to Edwards & Torcellini [2] students who were exposed to an adequate amount of daylight had better math and reading performance. Now, regarding noise pollution, it's important to note that the most common sources of it are ventilation and heating units [3], airplane flight paths [4], and road traffic [5]. As stated by Klatte, Bergström & Lachmann [6] classrooms with greater external noise tend to perform worse, therefore optimal sound insulation is highly recommended to improve the students' classroom environment. Temperature is also a crucial element to consider, as indicated by Earthman [7] the most adequate temperature for learning is between 68º and 74º, anything too extreme may lead to poorer performance [8]. Then, lastly, another element to consider is air pollution, as mentioned by Schneider [9], low-quality air may lead to decreased student attendance and may affect teachers' ability to teach well, hence locations within areas with high air pollution should be avoided. Additionally, the absence of accessibility to students with disabilities is another factor to consider, since it may become a barrier for such students to participate and consequently have a satisfactory learning process, therefore, elevators, ramps, automatic doors, and other assistive technologies are fundamental to improve the participation of such students [10].

Moreover, the initial project of the school facilities must always have a modular approach, both in terms of architecture and interior design, because it's the most advantageous way of preventing unnecessary future major financial and time losses. When you build a modular facility you already consider a lot of possible future scenarios, hence, starting changes after construction is no longer an unnecessarily expensive and time-consuming process. Aligned with modular design, minimalism is another concept to be included in this process, it fits well with modularism because it incentivizes the elimination of excess, including excessive decoration, unnecessarily complex architecture, and other illogical project choices. The school project should have a utilitarian approach, however, it should still be aesthetically pleasing, therefore, neutral decors such as plants, wall fountains, mirrors, abstract sculptures, and the like would be an adequate choice, since they aesthetically improve the environment and have no bias toward any ideology, avoiding styles and decorations related to certain political ideologies, religious ideologies, ethnic ideologies, and race-related ideologies, unless it is part of the school curriculum, otherwise, the education institution should always have a neutral approach, because it puts everyone in an equal level, not favoring any bias. Besides that, everything should have durable and sustainable materials, plants, trees, grass, and living walls especially should be a priority within the school environment, since they can have positive effects on mental health [11] [12] [13], besides familiarizing students, teachers, and others with a more natural environment.

Fig 1 - UWC Dilijan College [58]

Nowadays there are numerous studies dedicated to finding the best ways to harmonize nature and human constructions, among these concepts green architecture and circular built environments are the ones that will be covered here. As explained by Atmann [14] green architecture is a combination of environmental, political, social, and technological values to reduce the negative environmental impact of buildings by increasing efficiency and moderation in the utilization of building materials, energy, and development space. To be classified as a green building it must reach a certain level of each value, however, many factors must be considered, such as local climate, material availability, and skill set [15]. Many institutions offer their standard of greenness and also give their own accreditations schemes, hence, the concept of green architecture may vary according to each one of them, however, it's essential to know that energy efficiency, water efficiency, and indoor environment quality are features present in all institutions' standards [16]. As an interesting practical example of green architecture, UWC Dilijan College in Armenia [Fig 1] is an international school that included some sustainable concepts in its construction, earning a 2015 BREEAM certificate of an ecological construction standard [17]. Now, regarding the circular built environment, as mentioned by Thelen et al [18], industrial symbiosis, renewable materials, shared economy, proximity economics, reuse, recycling and upcycling, urban mining, detoxification of material cycles, sustainable consumption and production are the basis of such a concept, in short, the main intent of circular buildings is to reduce life cycle impacts and at the same time provide healthy and comfortable spaces [19], furthermore, circular concepts may be integrated into all phases of a building's cycle, allowing a high level of optimization [20]. Lastly, it is crucial to point out that turning education buildings into role models in terms of sustainability and the like may be a great way of familiarizing and incentivizing students to practice and support sustainable attitudes.

2.2 Education Methods

Overall, traditional tests are the standard in most education institutions, hence, the skepticism toward other education methods is justified, both students and teachers are used to such assessment methods, besides it brings lower expenses compared to other methods, however, it doesn't mean it is necessarily the most effective method of measuring learning and teaching. As a potential competitor, project-centered learning methods were created, the first big difference we notice is the larger gap of freedom within project-centered methods [21], in contrast with traditional ones, which are focused on creating a homogenous form of assessment for all students, as if they are all the same, with the same backgrounds, same preferences and same skills, it's quite clear that the simplistic nature of traditional tests never was focused in offering a freer and creative way for students to train their unique skills. Furthermore, the fact that project-centered methods allow students to develop their skills in real-world situations, shows that they are cultivating realistic skills that could soon be applied in their careers and even their lives, instead of answering unrealistic standardized tests and exams that may lead to an increase in stress [22] [23] and focus mainly on memorization, which in many cases may end up forgotten later, and maybe, what they "learned" through traditional methods may never be utilized.

Of course, the projects proposed must have minimum criteria to make an evidence-based assessment possible, standardization shouldn't be completely avoided, it just has to be used with a certain caution, to keep adequate space for creativity a moderate degree is acceptable and necessary, therefore, an effective form of structure to such projects is to create a standard guide to each type of project, including comprehensive step-by-step instructions of each part of the project, because the students must have at least a minimum mapping of what they are going to produce, otherwise, they may end up lost or doing a project that is unassessable. Moreover, throughout the making process, as it is a long-term form of assessment, the teacher must use an assessment table that encompasses all the crucial elements of the project, he must accompany his students in each step to ensure they are going to the right path. In case they fail in a step, they can continue and go to the next step, failing in one step shouldn't be considered as a general fail of the whole project, since the project's general score can only be determined after all steps were completed and assessed individually, besides it would demotivate students and create an unnecessary higher rate of failure in the classroom. Additionally, if a student fails the project's general score, (which encompasses the score of all steps) he doesn't have to remake the whole project, he only has to remake the steps with a low score. Each assessment must have a certain variety of project formats for students, each format is created for a specific type of student, which should be assessed previously through neuro-cognitive tests with an expert, all students must go through these tests as a way of building a precise general profile of the student's background, preferences, skills and other personality traits. Also, the “student profile” concept is an alternative to replace the “learning style” concept, which is currently widely discarded by the scientific community due to its unreliability. Basically, the “student profile” concept is a way of recording the general aspects of a certain student such as his background, his preferences, and his skills, however, it considers each student as an always-changing individual, avoiding the idea of static traits, that is, it is based on the idea that students are under constant change and the role of education and neuroscience professionals is to observe and use this information to improve the student’s performance. Each assessment must allow all types of students to have an opportunity to build something realistic and cultivate their skills, because having actual skills is not only beneficial for aspiring entrepreneurs, it is also becoming a top priority for many employers and companies, it’s noticeable that throughout the years a certain portion of the labor market started to value applicable skills over traditional qualifications, such as college degrees, diplomas and the like [24]. Furthermore, creative skills are probably one of the most important human skills, according to Kaufman & Sternberg [25] during the Middle/Upper Paleolithic period, humans could already display a considerable level of creativity, it was already a skill that was paving the path to the development of the current society, he states that the main reason for that is possibly due to a crucial transition that happened when humans started to use their intellect to develop complex vocal communication systems, it made the human species stand apart, no other animal was able to create such a sophisticated form of language, through such system ideas could be shared and propagated from one individual to another, permitting a broader usage of concepts through various distinct situations, including collaboration in creative projects.

Besides creative skills, another set of skills developed throughout the process in the project-centered methods, are self-teaching skills, because to facilitate the cultivation of creativity, firstly, students must have initiative, they have to develop a certain degree of independence, however, without a proper teacher and method, this is less likely to happen. That is why, the most adequate teacher to fulfill such a role would be the one who acts more like a mentor or guide and less like an authority, as we see in traditional classrooms, which turns the teacher into an authoritarian leader who shares his knowledge and students must mimic him and reproduce his knowledge, as if imitating will lead to learning. The adequate teacher would instead choose a more cooperative approach, he would share his knowledge as well, however, more inclusively and collaboratively, he would find manners to allow students to relate to the content lectured, in short, he would act more like an adviser that shares his understanding and offers aid when necessary, avoiding a superiority approach. Hence, such a teacher would incentivize the development of critical thinking and independent thinking, tracking a path to autonomy and eventually self-teaching. As stated by Zhang [26], the concept of self-teaching, or as he mentions "not-teaching", is an old concept that was already present in Buddhism and Confucianism thinking, this concept of education holds the belief that by not teaching, the students would learn to become less dependent on their teachers and would eventually develop means to acquire knowledge by their own. Of course, there is an adequate degree of self-teaching, firstly the teacher must initiate the student's knowledge journey, helping them with their first steps, however as the student begins to display signals of autonomy, the teacher should allow the student to follow his path, applying the not-teaching concept.

2.3 Education System

In recent times, if we look at the education system of schools around the world, it's noticeable that there are a certain variety of system formats, some being more inclined toward a traditional approach, others preferring a more avant-garde approach, and of course, there are some which are somewhere in between. The fact is, we are in a transition phase, eventually the traditional format will become obsolete due to its incompatibility with contemporary society, little by little avant-garde concepts of education are becoming more prominent. Needless to say, not everything from traditional education models has to be discarded, if an idea displays effectiveness, it has to be kept, it's ideal to gather the best of each set of concepts, as a great example of an education system that combined innovative practices with a traditional twist is the Finnish education system [27], that will serve as one of our main sources of inspiration throughout this article due to its success in the last years [28].

Initially, it's vital to point out some aspects regarding teachers, professors, and other education professionals, their role is the basis of every education facility, therefore their significance should be taken more seriously, that is, they should receive more fair and respectful treatment, they should be seen as one of the most crucial professionals in society, especially teachers. Unfortunately in many places around the world education professionals receive low payments, they don't receive proper training and qualifications, and lastly, they lack resources and technology, leading to low rates of satisfaction and eventually high rates of turnovers [29][30][31]. Therefore, it's logical to improve incomes within education roles, however, investments in high-quality training and qualifications are also fundamental, education professionals should receive advanced training in learning neuroscience, learning technologies and other education sciences, furthermore, education programs should be more selective, only highly-skilled and highly-talented individuals should be chosen to become prospective education professionals. Moreover, another essential addition should be the implementation of an awarding system that selects the best professionals in education to receive awards and decorations based on their performance and innovation, turning such individuals into role models and a source of inspiration to improve the educational environment, such an addition would be a great way to recognize and motivate education professionals. The Finnish education system is an exceptional example of some of the previous practices, their education programs are highly selective, only the best students from high school are chosen to become prospective teachers [32], Finnish culture considers such professionals as highly-regarded individuals, education careers are highly-valued within Finnish society [33], also they have a higher level of autonomy [34] and a high degree of satisfaction with their careers [33], which explains the reasons behind their success.

Now, concerning students, the education system must have a more personalized approach, avoiding static curriculums and learning paths, flexibility allows students not only to learn what they desire, when they desire, however also where they desire, obviously a certain degree of rules is essential, absolute freedom is not logically possible. Furthermore, not all students will have the same time availability, hence such a flexible curriculum system would allow these students to also study properly, decreasing school evasion. Additionally, repetition of years should be discontinued, students should only repeat subjects in which they previously had low scores, repeating an entire year may only demotivate students even more and lead to an unnecessary waste of time and resources due to a redundant learning path. Also, the school network should allow students to attend classes in other schools in case they need it, because for some students, attending classes always in the same school may not be viable. Regarding online classes, students should also have the freedom to choose such a learning model, however, a certain moderation is crucial, since in-person classes offer a more complete experience, therefore only in specific cases online classes should be recommended. A great way to enforce the flexible curriculum model would be the implementation of a credit system, similar to the American Semester Credit Hours (SCH) system [35], however with a more sophisticated approach, in this case, we will name it Flexible Credit System (FCS), due to its flexible nature, below there is a further explanation of each component of such a system:

- Levels:

  - Primary: refers to basic education, hence only basic level subjects have a valid credit within such level.

  - Secondary: refers to intermediate education, hence only intermediate level subjects (such as high school and technical subjects) have a valid credit within such level.

  - Tertiary: refers to higher education, hence only higher level subjects (such as academic and professional subjects) have a valid credit within such level.

- Types:

  - Elementary: refers to standard subjects that are considered fundamental to a certain knowledge field, hence they are rarely altered

(such as English in primary education, it is an essential subject that is compulsory in every primary curriculum or programming in computer science, it is a fundamental subject present in every computer science degree curriculum), such subjects are compulsory in every curriculum, regardless of level.

- Floating: refers to always changing subjects that are included within the curriculum according to the latest science and technology advances and demands, as a way of preparing students to become familiarized with the latest advances. Of course, such subjects must be related to the level or field, otherwise, they will have no purpose for students within such courses (for example students that are in a civil engineering degree program, they will have subjects such as "Innovative and Sustainable Construction" or "Construction Automation Technologies", which are some the most recent areas of study within such field), furthermore, such subjects are compulsory in every curriculum, regardless of level.

- Support: refers to subjects that are included within a certain curriculum only when a student displays significant struggle or unfamiliarity with certain social or educational demands as a way of complementing his knowledge to assist him in reaching the required level (for example a secondary level student who displays significant struggle with math and physics, as a way of assisting him to reach the same level of his classmates, support subjects such as" Math Tutoring" and "Physics Tutoring" are offered for him). Such subjects are not compulsory in every curriculum, only in certain cases they are required, as explained previously.

● Fields:

- General: refers to subjects within a broader field of study (for example in a computer science curriculum there will be programming and math which are elementary for every computer science course, hence it is included in every curriculum within a certain field, these subjects are intended to bring a wider approach, as a way for paving the path for specific subjects), every curriculum is required to have such subjects.

- Specific: refers to subjects within a narrower field of study (for example in some computer science curriculums there will be C and C++ subjects, while in others there will be Python and Java, hence it may vary according to the course, these subjects are intended to bring a more specialized approach), every curriculum is required to have such subjects.

Obviously, a minimum standard should be developed across the education system network to allow the proper operation of such a system, otherwise, it will lead to an ineffective network. Essentially, every curriculum must have elementary, floating, general and specific subjects, moreover, overlaps are completely acceptable and necessary, that is, elementary subjects will eventually be general subjects simultaneously in certain cases, just as floating subjects can be specific subjects simultaneously as well, floating subjects can also be general and elementary subjects can be specific as well, since fields and types are not directly correlated, now elementary subjects can never be floating simultaneously. To reach the required credit amount, students must attend a certain number of hours and a certain score within elementary, floating, general and specific subjects, additionally, support subjects only become compulsory when a student displays the need for extra assistance in a certain subject (or subjects if it is the case), therefore an independent credit bar will be generated called "support credits", fundamentally students within support subjects will have to reach the required credit hours for this independent bar, besides that, support credits don't have to be included in the student final assessment table, since their purpose is only to offer aid for elementary and floating subjects. In this system students are much more freer to personalize their curriculum and learning path, as mentioned before, students have the freedom to choose what, when and where they will study, once it reaches the required credit amount and it is under the education system standards, a great example of how this freedom works is the following situation: a certain student lives in a neighborhood close to School A, hence he studies most of his subjects there, however he is not satisfied with the floating subjects offered by such a school, then he searches on the internet and finds out about School B and School C which are located in other areas and offer different subjects that are not included in School A curriculum, however School C doesn't offer the subject he wants to study in his level, because it is a primary school and he is in secondary level, now School B offers the subject he wants in his level and since the school network system offer a diverse range of floating subjects depending on the school unit, he is open to choose what he wants, therefore he is able to study some subjects in School A and some in School B. The

core concept of the FCS is to turn credit hours into a sort of currency, students will be open to customize their curriculum in the most variable ways, depending on the number of credits they will be able to trade for diplomas, degrees and certificates, the main intent of such a network is to bring a dynamic and individualized approach.

It's indeed quite advantageous for the FCS to keep not only a local network for each school, however also a larger network for interconnection between schools within the same system, because it's a great way to build a database of reports, histories, and other useful information, such a network could be also a way to organize events, such as online conferences, classes, and meetings. Also, it would be enriching to the education environment to perform in-person events among schools, such as festivals, campaigns and seminars, furthermore, partnerships with organizations, companies, and other institutions would be an excellent way to bring the latest innovations, as well as experts from such fields as a way of inspiring and familiarizing both students and education professionals with the latest novelties. Moreover, as a way of preparing students for their future careers, every secondary school should bring career and academic counseling to a certain extent, preventing students from possible future regrets due to poor choices. When finishing their studies, students will not only receive their diploma, degree, or certification, however, also, they will end up with a portfolio, which will contain all their projects and performance, bringing a detailed summary of their general profile, including their skills, preferences, and background. Lastly, regarding student behavior, in case of misconduct, the student must receive a penalization according to the severity of the incident, which may include warnings, detentions (that include support subjects for "good conduct"), suspension, and expulsion, fundamentally, warnings are the lightest form of penalization, detentions are slightly more severe, they worth two warnings, suspension worths three warnings and expulsion worths four warnings, being the most severe of all penalizations and leading to the banishment of the penalized student from the institution.

2.4 Education Technologies

Throughout history education tools have always been an essential part of education, coming from ancient traditions that relied on papyrus, scrolls and books, to the information era, which includes eBooks, education apps, tablets, smartphones, smart boards, and others. Since the advent of computers and lately the internet, education has changed dramatically, many new possibilities have arisen, however, many of them are still mostly theoretical and undiscovered, that is why across the next paragraphs we will dive into three different technology categories and understand how each one of them may be beneficial for educational purposes, such categories are hardware, software, and networking.

In terms of hardware, some schools around the world already have a notable amount of devices, however, still, it's mostly not so well structured and in many cases it has an informal approach. The adequate structure of an intelligent classroom would include a smart board constituted of three to four large touchscreen displays (similar to the Samsung WAC Series), set next to each other forming a larger interconnected display, that is, these multiple screens might work as one dispositive, if for example a teacher wants to use a stylus pen to make some sketches on the board, he would be able to draw them continuously across all the integrated displays. Moreover, each student should also have a personal touch screen display (similar to iPad Pro or HP AiO) for education purposes, which he would use as a digital substitute for a notebook or a notepad. Of course, the student would still be able to use physical notebooks or notepads in case he prefers, however, digital displays would be favored. Furthermore, smart illumination is also a great addition to the education environment, according to Sleegers et al [36] cold lighting atmosphere makes students more attentive, while warm lighting promotes creativity. Another enriching inclusion would be the utilization of various hardware technologies such as Raspberry Pi, Banana Pi, Arduino, Lego Mindstorms, and others, these technologies would be a great choice for introducing students to electronic engineering, especially primary and secondary school students. Additionally, 3D printers and laser engraving machines could be also used simultaneously to bring a highly creative experience to classrooms. Lastly, as an extension for interactive displays, stylus pens should be present with every student and teacher, since they bring highly dynamic approaches to learning and teaching, allowing sketches, drafts, and brainstorming with ease across many displays. Moreover, a crucial consideration for such intelligent classrooms would be the implementation of practices to prevent blue lighting damage, because many types of screens emit such type of light, hence, protection methods such as blue light filters, blue light blocking glasses, and blue light blocking software should be present in every classroom [37] [38]. The inclusion of all these digital technologies brings a dynamic and enriching way of teaching and learning, as digital devices bring uncountable new possibilities to classrooms that traditional education tools couldn't provide. A notable example of a school that included some of the previous practices is Wenzhou Middle School of Zhejiang Province, such a school was a pioneer of Maker

education in China, in this school Arduino platform and 3D printing are used to allow students to express their creativity within school projects, allowing them to not only absorb information, however, also, create knowledge through practice skills [39].

Now, concerning software aspects, when developing an education platform, one of the first things to consider are "desirable difficulties", which is a sort of technique that makes the student take effortful and unintuitive learning paths as a way to learn more durably, according to Elizabeth Bjork and Robert Bjork [40] such an addition leads to better learning by increasing the processing of material, rather than being distracting, when a student is tested frequently about the material that he has just learned, learning is better [41], furthermore, during testing, spaced practice is a fundamental addition, a key aspect of spaced learning is that relearning material is most effective just before the learner forgets the material [41]. This requires sensing when a learner is getting rusty about the material, a level of attention that a teacher in a classroom cannot achieve at any scale, for that reason a few "probing" assessments are necessary to fine-tune the spacing for each student [42]. A good practical example of spaced learning is the awarded Estonian app Lingvist, this application uses advanced AI technology to teach languages in a highly personalized way, essentially, each user's learning path is built most optimally based on his responses [43]. Another great addition would be interleaved content, according to extensive research, this practice brings some benefits, instead of learning in blocks as in traditional methods, when learning math for example, multiplication alternated with division would be more ideal, since it would lead to the previously mentioned desirable difficulties, however, obviously in a large classroom environment it may not be always viable [41] [42]. Regarding video lectures, as indicated by some researchers, it was noted that ten-minute chunks or shorter are the best way of teaching [44], anything longer than that may lead to a state of mind wandering [45], therefore, courses should use up to 10 minutes of lecture segment, switch to another learning mode, then return to a 10-minute lecture segment, and so on [46]. Lastly, feedback is an essential element within learning, according to Sharma and Bonvillian [42], delayed feedback is also a desirable difficulty, however, it may take time, in certain cases pithy feedback may be beneficial in terms of the allocation of total time in a learning task, however, it is not always the case [47]. Simulations are also an effective way of teaching, although they have been utilized in pilots and driver training for many years [48], there are still many gaps unexplored, this versatile method can be applied in nearly any field, some of the biggest advantages of such a method would be the visual and auditory elements present in it, which may bring a more clear and concrete learning to students. Some innovative apps that could be enriching to the classroom environment as well, would be Obsidian, a minimalistic notes app that allows the creation of complex mental maps with simple commands, Reclaim.AI, a web-based time management app created as a Google Calendar extension, and Canvas, a graphic design app that allows the creation of a wide variety of visual projects with ease, such apps could be very useful in a diverse range of classroom activities. Additionally, an excellent example of an effective teaching model that utilizes software technologies within learning is the TEAL method, fundamentally it is a model that employs the interactive group structure with an emphasis on hands-on desktop experiments (pioneered by the Studio Physics courses) and added several new components [49] [50]. As stated by Dori et al [51] a fundamental pillar of TEAL methodology is the utilization of visualizations and simulations to understand better and manipulate physics concepts, diagrams and graphs, both two and three-dimensional visualizations, animations and simulations with the use of technologies allow students to explore and fully understand phenomena, reactions and events in real-time and in a natural dimension. Besides that, concept questions with "clickers" using the Peer Instruction methodology developed by Eric Mazur were also integrated into the TEAL methodology [52]. As reported by Dori & Belcher, the introduction of TEAL led to increased attendance, decreased rate of failure and more interactive teaching focused on helping students learn content rather than the delivery of content [53].

Finally, regarding networking within the education environment, firstly it's essential to consider an intelligent network that turns the school into an always adapting interactive ecosystem, as mentioned before in the Education System part, there will be a larger network that connects all schools within the intelligent schools standard, then, there will be a smaller local network, specially built for each school itself. The larger network will be useful for organizing events among schools, sharing information about classes and students as a way of building an education database, of course, certain information within such a database may be sensitive and private, that's why, a certain degree of confidentiality is required to manage such information, and lastly this network will be utilized to share instructions regarding intelligent education and the like, furthermore, online training classes will be provided through such a network. Now, in terms of the local network, fundamentally, it will be utilized to manage classes, assessments, complaints, maintenance, and other topics related to the school itself, it would be ideal to utilize micro-segmentation when building a local network for information security reasons, this

network would be also utilized to manage and connect IoT devices, such as smart lights, solar panels, presence sensors, air-conditioners, smart boards, automated windows and doors, security cameras and others, basically, every smart device would be integrated into the school network. Moreover, another convenient addition would be the implementation of an ID Tag system, essentially, each student and education professional would have an ID Tag, similar to Apple AirTags, however with some extra features, such dispositive would be used to identify students and education professionals, besides it would automatically communicate with sensors to record entry and exit time of the identified person, these sensors would be located at school entrances, classroom entrances, and laboratory entrances, as a way of recording precisely the attendance time of such individuals, all this information would be automatically added to the school database platform, allowing automated and convenient monitoring and tracking, this feature would eliminate the necessity of traditional roll-calls since their attendance would be recorded automatically.

2.5 Education Policies

As a great foundation to build an intelligent school, innovative education policies are a great start, firstly one of the additions to consider is a public-private partnership (PPP), some studies indicate that such practice may facilitate service delivery and lead to extra financing for the education sector as well as expand equitable access and improve learning outcomes [54]. Overall, PPP in school education may function to provide infrastructure services, support services, and educational services, moreover, in certain countries, government contracts with the private sector may provide some education services, including curriculum design, teacher training, management personnel, etc [39]. Secondly, another addition to think about is decentralization, local authorities should have a certain level of autonomy, because each region may have its demands and specificities, for example, for some schools, industry and technology subjects may be essential due to the local industry needs, now, on other schools, science and research subjects are more in demand as the regional research center have a high need of new scientists, hence, no education institution should be identical, adaptability is crucial to fit in within each context. An inspiring example of a policy model that includes a certain degree of decentralization are the Finnish education policies, according to certain literature, in Finland, local authorities have enhanced autonomy to maintain the basic and upper secondary level education institutions, also Finnish schools have some degree of autonomy as well, local authorities decide the degree of this autonomy, overall, schools have the authority to organize their educational services as long as the basic requirements, stated by the law, are met [55] [56] [28]. Furthermore, it would be advantageous to educational institutions if policies to incentivize the development of an education technology industry were implemented, allowing the creation of advanced technologies optimized to education fields, also, research centers specialized in education sciences and technologies would be a crucial addition as well since it would allow a cycle of development and generation of deep know-how that could be highly fruitful to education as a whole. Another exceptional inclusion would be the implementation of a conceptual school model, such a system would work as a medium for the latest technologies and methods developed by both private and public research, it operates similarly to "beta" and "alpha" versions of software engineering, the alpha version would be the testing models within research center labs and the beta version would be the close-to-completion model used in conceptual schools [57]. The model used in such schools should be properly developed and tested during the alpha phase in research labs, then, the most viable of all the tested concepts should be selected to go to the beta phase within conceptual schools, as a way for gathering know-how experience and for refining the model until it reaches a reliable level to become a RC (release candidate) and eventually a production release, that is, when it becomes sufficiently polished to become widely used within the standard education model [57]. Lastly, as indicated by Bolden & Tymms, regarding policymaking, it's fundamental to restructure the mechanisms of national policymaking so that it is not closely tied to the short official lives of government ministers, the government needs to set a general direction, however educational decisions relating to such matters as curriculum content and national testing should be devolved to a non-political body which is set up for the long haul [1].

3. Results and discussion

In terms of architecture, it was noted that basic elements such as lighting, noise, temperature, and air quality are fundamental to students' performance, moreover, accessibility is crucial to disabled students develop a satisfactory learning process. It was also noticed that a modular project is essential on both architectural and interior design levels, furthermore, minimalism should be aligned with modularism, because both concepts complement each other. Additionally, a utilitarian and aesthetically pleasing design with neutral decor elements is ideal for education environments due to its unbiased nature, prioritizing simple decors and natural elements such as plants and the like, which are also beneficial for mental health. Lastly, it was observed that green architecture and circular built environments are able to bring

numerous benefits to various levels of education environments.

Now, regarding education methods, it was noticed that project-centered methods are more beneficial than traditional test-based education because they stimulate the development of skills applicable to real-world situations. However, to allow an adequate assessment, a certain degree of standardization is required. Besides that, the student profile concept is crucial throughout the process due to its precise information that allows a personalized approach to improve students' performance. Finally, the self-teaching concept is vital to nurture and cultivate the student's independence.

About the education system, firstly, it was observed that education professionals and especially teachers should be more valued within society, hence, a better income, higher quality training, and qualifications are all pivotal to having better teachers and consequently a better education. Also, education programs should be more selective, only highly skilled professionals should be chosen to become prospective teachers. In regard to students, a flexible curriculum should be adopted, however, with a certain degree of rules. A great way to enforce a flexible curriculum would be the implementation of the FCS model, the core of such a system would be to turn credit hours into a sort of currency, bringing a dynamic and individualized approach.

In respect to education hardware technology, the Intelligent School classroom would include a smart board, a personal touch screen display for each student, smart illumination, hardware and electronic technologies for engineering education, 3D printers, laser engraving machines, stylus pens for interactive displays and techniques to prevent blue lighting damage. It was noticed that the inclusion of all these technological elements would bring a much more enriching and dynamic way of teaching and learning since such technologies allow many possibilities that traditional classrooms could not provide. Furthermore, respecting education software technology, the first things to consider are "desirable difficulties", which include spaced learning, interleaved content, and delayed feedback, it was observed that such a method leads to better learning. Also, concerning video lectures, it was noted that videos with up to 10-minute chunks are more adequate for students because they avoid the state of mind wandering. Lastly, it was noticed that simulations are a powerful and versatile way of learning due to their visual and auditory elements. Now, in respect to networking in education environments, it is essential to consider an intelligent network that turns the school into an always-adapting interactive ecosystem, that would include a larger network and a local network. Another convenient addition would be the implementation of an ID tag system that would be used to track and identify students and education professionals within the school environment.

Finally, relating to education policies, it was observed that one of the first additions to consider would be a public-private partnership since it would bring a more efficient implementation process on several levels. The second addition would be a certain degree of decentralization because it allows local authorities to have more autonomy to adapt their educational process according to their demands. Also, it would be advantageous to education institutions if policies to incentivize the development of an education technology industry were implemented. At last, regarding policymaking, it would be fundamental to restructure the mechanisms of national policymaking so that it is not closely tied to the short official lives of government authorities.

4. Conclusion

At last, as the final considerations, we conclude that various fields require attention when rethinking education, creative practices are crucial, especially within education methods, adaptive approaches are essential, especially within the education system, neutral concepts are fundamental, especially within interior design, decentralized dynamics are pivotal, especially within education policies, integrated networks are vital, especially within education technologies, efficient procedures are indispensable in all education fields and lastly, sustainable attitudes are critical, especially within architecture, if we include all of these concepts into the implementation process we end up reaching seven main principles of Intelligent Education that can be referred as CANDIES (Creative, Adaptive, Neutral, Decentralized, Integrated, Efficient and Sustainable). Evidently, despite the notable success of the several practical examples cited throughout this article, it's crucial to say that the models and techniques applied in such examples may not work in case they are reproduced in distinct circumstances, every example mentioned in this article should be considered firstly as an inspiration model and secondly as a practical evidence, they should never be simply mimicked, every concept mentioned here must firstly be adapted to its circumstances, a previous accurate planning is fundamental for every implementation. Lastly, as Intelligent Education is still a quite recent concept, further research is needed, therefore, more articles concerning such a topic are to be expected.

5. References

[1] Bolden D, Tymms P. Standards in education: reforms, stagnation and the need to rethink. *Oxford Review of Education*. 2020 Jul 15;46(6):717–33.

[2] Edwards L, Torcellini P. Literature Review of the Effects of Natural Light on Building Occupants [Internet]. *Office of Scientific and Technical Information (OSTI)*; 2002 Jul [cited 2024 Aug 18]. Available from: http://dx.doi.org/10.2172/15000841

[3] *U.S. Architectural Transportation Barriers Compliance Board*. Progress toward a new standard on classroom acoustics for children with disabilities [Internet]. 2002. Available from: https://pages.uoregon.edu/ftepfer/SchlFacilities/ATBCBacousticFactSheet.html

[4] Evans GW, Maxwell L. Chronic Noise Exposure and Reading Deficits. *Environment and Behavior*. 1997 Sep;29(5):638–56.

[5] Woolner P, Hall E, Higgins S, McCaughey C, Wall K. A sound foundation? What we know about the impact of environments on learning and the implications for Building Schools for the Future. *Oxford Review of Education*. 2007 Feb;33(1):47–70.

[6] Klatte M, Bergström K, Lachmann T. Does noise affect learning? A short review on noise effects on cognitive performance in children. *Frontiers in Psychology*. 2013;4.

[7] Earthman GI. Prioritization of 31 criteria for school building adequacy. *American civil liberties union foundation of Maryland*; 2004 p. 4–7.

[8] Allen MA, Fischer GJ. Ambient Temperature Effects on Paired Associate Learning∗. *Ergonomics*. 1978 Feb;21(2):95–101.

[9] Schneider M. Do School Facilities Affect Academic Outcomes? *National Clearinghouse for Education Facilities*. 2002;

[10] Hemmingson H, Borell L. Environmental barriers in mainstream schools. *Child: Care, Health and Development*. 2002 Jan;28(1):57–63.

[11] Bowler DE, Buyung-Ali LM, Knight TM, Pullin AS. A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*. 2010 Aug 4;10(1).

[12] Coventry PA, Brown JenniferVE, Pervin J, Brabyn S, Pateman R, Breedvelt J, et al. Nature-based outdoor activities for mental and physical health: Systematic review and meta-analysis. *SSM - Population Health*. 2021 Dec;16:100934.

[13] De Vries S, Verheij RA, Groenewegen PP, Spreeuwenberg P. Natural Environments—Healthy Environments? An Exploratory Analysis of the Relationship between Greenspace and Health. *Environment and Planning A: Economy and Space*. 2003 Oct;35(10):1717–31.

[14] Attmann O. *Green Architecture (GreenSource Books): Advanced Technologies and Materials*. McGraw-Hill Companies; 2010.

[15] Pickerill J. Critically Interrogating Eco-Homes. *International Journal of Urban and Regional Research*. 2017 Mar;41(2):353–65.

[16] Bahaudin AY, Elias EM, Saifudin AM. A Comparison of the Green Building's Criteria. *In: E3S Web of Conferences. Sintok: EDP Sciences*; 2014. p. 1015.

[17] Our Green Campus [Internet]. *Dilijan International School of Armenia Foundation*. [cited 2024 Aug 18]. Available from: https://www.uwcdilijan.org/uwcd-experience/our-campus

[18] Thelen D, Acoleyen MV, Huurman W, Thomaes T, Brunschot CV, Edgerton B, et al. Scaling the circular built environment pathways for business and government. Geneva, Switzerland: *World Business Council for Sustainable Development*; 2018.

[19] Pearlmutter D, Theochari D, Nehls T, Pinho P, Piro P, Korolova A, et al. Enhancing the circular economy with nature-based solutions in the built urban environment: green building materials, systems and sites. *Towards Circular Cities: Nature based solutions for creating a resourceful circular city*. 2023 Jun 15;2(1).

[20] Aliamin Y. Pathways toward Sustainable Architecture: Green Architecture and Circular Built Environment. *IOP Conference Series: Earth and Environmental Science*. 2021 Jul 1;794(1):012155.

[21] Dewey J. *The School and Society*. Chicago: University of Chicago Press; 1900.

[22] Heissel JA, Levy DJ, Adam EK. Stress, sleep, and performance on standardized tests: Understudied pathways to the achievement gap. *AERA Open*. 2017 Jun 9;3(3):233285841771348.

[23] Heissel JA, Adam EK, Doleac JL, Figlio DN, Meer J. Testing, stress, and performance: How students respond physiologically to high-stakes testing. *Education Finance and Policy*. 2021;16(2):183–208.

[24] Butrica BA, Mudrazija S. Skills-Based Hiring and Older Workers [Internet]. *Washington, DC: Urban Institute*; 2022 Mar. Available from: https://www.urban.org/sites/default/files/2022-03/Skills-Based%20Hiring%20and%20Older%20Workers.pdf

[25] Kaufman JC, Sternberg RJ. *The Cambridge Handbook of Creativity*. Cambridge University Press; 2010.

[26] Zhang M. Innovative Research on Pedagogy in the "Internet Plus" Era. *Clausius Scientific Press*, Canada. 2022;6(12):61–6.

[27] Simola H. *The Finnish Education Mystery: Historical and sociological essays on schooling in Finland*. Routledge; 2014.

[28] Üstün U, Eryilmaz A. Analysis of Finnish Education System to question the reasons behind Finnish success in PISA. *Studies in Educational Research and Development*. 2018;2(2):93–114.

[29] Avcı Ü, Seferoğlu SS. Bilgi toplumunda öğretmenin tükenmişliği: Teknoloji kullanımı ve tükenmişliği önlemeye yönelik alınabilecek önlemler. *Akdeniz Eğitim Araştırmaları Dergisi*. 2011;9(1):13–26.

[30] Drage K. Professional Development: Implications for Illinois Career and Technical Education Teachers. *Journal of Career and Technical Education*. 2010 Dec 1;25(2).

[31] Räsänen K, Pietarinen J, Pyhältö K, Soini T, Väisänen P. Why leave the teaching profession? A longitudinal approach to the prevalence and persistence of teacher turnover intentions. *Social Psychology of Education*. 2020 May 27;23(4):837–59.

[32] Sahlberg P. Finnish Lessons: What Can the World Learn from Educational Change in Finland. *Teachers College Press*; 2014.

[33] Simola H. The Finnish miracle of PISA: historical and sociological remarks on teaching and teacher education. *Comparative Education*. 2005 Nov;41(4):455–70.

[34] Soguel NC, Jaccard P. Governance and Performance of Education Systems. *Springer Science & Business Media*; 2007.

[35] Credit Hour [Internet]. FSA Partner Connect. *United States Department of Education*; 2011. Available from: https://fsapartners.ed.gov/sites/default/files/attachments/dpcletters/GEN1106.pdf

[36] Sleegers P, Moolenaar N, Galetzka M, Pruyn A, Sarroukh B, van der Zande B. Lighting affects students' concentration positively: Findings from three Dutch studies. *Lighting Research & amp; Technology*. 2012 Jun 22;45(2):159–75.

[37] Are Phone Screens Bad For Your Eyes? [Internet]. *Calgary Family Eye Doctors* -. 2024 [cited 2024 Sep 4]. Available from: https://calgaryfamilyeyedoctors.com/are-phone-screens-bad-for-your-eyes/

[38] Ebbett D. Ways to Minimize Exposure to Blue Light [Internet]. *BlockBlueLight*. 2019 [cited 2024 Sep 4]. Available from: https://www.blockbluelight.com/blogs/news/ways-to-minimise-blue-light

[39] Zhang J, Jing Q, Liang Y, Jiang H, Li N. Smart Learning Environments in School: Design Principles and Case Studies. In: Learning, Design, and Technology [Internet]. *Cham: Springer International Publishing*; 2016 [cited 2024 Sep 4]. p. 1–29. Available from: http://dx.doi.org/10.1007/978-3-319-17727-4_19-1

[40] Bjork EL, Bjork RA. Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In: *Psychology and the real world: Essays illustrating fundamental contributions to society*. FABBS Foundation; 2011.

[41] Willcox KE, Sarma S, Lippel PH. Online Education:

A Catalyst for Higher Education Reforms. *Massachusetts Institute of Technology*; 2016 Apr.

[42] Sharma SE, Bonvillian WB. Applying New Education Technologies to Meet Workforce Education Needs. *Massachusetts Institute of Technology*; 2020.

[43] How should I learn with Lingvist and why does it work? [Internet]. *Lingvist*. [cited 2024 Sep 7]. Available from: https://lingvist.com/help/how-should-i-learn-with-lingvist-and-why-does-it-work/

[44] Svinicki MD, McKeachie WJ. *McKeachie's Teaching Tips: Strategies, Research, and Theory for College and University Teachers*. 2014.

[45] Szpunar KK, Moulton ST, Schacter DL. Mind wandering and education: from the classroom to online learning. *Frontiers in Psychology*. 2013;4.

[46] Guo PJ, Kim J, Rubin R. How video production affects student engagement. In: *Proceedings of the first ACM conference on Learning @ scale conference* [Internet]. New York, NY, USA: ACM; 2014 [cited 2024 Sep 7]. Available from: http://dx.doi.org/10.1145/2556325.2566239

[47] Hays MJ, Kornell N, Bjork RA. The costs and benefits of providing feedback during learning. *Psychonomic Bulletin &amp*; Review. 2010 Dec;17(6):797–801.

[48] Hays RT, Jacobs JW, Prince C, Salas E. Flight Simulator Training Effectiveness: A Meta-Analysis. *Military Psychology*. 1992 Jun;4(2):63–74.

[49] Cummings K, Marx J, Thornton R, Kuhl D. Evaluating innovation in studio physics. *American Journal of Physics*. 1999 Jul 1;67(S1):S38–44.

[50] Beichner RJ, Saul JM. Introduction to the SCALE-UP (Student-Centered Activities for Large Enrollment Undergraduate Programs) Project. Varenna, Italy: *Proceedings of the International School of Physics*; 2003 Jul p. 1–17.

[51] Dori YJ, Belcher J, Bessette M, Danziger M, McKinney A, Hult E. Technology for active learning. *Materials Today*. 2003 Dec;6(12):44–9.

[52] Cinganotto L, Panzavolta S, Garista P, Guasti L, Dourmashkin P. TEAL as an innovative teaching model Insights from "Educational Avant-Garde" Movement in Italy. *Journal of e-Learning and Knowledge Society*. 2016 May 21;12(2):115–26.

[53] Dori YJ, Belcher J. How Does Technology-Enabled Active Learning Affect Undergraduate Students' Understanding of Electromagnetism Concepts? *Journal of the Learning Sciences*. 2005 Apr;14(2):243–79.

[54] Patrinos HA, Osorio FB, Guáqueta J. The Role and Impact of Public-private Partnerships in Education. *World Bank Publications*; 2009.

[55] National education systems: Finland [Internet]. *European Union*. 2018. Available from: https://eacea.ec.europa.eu/national-policies/eurydice/content/population- demographic-situation-languages-and-religions-25_en

[56] National summary sheets on education system in Europe and ongoing reforms: Finland [Internet]. *Pharmine*. 2009. Available from: https://www.pharmine.org/wp-content/uploads/2014/05/EURYDICE-national-summary-sheet-on-education-systems- in-Europe-Finland-2009.pdf

[57] Pierce M. Software Release Life Cycle (SRLC): Understand The 6 Main Stages [Internet]. *The Product Manager.* 2022 [cited 2024 Sep 13]. Available from: https://theproductmanager.com/topics/software-release-life-cycle/

[58] Scholae Mundi [Internet]. [cited 2024 Sep 22]. Available from: https://scholaemundi.org/i/projects/uwc-nc.jpg