

Innovation processes as a tool to design human neurobiology experiments

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Introduction

Recently the Danish Ministry of Science, Innovation and Higher Education announced (4th of June 2013) a new Innovation Foundation with a budget of 1.5 Mia DKK in order to ensure that public investments in research and development (R&D) are transformed into solutions that benefit society and economical growth. Transforming new ideas into solutions that benefit society can however not be accomplished just by yelling: “Innovate!” Universities need to educate in skills that make students able to transform ideas into actions. Furthermore, due to an increased demand for educations in R&D, there is also a need for educating students in the ability to transform novel ideas into research projects in order to give students the best prerequisites when approaching a career within research.

This assignment is a presentation of a new initiative I have taken in the course Human Neurobiology, taught at the Human Physiology programme at the Department of Nutrition, Exercise and Sport Sciences, in which I developed, in collaboration with the Innovation unit Katalyst at University of Copenhagen, an initiative, where the students had to design a novel research projects related to the topics of the course.

Problem definition

One of the intended learning outcomes (ILO) of Human Neurobiology is to give the students the ability to conduct and interpret human neurobiol-

ogy experiments. However the teaching learning activities (TLA) so far has only focused on the acquisition of theoretical knowledge about human neurobiology and interpretation of neurobiological experiments but not on the ability to conduct experiments. In order to facilitate this ILO I would like to test whether the use of innovation processes can improve the ILO.

Motivation for approaching this problem

In human neurobiology, which is my own area of research, (as well as other branches of natural sciences) a crucial part of research is to invent and design novel experiments. I would therefore like to introduce students to a novel way of designing experiments. I see the preparation process of experimental design as a very creative process. However, creative thinking is not something one just does. As part of my Adjunktpædagogikum I took part in a workshop on innovation processes in university teaching, presented by Katalyst (<http://katalyst.hum.ku.dk/>) from the Faculty of Humanities at KU. Afterwards I thought that using similar ways to invent novel products, which I found was used in the innovation processes presented by Katalyst, also could be used in teaching experimental design.

I would therefore like to use a short period during the course, where I test whether TLAs inspired by innovation processes can be used to facilitate learning in design of human neurobiology research experiments.

Using these innovation process tools, I hope that the students will have improved their ability to come up with novel questions that they would like to find the answer to, and develop hypotheses based on these ideas that can be transformed into experiments that test their hypotheses. I am not particularly interested in whether the students are just able to find other's experiments and replicate them, but rather design experiments themselves and argue why they take specific choices during the design process.

Description of the course

Human Neurobiology (see: <https://sis.ku.dk/kurser/viskursus.aspx?knr=143311>) is a master level course covering theoretical and practical aspects of human neurobiology research experiments. Teaching is done in a seven week period with two half-day (three hours) modules per week. The basic structure of each module is: 45 minutes lecture on scientific topic, one-hour student

presentations, twenty minutes lecture on scientific method, twenty minutes of presentation of student assignment for the next lecture. The final two weeks of the course was devoted to the innovative design of a neurobiological experiment (Design your own Experiment (DYOE)). They consisted of one hour and two times two hours where the students designed a neurobiological research experiment with the help of process tools developed in collaboration between Katalyst from KU and myself. Finally the students presented their proposed projects by the end of the course for a total of two hours. Formal assessment of the course is a 25 minute oral exam with one third of the question covering a topic presented in one of the 45 minute lectures, one third covering one of the student presentations, and one third of the oral exam was also to present their proposals of a neurobiological experiment.

In order to test transfer of knowledge from DYOE to the ability to evaluate the quality of previously proposed experimental designs I designed a multiple choice test that I applied before and after the DYOE.

Approximately 26 students had signed up for the course from different educational programs: sports science, biology, biochemistry, and molecular biomedicine. Around 16 showed up for the first couple of lectures. A few quit the course after having taken part in the teaching twice. Twelve students attended the final exam.

Transformation of a course – a two-step ladder

The course Human Neurobiology has changed dramatically during the last two years where it has been taught. Until 2010 it was a lecture course with 14 lectures lasting 2-3 hours and sometimes with one hour of discussion of an original research or review article.

Step 1: In 2011-12 I, together with Jens Bo Nielsen who is course responsible, re-organised the format of the course, by introducing student presentations from lecture to lecture based on four questions founded mainly in original articles. The students did the presentations in teams of 4-6 students.

Step 2: In 2013 I proposed inclusion of TLAs in the course, which closer resembled the ILO of making the students capable of “conducting and interpret neurobiological experiments”, and thereby constructively align the course better than previously.

The intervention - Design Your Own Experiment (DYOE)

The DYOE process was practically done over four days of teaching in the final weeks of a seven-week module. The DYOE was intentionally placed in the end of course in order to give the students the best possibilities of having been acquainted with neuroscientific methods through the short method lectures given the first 5-weeks. Furthermore, the student would have familiarised themselves with basic principles of neuroscience experiments thorough the studies they have presented during the student presentations. In the actual DYOE I wanted to use a topic which combined knowledge from several of the lectures and student presentations from the first 5-weeks of the course. The overall topic I asked the students to do was to design an experiment to study how cognitive processes influence motor control. Figure 14.1 gives an overview of the different elements that was introduced on the different days.

Getting ideas

One of my main concerns with this project was to inspire the students to get good ideas. It is very difficult to get good ideas on command. That was the main reason for involving Katalyst in this project. They provided me with a sketchbook of elements that I could include in the process. Many of the proposed elements use peer-feedback as the main TLA to achieve new ideas and to improve the ideas. Initially I will highlight some of the deliberate interventions I made in order to facilitate idea generation. First task I gave the students was 15 minutes to come up with their immediate associations based on the overall question. After a few minutes I overheard the work in the groups, and instead of coming up with a lot ideas, the students were already eagerly discussing whether a few of the proposed ideas were possible to implement, and whether or not it would work out to perform that inside in MR-scanner (or similar arguments). This meant that I had to intervene and change the settings, so I asked the students not to talk for the remaining part of the session with each other, in order to avoid that they used the limited amount of time to discuss rather than associate. Furthermore, I introduced three dogmas the students had to follow during homework. I gave all students a notebook, in which they could write all their associations and ideas.

Dogmas:

1. Do not search for scientific literature on the topic

2. Note all your ideas. Do not sort ideas before they have been noted.
3. Do not comment on each other's ideas within the group before all ideas has been presented

When speaking with the students on day two, it was interesting to hear how they individually had used different strategies to get ideas. Some got ideas while bicycling others at home by the desk. In general the students responded that the notebook was something useful, which they had brought with them.

Day 1 (1 h)

MSC: Presentation of the topic
 MSC: Inspirational lecture
 MSC: Group formation
 Groups: Get new ideas!
 Groups: Sort new ideas
 Groups: Present ideas to each other
 MSC: Assignment for next time - ideas
 MSC: Hand out logbooks
 MSC: Present Dogmas

Day 3 (2 h)

MSC: Lecture on switching direction
 Groups: Presentations of hypotheses
 Groups: Feedback from other group
 MSC: Feedback in plenum to the groups
 Groups: Work individually with feedback
 Groups: Presentations of reformulated hypotheses
 Groups: Feedback from other group
 Groups: Work individually with final presentation

Day 2 (2 h)

Groups: Presentation of ideas
 Groups: Feedback from the other group
 Groups: Work individually with feedback
 MSC: Feedback to the groups
 MSC: Presentation of assignment for next time - qualify your design with hypotheses in mind

Day 4 (2 h)

Group 1: Presents experiment
 Feedback from other group and MSC
 Group 2: Presents experiment
 Feedback from other group and MSC

Fig. 14.1. Overview of DYOE content.

Feedback sessions

One of the bearing principles in the innovation process suggested by Katalyst was the used of peer-feedback between the students. Below you find a small summary about some of the types of feedback that was included in the project.

Within the groups

During the whole project the students met within their respective groups a number of times. As described previously it was hard for the student not to comment on the practicalities related to the different ideas, however with the introduction of dogma 3, they responded afterwards that it had become better.

In the course evaluation of the DYOE it was mentioned that the groups were too large, which meant that too many ideas were generated, which made it difficult for the students to decide upon one idea. Apparently some of the usual group dynamic issues also arose in these groups, like someone who did not do so much work as the others. Some students also mentioned that dominant individuals were leading the groups and therefore, not all ideas were possibly appreciated equally. However, during the final presentation at day four, it was evident that all students at least appeared very engaged in the projects.

Initially I had tried to mix the group differently in order to mix their different skills as much as possible. One student replied in the special evaluation:

“Det var lærerigt at arbejde sammen med andre med en anden baggrund end ens egen. Det gav god dynamik fordi folk tænkte forskelligt.” (Student B).

Between the groups

After the first task, the groups met and exchanged their ideas. Group 1 had worked with a focus on using the scientific methods that they had been introduced to during the first five weeks of the course, rather than with a scientific question that puzzled them. However, because Group 2 had been very open and focused more on behavioural phenomena rather than specific methods, when Group 1 heard their presentation, they immediately realized that their focus on methods had put limits on their creative ideas. In the course evaluation students explained that “Keep it simple” had been one of the key learning objectives they had brought with them.

Later in the process some students reported that the feedback they received from the other group often was something they already had thought of, but for some reason also considered and/or discarded. The process of giving and in particular receiving feedback must have improved the students skills in arguing why they had take particular decisions during the

design process, and this was one of the key elements that I asked the students to put emphasis on, both during the DYOE and when preparing their oral exam. A statement made by one of the students in the special evaluation also supports this, when answering what worked well in the DYOE, the student replied:

“Feedback inden for gruppen og især mellem de to grupper gjorde, at projektet blev præciseret (man skal kort og præcist kunne forklare hvad man vil og hvor man vil hen for at andre forstår det) samt at der blev stillet spørgsmål, vi i gruppen ikke have overvejet.” (Student B).

“At vi fremlagde - reviderede og fremlagde igen nogle gange, ...det var godt med feedback!” (Student C)

During the final presentations and feedback on Day 4, the feedback and communication between the groups was extremely qualified and took part at a very high level.

Between the groups and teacher

A number of time slots during the DYOE sessions were devoted to my feedback to the students. First time (on day two) I deliberately did not give suggestions to the proposed ideas but rather interviewed them regarding the process. During the plenum session on day three I had the opportunity to point out flaws in the different designs, but I also put on the “provocative hat” and challenge some of their ideas. That I did after an inspirational lecture on how you sometimes need to change track completely, by giving some examples from my own research. Group 2 had been struggling to decide on an idea and during presentations on day three, I had asked a couple of times why they had picked certain methods without getting clear answers. I briefly mentioned whether they had considered some other techniques as a possibility. Immediately after Group 2 completely switched idea on what method they wanted to use and grabbed my suggestion, without much further consideration. That in the end turned out to be somewhat of a problem for the group, because they could not explain in detail the rational behind the choice of method, and they had only very little time to explain how they had thought of using that specific methods. Given that the students were suppose to make the design themselves and emphasis had been put on their ability to argue why they had made their choices, I did not avoid being the teacher with the narrow likelihood. It was clear in the evaluation that it had been frustrating for the group to work with an assignment where there was no clear answer to how to solve the task.

“Jeg savnede feedback i form af: ‘Det der holder slet ikke i virkeligheden’ eller ‘det der er bestemt realistisk’ ” (Student C).

In future use of DYOE I will probably increase the amount of scientific feedback in the final feedback session, but preserve the idea that the students have to develop their ideas themselves (within and between the groups) during the DYOE.

Because this whole process of using innovation processes was all new to me, I was, as a teacher, very much concerned about the process and asked the students a lot of questions related to the process, also in the final session. But during the process I did not want to intervene too much, because I wanted the students to develop the project themselves as much as possible.

Results of the intervention

Did the student learn to design human neurobiology experiment after four sessions of brainstorming, feedback, presentations and discussions? To the question: “What did you learn most from during the DYOE?” I received the following answers from the students:

“At det er svært at finde på et relevant og meningsfuldt forsøg, samt at det ofte vil kræve mange par øjne, førend forsøget ligger klar.” (Student A).

“Jeg tager med mig, at man i forbindelse med en opgave først skal undre sig og stille spørgsmål ved det, man ikke ved. Tankerne og ideerne skal blot sive eller vælte spontant ud, og så først bagefter går man praktisk til værk ifht. hvordan man vil undersøge problemstillingerne. ‘keep it simple’ er essentielt.” (Student B).

“Jeg lærte at det er rigtigt vigtigt med sparring og feedback når man vil lave et projekt. Man kan hurtigt komme til at overse noget.” (Student C).

I also asked whether the students felt they could use knowledge from the first five weeks of the course in the DYOE. One replied: “I gruppen startede vi med at tage udgangspunkt i de teknikker og metoder, vi blev præsenteret for i løbet af kurset og hvad vi ligesom kunne vise med dem ifht. opgavens overskrift, men hurtigt begrænsede det os voldsomt i idégenereringen. I stedet sadlede vi om, og i stedet stillede spørgsmål ved simple ting i dagligdagen, vi undrede os over og ikke vidste. Herefter kunne vi så tage fat i metoderne og bruge dem til hvordan vi ville undersøge den valgte problemstilling.” (Student B)

I further asked the students whether the DYOE had taught them think out of the box. In reply: “Har længe tænkt over, hvordan et forsøg designes,

så det her var en god måde at få det prøvet af på, samtidig med at man fik kyndig feedback.” (Student A)

I also asked the students whether they felt better equipped to design and conduct experiments in the future. In reply: “Jeg skal i fremtiden ikke arbejde med mennesker – og da slet ikke når de bevæger sig, men ’keep it simple’-tankengangen og konceptet med frie og spontane tankestrømninger/ideer efterfulgt af et ’hvordan’, kan nemt overføres til andre projekter og sammenhænge.” (Student B)

Summative evaluation of the students

Twelve students attended the final 25 minutes oral exam with an external censor. Six students received the grade 12, five students the grade 10 and one student the grade 7 on the 7-point grading scale. In the evaluation I asked the students whether they felt comfortable with the inclusion of their DYOE in the oral exams. In reply: “Ja! Man havde arbejdet så meget med det, så det var noget, man kunne falde tilbage på. Desuden var det en spændende diskussion med censor og lærer, hvor man netop skulle argumentere og ikke blot recitere lærerbogen.” (Student A)

Course evaluation

I received 7 replies (Student 1-7) of the official course evaluation. In addition I made a specific questionnaire regarding the students’ thoughts about the DYOE assignment. I received three replies (Student A-C) to this specific questionnaire.

Abstract test

In order to test the transfer of knowledge from the DYOE to other scientific branches, I designed a test in which the students should evaluate 20 abstracts and determine whether they were abstract taken from 1) High impact scientific journal, such as Nature or Science, 2) Specialised neuroscientific journals, 3) Scientific conference Proceedings, or 4) Unpublished MSc or BSc theses. Eight students participated in the test before the DYOE and 3 students participated afterwards. Only one student took the test twice, i.e. before and after DYOE. Based on these test results I cannot conclude whether there was any effect of participating in the DYOE on the ability to evaluate the originality and quality of scientific abstracts.

Increased ownership

During the final presentation on day four of DYOE it was very obvious to observe that all members of the two participating groups were very active and all took engaged part in the presentation. Furthermore, during the final feedback sessions all students were very active and gave very qualified feedback to each other. Both my pedagogical and vocational supervisor noticed that they had never experienced such a high proportion of motivated students that were active during presentations and discussions.

I believe that designing your own experiment based on your own question, and not a predefined specific question, increase the sense of ownership of the assignment, and that will improve motivation for actually taking active part in the assignment. That was also evident given the amount of additional material that the groups had made for the presentation. One group had illustrated their experiment with videos.

Future directions

For future DYOE I am very curious to see the effect of more groups than two and how that may influence the student's innovation process and how it possibly changes the dynamics interaction between the groups. Only 12 students ended up taking part in the DYOE and the exam, which puts limit on the number of groups that can be formed. Initially, when designing the DYOE with Katalyst we were aiming at 4 groups.

Furthermore, it would also be interesting to follow-up on the DYOE with practical assignments, where they students could come into the lab and try out their ideas. One possibility would be to encourage students to sign up for their practical masters thesis work with their ideas from the DYOE as the foundation.

Conclusion

It has been very inspirational to see that one's ideas of a new way of introducing students to experimental design worked out well. Both in terms of practically running the DYOE intervention, but also in terms of the students' enthusiasm and willingness to take part in this teaching experiments. And finally, also with respect to actually being able to make the students

able to learn, what I initially had thought they were going to learn. It has also been a great learning process for me as a teacher to propose new ideas and try and develop them into actual teaching learning activities. It was definitely possible to achieve the ILO with new TLA.

I was impressed by the students' thoughtful insight into their own learning process, and also how well they complemented each other during the feedback sessions. The peer-feedback worked very well, although some students now and then felt they lacked feedback from the teacher.

The idea of looking at the transfer of knowledge from the DYOE to other branches of science turned out less successful than expected, and testing this transfer needs to be improved in future implementations of DYOE.

It was very surprising for me to see how well the different interventions actually worked while performing the DYOE, and it proves, at least to me, that it is possible to guide teaching into new fields by making an effort in organizing the TLA well and in accordance with the ILOs.

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All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2013-6/

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