Teaching creativity creatively

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Abstract

The first steps toward innovative technologies in education are often initiated at individual level, especially in small sized universities. Experiencing limitation in resources, teachers hunt for the cost-effective, creative approaches, using open and easy to learn tools, developed and proved models and time-saving methodologies. After implementation of innovative learning designs, they try to justify the benefits for the students. Primarily, learning outcomes and student's satisfaction are evaluated. The paper describes technology-based changes in teaching Theory of Inventive Problem Solving" (TRIZ) course at Lappeenranta University of Technology in a way of roadmap. It aims to reveal changes in learning process, based on student's satisfaction of traditional and flipped courses. The online part of the course is built in a flipped classroom form using open e-learning platform, interactive video hostings and Facebook group for materials delivery. The in-class sessions consists of discussions with originally developed feedback system and problem-solving group works. The data is gathered by the asynchronous surveys provided by the LUT administration and specific surveys, customized by teachers and instructors of the course.
The results in blending of TRIZ course demonstrate how systematic creativity tools assist the inventive course design and address the gaps and drawbacks in teaching. Shared student feedback basically shows positive response to the teachers efforts.

Keywords

Teaching, Flipped classroom, Creativity, TRIZ,

Introduction

Digitalization and total connectivity result in tectonic changes in many businesses. Uber, AliBaba, AirBnB became the biggest taxi, retail or hospitality companies, respectively, having zero tangible assets at the same time. It can be anxiously presumed that global transformation period in education has just began. The main drivers of this transformation are demonopolization, globalization, openness, flexibility and practice orientation. At the same time, the trend of younger generation perception preferences can be added to this: they prefer watching to reading, integration to deduction, multipurpose to concentration. And teaching technologies that enable this transformation are typically named as e-learning or digital education, blended learning, flipped classroom, project based learning and some others.

Having agreed to this, at least partially, “an old school professor” might revise her/his way of teaching and face a number of questions. What should be digitized, flipped, project-based in my course and what should stay as it is? What is the proper share of in-class and “outdoor” (computer-based) activities? How to bridge them? How much time is needed to produce one time unit of teaching video? How to evaluate the efficiency of on-line and in class activities? How technically demanding the digitalization is?

The paper presents rather initial speculation on the subject than solid statistically supported general results. At the same time, a very specific experience of transformation of one of the courses taught at university for a number of years is presented. And this specific teaching experience in rather new and unusual subject, is another focus of the research. The subject is the systematic creativity, grounded mostly in TRIZ, the Theory for inventive problem solving. The approach was introduced in 1956 (Altshuller, Shapiro, 1956) and made it way to the public, industry and science, see recent reviews (Morhle, 2005, Ilevbar, 2014 and Chechurin, 2016). Ironically, the subject should itself be the instrument of inventive changes in the way of teaching. The experience of gradual migration from traditional class to flipped one, the first statistics on results and lessons learnt are supposed to be the main contribution of the report.

Background

Worldwide interest to TRIZ has slightly decreased in the recent years. The amount of scientific papers for the term “TRIZ” in Article title, Abstract, Keywords are currently in the “Fade” stage”. According to Google Trends, the current frequency of search term is low, constituting 30% percent of the maximum in 2004. The interest by region tool shows mainly developing countries in Asia. Worth to mention, that relatively strong surge of interest varies for the regions with the highest proportion of people searching for the term “TRIZ”: Angola (Oct. 2005), Trinidad & Tobago (Feb. 2004), South Korea (Sep.2004), Mozambique (Feb. 2006), Taiwan (Nov. 2006), Brasil (Aug. 2017), Peru (Apr. 2004), Iran (Feb. 2004). The amount of papers in Finland is negligibly small and the overall interest to the term in the country goes down with the highest peak in February 2015.

The inventive design requires special knowledge and innovative solutions. TRIZ is a systematic tool to support idea generation and inventing. Many researchers conclude that companies appreciate introduction of TRIZ approach to business practises (Ilevbare, 2013). Companies are the main consumers of TRIZ education. While service providers are mostly in consulting, the professional TRIZ education, including e-learning tools, remains largely commercial and proprietary. It results in limited information and access to the TRIZ in the open online environment.

TRIZ is taught in a number of universities across Europe, however the hubs remain small. Having been applied to engineering problems, generally it is a part of the programs in Industrial Engineering or Mechanical Engineering departments. Teachers use traditional lecture-based learning design in for TRIZ courses. Scopus database search query TITLE-ABS-KEY (*triz*) AND TITLE-ABS-KEY (*blended* AND *learning*) OR TITLE-ABS-KEY (*moocs*) OR TITLE-ABS-KEY (*e-learning*) OR TITLE-ABS-KEY (*flipped* AND *classroom*) OR TITLE-ABS-KEY (*video*) OR TITLE-ABS-KEY (*online* AND *learning*) yields 18 papers only. 9 papers describe the digitalised ways of teaching TRIZ, two of them describe TRIZ application for classroom digitalisation and others are not relevant. The authors develop the online or blended approaches and environments (Jou, 2010), game based TRIZ learning (Leung, 2007).

TRIZ digital resources for education are limited or old fashioned and do not satisfy the sort of standards of constantly changing user-friendly interfaces. For instance, the acknowledged software packages (Ilevbare, 2013) are either not available *(Innovation WorkBenchs by Ideation International*), or expensive (*Goldfire by Invention Machine, TriSolver*) or seems old-fashioned in terms of design adaptivity (Creax Innovation Suite). First five pages of Google search for term “TRIZ” yield mainly the textual online manuals like “Oxford Creativity”, “The TRIZ Journal”, “Creating minds”. The only one user-friendly tool TRIZ40 that seems to be quite popular, but unfortunately reduces the whole method to contradiction table, a particular and superficial tool. There are some open online courses within the modern e-learning platforms on OpenEDU and 4Brain platforms but they are in Russian language only. TRIZ courses are not found in Linda, EDX, Coursera and other major e-learning platforms. “BioTRIZ” and other personal channels are found in YouTube but not much activity detected. Thus it tells that TRIZ coverage in open online space is small and more powerful learning massive open online resources do not contain any TRIZ courses or even any references to them.

Case

Course redesign (From traditional to flipped classroom)

It was presumed that the creative thinking should be taught creatively, using largely the advances of digital medium changes. 3 year long TRIZ deployment project co-sponsored by Finnish government, LUT and a number of industrial companies (ABB, Konecranes, TuuliSaima and Innotiimi) was used to conduct the training for engineers, analyse the results and redesign the course. Having started with traditional deck of presentation slides the materials were selectively converted into videos and used for regular courses of TRIZ in LUT also.

Pioneered in 2011, the intensive course on Systematic creativity and TRIZ has been taught by the authors at the department of Industrial Engineering and Management of the School of Business and Management of Lappeenranta University of Technology (Finland). Currently, there are two main forms: standard (long) and intensive (short). Long course lasts 1 period (two months) with the total workload of 156 hours (lectures 28 h., exercises 28 h., teamwork 38 h., reading 49 h., exam 13 h.), which is equal to 6 credits. The short-term course within summer and winter school includes two levels of TRIZ “Systematic creativity- TRIZ basics and “Inventive Product Design and Advanced TRIZ course”. The total workload of each course is 78 hours, where lectures and exercises take 24 hours, teamwork and a limited project work are equal to 20 hours, 8 hours of presentations with the results of project work

and 26 hours of independent work. The grades are evaluated mainly based on the final project work.

From 2011 to 2015, there were no significant changes in a course design in terms of the structure. The first attempt to re-arrange the course was done within the Summer school intensive in 2016. The target was flipped classroom design, where the in-class time is devoted to activities and pure lecture is substituted with digital preparation materials, mainly videos.

Fig.1 compares the transition from traditional to flipped classroom design. There are three different designs of the same short- term course, which are described in terms of elements and duration of the course. First, the videos were implemented. Following that, the design was extended by quizzes and other materials, which were gathered on the open e-learning platform “Thinkific” as a 6 modules course http://triz.thinkific.com. For the Summer school 2017, the EDpuzzle web-based platform combined videos with instant questions. In addition, the in-class part was activated. The students were randomly grouped in four teams. Each team had its mentor, a PhD student. Class activities consisted of generation of ideas, quizzes, games, role changes, cases, teamwork. Having been implemented, discussion in the beginning of the class connected the online and offline parts. Pure lecturing part was practically eliminated.

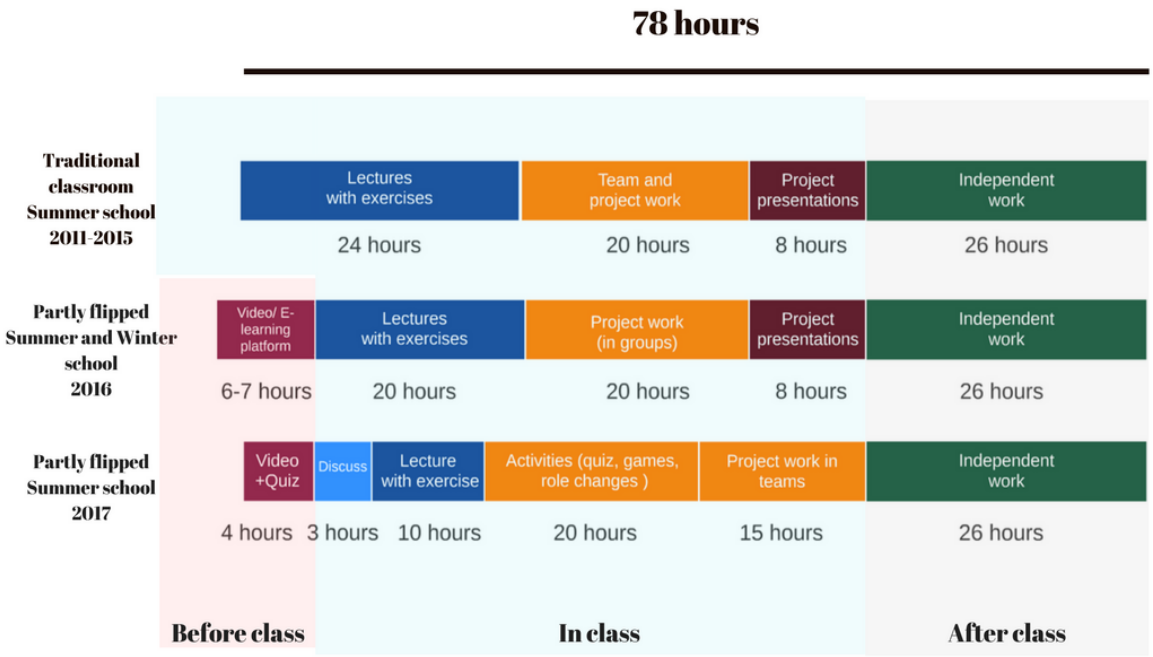

Figure 1: Course redesign from Traditional to Flipped classroom

Instant Feedback system development

The design of the instant feedback system was inspired by the following very generic, even philosophical principles of TRIZ:

- A single useful action should be redesigned periodic, the periodic should become continuous. (“Continuity of useful action” inventive principle)
- A system should be designed dynamic and adaptive. It is to address the challenges and changes from the outside immediately (“Trend of dynamization” of TESE, trends of engineering system evolution)

- Redesign of a system should increase its ideality. Ideal system is the system where even the most aggressive design ambitions, have become true without compromising the cost or any design generated harmful factors (Ideal final result, IFR concept).

These principles were a good departure point (and navigation tool) for the course improvement ideation. They were read as follows:

- Ideally, the teaching session is adaptive, the pace of teaching, the contents, the number of examples, the background of examples and other elements are to be chosen immediately to have its maximum efficiency on the participants.
- The feedback system should enable continuous reading the satisfaction of the audience, especially in the case when the audience is big (visual or verbal personal contacts are limited) or new (requires some time to comfort itself with new teacher/presenter and start reacting more open).
- The system should be light, transparent, easy to use, using the existing resources (no additional devices is needed).

The prototype for the system was found in some advanced universities (like MIT) that practiced an “extra screen” in lecture room. The second screen is used by the audience to tweet immediate feedback, questions or suggestions, openly, visibly but without interruption of the teaching. Being functionally exactly what we wanted to reach, the prototype turned out to be technically demanding. Indeed, it requires one more screen, projector and internet connection (with subscription to either messaging service like Twitter, or web chat room). Instead the authors piloted and experimented the feedback system that delivers the audience’s comments to the same screen, over the presented materials. Comparing to Twitter-like solutions, it limits the dialog by one room and gives anonymous access without registration. Unlike voting systems, it does not require special equipment and additional screen like Slido, Tweedback. Communication is initiated by students rather than by professor, whereas generally teachers use feedback systems to get answers on his/her questions. The detailed description and prototype can be found here and tested on Windows PC http://askbox.strikingly.com/. It is planned to improve current solution toward more adaptive and autonomous system which enables not only commenting or questioning but rather to transfer the current class mood to the teacher instantly.

Video recording

To substitute lectures by videos was the most radical, complicated and resource-intensive element in the course transformation. From the beginning, the creative and resource-effective approach for the video design and developments was used. Short (coffee break long) recording meetings and smartphone camera shooting provided the first video samples. They were used as the departure point for more structured and quality recordings later on. 5 core videos (1 hour long in total) covering 5 main topics took 10 hours of professor and 80 hours of assistant devotion. 90% of working time was spent on editing, the rest for the meeting, preparation and recording (Shnai, 2016). The duration of each video was 10-15 minutes with 3-4 inner sections. The video typology was designed based on literature review of flipped classroom experiments and on user-friendly videos in the MOOCs (Massive Open Online Courses). To economize the cost, all videos were recorded using smartphone, tripod with the free access to LUT studio with minimal equipment to control the sound, background and light. Editing and design of videos were done by the assistant using free open software. Subsequently, they were published on the open free YouTube host https://youtu.be/OtHqqQa8Doo. Following that, the videos were embedded in open video or learning management systems like Thinkific or Edpuzzle to integrate them with the full course design.

Data collection and data analysis

To track student's satisfaction two different surveys were conducted. The administration of Lappeenranta University of Technology distributes to students a general questionnaire form on completing the each course. In addition, student's post-course asynchronous semi-structured survey was developed with respect to more specific issues and elements in course design. Questionnaire form was developed based on the rigorous literature review. The data was collected after several days of course completion. Summer school course in 2017 attended 29 participants, mostly of MSc and PhD levels. Course participants' ratio of engineering background students and management was approximately 4:1. There were 3 guest students from China who did not take part in the LUT developed survey. The response rate in general LUT survey was approximately 50% (13 respondents from 26 accounted participants) and in the specific survey, conducted in the class, response rate was 100% (29 respondents from 29 participants). Furthermore, the entire process of flipped classroom implementation was accompanied by observations. The paper presents only partial results about student satisfaction from the latest redesigned course within Summer school 2017. In addition to it, the qualitative guidelines and comments based on our overall experience are given.

Course outcomes

Student satisfaction according to general survey provided by LUT

The student satisfaction for the Systematic Creativity and TRIZ basics was tracked from 2013 to 2017, where the first three years the courses were traditionally designed and last two designed in the flipped form (X-axes). The Y-axes describes the student satisfaction in zero to five scale. Mainly the satisfaction for this course is higher than 4.5. The percentages written on each column show response rates for each course. The number of participants in each year is not vary significantly in a range from 25 to 35. It can be traced that response rate increases and the results of student's satisfaction are more representative (Figure 2).

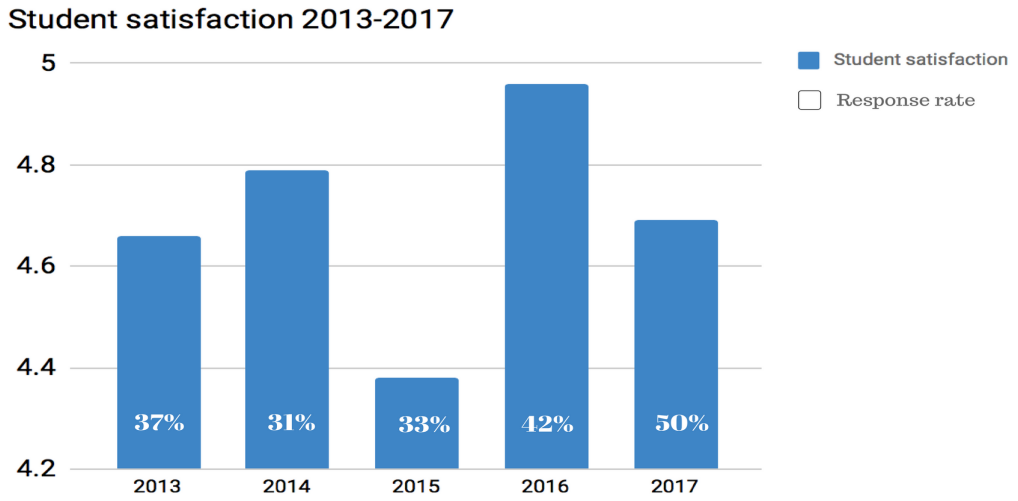

Figure 2: Student satisfaction of Systematic creativity and TRIZ course from 2013-2017

In addition, the student satisfaction by the course "Systematic Creativity and TRIZ basics" was compared to student satisfaction by other courses of Summer school 2017 in LUT. The

student satisfaction constitutes average of course satisfaction and lecture satisfaction. Out of 14 summer school courses we analysed the responses on 10 courses, where the more detailed overall satisfaction was given. These courses involve two levels of TRIZ “Systematic Creativity and TRIZ basics” and “Inventive Product Design and Advanced TRIZ “where the first one was designed in flipped form. As on the Figure 2 above, Figure 3 shows the “Overall satisfaction” with response rate.

The courses for 2017 are spread along x-axes. The same as on the graph above, y-axes describes the student satisfaction. And the numbers on each column represent the response rate for the course. The highest response rate is 60 % and the lowest is around 20%. Also the courses with lower response rates have lower satisfaction (Course 3, Course 7, Course 9) and the same in the opposite way (Systematic Creativity and TRIZ, Course 4, Course 6, Course 8). The highest satisfaction rate was for both courses of TRIZ (basic flipped course and advanced traditional course) and Course 8. The response rate for TRIZ courses was counted from 26 participants and for course 8 from 13. It is worth to mention, that the first course of TRIZ (flipped classroom) and course 8 have relatively high response rate in comparison with non-flipped second TRIZ course.

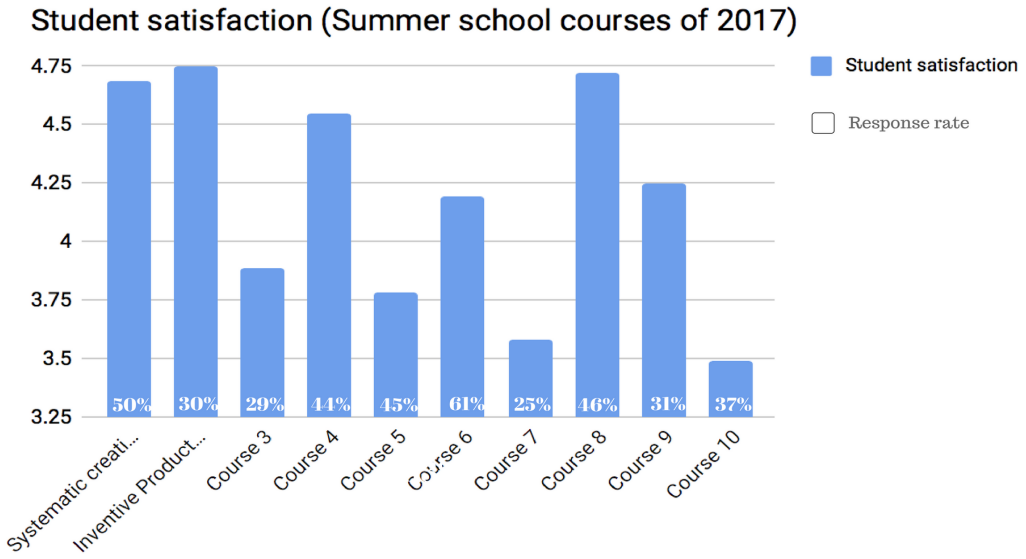

Figure 3: Student satisfaction for Summer school 2017 courses

Student satisfaction (specifically developed survey)

The amount of involved respondents was 29 (26 LUT accounted participants and 3 guests from China) and Response rate was 100%. The main results reveal positive feedback from most of the students. General perception about course design is given on the Figure 4 below. The 7 point Likert-type scale was used to reveal student agreement. Y-axes describe the amount of respondents. The first graph shows the student’s estimation of the usefulness of the course design for their study and the second graph the satisfaction with flipped videos and activities.

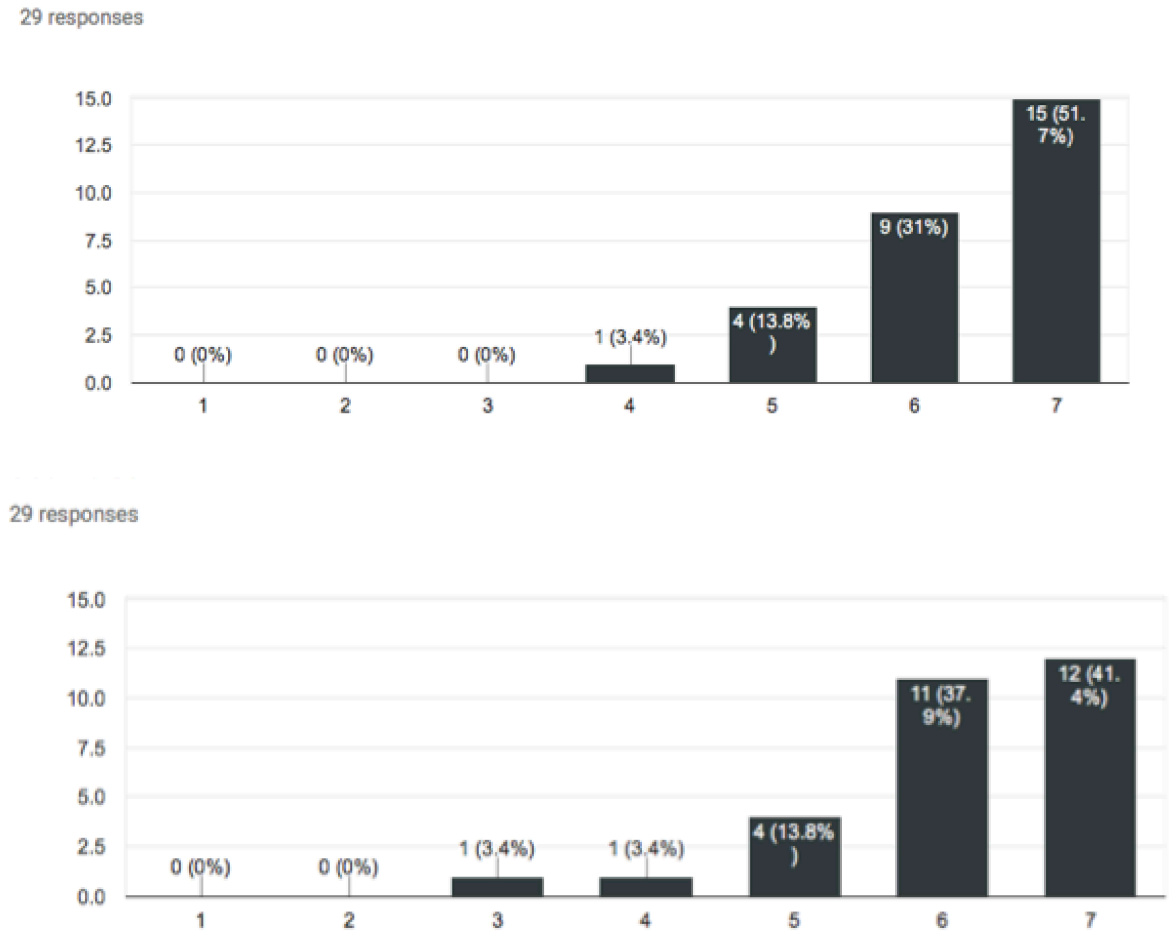

Figure 4. Overall perception of the course

> *"The course has been most interesting and enhanced my capabilities in problem solving. Leonid has truly thrown himself into the fire and is a very inspiring lecturer. Early morning classes are often tiresome and uninviting, but not this one!"*

> *"It has been an incredible course, because I think we have learned many methods without realizing it. I really enjoyed and recommended"*

The student's perception about the videos implemented before the class was also positive. Most of them strongly agree that videos help them to understand the materials better, increase involvement and interest. However, they were not so sure that videos are helpful for preparing questions and comments in advance.

> *"Videos could be more precise, with more details and examples. Though, all these is given in the classroom."*

> *"Well I believe the idea of the video is especially nice because you can go through them even after the course. I would like to questions to be framed better and I think with continuous feedback and improvement, they can be even better"*

> *"Videos were mostly good and informative. The following questions were mostly unusable and annoying in their inaccuracy"*

"It would be better to have longer videos, not so concentrated. When every word is important it is hard to keep concentration on every second during all 12 minutes. May be it is better to add more examples in the video and repeat main points from different angles."

In addition, students support the idea that in class activities increase communication, involvement, motivation to learn, understanding of TRIZ tools, having fun.

"It was nice to have several lecturers in this course, to see and take part in discussions they make. Also I liked the idea of changing activities at certain time (from group work to independent work"

Design guidelines

Some design guidelines and comments can be proposed based on the sequence of experiments with respect to students and professor opinions and learning analytics from the used tools. It seems that most of them can be generalised and probably be helpful not only for TRIZ course re-design.

- Build the bridge between online and offline materials

The connection of online and offline parts is relatively important. By adding the discussion in the beginning of the class the initial level of student's understanding was revealed.

- Course time increase by the preparation materials can lead to student's overload, especially within the intensive course.

It is beneficial if students are familiarised in advance with the flipped classroom structure of the course. And if the in-class time is decreased, motivating students and making them more open to innovative learning approach.

- Share the preparation course materials in advance. Make the preparation materials «not possible» but required
- Give special attention to video typology, design and place in the course

Based on the detailed surveys, the 30 % (from 29) of students believe that "Videos didn't give enough information" and 20% that "Videos are too fast". Therefore, the videos can be improved in these directions. In addition students mentioned that 45% percent of people believe that videos are useful "before the class" and 38% after class.

- Add motivation (like quizzes) to increase the video views
- Involve differently designed activities

Increased time for activities and 4 mentors lengthen the personal communication, avoiding free riders in the class. Teamwork was also beneficial for in-active students in order to open their potential and strengthen their social status in the university environment.

- Begin with the small video fragments development

Learning outcomes

Measurement of the grades is not as simple in the described course, as possible in more fundamental subjects. Whereas, the grade system for math or physics can be standardised, creativity assessment is not subjective and can be interpreted differently.

The grades for this course are commonly constituted based on the final projects reports.The flipped classroom design of 2017 was estimated based on the overall in class work and learning analytics from video views was taken into account in questionable situations. Increased time for variety of different activities, involvement of 4 mentors and relatively small

amount of participants for each class team gave the detailed perception about each student in personal.

Conclusion

The study presents the experience and results of digitalization of university course on TRIZ, the theory for inventive problem solving. It demonstrates how principles of systematic creativity assist the inventive course redesign. We feature instant feedback system prototype, original blended course design, dynamic bridging of in-class and off-class activities, focus on project/team work in application to the specific course. Experience based speculations on how to start blending of teaching, what difficulties should be expected and how they are circumvented can hopefully save some efforts of readers, interested in the same activities. Course redesigning is used to support the main outcomes as well as general success of the journey.

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