If We Could Start from Scratch, What Would Schools Look like in the Twenty-First Century? Rethinking Schools as a Locus for Social Change

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Abstract Today's debate about education is prone to focusing on system optimization, test score improvement, and budgetary concerns. However, education is much more: it is primarily about a vision for our societies. As we think about a new vision, it has to speak to the ethos of our time. Today's youth are heavily focused on social change, addressing global problems such as climate change, systemic racism, and economic inequality. This requires new content and pedagogies. Thus, schools should be rebuilt to support such endeavors, emphasizing ways of learning in which students have more agency and learning is more relevant. Currently, the schools where this work is possible are most typically located in affluent countries and regions. We should work to democratize the possibility of "learning how to change the world," making public schools a viable locus for fostering social change.

Keywords Educational change · Constructionism · Maker education · Critical pedagogy · Social justice

1 Introduction: How Do Educational Systems Get Built?

Today's debate about education is prone to focusing on system optimization, test score improvement, and budgetary concerns. However, education is much more than that: it is primarily about a vision for our societies. It is humanity's way of encoding culture and knowledge into a civilization's DNA and transferring it to future generations. As such, it is a society's way of shaping itself and paving its own future. It is high time we treat it as such.

When talking about education, we should thus start from a vision of what a school, city, or nation wants from it, and then work towards engineering and implementing that vision. Unfortunately, today's educational debate is dominated by a

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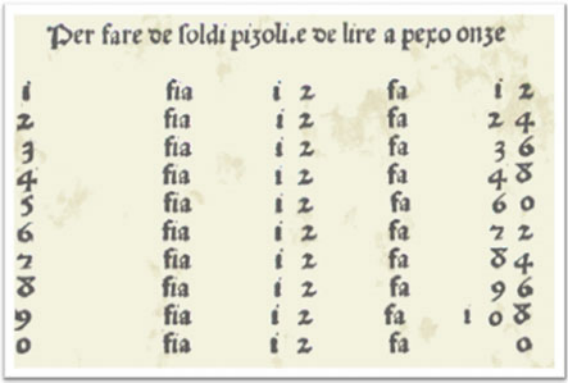

Fig. 1 Page from Treviso Arithmetic textbook from 1478 (Swetz 1987)

bean-counting discourse that, instead of considering what young people are interested in learning or who they want to become, looks at schools to ensure countries' competitiveness on the international market.

Education systems are built by starting with societal needs, and then working backwards from there: building national standards, then creating textbooks, educational materials, and professional development for teachers—all before learning makes it into the classroom.

An example of this process in practice is depicted in Fig. 1, which shows an excerpt from the Treviso Arithmetic textbook from 1478 (Swetz 1987)—specifically, a section on multiplication table algorithms. The book also covers addition, subtraction, and long division. The author explicitly starts with the rule of three and then moves on to problems concerning discounts, partnerships, bartering, and coin alloys—all very relevant for 15th-century Venetians, who needed the skills to do quick math operations for business purposes.

Incredibly, the same content is still being taught in schools today, well over 500 years later! This is in spite of the world having changed immensely in the centuries since. For several years now, machines have replaced humans working on routine and/or manual tasks (see Fig. 2). On the other hand, the need for professionals capable of dealing with tasks such as unscripted communication or unstructured problem-solving is ever growing. Simple arithmetic skills are no longer in high demand, as we can easily delegate such tasks to our ubiquitous smartphones.

Therefore, one piece of our educational puzzle is to figure out the societal needs of the twenty-first century. They are undoubtedly different from those of 15th-century Venice, even though we are still teaching the same content. One way to determine our needs is the type of quantitative research that Autor et al. (2003) did.

However, the other puzzle element cannot be measured, as it is not something economists can study by running a regression and observing the impact of a given variable. That second aspect is about a vision for the future and the kind of society we want to work towards becoming. One example is how we arrived at universal suffrage. One hundred years ago, when women still did not have the right to vote, many movements worldwide began demanding change. The required legislative modifications

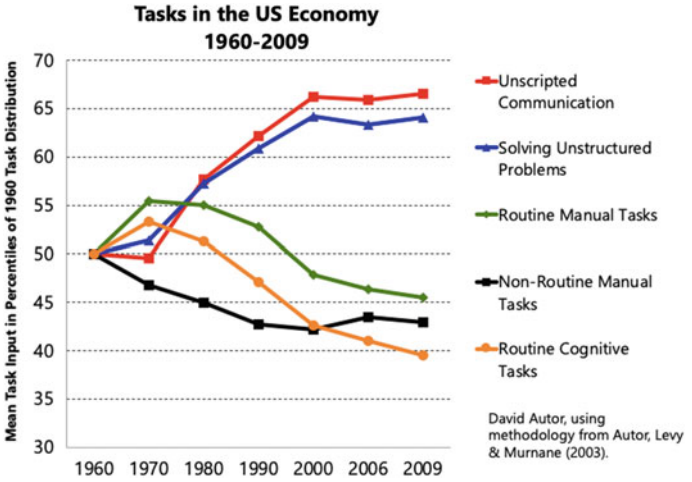

Fig. 2 Source: Autor, based on methodology from Autor et al. (2003)

were not preceded by studies proving this would be economically advantageous—it was simply a matter of principle, a vision of society that people believed in, where everybody had equal voting rights.

2 What is Our Vision for the Future?

When designing an education system, we should thus heed not only the economics, but also the vision: what do we want kids to be like now and in the future? When we look at how we build education systems, we should consider both the societal needs and the societal *ethos*. This we see reflected in Fig. 3, where societal needs and ethos inform the curriculum.

Today's society is changing at a swift pace. Ten years ago, data science and artificial intelligence were still in their infancy, many professions did not even exist, and many issues were not yet a big concern for our societies. When things keep evolving so rapidly, national standards cannot be written in stone and expected to last 30 years or more.

We should advocate for systems that will allow national standards to be reviewed and adjusted every five years or so, removing outdated/obsolete content (e.g., spending three years learning arithmetic) and replacing it with more relevant topics. Given the limited time frame available in a school day, it is all about making informed choices: after all, we cannot cram all the content from both the fifteenth and twenty-first centuries into the same 24-hour day.

Once we accept that national standards should evolve regularly, it becomes apparent that we should stop focusing on designing lesson plans to be followed

Fig. 3 How our current educational systems got built

precisely in the classroom. Instead, we should design learning spaces, toolkits, activities, and guidelines that are flexible and enable different kinds of learning, particularly project-based learning.

Teacher professional development should also be reviewed. Instead of training teachers as technicians that will teach a curriculum and deliver a lesson plan exactly as prescribed in the textbook, we should encourage teachers to be intellectuals and designers in the classroom.

By now, some countries have realized that fundamental changes are needed. In Canada's British Columbia, a new course, "Applied Design, Skills and Technology," is mandatory for all students in Kindergarten through Grade 12 (British Columbia Ministry of Education 2016). This means that, alongside the usual classes that teach math, science, languages, arts, and so on, there is a class where students learn design, computer science, and maker content. Similarly, US public policy—in the form of the Next Generation Science Standards (NGSS)—deems it mandatory for all students to build prototypes and design and optimize solutions (NGSS Lead States 2013). In doing so, it encourages students to do engineering and project-based learning in science classrooms.

3 Sobral, Brazil: Examples of Possible Change

Along these same lines, in the northeastern Brazilian city of Sobral, the science program is being completely revamped, from curriculum redesign to makerspace implementation and teacher training. The municipality is implementing an approach to learning sciences where students learn how to build hypotheses, use models to explain scientific phenomena and apply their knowledge to solve issues in their community.

Figure 4 shows a lesson plan on vertebrates redesigned by a local teacher in Sobral. Traditionally, this would involve drawing maps, with the teacher listing the different species' characteristics on the whiteboard, and the students then being expected to memorize them. Instead, the teacher created a laser-cut toolkit in the makerspace that allowed them to create their own made-up vertebrates. Students thus created ocean giraffes that could swim and imaginary dinosaurs. Not only was this activity significantly more engaging than the traditional approach, but it also had more to it than creating made-up animals. Part of the unit also required the students to come up with their animal's various features: what kinds of food do they eat, how do they breathe, how do they reproduce, how do they move? All these characteristics also had to be justified. For instance, one student who presented a made-up marine dog-like animal explained that, while it would still swim with its tail above water, it would need thorns all over to help it escape from underwater predators. In this case, being creative is closely related to the subject matter—the animals were made up, but students had to use science to justify their choices.

One of the unit's main learning goals was to match form and function—a fundamental idea in biology. But instead of simply memorizing the course content, the students actively designed an animal, matching form and function in a very authentic way. This was followed by a large school fair where the students shared their imaginary animals along with their reasoning for the choices they had made. The unit was redesigned by a teacher we had previously trained at a normal public school in Sobral under no particularly special conditions.

Another public school teacher in Sobral redesigned a unit introducing the nervous system and how our body's internal sensors send signals to the brain, thus allowing us to control our limbs. Here the teacher had students "build neurons" using robotics kits that would mimic the human nervous system, instead of just memorizing facts about the human body.

In a school in California, a teacher reimagined the in-class microscope experience, finding issue with how students only got three minutes each with one of the

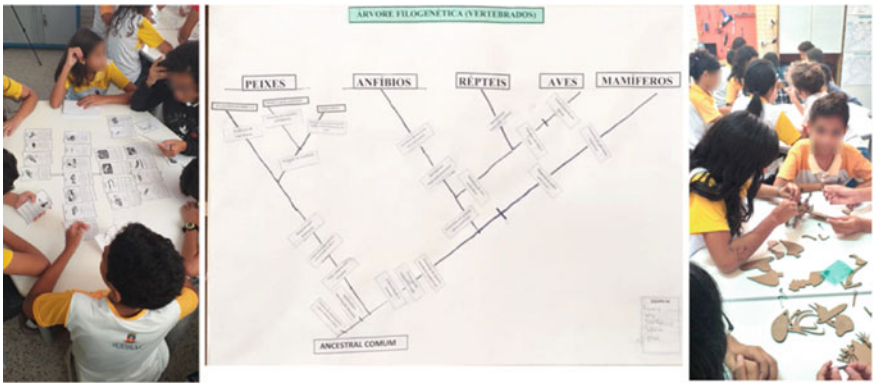

Fig. 4 Lesson plan redesign: Vertebrate animals

microscopes available in the science lab. Instead, each student built their own five-dollar laser-cut wooden microscope, complete with plastic lens. Not only did each student now have their own microscope in class, but they could also all take their microscopes home and conduct all kinds of investigations.

A further real-life project was found in Thailand, where students living in a rural community were faced with an irrigation problem: they never knew what the ideal time was for irrigation. They decided to build a robotic system that would detect air temperature and soil humidity and use this data to water the plants at the optimal time, thereby minimizing evaporation. Such projects are being created worldwide, even in places with limited resources.

There are therefore many examples of how it is possible to build this new kind of structure, where instead of fixed lesson plans followed precisely by teachers, we are building toolkits and environments that allow rich learning to happen.

However, while it is true that we have all these new possibilities in classrooms, no matter where we go, we find that three fundamental mistakes are almost always being made.

4 Three Mistakes in Progressive Education

The first mistake is the lack of a national plan. It is tempting to think that all you need is a few great teachers and plenty of positive energy. However, without a national plan, and national standards, one cannot build a sustainable system that includes project-based learning and maker education, nor can one create the incentives and policies to make such an approach universal. This is why we ought to look towards the countries that have already started to develop such standards—like Canada and the United States, as mentioned previously.

The second mistake is that many attempts fail to truly integrate making into the curriculum. It is not enough to have afterschool programs, maker fairs, and other extracurriculars, if most students remain stuck in the old education system. Integrating maker education into everyday teaching (and into the standard 45-min time frame typical of regular schools) is crucial, because that is what makes it genuinely democratic. An afterschool program naturally involves self-selection, and only some kids will participate. But a regular class with these innovations, designed for everybody in the school, will automatically allow all students to participate and benefit. This also happened in the projects mentioned above, from the vertebrates and nervous system to the microscope.

The third mistake is an excessive focus on technology: buying an abundance of equipment and creating fancy spaces but forgetting that, without the teachers and staff running those spaces, they will be near useless. Spending too much money on equipment might lead to having not enough money for teacher training or curricular development. In the Sobral schools, the Secretary of Education was told that it was necessary to hire one additional lab teacher per school for an effective maker education program, because you could not thrust yet another responsibility upon

the existing teachers. Thanks to a robust training program and a support system in place for both new and established teachers, incredible projects are now coming out of Sobral—but the key to success was having well-prepared people running those programs, not just the equipment.

5 The Future of Education Looks like the Present of Makerspaces

We often talk about maker education as something new and separate from regular schooling. However, if we could start building an education system from scratch, how would we go about it? If we think about what current research says about how humans learn and how to encourage that in a school environment, we realize that much of it is already happening in today's makerspaces: project-based learning, education that is meaningful to kids, student agency, inclusive environments, new types of skills, use of technology as an expressive material. *Thus, if you redesigned schools from scratch, they would probably look like a well-functioning, inclusive makerspace.*

Since what we are doing in many makerspaces is the best form of education that we can imagine, perhaps we should stop using the terms "education" and "maker education" as we do now. We should instead use "education" to describe what goes on in makerspaces, and use another term, such as "traditional education" or "old-fashioned education," for the rest. This was something Seymour Papert suggested about conferences on "technology in education" as far back as 2004: he wanted us to simply call them "conferences on education." He recognized that, when we create a qualifier for a particular type of education, the message is that it is separate from mainstream schooling—not the "real thing" (Papert 2004). Yet, what goes on in makerspaces should not be considered a separate, special or subordinate kind of education—it should be the typical activities in which all students can take part.

This does not mean that we necessarily need to replace everything in schools completely; but this novel approach should be the backbone of the modern education system. In contrast, the old approach can be relegated to a supporting role for when traditional learning methods are perhaps better suited. Of course, we must also be wary of embracing the naïve discourse of "completely replacing schooling overnight." There is still knowledge that can be taught using more traditional methods, but it should be a much smaller percentage and should not dominate the landscape of education.

Bringing about change is possible, though, as shown by a European country with which we have been working for over seven years. Within this relatively short timespan, hundreds of the schools there have developed a maker program. They also started a regular national conference for teachers to share their experiences and conduct regular professional development programs. In fact, they have been so successful that the Minister of Education commissioned the development of a new computer science and maker education class, which will be mandatory for all students

nationwide. This is a great example of how you can start building an educational infrastructure that caters to today's and tomorrow's needs. And the best part is that it is not a 50-year project: achieving great things is possible in as little as ten years with solid, research-based programs.

6 Conclusion: The *Ethos* of Our Time

We have already established that the educational system should cater to ever-evolving societal needs and the societal ethos. However, what is the ethos of our world today? We are no longer in 15th-century Venice; we are not in the industrial revolution anymore. So, where are we? Three sets of young people come to mind.

In 2018, the Dutch teenager Boyan Slat founded The Ocean Cleanup Project. He managed to fundraise millions of dollars to build enormous machines that would help remove plastics from the ocean. Also in 2018, the survivors of a high school shooting in Parkland, Florida, became activists who took it upon themselves to change the gun control legislation in the US, leading to the March for Our Lives protests. Finally, in that same year, Greta Thunberg became one of the most well-known climate change activists worldwide, starting with her modest one-person school strike. What do these stories have in common?

It seems clear that young people now cannot wait 20 years for things to happen. You cannot tell these youth that they will have to learn some disciplinary content and then wait two decades to apply it. They are connected to everything, and they have a sense of urgency because of climate change at our doorstep, the dying oceans, and social issues such as systemic racism coming to a head. All of this is happening in front of their eyes; this is a generation that feels the urgency of changing the world. They are passionate about so many things: they want to save the environment, they want to live in a better place, they want to promote gun control, they want to end systemic racism once and for all. It is essential to democratize their ability to follow their dreams and passions, because it is incredibly unfair that, while some people are allowed to do so—like those mentioned above—others are not. Boyan Slat, Greta Thunberg, and the Parkland survivors are exceptions. They also come from developed countries and more privileged backgrounds. But what if we created an education system that would make such youth the rule, not the exception?

Let us democratize the possibility of falling in love with projects and ideas, and making a difference, so that the generation growing up today can make the world a better place now—not in 20 years, when it might be too late. Schools should help children and teens become the people they want to become—not economically, but as people and citizens. To achieve that, we should make sure that the knowledge we teach students is not just about how to do arithmetic but also about climate change, social justice and equality, and any number of other current issues.

We have to make these difficult choices—arithmetic or climate change—because the school day still has a limited number of hours. Consciously choosing to cover content from five centuries ago alongside today's content will cause us to come up

with a superficial curriculum that does not go anywhere and that does not fulfill the goals of today's youth. And what are those goals? What is the DNA of the society that we want? How and what do we want those children and teens to learn so that, in the future, they can become more like the inspiring young people mentioned above?

Much in the same way that, in 15th-century Venice, school served a social purpose, because of the enormous need for the skills used in commerce, the social purposes we should focus on now are social change and environmental protection. These are not superficial interests for children these days. They are what students care about and also what we as the responsible adults in their lives should foster in them. Moreover, if school does not serve this purpose of democratizing the possibility of falling in love with changing the world, then it will—once and for all—lose its purpose.

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