Online Based Innovation - online tools and teaching to support global collaboration and distributed development projects

Mr. Joona Kurikka, Aalto University

Joona Kurikka is a PhD Researcher at Aalto University and Associate at CERN, working at the innovation experiment IdeaSquare. As part of his work at CERN, he is coordinating and teaching student project like Challenge Based Innovation and various smaller innovation workshops, hackathons and other projects. His current research focus is on processes and ICT tools for distributed collaboration and learning.

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Abstract

This paper is based on work done at IdeaSquare, an innovation experiment at CERN, the European Organization for Nuclear Research.

Challenge Based Innovation -course (CBI) is a 4-6 months long format developed by IdeaSquare and collaborating universities. During the course, graduate students visit CERN for 3-4 weeks, and rest of the project is distributed globally in the premises of the participating universities. This paper focuses on the second iteration of the course, which was done in collaboration with 7 universities, across 8 time zones and with 46 students from engineering, business and product design.

The main research question of this paper is, what elements should be considered when scaling such a project from small and partly co-located "Challenge Based Innovation" to bigger and fully distributed "Online Based Innovation" while maintaining the strong connection with fundamental research at CERN to inspire new solutions for the targeted societal challenges. The research question is approached by analyzing the usage and results of an experimental online collaboration platform put together by the author, and the remote interactions of the participating 46 students during the course in 2014- 2015.

In addition, this paper introduces recommendations for setting up such a global collaboration project and to optimize the learning experience and collaboration aspects for the participating students.

Introduction

CERN, the European Organization for Nuclear Research, has been carrying out groundbreaking fundamental research in particle physics for over 60 years and has made numerous important discoveries in the field – latest widely known example being the Higgs boson in 2012. The current research endeavors gather over 12 000 scientists from around the world to collaborate in scientific experiments, and to develop new hardware and software solutions for the highly accurate technology-driven prototypes. Over time, some of the research discoveries and instruments have found their way to wider audiences and have had a significant impact on our everyday life, as in the case of the World Wide Web or proton therapy.

IdeaSquare at CERN is an innovation experiment established in 2013 to explore new ways to demonstrate the value of applying solutions developed for fundamental research to societal challenges and create a positive feedback loop for ideas and potential technologies back to the

research. To fulfill this purpose, IdeaSquare is hosting long-term research projects on detector R&D as well as facilitating multidisciplinary student projects and promoting different innovation-related events and hackathons. Most of these activities are hosted at a dedicated building, also called IdeaSquare, at the main CERN campus.

Teaching and project goals

As CERN is an international research center and not a teaching university, the starting point and goals for a student project differ from a typical university course. Our main target with CBI and other similar projects is to find new connections between societal challenges and fundamental research. This will, hopefully, help us to offer an additional demonstration on the value of fundamental research, and for the societal return on investment that publicly funded projects like CERN have towards society.

Teaching and product development methodology called Design Thinking (Simon, 1969, Brown, 2008) has been a significant inspiration to the course development, together with the overall human-centered approach and a pedagogical area called inquiry-based learning (Barron, B. and Darling-Hammond, 2010). Inquiry-based learning includes Project-Based Learning, Problem-Based Learning and Learning through Design, all of which CBI draws some content, but has the closest connections with Project-Based learning (Dym et al., 2005), which is defined as "learning through complex, open-ended projects, which typically results in a product or concept". Similar settings are faced in academia by project-based development courses such as ME310 in Stanford University and IDBM and PDP -projects at Aalto University, and in globally distributed corporate product development organizations; "skunkworks" or consultancies.

Research methodology

The author is currently working at CERN as part of the IdeaSquare development team and has participated in planning and coordinating the CBI course. The material for this paper has been collected and analyzed from this viewpoint using participatory action research methodology (Whyte, 1991; Baum et al., 2006)

The primary data for this paper was collected from the usage of the online working platform during the course, and three extensive and compulsory surveys that all the students (n=46) answered before starting the course, after the first visit to CERN, and at the end of the course.

Challenge Based Innovation

The second iteration of the Challenge Based Innovation was conducted during the academic year of 2014 - 2015, coordinated by a two-person team at IdeaSquare in collaboration with seven universities: Aalto in Finland, NTNU in Norway, IED, ESADE and UPC in Spain, UNIMORE in

Italy and Swinburne in Australia. In addition to the geographical variance, we wanted to increase the overall variance of the student pool to get more exotic and unique ideas. The participants were mostly graduate students from various fields of engineering, business and design disciplines, and just three of the participants had studied a significant amount of physics.

In more details, 6 of the students were working on their undergraduate degree, 33 were on the graduate level, 6 MBAs, and one PhD. The division between different disciplines was planned to be fairly even, and the student backgrounds were business (13), design (14) and engineering (18). The gender balance was more uneven, 14 females and 31 males. The average age of the students was 26.8 years, with student ages ranging from 22 years to 57 years. The students were divided into six groups trying to maximize the variance of these factors. Each group was also divided into two geographical locations, for example, combining students from Australia and Norway.

The course also connected with 18 representatives of teaching staff, including 6 professors and 12 teaching assistants, who were participating in the weekly coaching sessions and collaborating with IdeaSquare on creating the shared online teaching material.

All the collaborating universities were selected based on them having previous expertise on similar design thinking -driven product development courses and active prototyping experience with students. The two biggest and partially overlapping common nominators were the ME310 / Sugar community around Stanford University's d.School (Carleton and Leifer, 2009) and Design Factory Global Network initiated and coordinated by Aalto University (Oinonen, 2012)

Before joining the course, the students were asked about their experience in similar project courses, project work, and international collaboration, and over half of them (n=26) had worked in an international team several times, and only a small fraction (n=8) had no international teamwork experience.

Their average self-reported time of using a computer was 6,5 hours per day, and most of them identified being active in social media (28 yes, 17 sometimes, 1 no). The students also had a fairly positive approach towards computer-based learning tools, averaging to 8.4 out of 10 in Likert scale.

Structure and timeline

The first iteration of CBI was a small pilot, bringing together 17 students from 3 different universities (Kurikka et al., 2016), The second iteration of CBI described here was an experiment on various methods of scaling up the course, especially through larger global collaboration and online tools.

The students started their first 2-week visit to IdeaSquare on 15.9.2014 and came back to IdeaSquare at the end of the project for another two weeks to build and integrate their final concept prototypes, culminating to presentations at the CERN main auditorium on 26th of February 2015.

Image 1: *The common working times at CERN were 2 weeks at the beginning and 2 weeks at the end of the course.*

The first two weeks were used to introduce the students to their CERN contacts, to a wide range of technological opportunities and the need-driven approach and overall structure of the Challenge Based Innovation. In addition, the first two weeks were considered crucial for the team building and creation of the remote working practices between the different halves of each distributed student team. The exercises were for example "Container Challenge" described by Kurikka and Utriainen (2014) and later globally coordinated "Egg drop challenge" (Kriesi, 2015). The first two-week visit was also used to introduce and familiarize the students with the common online platform described in the next chapter.

Developing and testing the online tools

The online platform tested with the CBI students during the course was based on the existing open source learning management system called Open edX, which is also used to run one of the biggest MOOC platforms operating today, edX (Porter et. al., 2015).
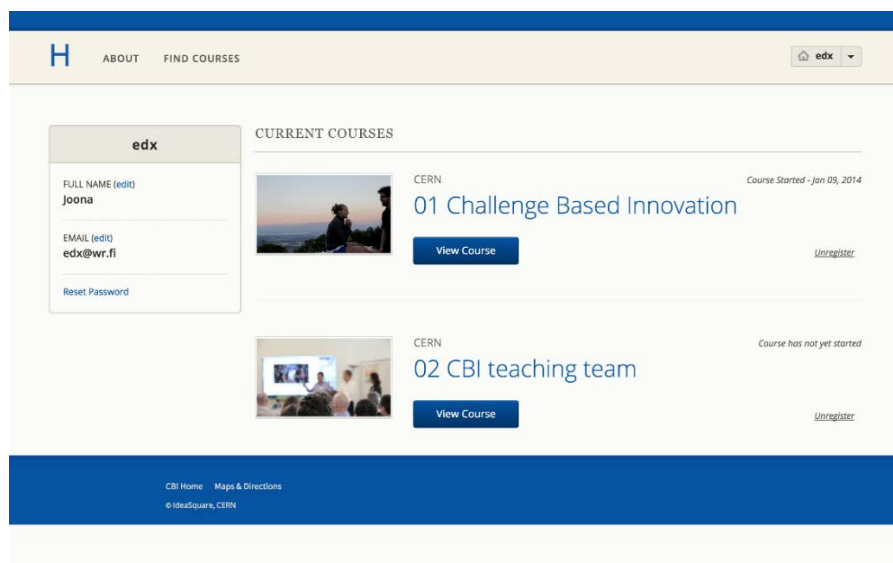

Image 2: *Platform main view*

To be able to fully customize the platform, the author installed a fully self-contained version of the latest stable release from Open edX to CERN computer infrastructure, more specifically to an Ubuntu 12.04 Linux server running on OpenStack virtual computer cluster. Such installation, or similar virtual computer setup, allows dynamic scaling of computing resources to match the number of participants, ranging from a couple of test users all the way up to millions of users currently visiting edx.com.

The standard Open edX setup was extended with external file hosting with OwnCloud (running on a separately hosted CERN server) and also accepting student submissions through Google Drive and Dropbox.

As part of the course preparations, the IdeaSquare coordinators prepared and agreed on the content division between the participating universities, so that each participant was responsible for producing shared teaching material and exercises for a few content blocks as described in Table 1 below, and shown in one example lecture in Image 3. The content division was agreed before the start of the course, and most of the weeks, a single university took responsibility of creating the material, which was then validated by the CERN coordinators before publication. There were also some topics, for example, "Needfinding & user approach" which were created in collaboration with two or more locations. These course topics were divided into three working phases, shown in Table 1 with different colors. Yellow represents the first stage of the course, which was about understanding the context and user needs. The second stage (purple) focused on building and testing small, iterative prototypes. And during the last third of the course, the students prepared, built, tested and refined their final proof-of-concept prototype. These results were then presented at CERN during the final gala.

Table 1 – *overview of the teaching content distributed among the collaborating universities and IdeaSquare coordinators.*

15.9 - 21.9.	**Kick-off @CERN**
22.9 - 28.9.	**Kick-off @CERN**
29.9 - 5.10.	Needfinding & user approach
6.10 - 12.10.	Benchmarking/Basic research
13.10 - 19.10.	Problem convergence & data syntethisation
20.10. - 26.10.	Testing, Hypothesis setting, and low-resolution prototyping
27.10 - 2.11.	(Low-resolution prototyping)
3.11. - 9.11.	Design mission convergence
10.11. -16.11.	Ideation & POV formulation
17.11. - 23.11.	Solution prototyping 1
24.11. - 30.11.	Black hole ideation
1.12. - 7.12.	Solution prototyping 2
8.12. - 14.12	Solution convergence

15.12. - 21.12	Final deliverables/project handoff
22.12. - 28.12.	**(Xmas holiday)**
29.12. - 4.1.	**(Xmas holiday)**
5.1. - 11.1.	Kickstart the year - Power crunch
12.1. - 18.1.	High-resolution prototyping
19.1. - 25.1.	(additional video material/topics supporting the building phase, no scheduled topic lectures from this point onwards)
26.1. - 1.2.	Gala demo/penultimate
2.2. - 8.2.	Story/Impact... etc. inputs and deadlines related to deliverables
9.2. - 15.2	
16.2. - 22.2.	**Gala @ CERN**
23.2. - 27.2	**Gala @ CERN**

Extensive peer learning was one of the targets for CBI, and accordingly a significant contribution to the online content came from the weekly submissions by the student teams (Image 4) sharing their results for the given exercises in form of video clips, pictures, and short documents, including, for example, the description of their prototypes, testing results and user feedback. This exercise submission format was designed to support global idea exchange between the six student teams working on different project topics, and getting feedback and review ideas from the other participants. The platform also acted as course calendar and newsfeed of past and upcoming general announcements and exercise introductions.
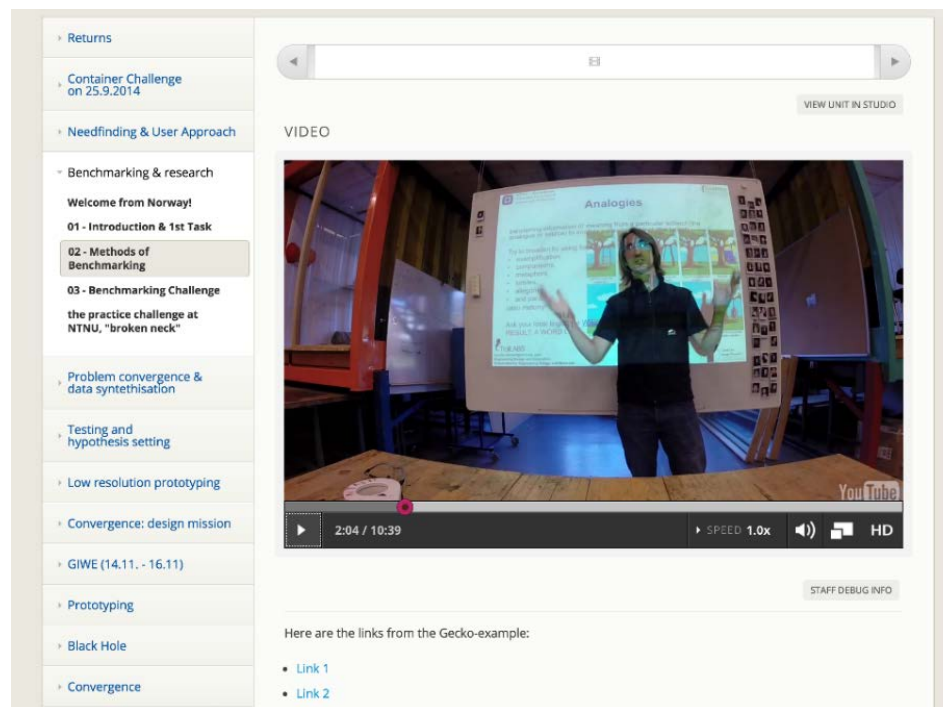

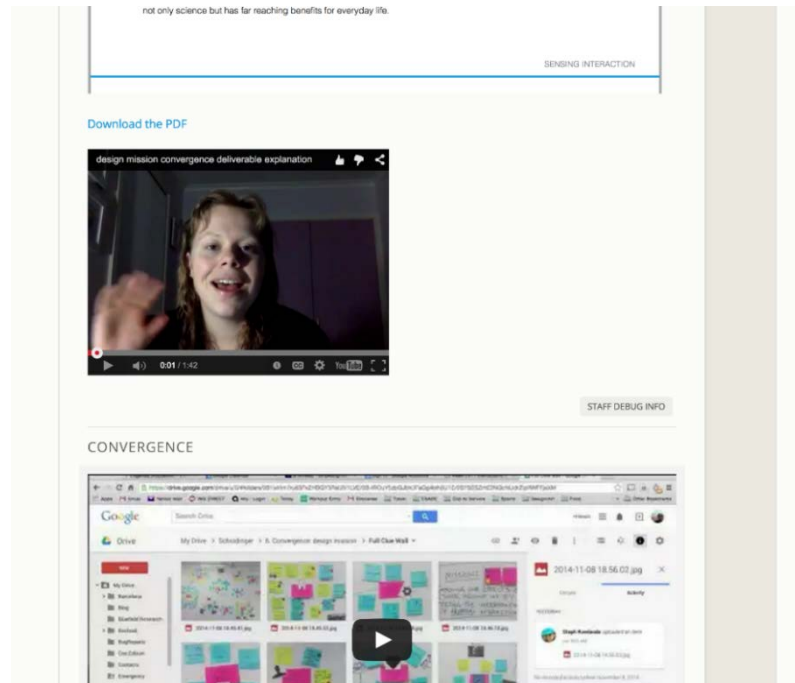***Image 3*** – *Benchmarking lecture coordinated from NTNU*

***Image 4*** *- one of the student team submissions from the platform*

At the end of the course, all the participants we asked to evaluate the overall experience with the online platform, as a part of the extensive final survey. The evaluation was divided into two freeform questions, which asked about improvement areas and positive elements of the platform. The 114 comments received were classified by the comment tones to positive (45%), neutral (28%) or negative (27%), as shown in Table 2, and the feedback topics were divided widely. The most positive elements were the commenting and feedback between different teams and access to the global teaching material and content. The biggest negative factors were related to the overall complexity and number of online platforms in use (*"too many platforms in general for students, this course added my platforms from 9 to 12"*).

Table 2 *– Feedback tone division*
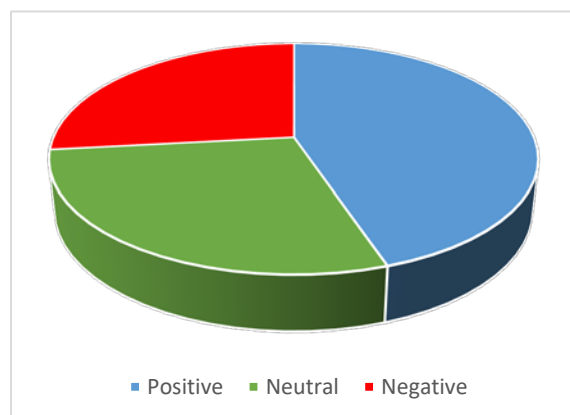
In addition to this shared platform, all the teams were encouraged to set up and customize their own collaboration environments for working and developing the content among the globally divided student team and then submitting the results to the shared platform for the whole course to see. Researching these self-selected tools and their usage was also used as a method for the coordinators to identify the gaps and possible extensions for the next iteration of the course online platform. As shown in Table 3, most of the self-selected tools are related to either communication or collaboratively working on written documents.

Table 3 – external tools used by the course participants, based on individual survey responses
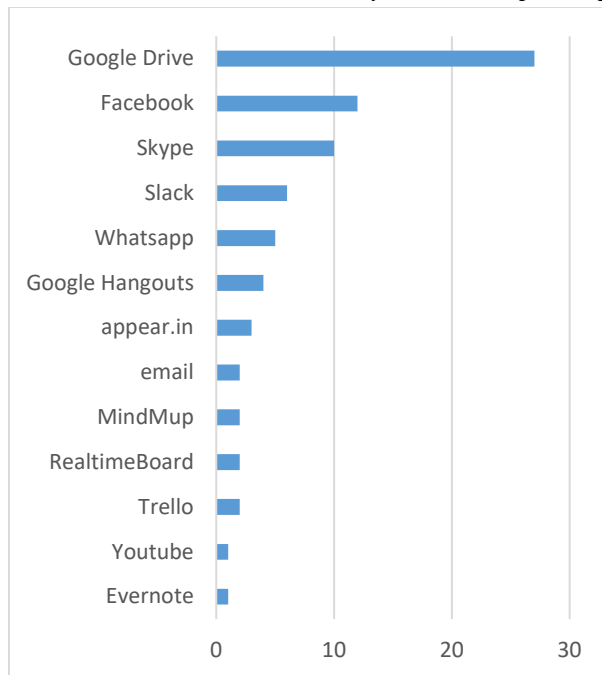
Lessons learned and future research

Part of the survey responses were also analyzed separately by Utriainen (2015) and Jensen and Utriainen (2017), and their observation was, that the remote collaboration was experienced to be more difficult than working in a co-located setting in the measured 9 different design activities.

This supports the observations made during the course coordination, and especially the comparison between intensive working periods at CERN and less intensive working periods in home universities. It looks like several factors in the course structure has had a significant effect in the experienced differences in difficulty, and the current version of the online platform was not enough to compensate the experienced difficulty of working in remote teams. Also, without a valid control group, the exact effect of the online platform is difficult to estimate. The

comparison to student feedback from preceding similar courses hints to a noticeably positive effect, the exact amount of which needs further research.

Balancing the student schedules and compensation in different countries had a significant variance, and the credit compensation from the same contributions varied between 12 ECTS credits to 40 ECTS credits due to different structures in participating universities. When this kind of global course collaboration is done more frequently, the university systems can hopefully adapt and create more uniform structures to make sure student incentives are better aligned. The compensation was also directly related to the amount of time the students could use to the course work. The self-reported working hours varied from 4 hours to 60 hours per week during the course duration, with an average of 21,2 hours. Out of this time, the coaches and professors shared estimated 3,14 hours with the teams per week.

The amount of structure and deliverables was another topic collecting a lot of feedback comments, and the opinions divided a lot. On one side, many of the students were hoping for more structure and instructions and more well-defined questions instead of the need-driven Design Thinking process. On the other side, many of the students also liked especially this openness and freedom of the course and disliked the compulsory assignment submissions.

Also, the amount of feedback and comments were felt to be too low, which reflects the inability to motivate the peer review of the team submissions, and amount of coordination resources – for the future iterations we need to either make sure more of the global coordination and exercise evaluation is shared among the collaborating universities, or arrange more resources for coordinating and managing the collaboration and technical implementation from CERN.

Overall, the online platform testing with CBI 2 was a successful probe into the limits and possibilities on how such platform can be used and is useful, and how the other elements of the course design can affect these limits. Enabling students to collaborate and learn in such environment, and offering them the best possible tools to do so is not an easy task. The work of a teacher in such projects is considered to be closer to coaching than traditional academic lecturing, and the online tools have to facilitate smooth communication and exchange of ideas across long distances in both geography and working styles. From the technical perspective, the platform worked well, achieving 100% uptime and no connectivity issues during the 6 months of operations and globally distributed user population. However, as the number of external tools used by the students and the division of the feedback shows, there are still several areas of improvement. Based on these results, we are planning to address this in the future iterations of the platform, starting by integrating more collaborative elements, for example for written documents, source code, and 3D models. In addition to better working environment, this would also allow capturing and sharing the whole work process, not only the submitted results.

To be able to test the practical usage and scalability of such platform updates better, we think that the next step would be to part with the "extreme" collaboration variance pursued in the CBI format, and test and develop the next pilot version of the online platform in more engineering-driven and more defined challenge, which would still be technically challenging and draw inspiration from fundamental research. Two of such topics are currently under development under a new project label, "Online Based Innovation" with relevant groups of universities focused on high-speed aviation and nanosatellite design.

Conclusions

From IdeaSquare's perspective, the second iteration of CBI was considered a success, producing interesting concepts and gaining media visibility in major publications such as Financial Times (2015). Four out of the six student concepts were pursued further after the course by parts of the teams through startup accelerators or design competitions, and one student team also continued to launch an unrelated, but strongly CBI-inspired, successful Kickstarter project. From the online platform's development perspective, the successful implementation of the course helped us to collect a lot of interesting feedback and test usage results to estimate which areas need more focus in the future development iterations.

As such, the first platform iteration has many positive elements but is not yet completely capable of supporting fully distributed projects with open-ended and intensive learning experiences like CBI, at least in a way that would produce as good and as interesting results as the "traditional" co-located and heavily coached version. However, there is still promising signs about a future version that could capture at least some, if not all, elements of such process, and help to create a scalable online approach for finding new connections and inspiration between fundamental research and solutions to societal challenges. In the context of a course like CBI, this requires additional development work especially in improving the quality of communication and encouraging the students to share also unfinished steps of the process to receive feedback from their peers and instructors earlier in the process, and ease the difficulty of commenting other participants work. This intensive peer learning and feedback worked well during the collocated sessions of the course, but the higher communication barriers of the current online tools hindered it a lot during the remote sessions. The ultimate goal of such a platform would be to make the remote collaboration more enjoyable and more productive than collocated face-to-face work.

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