The methods they are a changing!

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ABSTRACT

Well-known teaching methods are altered by technology and social change. Three methods are exemplified and discussed; learning through frustration, teaching the teacher and simulation. The primary focus has been on how these changes have impacted the teaching methodologies, also how day-to-day learning can be altered. A secondary focus has been on the importance of timing in teaching planning.

Keywords: Simulation, teaching methods, project based learning, learning outcome, motivation, emotions.

1. INTRODUCTION

This paper is based on a keynote delivered to the ICETI conference in Orlando, USA on March 10, 2020. The background of the keynote was an ongoing study into new teaching models and methods in a mainly project based teaching environment. The models that were introduced were tentative and under development when the keynote was given. No one at that time could have imagined how much the Covid-19 would change teaching, and that schools all around the world and at all levels would have to digitalize at such a rapid rate. Out of this crisis has, however, arisen opportunities to test some of the new methods and models.

2. BACKGROUND

PBL and PBT

I will not, in this paper, embark on long descriptions of the pros and cons of project based teaching and learning. This paper is based on the principles and definitions laid out by, for example, Blementhal et al[1], Sahin et al[2] and Hmelo et al[3], and understanding this paper requires a grasp of these methods and the contexts they have been developed in. Architecture and Design colleges are almost archetypes of this way of teaching. The Oslo School of Architecture and Design (AHO) has migrated, over the years, from a very strict master-apprentice model to mixed models in which practitioners and professional teachers build the curriculum together. Starting almost without lectures, the increasing size of classes from 12 to 60 students paved the way for major long lecture series and shorter projects of a duration of one day to a year. Describing the education model used at AHO as a hybrid of project based and lecture based teaching is therefore a very close approximation [4].

Inspiration

This paper and the methods suggested arise from 26 years of experience in teaching lectures and projects, from bachelor to PhD level. The methods have been developed in response to the introduction of new technologies, and in response to changes in socio-cultural behavior in this timespan. This does, however, mean that the methods suggested have not been widely tested, and are not deeply grounded in the literature. That said, the methods are exemplified and the pedagogical reasoning behind them should be well known and well referenced.

3. THREE METHODS TO CONSIDER

The following 3 methods are presented using examples, and are supported by literature references. It can, however, be argued that the word method is a little pretentious in this context. Approach would probably be more correct. All methods are, however, based on a universal and well-know phenomenon, that we have been aware of for a long time - namely, students' motivation to learn[5]. The great difficulty in teaching anyone anything who is not motivated to learn, is a very well-known phenomenon. What actually motivates people is, on the other hand, more difficult to tie down. People are motivated by many things. I have, however, divided motivation here into two main categories - intrinsic and extrinsic motivation or inner and outer motivation[6]. Extrinsic motivation, in brief, are rewards and penalties imposed by external sources, educational grades, salaries, and punishment all being examples of this. Intrinsic motivation is an inner drive. You learn something because it gives you an inner, personal satisfaction, examples including becoming proficient in a sport or physical training in which there is no competition to win, solving a puzzle, learning to draw or to play a musical instrument[7]. All these examples could also be driven by extrinsic motivation. Some researchers believe that there is no such thing as an intrinsic motivation, and that all motivation is in one way or another extrinsic [8]. This is, however, not something I will expand upon here. The methods discussed move between both types of motivation. With this in mind, let's take a look at the three methods or approaches.

Learning through frustration

Emotions, even those that seem to be negative, can be an asset in learning[9]. This field has been investigated by a number of researchers, some emotions from this work appearing to be obvious motivators to learn[10][11]. It goes without saying that when learning to pack a parachute before your first jump, you are highly motivated to get it right. Fear is therefore a well known and well exploited motivator. Learning in a safe environment has, however, been highlighted as being an important value for motivation[12], and is in many ways the opposite of fear. A safe environment is for some people demotivating. There is no gain without some risk and without something being at stake[13]. I could go through all the emotions here. However, I will move directly to the emotion I want to talk about - frustration, and I will exemplify it by explaining how it can operate. When we started teaching CAD (computer assisted design), we began by teaching long courses that went through all aspects of designing objects such as tea

Figure 1: Frustration, could it be a good thing? Drawing by Stein Rokseth

cups, brackets, and bottles in a digital format. The outcome was, however and to our great surprise, not very good. Our students constantly asked for further courses and could not apply the knowledge from the courses in their projects. We therefore completely changed, after some years of using this approach, how we taught CAD. The students were given a half day introduction to the program, and then were told to start on their own project. Needless to say, they became almost immediately frustrated. They were not able to construct the shapes they wanted. We addressed this by bringing in student assistants from the senior years with good CAD skills. Two assistants for 30 students, however, meant that they did not receive help straight away. While waiting for help, the students in their frustration started to try bypassing the problem, testing out other ways to construct the shapes. A number of things then happened. They either solved the problem by doing it in a different way, so not needing any assistance when it arrived. Or they were highly motivated to find out how this could be solved. A side effect of both was that they, by tinkering with the software, acquired the skills they needed almost unconsciously. This tinkering paid off later when another challenge arose, and them suddenly remembering this type of problem from before. This is of course nothing new. All teachers have experienced students that figure out how to do it themselves before help finally arrives. The trick here is, however, to balance this. What is the correct point in time to receive help. Not too early, but also not so late that frustration boils over into pure rage. And how can we facilitate this in a productive way. Timing is essential, and teachers need to be attentive and find a well-functioning way of doing this. Resources are usually limited, and students will normally have to wait a while. But waiting too long is highly counter-productive. We discovered something new this spring about the second aspect - facilitating. All our teaching became digital (zoom) this spring, including CAD teaching. The assistants sat

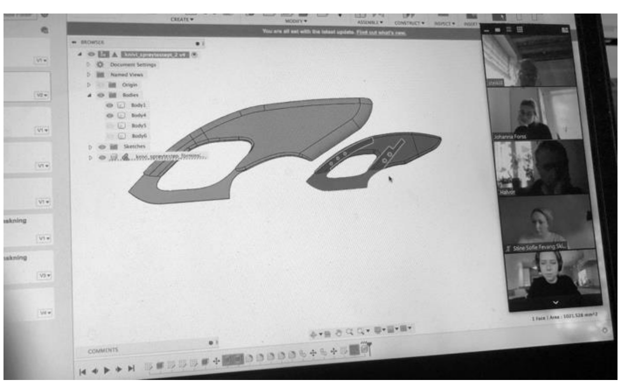


Figure 2: Screenshot of a zoom discussion of CAD file in larger group.

at their desks and interacted directly with the students on their machines. The session could also be recorded. This worked out better than being physically present, as the students found themselves more comfortable being in the digital queue, and those who figured out how to solve the problem by themselves, deleted themselves from the queue. It was also much easier to present common problems to the other students by showing the solution on all screens simultaneously. Our goal now is to investigate further allowing students to be helped by other students, using the digital platform. This leads us to the next method.

Teaching the teacher

The term teaching the teacher or training the trainers usually means educating people to become teachers or trainers. This usually takes place at colleges, universities or training camps.

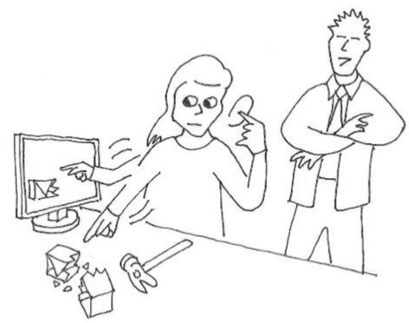


Figure 3: Teaching the teacher. Drawing by Stein Rokseth.

In this example, however, the teachers have already become qualified and do not need to be taught by other teachers, but by students. If we look at the highly disputed[14] pyramid of learning, or cone of experience developed in 1946 by Edgar Dale and The National Training Laboratories[15], as shown in Figure 4, we can see that the most powerful tool is the teaching of others. The pyramid is, as mentioned, highly disputed. The impact of teaching others is, however, significant. This paper does not want to start a discussion on the cone of experience, and the significance of teaching others as a pedagogical tool.

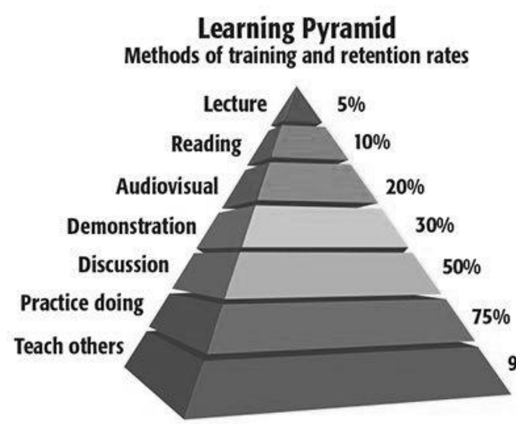


Figure 4: Cone of Experience, a disputed model for learning impact. Source: National Training Laboratories, Bethel, ME

The significance of this should not, however, come as a surprise. When you explain something to others you are, according to Donald Schøn[16], also reflecting on your own knowledge and process, a fuzzy notion that you have in your mind suddenly needing to be communicated verbally, in writing or by demonstration. This method is not used by many, for different reasons. Those who were top of their class usually were, however, asked on occasions to "help" their fellow students. I mentioned student assistants in the previous section. The outcome for the assistants in this is threefold; they earn money, they gain curricular points which they can include on a CV, and they substantially improve their skills. This is, however, well known. But there is more to this than that. I mentioned in the previous section that tutoring on zoom opened up the opportunity to present both problems and solutions to the whole class. This suddenly became an interesting arena that students could use to solve other problems than their own, so gaining further insight. The icing on the cake was, of course, solving something the teachers (assistants) could not, a motivation force in itself. This made something that I have observed for a long time even clearer. Teaching the teacher turbocharges motivation. Let me exemplify. I have tutored 150+ master/diploma students in their thesis preparation in the final year of a 5 year master program. The students choose their thesis topic. They therefore have an interest in and some knowledge of the field they have chosen to study. Even so, at the beginning of the student/teacher relationship, it is I the teacher who encourages and guides the student. Then, at some point, this turns around. The student starts to pass the teacher (me), and we start discussing the topic as peers. This is the sweet spot of the project, the point at which you know it will end well. From this point on, with very few exceptions, the student starts to excel, and the joy of teaching the teacher is an obvious motivator. How should this insight be utilized? Again, it is a question of timing. When you know that this fulcrum point exists, then you can aim for it and charge full speed towards it[7]. Asking questions when you don't know the answer is something both teachers and lawyers (in court) hate. This winning formula, however, brings us to the last method.

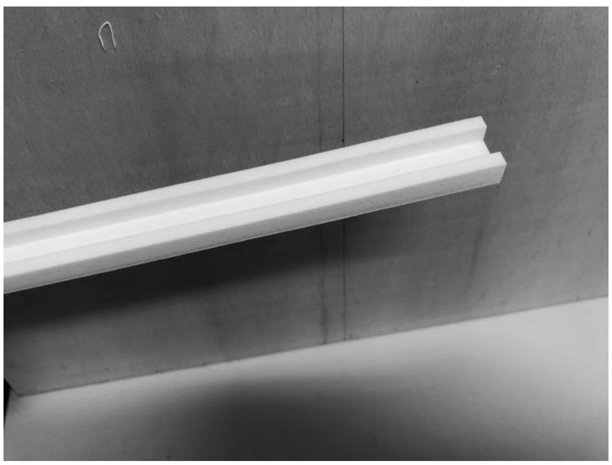
Simulation

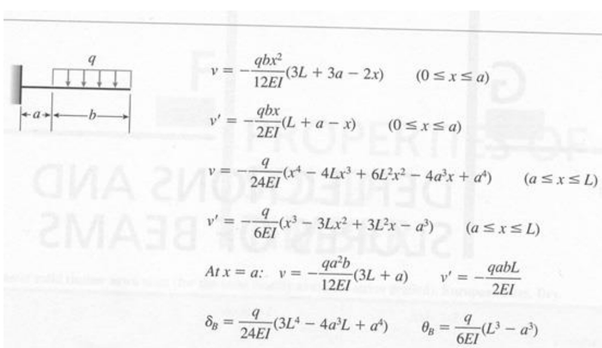
Gaming and simulation, usually in combination, have been a well known teaching method for a long time [17], and its effect is thoroughly documented. These also, however, have the well-known side effects of being too entertaining, addictive and requiring expensive equipment[18]. This paper will not go into the gaming part of the combination, just simulation. Simulation is also not a new tool or method. We have been testing and learning how to use equipment for eons. And not just us humans, but animals too, lion cubs learning how to chase and fight by playing with other cubs. Human kids also have been given miniature hammers, saws, pots and pans as far back as we know. New technology has improved and opened up new areas to simulation, preparation for disasters and other situations that are hard to prepare for without experiencing them, now being possible through simulation[19]. This method could also be used slightly differently, which I will illustrate through an example. Teaching material science and mechanics at an architect/design college can often be a challenge. Students at these colleges are visually oriented, and traditional blackboard lectures do not work well. An obvious solution has been to carry out lab tests, make a beam, apply loads and see when it breaks. A well known method for introducing mechanical principles has, therefore, been the ever popular pasta bridge. In this fun exercise, the students use pasta and glue to construct a small model bridge, which they then test with a load. This exercise has, however, become both superficial and to some degree meaningless. The students do not know whether it breaks when the calculations say it will and we therefore have to return to equations and the blackboard. Lets, however, take a step back. There are several myths that tell of engineers having to put their lives on the line when designing and building bridges and ships. One myth tells about roman engineers being required to stand under their bridge when the first legion marched over it. There is no reliable evidence to confirm this. But it is an interesting myth. These engineers trusted their lives to their experience and to well-known mechanical principles[20]. We, however, don't have to do this anymore, which is probably a good thing! We, since the 1950s[21] and increasingly in the intervening decades, have been using computer simulations. I could fill a whole series of papers on explaining computer simulations. However, the short description is that computer simulations predict a result based on mathematical models, boundary conditions and relevant input[22]. We all use weather forecasts. These are based on computer simulations[23]. Sometimes they are spot-on, and at other times they are way off. The key to simulation usefulness is, however, how they are visualized. In the beginning, back in the 1960s/1970s, the results of computer simulations were very long strings of numbers. They could be easily interpreted by scientists, but were nonsense to everyone else. The new tools that emerged in the 1980s for visualizing the results meant, however, that the results could suddenly be understood by anyone[24]. These visualizations also enhanced the understanding of very complex situations. So far so good. A product designer/architect is able to create a digital representation of a building, an object or in some cases even a situation[25]. Sometimes these simulations are spot-on, but sometimes they fail in a major way[26]. Trusting simulation so much that we feel we can teach our students about mechanics by just teaching them how to use a computer simulation program could, however, be fatal. Simulation can produce a result that is visually perfect, but can if data, assumptions or mathematical models are wrong, be disastrous[26]. A simulation will also not give any warning when it is wrong. If you do not have an understanding of what to expect, then you will not know when a simulation has failed. What, based on this, is the third component in how we can use these wonderful and powerful tools to give us deep insight and understanding in a fun and playful way?

Figure 5: Simulation, Theory and practice. Drawing by Stein Rokseth

Could calculus, simulation and 3D printing be the trinity? We did the following. The students were to investigate the impact of loads on a beam, or what would happen if a given beam were given a specific load. How much would it bend and will it break? And could we learn something from this experiment that could be transferred to a future situation? The images below show the lesson. Figure 6 shows the little 3D printed beam, Figure 7 shows the complicated formulas used to create the calculation and Figure 8 shows the actual testing of the 3D printed beam.. Figure 9 shows the simulation with a load on the beam and Figure 10 shows the result of the simulation and the measurement of bending (5mm). 3D printing allows examples of constructions for testing and simulation to be easily created. Combining simulation (here typical Finite Element Analysis or FEA[27]) in this way has been tested and discussed[28]. 3D printers have now been implemented at a number of schools. Finding numbers is difficult, but according to Statista[1] the annual number of 3D printers shipped in 2018 was 1.4 million worldwide. They predict this number to rise above 8 million units in 2027. We here have found three routes to a result.

Would they all give the same answer? How far off are we? And where lie the errors? We, in this lesson, introduced several ways to find answers. Critical thinking was, even more importantly, heavily challenged! The students saw the benefits of all methods, they had fun doing it and came out with a deep understanding of the competencies needed to use all methods.





$$v = -\frac{qbx^2}{12EI}(3L + 3a - 2x) \qquad (0 \le x \le a)$$

$$v' = -\frac{qbx}{2EI}(L + a - x) \qquad (0 \le x \le a)$$

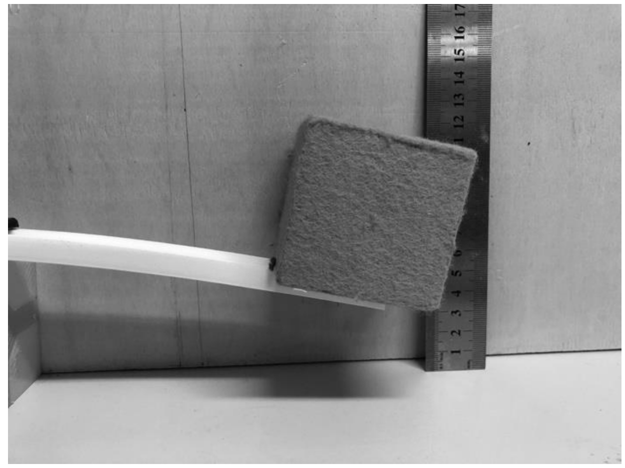
$$v = -\frac{q}{24EI}(x^4 - 4Lx^3 + 6L^2x^2 - 4a^3x + a^4) \qquad (a \le x \le L)$$

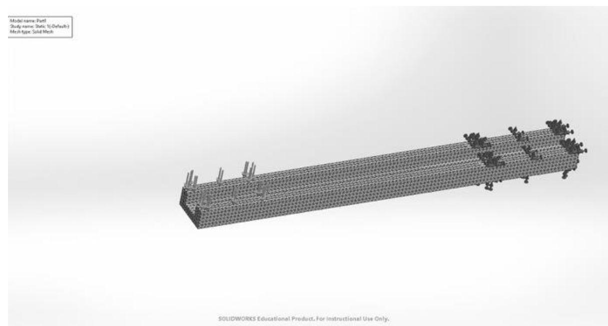
$$v' = -\frac{q}{6EI}(x^3 - 3Lx^2 + 3L^2x - a^3) \qquad (a \le x \le L)$$

$$\text{At } x = a: \quad v = -\frac{qa^2b}{12EI}(3L + a) \qquad v' = -\frac{qabL}{2EI}$$

$$\delta_B = \frac{q}{24EI}(3L^4 - 4a^3L + a^4) \qquad \theta_B = \frac{q}{6EI}(L^3 - a^3)$$

Figure 6 (top): The plastic beam, photo by Steinar Killi; Figure 7 (bottom): Formulas for load on a beam.





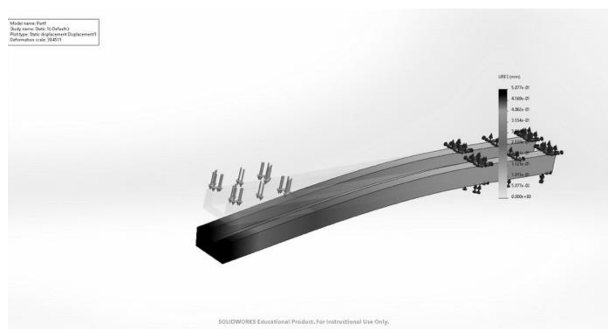


Figure 8 (top): Beam with load, photo by Steinar Killi; Figure 9 (middle): CAD drawing of beam with loads and boundary conditions, screenshot by Steinar Killi; Figure 10 (bottom): Simulation of Beam with load, screenshot by Steinar Killi.

The take away from this third method is therefore that it can help students connect new methods to old methods, and learn that there are many ways of achieving a goal. Reflecting on the methods and combining learning methods can also enhance meta cognitive strategies[29], a number of researchers viewing this as an effective learning education strategy [30], [31]. This is based on reflecting on what we know, how we know it, and how we can enhance awareness when learning, which again relates to Schøn[16] and reflecting on your practice. This time, however, both for teachers and students.

4. DISCUSSION

All three rise out of well tested methods, all methods playing on motivation, how to spark it, enhance it and prolong it. If we look a little closer at the variations in the methods presented we can, however, see some clear relations and transferable values.

[1] Global unit shipments of 3D printers from 2018 to 2027. Access the source link here: https://www.statista.com/statistics/370297/worldwide-shipments-3d-printers/

Firstly, all methods are based on timing, which can't be stressed enough. The frustration method is a knife-edge balance; too much and its contraproductive, too little and it is annoying. In the second "teaching the teacher" method, timing comes into play. An asymmetric potential between the student and teacher that is the opposite to the normal must be present in this method. In other words, the students have to have an insight that the teacher does not have at that point in time. Encouraging and opening up for this could, however, leave the teacher feeling vulnerable. A teacher who is aware of this will anticipate it and celebrate it when it happens. The third is simulation, this being founded on the order of events. What comes first? The calculus (theory), physical testing, or simulation? We started, in the example described above, with the calculus, then simulated and then tested, testing being a type of proof. The order probably depends on student maturity, the type of theme (in this example mechanics, but could be almost anything) and what is to be emphasized. A consciousness of the timing is, however, important.

All three methods are, secondly, altered by technology. This is, however, to be expected, as new technology usually leads to changes in teaching tools and methods, teaching methods also being changed by social change. We will probably now therefore see a veritable landslide of research based on Covid 19, not all the findings being bad. Most schools have been forced, at all levels, to speed-up their digitization of teaching due to the lockdowns. This at first glance seems to be a bad thing. But we also see some nuggets of good, as indicated by some of the examples.

Thirdly, talking about methods is always risky. The three examples hint at a change in well proven methods. One could, however, instead just call theses new approaches.

5. CONCLUSION

As stated at the beginning, this paper is based on a keynote of 40 minutes, but intends to go a little deeper than the keynote. Some references for all the claims made can also be given here. All three methods are old. The intention is to alter or renew them in some way, hence the title of this paper. These changes have all arisen out of teaching experience in a teaching environment at an architectural/design school. The changes have not been verified as being universal in any way, not at these types of school or others. It is, however, my intention to inspire other teachers to challenge some of the methods we use today. Finally, one of the oldest methods is in desperate need of being refurbished and upgraded. This method is how we give lectures, which I intend to address. We have, in this period of rapid digitization, given most lectures on platforms such as zoom and teams, this opening the eyes of many lecturers to the opportunities that lie ahead. For example, you could record your lecture, play it at a set time and take questions as it plays via different chat tools on the platforms. You could, as a teacher, perform the impossible - being at more than one place at the same time. Students could write questions, you could answer them and other students can read them, all while the lecture continues.

As we all can see, the teaching environment has been tremendously changed by Covid 19. Could, however and paradoxically, this period of episodic change in the world lead us into to a new era of "The rise of the Lecture!".

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