Using continuous assessment with feedback loops to generate useful data for learning analytics

Ole Eggers Bjælde
Science and Technology Learning Lab, Aarhus University, Denmark & Department of Physics and Astronomy, Aarhus University, Denmark

Annika Büchert Lindberg
Science and Technology Learning Lab, Aarhus University, Denmark

The combination of feedback loops and continuous assessment through learning management systems can enhance student learning and produce data to illustrate it, to both students and educators. This paper presents learning designs, examples and data, representing this combination, in which students receive feedback from different sources and are given the opportunity to apply the feedback to improve their performance, hereby closing a feedback loop. The examples and data, presented in this paper, come from higher education in Denmark where assessment since 2016 has been in a transition phase from single end-of-semester exams to continuous assessment. Data in this transition phase is extremely helpful in documenting the effect of the learning design and in informing the teaching and learning process, for example in demonstrating how students use feedback to increase their scores and in allowing educators to identify students at risk of failing or dropping out. The generic learning design will be used as inspiration for educators to ensure that student learning is supported by both continuous assessment and feedback loops. In addition, the design will be developed further to strengthen the focus on the development of students' evaluative judgement.

Keywords: Continuous assessment, feedback loops, learning analytics, learning design, higher education

Introduction

Assessment and feedback are two of the strongest drivers for student motivation, engagement and learning (Boud & Falchikov, 2007; Hattie, 2009). From a research and development point of view, the bond between the two has been strengthened as the focus has shifted from assessment *of* learning, through assessment *for* learning towards assessment *as* learning (Brown, 2005; Weurlander, Söderberg, Scheja, Hult & Wernerson, 2012; Earl, 2013). Assessment is not merely an adjunct to teaching and learning, but is in itself a learning process, accentuating the importance of the inherent feedback in the assessment procedures (Dochy, Segers, Gijbels & Struyven, 2007; Carless, 2015).

Research suggests that assessment and feedback can be particularly effective, when (a) assessment occurs in the form of low-stake graded tasks distributed throughout the teaching period, here referred to as continuous assessment (Bassey, 1971; Heywood, 2000), and (b) students are actively acting upon the received feedback to improve their performance and thereby closing a feedback loop (Boud & Molloy, 2013; Carless & Boud, 2018). The combination of continuous assessment with feedback loops has the potential to enhance both students' engagement and their capability to make decisions about the quality of work of self and others, and by so developing students' evaluative judgement (Tai, Ajjawi, Boud, Dawson & Panadero, 2017) and supporting a deep learning approach (e.g., Heikkiläa & Lonkab, 2006).

One way to support educators in efficiently adding continuous assessment and feedback loops into their courses is to utilise technology and its ability to collect, monitor and analyse student data. Data, in this case, is the result of students engaging in feedback and online assessment activities in a Learning Management System (LMS), producing digital traces in great amounts. These traces can be analysed through learning analytics to provide information on how students learn during feedback loops and assessment. Resubmission of assessment tasks will provide valuable information about how the students utilise the feedback obtained (Boud & Molloy, 2013). Regardless of the great potential, however, translating data into substantial improvements in learner and educator experience has proven difficult (e.g., Ellis, 2013; Pardo, 2017) with researchers emphasizing the need for more empirical research evidence.

In 2016 continuous assessment officially became a possible form of examination in higher education in Denmark due to its potential impact on the quality of learning. Universities in Denmark are therefore presently in the transition phase from assessment *of* learning to assessment *as* learning. This paper will illustrate the first pilots introducing continuous assessment with three different types of feedback loops. The feedback loops are supported by technology and are ranging from simple automated feedback, through feedback from teaching assistants with rubrics and to peer feedback with self-selection. In addition, this paper gives suggestions for the analysis of the produced digital data and how it can inform students and educators about learning and points of action. These suggestions follow the mantra: Activity - Assessment - Analytics - Action. The paper gives specific examples of designs, tasks and data from such activities from four first and second-year undergraduate courses (units) and one Ph.D. course at Faculty of Science and Technology at Aarhus University in Denmark, each with 40-120 students in the fall of 2016 or 2017.

The design: Continuous assessment and feedback loops

Our generic design of tasks which combine continuous assessment and feedback loops is shown in Figure 1. The design is inspired by Learning Design Tool (LDTool) from University of Wollongong - see e.g. (Bennett, Agostinho, Lockyer, Kosta, Jones, Koper & Harper, 2007; Agostinho, 2011). In the model, students first meet a description of an assessment task, set by the educator, including feedback and assessment criteria. Hereafter they make a first draft/attempt to which they receive both formative feedback and a formative score. The students then complete the feedback loop by making a revised draft/attempt. In most cases this becomes the final submission, however, the number of loops can vary. The students finally receive a summative grade or a score for the final submission but no feedback. Note that tasks are set by the educator but when students engage in these tasks, we refer to them as activities.

There are several possibilities for adjustments in the design; the type of task, the source of feedback, the type of feedback and the number of iterations. The data collected in assessment tasks can be averaged, compared, combined and reported to provide a foundation for learning analytics, e.g. student scores, visualisation of "at risk" students, learning outcomes etc. But the learning analytics is only valuable when students or educators act on it. In the following section we present three examples of activities with different sources of feedback and different cycles of feedback.

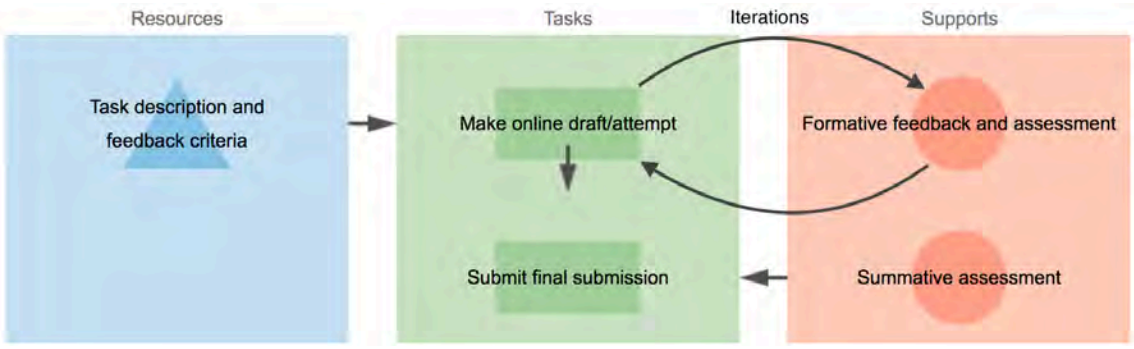

Figure 1: Generic design combining feedback loop(s) with continuous assessment. The design is represented in an alternated version of LDTool. The focus is the learning tasks developed by the educator. These tasks determine student activities.

Examples

In this section, we present short examples of tasks that were designed with analytics in mind. All four undergraduate courses used slightly different variations of multiple-choice tests with feedback loops, one course used assignments with resubmission. The last example is developed in a course for Ph.D. students and will in the future be deployed in one or more of the undergraduate courses.

Continuous assessment with automated feedback loops

Purpose: To practise scientific terms and concepts and to ensure that all students are at approximately the same academic level.

Context: Four first and second-year undergraduate course in relativity and astrophysics, nanoscience, molecular biology and ecology. This type of continuous assessment contributed 5-100% of the final grade.

- Activity: Online tests where students have the possibility to improve their performance through feedback loops (Figure 2). The students are here encouraged to practise and to improve their performance by engaging with the test until they are satisfied with their own result or to engage in voluntary homework (with multiple iterations) before performing the test.
- Assessment: Students receive both formative feedback and a score. The formative feedback guides the students towards the correct answer but does not provide the correct answer (indirect corrective feedback). Feedback is authored by the educator or publisher of the textbook but is provided automatically through the LMS.
- Analytics: The data collected during the assessment and feedback is scores, number of questions answered, difficulty, time on task. The data is averaged and combined and, subsequently, reported to the educator (for further details read the section: Analytics).
- Action: Students can engage with the test until they are satisfied with the result. Educators can follow the performance of individual students compared to the class average and may be able identify students at risk of dropping out or failing the course. Educators can contact students at risk (for further details read the section: Discussion).

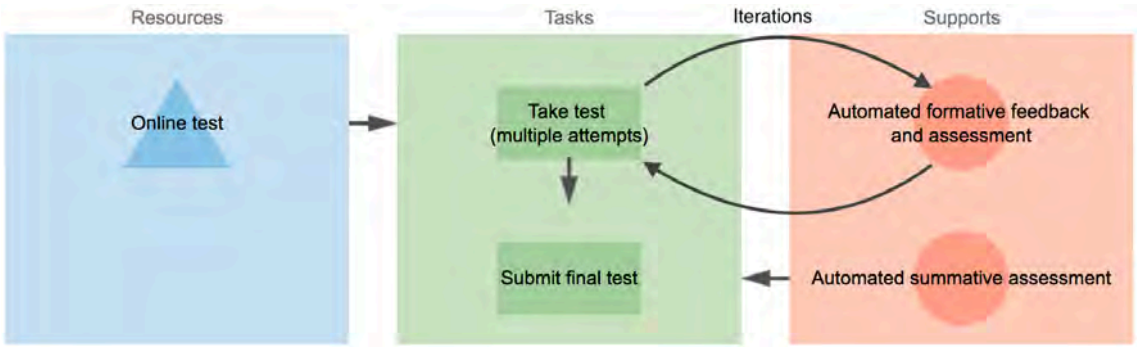

Figure 2: Continuous assessment with automated feedback loops.

Continuous assessment with formative feedback loop through rubrics

Purpose: To practise using correct terminology, academic writing and problem solving, incl. calculations.
Context: First-year undergraduate course in relativity and astrophysics. This part of the continuous assessment contributed 12% of the final grade.

- Activity: Online assignments with the possibility for resubmission after the first grading and feedback (Figure 3).
- Assessment: Teaching assistants give feedback and a score, using a rubric of predefined assessment criteria that students have co-developed at an earlier stage in the course. Based on the feedback and score, students improve their assignment and submit a revised version. This revised version only receives a score.

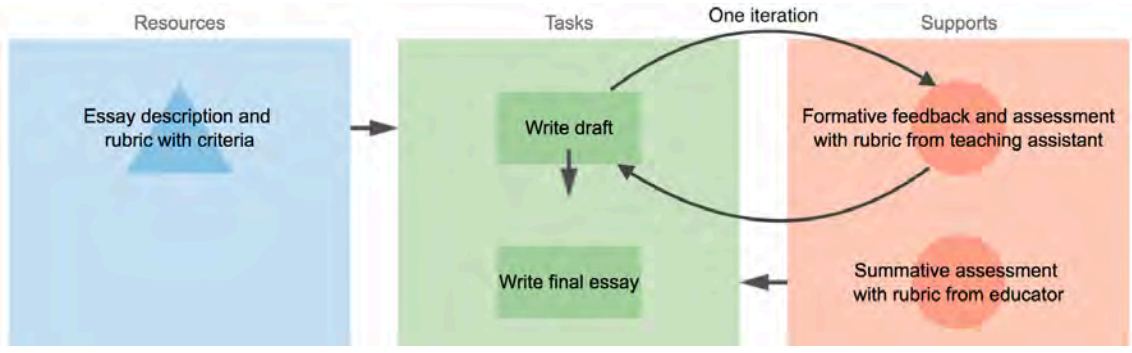

Figure 3: Continuous assessment with formative feedback loops through rubrics.

- Analytics: Students receive an initial score and a final score. These scores contribute to the final grade. After the grading is completed, students as well as educators can see the gain for themselves or for the entire cohort of students.
- Action: Students can use the initial score (and feedback) to improve their performance and the final score to see their learning progress. The educators can directly measure the effect of feedback and keep track on students' learning process.

Continuous assessment with double feedback loop

Purpose: To develop project ideas through feed-forward and to improve, be inspired and share the final project with peers with similar projects.
Context: Ph.D. course in Science Teaching for students acting as teaching assistants.

- Activities: Students initially describe an intended (teaching) experiment and receive feed-forward from educators (first feedback loop). The students hereafter perform the (teaching) experiment and report in a poster format. Student receive peer feedback on the draft poster (second feedback loop). A final version of the poster is submitted after revision, based on the received feedback (Figure 4).
- Assessment: In the first feedback loop the intended experiment (project idea) has to be approved by the educator before the students can proceed. In the second feedback loop the students provide formative peer feedback on minimum two draft posters, one assigned to them and one or more with free selection, where the student read peer posters and decide which poster(s) they prefer to review. The peer review is double-blinded. The feedback is based on criteria which the students applied on poster exemplars earlier in the course. The final poster has to be approved by the educators.
- Analytics: As scores or grades are not assigned in PhD courses these are not available. The data available is student responses to a peer feedback questionnaire.
- Action: The educator can adjust the peer feedback process to accommodate students' perception of the peer feedback process.

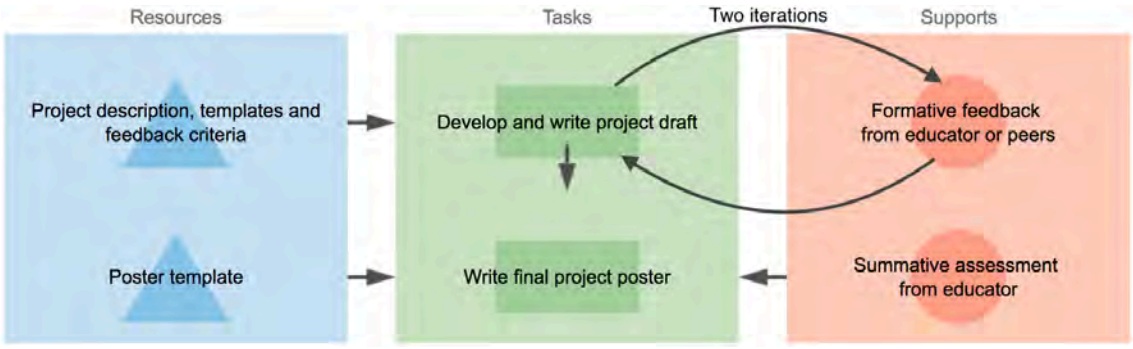

Figure 4: Continuous assessment with double feedback loops.

Analytics

In this section of the paper we present three examples of data, generated through a subset of the continuous assessment activities, described above. We defer a discussion of the data to the section below. All data presented here is generated through Learning Management Systems in undergraduate courses at Aarhus University in Denmark and for the Ph.D. course through a tailored peer feedback system.

Analytics with automated feedback loops

Figure 5 shows data from a first-year course using nine multiple choice tests as part of the continuous assessment. Each test contained seven questions, giving one point each. Feedback loops were introduced into the test such that students received automated feedback on the test after which they were allowed to retake the test, as many times as they wanted. Only the last attempt would count towards the final grade, each test weighing 0.7% of the final grade. Data shows that students, on average, used between 2 and 4 submissions, that average scores on first attempts varied between 3.4 and 5.7, and that practically all students obtained a final score of 7 (note the smaller error bars compared to the error bars on the first attempt). Question types were not only multiple choice but also included matching questions, ordering questions, questions with multiple correct answers, etc. The difference in number of attempts and correct answers in the first attempt can most likely be ascribed to this variation in question type and that the level of difficulty varied over the nine tests.

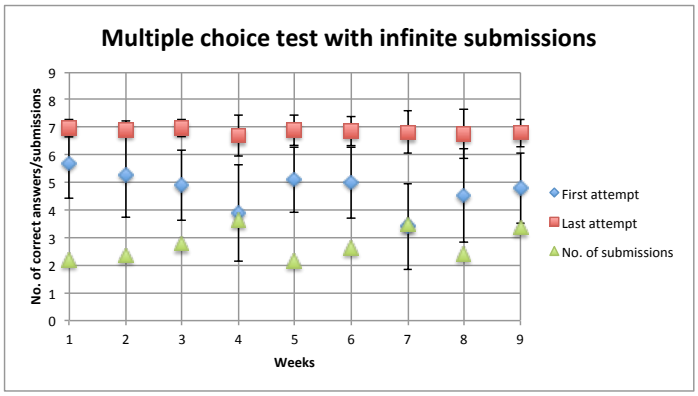

Figure 5: Analytics from continuous assessment with automated feedback loops in relativity and astrophysics. Number of correct answers to nine multiple choice tests with infinite submissions. Blue diamonds: Number of correct answers in the first submission. Red squares: Number of correct answers in the last submission. Green triangles: Number of submissions. Error bars on first and last attempts are one sigma error bars. Error bars on the number of submissions have been left out for aesthetic reasons.

In the course ecology students had multiple attempts when performing the voluntary homework, but only one attempt for the two tests each counting 15% of the final score. The analytics illustrated in figure 6 is reporting on student performance and engagement to the educator. For each homework/test the maximum assigned points is reported together with the class average score for all students. The individual performance for each student is indicated with the actual score for each test, the proportion of the questions answered, and whether the students are at risk of failing this part of the course. No correlation was found between the homework scores and the test scores or between the number of homework assignments completed and the test scores.

Test name	Homework A	Homework B	Test C	Homework D
Assigned Points	15.00	17.00	18.00	19.00
Class Average	11.0	12.9	12.0	11.2
Student 1	14.7	15.5	12.7	19.0
Student 2	8.3	0.0	12.7	0.0
Student 3	13.2	14.9	11.0	18.0
Student 4	13.7	13.9	12.7	18.8
Student 5	6.4	0.0	7.2	8.9

Figure 6: Example of analytics provided by a publisher showing continuous assessment with automated feedback loops from ecology (similar in nanoscience and molecular biology). Maximum assigned points and class average are shown together with individual performances for each student. Analytics for each student are: score for each homework/test; the proportion of the questions answered (rectangle ranging from white to blue; white indicates questions not answered, blue the questions answered) and risk level (increased intensity of the red colour indicate increased risk level).

Analytics from formative feedback loops through rubrics:

Table 1 shows results from a first-year course using four assignments with resubmission. These assignments tested academic writing skills, use of technical terms, problem solving and scientific argumentation. Feedback loops were introduced such that students received scores and feedback on their first submission, using a rubric. Subsequently they were allowed to resubmit, taking the feedback into account to improve their performance. Each test had a maximum score of 30 points and each counted 3% of the final grade. Table 1 shows the gain, going from submission to resubmission. The gain is calculated such that a student who obtained 24 points in the first round (initial score) and 27 points in the last round (final score) obtained a gain of 50% - or half the improvement that the student could have obtained. The calculation is

$$Gain = \frac{final\ score - initial\ score}{30\ points - initial\ score}$$

Table 1 is divided into students obtaining between 0-14 points as initial score, 15-20 points, etc. This selection was decided to track the progression between assignments. Note that a few students obtained a maximum of 30 points as initial score in each of the four assignments and, hence, were not able to improve their score. Some students chose not to hand in their assignment more than once and did thus not record any improvement. These students (9, 12, 12, 21 in assignment 1-4) performed below the class average and are not represented in Table 1.

Table 1: Analytics from formative feedback loops through rubrics in relativity and astrophysics. Shown vertically are the four assignments and horizontally is a division of students in terms of their initial score. Shown in percentages are the gains from submission to resubmission. In parentheses are the number of students in each point interval (shown in the top row), 30 points are max. Because of large standard deviations, none of the quoted numbers are statistically significantly different.

	0-14 points	15-19 points	20-24 points	25-29 points	30 points
Assignment 1	67,7% (39)	72,2% (19)	87,6% (15)	84,7% (11)	N/A (3)
Assignment 2	62,6% (11)	65,4% (22)	75,4% (34)	83,1% (17)	N/A (1)
Assignment 3	57,1% (12)	67,9% (13)	81,7% (28)	90,3% (22)	N/A (8)
Assignment 4	81,1% (7)	65,8% (12)	72,5% (33)	76,8% (14)	N/A (6)

An analysis of final grades vs. obtained gains led to no conclusions or statistically significant correlations of interest, apart from a remarkable number of students obtaining very high final grades (feedback loops may have had a role in this), only seven students failing the course and nine students dropping out during the course. Due to the low statistical value of this data, it is not presented.

Analytics from double feedback loop:

Assessment data is not collected for the tasks performed in the double feedback loop. The data collected here is from a questionnaire related to the peer feedback process (Papadopoulos, Bjælde, Lindberg & Obwegeser, 2018). Papadopoulos et al. find that students with a preference for the double-blinded peer feedback process are more engaged in the activity by reading significantly more peer posters and that they appreciate both receiving and providing feedback from and to peers. In addition, all students indicate that reading other students' poster was more helpful than receiving comments from peers.

Discussion and conclusion

The reason for developing the presented learning design has been motivated by current trends and issues within higher education in Denmark. These include a) a stronger focus on formative feedback to boost students' motivation and to strengthen dialogue between students and educators, b) a more competent use of digital tools in higher education - including a better knowledge base of the value that technology can add such as assessment and feedback analytics, c) better opportunities for continuous assessment, and d) higher retention rates (Uddannelses- og forskningsministeriet, 2018a). Based on these reasons, we divide the discussion of the presented examples and data into three categories: Improving retention rates, making student learning and progression visible to students and educators, and further development of continuous assessment with feedback loops.

Higher retention rates

The currency within higher education in Denmark is students. The more students, universities are able to lead through courses with passing grades, the more money they receive from governmental bodies. However, universities are not willing to lower the academic standards. This leaves two options; support learning sufficiently to help students pass exams or identify students in the risk of failing or dropping out and help them. Research on continuous assessment has demonstrated its potential to boost students' motivation to work continuously during a course rather than emphasising last-minute cramming before a final exam (Trotter, 2006;

Gibbs and Lucas, 1997), strengthen the effectiveness of (formative) feedback, including the possibility to act on feedback (Bearman, Dawson, Boud, Hall, Bennett, Molloy & Joughin, 2014; Richardson, 2015; Bjælde, Jørgensen & Lindberg, 2017), assess a wider range of skills than a traditional exam (Glofcheski, 2017), and to reduce exam anxiety (Falchikov and Boud, 2007; Shields, 2015). For these reasons and because of the possibility for giving frequent formative feedback and assessment, continuous assessment is suggested as an early intervention to strengthen the self-efficacy in first year students (Tinto, 2017). All in all, continuous assessment focus assessment into a more learning-oriented direction and should have potential to improve retention rates. Several studies have also reported on students performing well in continuous assessment activities (Bridges, Cooper, Evanson, Haines, Jenkins, Scurry, Woolf & Yorke, 2002; Simonite, 2003; Bjælde, Jørgensen & Lindberg, 2017), since students are more in control of the effort they invest in low-stake online assessment activities, compared to a traditional high-stake final exam. The examples provided in this paper follow this trend. Moreover, relatively unlimited time available for performing tasks, the possibility for collaborative work and the application of feedback through feedback loops in continuous assessment should also reduce the number of students failing our courses. This is exemplified by only seven students failing the first-year course using assignments with resubmission. Note in addition, that the number of students obtaining high grades in the same course was remarkable (Bjælde, Jørgensen & Lindberg, 2017).

The use of continuous assessment offers an effective way of identifying struggling students. Students who fail to answer or engage with automated feedback loops can be students in danger of dropping out. In two of the first-year courses mentioned (nanoscience and molecular biology) in this paper, the educators contact students who obtain below a (low) threshold score. Because the multiple-choice tests focus on learning fundamental technical concepts, students who perform poorly in these tests will struggle when these concepts become part of an expected knowledge base that can be built on. In one of the two courses, only two students out of 79 dropped out of the course, and the educator ascribes this primarily to be a result of the action to contact struggling students (personal communication with prof. Erik Østergaard). In addition, students with disabilities e.g. dyslexia can be spotted early and be supported.

Making student learning and progression visible to students and educators

Feedback loops provide opportunities for students to engage in dialogue and to act on feedback, thus avoiding a common pitfall coined “feedback as telling” with students as passive receivers (Tai et al., 2017, Carless & Boud, 2018). Often students are told of their strengths and weaknesses, but seldom get a chance to transfer this information into actual improvements of a specific deliverable. Or as put in (Sadler, 2015): “learners do not always learn much purely from being told, even when they are told repeatedly in the kindest possible way”. The absence of opportunities for dialogue and application of feedback are likely among the causes for why many students in the UK, in Australia and in Denmark are dissatisfied with both quality and quantity of feedback (Hounsell, 2007; Mulliner & Tucker, 2017; Carless & Boud, 2018; Uddannelses- og Forskningsministeriet, 2018b). The feedback loop examples provided here encourage students to engage with the feedback and to be an active participant in the feedback loop.

A multiple-choice test with infinite submissions and automated feedback is perhaps the simplest version of a feedback loop. However, as demonstrated in the previous section, students who engage in such an activity do what it takes to reach the maximal score, thus fulfilling the aim of the activity; to ensure all students grasp fundamental terms and concepts. The students are not forced to take the tests several times but actively choose to do so. The data presented from the course relativity and astrophysics showed that students used, on average, between 2-4 submissions to obtain a maximal score on all seven questions. Since each question had an average of four possible answers, this leads to the conclusion that none or only few students are randomly guessing. It may well be that they discuss and help each other in a group, however, learning does not have to be an individual activity. The fact that number of submissions and number of correct answers in the first attempt is more or less unchanged throughout the semester, furthermore suggests that students do not resort to randomly guessing once they become familiar with the type of activity. Multiple-choice tests with infinite submissions thus change the assessment focus from student performance to student learning as the majority of students are motivated to practise until they receive a “perfect score”. Allowing for multiple submissions of automated tests increase the learning without requiring additional resources from the educator.

In terms of assignments with resubmission, Table 1 show that, in this example, all students, who actively chose to resubmit, learned from feedback in a rubric and were able to improve their score. This learning is visible for both students and for the educator. Two quotes from the student evaluation of the course support this: “I really like that you can resubmit, because the focus is more on the learning process than a result.” and “Totally nice that you can resubmit so you don’t get stressed out and you learn much more.” There is a trend that students

who made a good first submission were almost able to perfect their submission, after feedback. But, also students who obtained a low score in the first submission obtained an impressive gain, on average, after feedback. The improvements because of feedback will, of course, depend on the type of feedback given. In this case, feedback was given in a rubric with predefined criteria, and it would be highly interesting to be able to compare the gains quoted in this paper with gains obtained through other types of feedback. We leave this for future work. Had the data shown a correlation such that one group of students had not been able to use feedback, this would have called for action from the educator. This, luckily, appears not to be the case in the presented example as both low and high performing students benefited from the feedback.

In the near future, at least one of the undergraduate courses will use the double feedback loop in combination with a collection of assessment data. This combination will provide both students and educators with an insight into the feedback preferences and potential trends in learning gain from feedback loops. In addition, the exploration into the perceived quality of peer feedback from peers that choose to provide feedback on a self-selected piece of work compared to feedback to pre-assigned work will be interesting.

Further development of continuous assessment with feedback loops

Despite concern about use of online multiple-choice tests these can be time-efficient for educators and provide pedagogical benefits for students such as self-assessment and immediate feedback (Bennett, Dawson, Bearman, Molloy & Boud, 2017b). In the ecology course, tests included both multiple-choice questions and calculations where students had different variables. In the evaluation of the tests, one of the students wrote “It would be nice with more questions with different variables as all students have to calculate by themselves”. Questions with different variables can minimize plagiarism also when students are working together, which is encouraged in the course described here.

Although university educators develop learning designs, they seldom reuse learning designs created by other educators and they rarely represent and visualise their own designs (Bennett, Agostinho & Lockyer, 2017a). In this paper, we have simplified a learning design into a generic design combining continuous assessment with feedback loops. This design will be used as inspiration for Danish educators that are transforming assessment from one high-stake end-of-semester assessment to several low-stake continuous assessments, distributed throughout the course. Sharing designs will especially be important in the initial phase, as this is the stage where educators in particular need additional support (Bennett, Agostinho & Lockyer, 2017a). Another important feature of the assessment design is that it is supported by existing technology that will facilitate easy implementation. When educators are developing new assessments, they might abandon them quickly due to technical failure (Bennett et al., 2017b).

The generic design combining feedback loop(s) with continuous assessment is, in our view, also a way to put more focus on evaluative judgement where students are engaged with assessment criteria multiple times, assess peer work and are active in feedback dialogue (Tai et al., 2017). Tai et al., 2017 suggest that the use of exemplars and co-creation of rubrics are furthermore an important part of developing evaluative judgement among students. Two of the examples provided here are using exemplars and co-created rubrics in the tasks that students perform before “entering” a feedback loop. Hopefully, the learning designs used here could be a starting point for developing effective learning designs, as requested by Ajjawi, Tai, Dawson and Boud (2018) in a recent book.

Concluding remarks

The combination of continuous assessment and feedback loops can be seen as an agent of change of the nature of assessment into a more learning-oriented direction, informed by data. This data will not only inform the design of feedback and assessment activities but also serve as method to monitor student learning and progression, and thus lead to potential actions for educators and students.
Despite the simple nature of the learning design combining continuous assessment with feedback loops, illustrated in the paper, the learning design does indeed lead to informative data for both educators and students. In the presented examples, data is used by students to revise and improve tests and assignments and by educators to measure the effect of feedback and to identify and contact struggling students. Thus, the data helps to document the effect of the learning design, which can serve as inspiration for other educators, and to inform future changes and additions to the learning design. Future research could add to this body of knowledge by exploring the learning potential of other types of formative feedback as well as more examples of data, both quantitative and qualitative, and the actions they prompt.

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