provocation exercise: starting from scratch

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abstract:
The purpose of this contribution is to trigger a (self- and group) reflection about the way we, as a society, organize education, and this by starting from an extreme opposite: imagine there is no education system at all, and you have to organize it from scratch – how would it look like? I will argue that the system you would come up with will in no way look like the system we have today. Many of the good reasons for which education once has been organized that way, do not apply any longer. Yet, the education system remained, as a relic of a past that itself has ceased to exist. Once we are aware of the historical box around education, what holds you back from thinking outside that box?

unprocessed input by participants (there is a second video with a digest of this input)

thought trigger 1 : Consider your own teaching practice, or the teaching you know from the people around you. Go in your mind over the entire process, from planning and implementing the course, delivering it, and assessing it. List a few features or actions that would not have to be altered if you were teaching in the Middle Ages. Point out why it is good, neutral or bad that those features or actions did not evolve.

The majority of the teaching that takes place in my university takes place through lectures in which the teacher explains things to a room full of students. During these lectures students write down (on paper) what the lecturer is saying (often with many transcription errors). It is very difficult to do anything different to this. I have tried asking for my number of lectures to be reduced but have been told no. Generally if you try to do other things (e.g. videos, computer classes) you have to do these in parallel to 3 hours of lectures per week. Being innovative thus increases your work load substantially.

Summative assessment is through timed, written exams. Formative assessment, meanwhile, is a written problem sheet that the students have the choice to do or not. Students hand in written work at the start of the lectures. This work is marked by graduate students who are given a detailed mark scheme (i.e. full solutions) by the lecturer. The mark is thus not much more than a tick if the answer is correct and a cross if it is incorrect. There is no discussion as to whether sufficient working has been provided or whether the work is clear. The students doing the marking will complain bitterly if you ask them to do anything more than this. Furthermore, senior staff will tell you that you "cannot expect graduate students to be able to make professional judgements on undergraduate student work," which is bizarre. Surely we have just spent the previous four years teaching them a profession so they can make professional judgements. If we have not done that then what have we been doing?

Notice also that time is spent in lectures giving students back their written work. In other words, something like 30 minutes of lecture time each week is spent with students filling forwards and

searching through a pile of written solutions for the work that they handed in the previous week, which is dumb.

All of this could be done, without change, was technologically possible in the middle ages.

What is good about this approach is that it is not particularly labour intensive for lecturers. In addition, it is familiar and it the way that we were taught. We thus know how this works and are less likely to make errors. In my opinion, however, most lectures including my own are painfully boring. This way of teaching is also inflexible. If a student is unwell or disabled they miss all of the instruction that was provided.

Summative assessment that is built around exams encourages students to cram for the test. Their work is thus not spread evenly over the semester. Also thought is often not put into how the material that has been taught has been assessed. Take a typical exam paper in which students have to do 4 questions from a choice of 6. The student can learn half of the module content, ace three questions and get 70% (a first). In other words, this systems allows students to get high marks even if their knowledge of the material is shaky at best.

Lastly, because the focus is on solving problems, there is a tendency to focus on the mechanics of the problem and not on the conceptual details. In physics for instance you can set simple conceptual problems on basic topics such as Newton's laws and find that final-year students do extremely poorly. These same students, meanwhile, are able to work with Lagrangians and Hamiltonians. The strategy that they are using is one of "plug and chug." In other words, they have memorised formulas and methods for solving problems but they have little understanding of what they are doing. As a case in point our mathematics students enter university able to differentiate functions using the product and chain rules. Very few of them can write out the definition of the derivative. Even worse, you can present students with a page of mathematical derivation and ask them what type of mathematical object one of the symbols on the page is. Many of them will not understand the question. Furthermore, when you give them a list of options (integer, scalar, vector etc) they will simply guess.

1) I would go through practical examples and carry out experimental part myself, in front of the students. This is essential part of learning from an expert: apart from raw course material a lot is communicated non-verbally, through behavior and even habits. Routine parts e.g. preparation of operation table or a lab equipment could be done w/help of assistants (students maybe, at a later stage), but all the crucial practices showed with personal example.

2) I would include free-form essays and/or projects apart from common quizes or tests. A learning mind must be proactive. (Note: no burning at a stake for students that seem to be thinking too radical! A disciplinary talk instead - maybe.)

talking in front of the students (neutral: it can be beneficial to some students but annoying for others)

basic convening is similar to enjoy the direct interaction even if more expensive in term of money and even time

- Prepare the course: good, one needs time to have a clear line of thought, and to be pedagogical

- understand the level of the class: good, one needs to adapt to the audience

The structure of planning (target audience) and putting down concepts. Good that this basics are the same

Good: well preparing the subject, using a do-yourself approach, let the creative/imaginative part of the learner also play a role (interaction). Bad: top-down approach (I teach, you learn). Neutral: geometrical disposition (teacher opposite students).

Lecture preparation: literature reading is rather similar. Besides the location of the sources (online vs physical library) for the most part the activity consists in reading material and selecting what to present and how

Frontal lecture: the picture above does nod need further explanations

Exams (both oral and written) are also carried out the very same way: questions are asked and problms are designd to assess the student preparation.

Reading from a fixed script: boring.
Assessment and quick forgetting.
Assessment is the objective, not to have learned (sustainably!).

Dissecting the world into a curriculum of mutually exclusive "modules": no comprehension.

presenting a topic in front of an audience that takes note of it. a form which is even closer to the Middle Ages: some colleagues have a set of notes that are copying on e.g. the visualiser during a class and the students are copying. This goes back to before books could be printed, they were only a few copies and so everyone was making their own copy. I personally dislike this latter form - why don't give the notes directly to the students? I believe that many students find it pointless as well and they are not very motivating. The less extreme form: having that for 1 hour, if the teacher is not very good at stage can be 'hard' to follow. Since it is not in the form of notes, it does request students to work on their notes afterwards. The latter is a useful exercise but likely only the top students are doing that. The rest may have a set of notes that may not make sense in a few months

-/+ ex cathedra lecturing: I think this is very efficient in terms of content distribution (1 to many), establishing a minimal human link (absent from most online material, though a regular podcast or live forum discussion can enable this kind of link) and allowing for a degree of interactivity if students ask questions. There are clear limits for groups beyond a few dozen people - there is never interaction with a larger number of people, only transmission.
-/+ hierarchical stratification between prof (event. TAs) and students: the difference in knowledge on given topic is objective, as should be the students' need/desire to learn. Often the relationship goes beyond information transmission, to coaching, mentoring, and about other topics (life in general, critical thinking, how to approach problems, careers, curriculum choices ....)

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Good lecturing practice. Using good communication practices and if students have the right motivation, this can be very cost-effective.

thought trigger 2 : Idem, but now: List a few features or actions that would not be possible at all if you were to teach your course in the Middle Ages. Point out why it is good, neutral or bad that those features or actions emerged in present-day teaching.

I (and some of my colleagues) use short videos to teach students. After these videos I have a series of short comprehension questions that ask the students about the content of the video. I find that this approach is mixed. Some students watch these videos and work through the comprehension exercises. Many, however, do not.

Another thing I find very useful is to set computer programming exercises that test students on the module content. I like computer programming exercises a lot as they really test students on the module content. At the same time, however, students find these exercises extremely difficult. They, therefore, give up on these exercises quite quickly. One solution to this problem is to make the exercises count towards the final module. The problem with this, however, is that often the work the student produce is either right or wrong. If the computer programming counts 50% towards the module mark the student thus gets a mark that is either 0 or 50. In other words, there is little differentiation between those students that worked hard and those that did not.

A separate issue with computer programming is that students can copy a colleagues work. This problem is something that I worry less about, however. If students choose to cheat and to not engage with the material then I believe they will be found out when they enter the workplace. If you ask such a student a few questions in person and you quickly reveal their lack of understanding and that their degree was not worthwhile. In other words, students that cheat are only really cheating themselves.

Within lectures I use Socrative to poll students and get them to answer questions. This approach creates interactivity in lectures. At the same time, however, there is a limit in terms of what knowledge can be probed using a multiple choice question.

On a final note, virtual learning environments and scripting can be used to automate repetitive assessment. These technologies will improve still further with the development of artificial intelligence. Such tools have the potential to massively increase our efficiency. There really is no excuse for collecting hand written work and handing it back. Doing so is wasting our own time and the time of our students.

Displacing the medieval concept of the teacher-priest, by the late 17th century (Newton) the lecturer was not the centre of teaching. The principal role of the university became to establish the syllabus and assess students' learning. Students are free to draw on books, lectures (and now) local and international internet resources to put together their own learning experience. This is a wonderfully liberating vision, and we must take care not to suffocate it.

Technological advancement brings development of means of communication and distribution of educational materials in newer form. In Middle Ages even printed out quiz task per a student was

not possible... Now we can have interactive textbooks and simulation environments for practice. All these I would use gladly.

At the same time, these are merely enhancements for the form. And the content I would try to keep as traditional as possible.

use tablets to have the students solve some problems live (anonymously)

a pc with just in time capability of modifying adjusting and integrating is even better than in respect to early 80's with diapositives then getting transparencies, not to mention black (or withe) boards: everything sometimes useful but limited

- Give presentation with slides: not necessarily good. Having to rewrite things (e.g. on a blackboard) while presenting gives a natural pace to the course, allowing students to write at the same time (and rewriting is an essential component, I think, of active learning). And sometimes things we just copy-paste between slides seem obvious, and we risk to just jump quickly from one slide to the next. But if one needs to explain them to an audience, subtle things that seemed obvious are not anymore, and the teacher is forced to explain them (or not to leave e.g. symbols in formulas unexplained).

- Record the presentation. This is good, to allow more people to access the material. But we should be careful that the students don't feel that they are authorised to be distracted during the actual course because they can re-see the lecture.

Show simulations or real life recording of physical phenomena. To experience one think makes the understanding much easier

Good: more collaborative approach, less top-down; exploit technology to create more effective communication; empathy (we - probably, not sure - tend to care more of the feedback given by students). Bad: speed (sometimes we teach at a rate not possible to be effective, maybe also because of powerpoint technology); lack of more general vision (today's teachers are certainly more focused on micro-knowledge: good teacher able to provide different point o view, different philosophy to approach a problem are rare, or discouraged); lack of inter-disciplinarity (sort of related to previous): a course on dft would rarely provide points of view coming from, say, semantics or social studies.

Preparation/teaching/assessment, athough conducted the same way, are much easier streamlined thanks to digital infrastructure: availability of material, videlectures (live and recorded), online assessment through testing.

Use of external resources: we have potntially access to a huge amount of external resources which are easily incorporated in the learning process. In the middle ages the teacher was probably the only source of knowledge

Focus on practical aspects: much of the theoretcal aspects can be covered with videolectures/pre-made material, leaving precious time for the teacher to interact practically with the students, on learning-rich activities, such as problem-solving, lab work.

Extensive use of programming tools: in the last few years, computational resources have become so cheap that a student's laptop can run some serious number crunching. But we have been students when this was not possible, and that has shaped us as teachers. Why do we teach a pedulum: because after three pages of math tricks and approximations we end up with a harmonic oscillator which can be solved with pen and paper. But our student will have learned a great deal about math tricks, but very little about physics. We had no alternative 1000- 100- or even 20-years ago. Now we have no excuses!

Discussing on a forum populated by people all around the world: an incredible learning resource even for top experts.

Picking from hundreds of existing options to explain something: You may find something great, but it tends to be hidden in a pile of (nonetheless popular!) rubbish.

in-class interactive quizzes (one could use raise your hand approach, or write your answer) but those tools give anonymity, immediate feedback, stats for the teacher and the load is on preparing good questions (one can use a question bank) rather than in the marking. Can tap into a game-competitive component to get the attention of the students

self-guided exercises (e.g. in repl.it): students can see by themselves what they are doing wrong/right and where they are and getting feedback. Automatised marking and stats for the teacher. Again, time in preparing good resources. Students may not engage though. Need incentives.

+ democratization of access to learning
+ access to huge amounts of auxiliary data and resources. Even having a few dozen books on hand, for a given topic, was not an option in the middle ages

+ rapid deployment of visual material with accurate drawings, pictures, etc... Blackboards were probably not even in use, and they are often not very clear/precise/etc... Their main advantage is the dynamical building of a schema, with an order of appearance and comments on the different parts. 3D objects and trajectories are an issue to be represented, and even more so with no support

Asynchronous and Online! Hugely increases accessibility to education. Even discussions can be asynchronous.

thought trigger 3 : Imagine you are with a few thousands of other people on a fleet of space ships, traveling at 1% of light speed on a few-centuries colonizing mission to another planetary system. There are 100 people on every ship, of all generations. There are 100 ships. You are in charge of teaching science to all children in this fleet, such that they can teach the next generation etc., such that the correct knowledge is there when those future generations will reach the destination. How would you organize this science education? You have all existing and yet to be invented educational technologies at your disposal. Just be aware of the limitation that collecting all children of the same age together in one of the ships is a cumbersome and

expensive logistic operation that might take place only every two (Earth-) months.

I think there are two ways of organising education on these spacecraft. Furthermore, I think that the future of education will take one of these two routes and that unless more colleagues begin to engage with innovative approaches the dystopian future is more likely.

In a dystopian future education revolves around instruction much as it does now. Technology, however, allows classes with thousands of participants. Student work, meanwhile, can marked automatically by systems of artificial intelligence. As a consequence, physical teachers play only a role small role. Instead a group of super teachers work together to prepare material that is delivered to huge cohorts of students.

This one-size-fits all model continues to deliver the same results that we currently have in terms of social mobility. In short the education system works to persevere the status quo. If your parents were professionals you will become a professional. If your parents are not professionals then you will not become a professional.

In a dystopia where teachers do engage with smaller groups of students their role is prescribed by the education system. In other words, teachers working with students have their lesson plans and curricula controlled by the body of super teachers who control the system. Front line teaching becomes an unskilled profession.

You can see how the education system might already become stratified when you think of the videos and MOOCs online. Some of these courses have many thousands of participants, while others have almost none. What I worry about here is that we are seeing the start of something similar to what has been seen in the creative industries. In these industries the majority of the money is made by companies that run platforms such as Spotify/ITunes. This situation is tolerated because a small group of global artists can make a substantial fortune. The majority of artists, meanwhile, are increasingly forced to provide content for free. The net result is that countless individuals, who might in the past have made a living as a musician, now need to take on some other employment.

In a utopian system the central activity is formative assessment. From an early age students are taught that they are the most important actors in their own education and teachers work with students to tailor content to each individual student. The role of the teacher becomes more like that of a coach. They are there to help the student when they get stuck and to provide some focus to what the student is learning. In addition, everyone plays a role in the education of the next generation. For example, if the students want to learn about how to captain the star ship then the systems are there in place for students to talk directly with the captain.

Reflection is a key activity in a utopian education system. Students are encouraged to reflect on their own learning and teachers are encouraged to reflect on the way that they facilitate this learning. This reflection leads students and teachers to have a better understanding of each other. As teachers and students now understand each other much of the (idiotic) educational language around meritocracy and "no child left behind" disappears. Furthermore, all the language of educational disabilities disappears. In a utopian system students will no-longer have dyslexia for instance. Instead such students are given the additional help they need to master spelling

and grammar. If it proves to be not possible for them to master some activity they will instead be encouraged to take on work which matches their particular skill set.

In short a utopian education system recognises that nothing that a teacher will ever do will force a student to learn. We thus have to trust that students want to learn and that they need to be given the confidence do so in their own creative way.

I would leave them with very detailed guided simulations and data-banks for all the planetary surface subjects, very well secured. Really well and with multiple backups.

The task of N-1 generations is to maintain fleet health and operation, thus they should learn about all phenomena around them, including medicine, physics, fleet ships mechanics and functioning. To be good operationists aiding the fleet autonomous AI systems. AI-guided simulation programs and courses will be good for that. And for the final Nth generation you won't have a better choice too - since any knowledge passed through generations about a subject that can not be directly experienced will become a ritual not connected with real situation. Of which, by the way, researchers on Earth would have only slightest ideas.

students are different from one another, it would thus be ideal to have different learning options for them (actually as many as possible so that they can pick what is the most appropriate for them), it could be as different as professor for one-to-one live lessons or video lectures

is it possible to have local tutoring at every ship? this will help caring for learning even if they are less prepared that the sole teacher.

then one could use telco tech, taking into account that maybe 1% light speed could be a problem even if relative velocity is almost zero, but you said one could benefit of future tech

Identify one or a few teachers for each spaceship, who could teach to the various young people. Implement a system where older young students become teacher for the younger ones. When possible, every 2 months, organise sessions with everybody working together, to make sure in groups of the same age that the content learnt is the same, and reinforce learning. Record videos of lectures in these occasions, and/or use "books" or a digital version thereof, reviewed by all teachers, for future reference; and try to keep an historical reference to avoid loss of information over time.

If time is not an issue. I would cover one single small topic at the time with the following steps: 1) make the person to experience the phenomenon with their hands as much as possible 2) teach the more theoretical (math) math with short videos 3) when possible to meet, a revision of all the topic so far with discussion among peers

Difficult to say the least. Few items come to mind: 1) create a maximum of learn by doing situations (by advanced simulation techniques), for the danger of an hyper-theoretical society confined in a space ship seems obvious; 2) profit of the start from scratch situation to create a teaching/learning system in which knowledge is not separated from emotion and ethics. If

learning is living (and growing) why these three points should be separated (or worse antagonising themselves)?

Lifelong learining: if technology has advanced to the point of deploying such ships to embark in the missions, we can safely assume all our basic needs are taken care of (food, energy, health...) and all our time can be devoted to learning. That is indeed our mission and not only children will be involved, but everyone on board the ships.

Not constrained by practical needs the learning can be made more flexible: people can study at their pace, with assigment and exams takn when they are ready for it.

Videolectures (preregistered) and videomeetings (interactive) are the norm. Laboratory activity can be carried out with advanced virtual reality infrastructures.

PBL approach: students are constantly challenged to solve problems (alone and/or in groups) and receive minimal help along the way to guide their learning in the process. They can access all resources they deem necessary (literature/videos/computng) and all tools are freely available.

What about homeschooling? ;-) No, honestly. Parents seem to play an enormously important role to instill "need for cognition". And once one has that, the remainder of education is peanuts.
BTW: In the spaceship situation, the generation that eventually can hope to arrive somewhere has huge incentives to learn agriculture, medicine and whatsoever. But looking at current students: Why would you study, say, differential equations when you hear & see that on the job everybody gets along with typing something into Excel?

Likely a mixture of self-directed activities, project-based work, study-groups supported by (3D) videos/enhanced virtual reality demos and continuous assessments in the form quizzes/challenges. Every kid could have an assistant (R2-D2 or CP3O like or an advanced Alexa ;)) caring for their learning (can work as an agenda + logbook + sensor for discomfort/frustration/surprise + search engine + ???). There will be also some coaches/supervisers but in general the older kids will care of younger ones, help them out. Project-based work can be also done in group of different ages and kids can progress from helping with rather simple, repetitive task, to leading the project at later age.

- perhaps a nested system with local learning alternating with wider levels, either through representation (best students? chosen/elected based on speaking capacity?) or full participation of everyone in wider discussion groups. The communication and grouping should be dynamic to put together the most appropriate people on given topcis as needed
- organize a rotating system where people go from one space ship to another for a few years to exchange (Erasmus++)
- need redundancy to make sure things are preserved (improved?) in a robust way, and do not go off on a tangent with some pseudoscience theory taking over (perhaps just because it is well presented in one instance and everyone gets on board)

- one specificity may be the lack of possibility to re-test or re-derive the knowledge if specific experiments are not possible in these conditions. Need to only _preserve_ the knowledge on these topics, as progress and verification are impossible

Personalise (Adaptive) learning for identified key knowledge and skills - the system monitors and controls progress. "Learning to Learn" would be a key skill.

Some questions that were raised during/after the presentation of the digest of the above input :

Q: “Good” lectures and “good” videos may lead to the illusion of understanding (for both the students and the teacher/videomaker). Otherwise, we wouldn’t need a Force Concept Inventory. See e.g., http://www.physics.usyd.edu.au/super/theses/PhD(Muller).pdf and https://www.pnas.org/content/116/39/19251

A: Right. Teaching is much more than lecturing, be it face-to-face or online. The illusion of understanding evolves to real understanding only by active mental efforts by the students, often realized by solving real problems that make them think about the material. Any course should pay a lot of attention to this aspect, be it face-to-face or online.

Q: note taking has other effects in integration of the information

- JL Some notetaking may be useful, however.
- BM Agreed - forces you to concentrate - better with recording as you can pause.
- GP I agree. Note taking is very important in my experience from just listening to actually learning
- SC I’m not against that kind of note-taking (I did take notes during this workshop, and found that a very helpful action for my understanding!). The comment was rather about organizing a lecture with the sole purpose of multiplicating the notes of the teacher into the notes of students.

Q: Are we being forced to solve lots of problems that would not exist if the students were motivated? Perhaps we need to only work on motivation.

A: That’s the bottom line, indeed. Teaching to a motivated group will almost always work, whatever you do. But not all actual students are motivated for your specific course, or for the entire duration of your course. If you succeed to keep that motivation high throughout your course, you will be considered to be a successful teacher. And many of the methods we discuss here, are essentially methods to increase or keep the motivation.

Q/C: The pendulum can be very useful to teach the concepts of errors and measurement. Best done at home.

A: I agree that there is still value in studying simple cases as the pendulum. But I also think that there are opportunities in studying more complicated systems with numerical solutions. This can be done nowadays, whereas that was simply not possible a century ago. It’s a ‘new’ degree of freedom. It would be strange if that would not lead to new opportunities for

teaching. Back then, they were forced to stick to the pendulum. We are still allowed to study it, but have the option to do other things as well.

Note: there is a second video with a digest of the ideas written down by the participants.