21

Evaluation of continuous formative assessment during lectures

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Introduction

Feedback is an important part of the learning process for students, and helps facilitate learning. Feedback may be given as formative or summative assessment of students' learning and knowledge. Summative assessment is retrospective feedback, in which students' learning is evaluated at the end of the learning experience, like an exam. Formative assessment is prospective feedback, in which the students' learning is continuously monitored, and they receive ongoing feedback to facilitate learning. For feedback to be useful for the students, it is important that the student see the relations between the learning objectives and the feedback, and that the feedback do not come too late in the learning process (Rienecker & Bruun 2013). Formative assessment is much more likely to enhance self-efficacy in students than summative assessment (Hattie 2012), where the feedback might come to late in their learning process to make a difference. Studies show that students want clear, explicit and constructive feedback that are learning-oriented, continuous and timed so it may be used prospectively (for review, see Rienecker & Bruun (2013))

According to John Hattie (2012), effective assessment for learning is based on the five key factors that:

1. *"students are actively involved in their own learning processes",*

2. *"effective feedback is provided to students",*

3. *"teaching activities are adapted in response to assessment results"*

4. *"students are able to perform self-assessments"*, and

5. *"the influence of assessment on students' motivation and self-esteem is recognized"*.

From this, it is clear that the students need to take an active role in their own learning process and that proper feedback will help students to be able to assess their own learning. For feedback in classrooms to work best, it is also important to clarify and share the intended learning objectives as well as have learning activities and discussions that provide indications of the students' understanding of the curriculum in order to give feedback that facilitates learning. Student activities within the learning objectives not only provides the teacher with feedback on the students learning and his/hers own effectiveness of their teaching, but also provides the students with the ability to conduct self-assessment of their learning.

Formative assessment can be obtained by activities performed by the teacher or students that give feedback about the students learning, which then can be used to modify the teaching and learning activities. However, assessments can be time-consuming and need to be made manageable and time-efficient (Brown & Race 2013). One way of saving time is to give feedback collectively instead of individually. Moreover, activities could be performed fast, by using rapid prompts during the lecture or brief student activities covering the learning objectives. Thus, including feedback of students learning in a lecture may not take extra time to prepare, but may provide an opportunity to adapt the teaching to optimise the learning possibilities for the students and facilitate learning.

Problem definition

The course 'Fundamentals of Neurobiology' was the final course of a series of 'Fundamentals' courses at the Danish Research Centre for Magnetic Resonance. Most of these courses were held for the first time within the last year. However, the learning objectives for some of these courses were not clear, and the students appeared disengaged during the courses with unclear learning objectives. Moreover, some students did not learn what was intended, or they say that they only learned something by reading the curriculum, and not by the teaching. Because of the lack of clear learning

objectives in some courses, it has been difficult for the teachers and students to assess the students' learning. In some courses, there were no evaluations of the students learning, and it is unknown what parts of the curriculum the students learned and to what extent they learned it. In the present project, I wished to make clear learning objectives for all the lectures and to use student activities to conduct continuous formative assessment throughout the Neurobiology course. I hoped this would engage the students, facilitate learning, and enable the students to guide their self-assessment of their learning, as well as enable me to modify my teaching according to the students learning of the intended learning objectives.

Objectives

The aim of the study was to gain experience with continuous formative assessment of the students' learning by means of student activities to engage the students and facilitate learning in a lecture setting. Specifically, the study aimed at assessing the students' knowledge of the lecture's learning objectives before and after the lecture. This would provide me, the teacher, with some feedback about the students learning during the lecture for me to adapt the teaching to guide the learning experience of the students, as well as to provide the students with clear learning goals to guide their continuous self-assessment of their learning.

Methods

Course overview

The course "Fundamentals of Neurobiology" is part of a series of 'Fundamental' courses at the Danish Research Centre for Magnetic Resonance (DRMCR) at Copenhagen University Hospital Hvidovre. The DRCMR has many Danish and international undergraduate and graduate students with different educational backgrounds. To ease the students' introduction to a highly interdisciplinary research field, it had been a wish from both the students and the senior researchers in the department to create a series of "Fundamentals" courses for all undergraduate and graduate students in the department. The series of Fundamentals courses (in Maths, Statistics, MRI, Study design, Neuroimaging, and Neurobiology) began in August 2014 as

an annual curriculum, and the Neurobiology course was held in May-June 2015 for the first time. The neurobiology course consisted of six 1-hour lectures with approximately one lecture per week. Attendance was voluntary. I was the course responsible, selected the curriculum, and planned and conducted all the teaching myself. The level of the course was equivalent to a third or fourth year elective course at the university with little prior neurobiology needed to attend the course.

Student background

A total of 24 students (6 MSc students, 12 PhD students, 6 Postdocs) participated in the Fundamentals of neurobiology course. The students had many different educational backgrounds spanning from psychology and medicine to engineering and physics (see Table 21.1). Moreover, some of the students had never had any previous introduction to neurobiology, some had read about the topic themselves, and others had followed one or several neurobiology courses. The neurobiological background of the students is presented in Table 21.2. The course curriculum and lectures were mainly aimed at accommodating the students with no, little or some neurobiological background, but students, who previously had followed several neurobiology courses, could come to the lectures to brush up their knowledge. The participation rate in all six lectures was highest for the students with no or little previous neurobiology exposure, and lowest for the students, who had already followed several neurobiology courses (see Table 21.2). The course participation rate, thus, appeared to reflect the target audience of lectures and course.

Table 21.1. Educational background of the students following the course.

Educational background	N
Psychology	7
Engineering	5
MD	4
Neuroscience	3
Linguistics	2
Physics	2
Radiographer	1

Table 21.2. Neurobiology background and participation rate of the students.

Neurobiological background	N	Participation rate
None	2	100 %
Own reading	5	70,8 %
Followed one neurobiology course	9	64,8 %
Followed several neurobiology courses	7	57,1 %

General study design

The aim of the study was to gain experience with continuous formative assessment in a lecture setting to help facilitate student learning. In order to do this, learning objectives for each lecture were made, and students' knowledge of the learning objectives was assessed in the beginning and in the end of each lecture. The study used the following design:

1. Make learning objectives for each of the lectures
2. Design and prepare student activities for each lecture that covered the learning objectives
3. Present the lecture's intended learning objectives in the beginning of the lecture
4. Assess students knowledge of the lecture's learning objectives
5. Lecture, including additional student activities and discussions
6. Assess students knowledge of the learning objectives at the end of the lecture
7. Summarizing, explaining, discussing and/or reflecting on the learning objectives in plenum, peer-to-peer or by teacher at the end of the lecture

The student activities were centred on the lecture's learning objective. Data was collected before the lecture to assess the students' prior knowledge of the learning objectives, and by the end of the lecture to assess if the students knowledge of the learning objectives after the lecture. This design allowed for comparison of the students' knowledge of the learning objectives before and after the lecture, which was used as an indicator of student learning during the lecture. In case the students did not appear to have learned the intended learning objectives, the teacher could allocate additional time to explain or discuss parts of the learning objectives. Data was collected from student activities in five out of the six lectures. In the present project, I only used data collected from three of the six lectures (Table 3), using questionnaires, mind-maps, or an essential overview figure.

Table 21.3. Assessment method of students' knowledge of learning objectives.

Lecture	Number of students	Data collected	Method
1	21	20 before/18 after	Questionnaire
2	14	14	Mind-map
4	22	16	Overview figure

Questionnaires

For the first lecture, students filled in a questionnaire online 1-2 days before and 6-13 days after the lecture using the free web-based survey solution SurveyMonkey (https://da.surveymonkey.com). The questionnaire given after the lecture is presented in Table 21.4. The questionnaire given before the lecture consisted of Questions 3-7. The questions covered the lessons learning objectives (Table 21.5).

Table 21.4. Questionnaire used after lecture 1. Questions 3-7 also used before the lecture.

1. Did you read the chapter before the lecture?
2. Have you read the chapter after the lecture?
3. Name the three glial cell types in the brain:
4. What three main morphological regions does a neuron have?
New page:
5. What is the structure neurons communicate with called and what does it consist of?
6. What is/are the primary function(s) of: Oligodendrocytes: Astrocytes: Microglia:
7. What function does the blood-brain barrier serve?

Mind-map

In the second lecture, the students were asked to make a mind-map of their knowledge on "membrane potential" and "axon potential" with the lecture's intended learning objectives in mind (Learning objectives; you should be

able to explain what a membrane potential is at rest and how it can change dynamically; explain what an axon potential is and how it works). Students made the mind-map using a green pen in the beginning of the lecture and added to the mind-map with a red pen in the end of the lecture (see Figure 21.2). When finished, the students discussed the mind-maps with their peers, and in the end, knowledge gaps in the mind-maps were discussed in plenum.

Essential overview figure

In the fourth lecture, an essential overview figure (Figure 21.1), capturing the essence of the lecture's learning objectives, was used to assess the students' knowledge of the learning objectives. Students filled in the empty boxes in the figure with a green pen in the beginning of the lecture and with a red pen at the end of lecture. The figure was then gone through and discussed in plenum in the end of the lecture, and boxes that the students had difficulties with were explained and discussed.

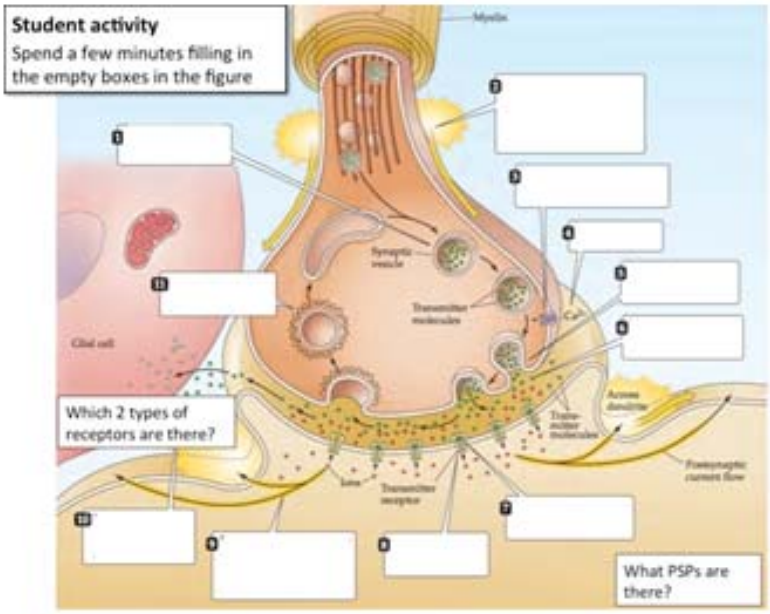

Fig. 21.1. Essential overview figure capturing the lecture's learning objectives. Students filled in the empty boxes in the beginning and the end of the lecture.

Evaluation

At the end of the last lecture, students gave oral feedback in plenum about what they liked and did not like about the course. Moreover, they students were specifically asked about their view on having to do the same student activity in the beginning and end of the lecture. Finally, the students were asked to reflect on their learning experience with this setup for a few minutes and send their reflections by email.

Results and experiences

Lecture 1: Questionnaires

Five questions in the questionnaire covered the lecture´s four learning objectives, which are presented in Table 5 together with the percentage of students that got correct answers for each of the four learning objectives before and after the lecture. Most of the students already had obtained the first (93%) and fourth (90%) learning objective before the lecture. Thus, the lecture was adapted beforehand to allocate more time to the second and third learning objective, which, respectively, only 50% and 38% of the students got corrected before the lecture After the lecture, an additional 44-51% of the students were able to correctly answer the questions covering the second and third learning objectives. Thus, it appears as if the additional time spend on these learning objectives during the lecture might have been wisely spend. As the questionnaire was filled in after the lecture, feedback was given in the beginning of the second lecture two weeks later, which appeared somewhat suboptimal given the relatively long time interval between the two lectures.

Table 21.5. Correct response to questions within each learning objectives before and after the lecture.

Intended learning objective (Students should be able to:)	Before	After
1) State the general features of neurons	93%	100%
2) Name the three major glial cells types in the brain	50%	94%
3) State some of the primary functions of the different glial cells	38%	89%
4) Explain the function of the blood-brain barrier	90%	90%

Lecture 2: Mind-map

In the second lecture, the students made a mind-map of their knowledge on "membrane potential" and "axon potential" with the lecture's intended learning objectives in mind in the beginning and in the end of the lecture. Examples of mind-maps are given in Figure 21.2.

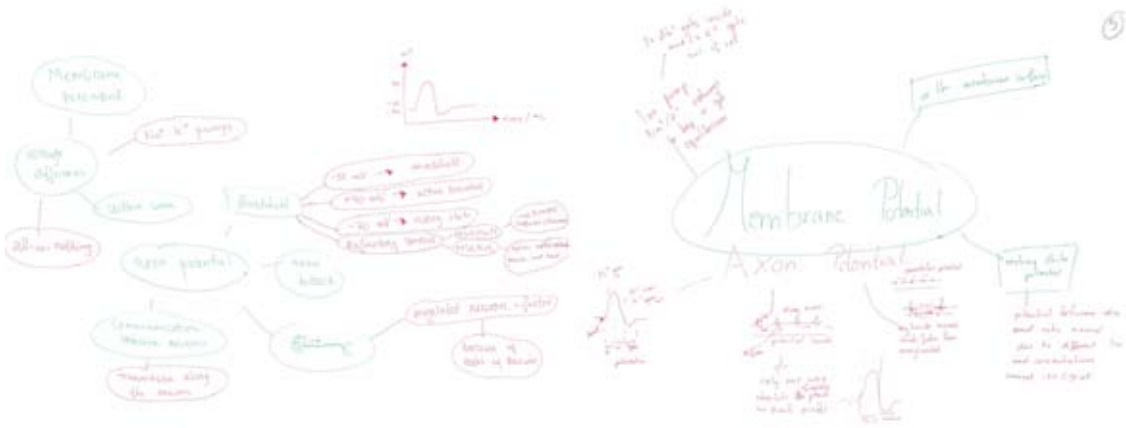

Fig. 21.2. Example of two mind-maps. Students used a green pen to make the mind-map in the beginning of the lecture, and added to the mind-map with a red pen in the end of the lecture.

In general, there were large variability between the students in the amount of information and details given in the mind-map. Some students were able to make detailed mind-maps already in the beginning of the lecture, while other students were unable to write anything. Though it is difficult to quantify mind-maps, all mind-maps were evaluated on whether the information on the mind-map were correct and detailed enough to indicate that the student had obtained the learning objectives, both in the beginning and end of the lecture. For the 'axon potential' learning objective, five out of 14 students appeared to fulfill the learning objective in the beginning of the lecture, while this had increased to 13 out of 14 students by the end of the lecture. For the 'membrane potential' learning objective, 11 out of 14 students appeared to fulfill the learning objective in the beginning as well as end of the lecture. However, two students had not included membrane potential on the mind-map, and, thus, it is unknown whether they forgot to write it down or whether they did not know anything about the topic. Qualitative evaluation of the mind-maps revealed that all students had added

more information to the mind-map in the end of the lecture, including general information on the topic, drawings, as well as details. Thus, even students that already had sufficient knowledge about the learning objectives appeared to either have learned something or refreshed their knowledge on the topic. Finally, the knowledge gabs in the mind-maps were discussed peer-to-peer, and in plenum.

Lecture 4: Essential overview figure

In the fourth lecture, students had to fill in 11 empty boxes in an essential overview figure using a green pen in the beginning and a red pen in the end of the lecture. In general, students had filled in more boxes in the end than in the beginning of the lecture. In the beginning of the lecture an average of 6.1 out of 11 (range: 2-11) boxes had been filled in. In the end of the lecture, an average of 6.5 (range: 1-10) boxes had information added, so that an average of 10.2 of the 11 (range 7-11) boxes had been filled in. Next to having more boxes filled in, the boxes also contained more information, more details, and corrections had been made. Examples of additions and corrections made from the beginning to the end of the lecture are presented in Table 21.6. Finally, the overview figure was then gone through in plenum with students responding on what should be in each box. The boxes that some students had difficulties with were explained and discussed by the peers and teacher in plenum, and misconceptions were clarified. It appeared as if the students had understood the learning objectives by the end of the lecture, as well as in the two following lectures, where the learning objectives from this lecture were essential background knowledge.

Table 21.6. Examples of edits made in overview figure from the beginning to the end of the lecture.

Type of changes	Before	After
Additions:	Ion channel	Voltage-gated Ca^{2+} channel open, Ca^{2+} influx
	Open ligand-gated ion channel	Ion-channel=receptor, transmitter bind to receptors
Corrections:	Synaptic cleft	Ca^{2+} influx
	Ion channel opened, Ca^{2+} release	Voltage-gated ion-channel open, Ca^{2+} influx

Evaluation

The students evaluated the course orally after the final lecture. In general, all students liked that clear learning objectives had been presented in the beginning of the lecture. Furthermore, all students liked that there had been student activities, particularly the activities during or at the end of the lecture. However, only some students found the student activity in the beginning of the lecture helpful, while others thought it was a waste of time. There was also some variability in which of the student activities the students liked, in that some liked the quiz, others the figure and yet others the mind-map. However, the students agreed that variability in the student activities had been nice. In addition, all students liked that the learning objectives and answers were discussed in the end with the peers and/or the teacher. Finally, I asked to get some written feedback from the students on how they felt about the learning objectives, the student activities and the setup of the lectures. Here are some of the statements from the students:

Student 1: *"I thought it was a huge help to get the clear learning objectives as well as the mind-map exercises. It was a great help when reading and it also made me more curious when reading. I also think that the information stick better to the memory. I liked the quiz before and after, but I also thought that it was nice it was not the same each time, because I think that might have been too much. Then it was nice that you changed between different formats (quiz, red/green pen etc.)"*

Student 2: *"Starting with getting the objectives and trying to remember what you already knew about the subject was a good starting mode: you got reminded of things that you perhaps once knew and felt you should know better, which helped focus the attention during the subsequent lecture. It was also a motivation in the sense that you knew you were going to fill out your paper again later and then wanted to improve. Filling it out in the end also served as a nice recap and you left with the feeling that you learned something in class."*

Student 3: *"To get the learning objectives in advance, in the beginning, but also before the lecture is very good. I found it the most useful to fill out the learning activities after the lecture, and especially to discuss the answers with the lecturer and the peers. But of course, it was a bit funny to see how much more you could remember after compared with before the*

lecture. I liked the figures with the empty boxes best. Also the black board lists, where the students should tell everything they've learned at the end - a good recap of the lecture"

Discussion

Students' knowledge of the lecture´s intended learning objectives was assessed before and after the lecture using different types of student activities. Comparing the student's knowledge of the learning objectives before and after the lecture revealed considerable learning of the learning objectives during the lecture. Moreover, for some of the student activities it was clear that even for students that already had obtained the learning objectives before the lecture, additional learning or refreshment of knowledge occurred.

Originally, I became interested in conducting this project to receive feedback on my own effectiveness as a teacher as well as how I could help the students facilitate learning via student activities and feedback. When reflecting on this matter, I did receive a lot of input on my own teaching skills, on which student activities seemed to work and which needed further development and on how to get information about the students learning. Moreover, it was interesting to see how little effort it actually required to change and adapt the teaching according to the information I received from the students' learning during the student activities. By receiving continuous information about the students' ongoing learning, it required little additional effort or time to further explain and discuss some of the topics that the students found more difficult as well as catch potential misconceptions, and correct these immediately. One student wrote that "*I found it the most useful to fill out the learning activities after the lecture, and especially to discuss the answers with the lecturer and the peers. … Also the black board lists, where the students should tell everything they've learned at the end - a good recap of the lecture*". Moreover, as all students liked that the learning objectives and answers were discussed in the end with the peers and teacher, this might reflect that the students felt they learned something from receiving collectively feedback on correctness of their learning.

While I think I received a lot of input on my own teaching skills, and input on how to get information to adapt my teaching and provide better feedback to the students, it quickly became clear to me that a really important aspect of formative assessment was getting the students actively involved in their own learning process. The student activity before the lecture

appeared to promote the students' self-assessment of their current knowledge of the lecture's learning objective and made it clear to the students that they might have some gaps in their knowledge. Similar to this thought, one student noted that: *"you got reminded of things that you perhaps once knew and felt you should know better"*. Moreover, it appeared as if the students' ability to conduct self-assessment during the student activities also motivated the students to further learning, e.g. *"It was also a motivation in the sense that you knew you were going to fill out your paper again later and then wanted to improve"* and increased their self-esteem, e.g. "*Filling it out in the end also served as a nice recap and you left with the feeling that you learned something in class*". In the end of the lecture, students received feedback on their concepts and knowledge of the learning objectives, and were able to discuss the learning objectives and potential misconceptions with their peers and the teacher. This allowed for further self-assessment of their learning. Finally, a student noted that: "*there were clear learning objectives and quizzes. It was a great help when reading and it also made me more curious when reading. I also think that the information stick better to the memory*", suggesting that getting the learning objectives and student activities before reading the curriculum, have helped guide some of the students and their learning process when reading the curriculum.

In the present project, data was collected using three different kinds of student activities; questionnaires, mind-maps and an overview figure. Different students like different activities, but the students agreed that it had been nice that different activities had been used. It should be kept in mind that different activities provide different kinds of information regarding the students' learning. An overview figure is a very concrete task and may provide information about the students learning of a limited topic, questionnaires may be made simple or complex depending on the learning objective, and may be used to get information about concrete questions as well as about the students' conceptualization of a certain topic. Further, a mind-map may both capture the students' knowledge of details as well as their conceptualization of the topic. All student activities used in the present project have their pros and cons, so note, it is important to keep in mind what the learning objectives are, and to choose student activities accordingly.

The same student activity was performed twice, once in the beginning and once in the end of the lecture. This was done to compare the students' knowledge of the learning objectives before and after the lecture to infer something about the students' learning during the lecture, and was merely a

study design to collect data. While it appeared to help some students focus their attention and made them aware that they learned something during the lecture, it may not be realistic time-wise to do this in future lectures. Moreover, it might not have been the student activity in the beginning of the lecture per se that helped focus the students' attention, it may have been the additional time allocated to clarifying the learning objectives. In the future, it might be worth testing whether additional time allocated to go through the learning objectives either before or in the beginning of the lecture yield the same result. Finally, a student noted that: "*I think it is much better to have the same learning objectives repeated (shortly) as the first thing in the next lecture - and maybe do this in the way where the lecturer asks the students to tell what they have learned / how much they remember*". It is definitely also worth trying to repeat the previous lecture learning objectives in the beginning of the next lecture, as repetitions facilitates memory.

In this project I only scratched the surface of how formative assessment may be used to facilitate learning in students. I tried three different student activities to get information about the students' learning in order to adapt the teaching activities to facilitate student learning as well as give the students feedback on their learning. It was definitely worth the time and effort to get information about the students learning and to evaluate the students learning formatively. Misconceptions were easily caught, and clarified through discussions with peers and the teacher. It required little additional effort from me, but it was a great satisfaction to be able to assess that the students had in fact learned what was intended. Finally, the clear learning objectives and student activities also appeared to help students read and memorize the curriculum and guide their self-assessment of their learning. I recommend other teachers to dive into using continuous formative assessment in their teaching, and I will continue to strive to develop my teaching around continuous formative assessment of the learning objectives.

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2015-8/

The bibliography can be found at:

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