

# Formative feedback through digital MCQs: Students' perceived learning in a bachelor-level physiology course

M. A. Sundset<sup>1</sup>, N. Q. B. Norli<sup>1</sup>, C. R. P. Bjørndal<sup>2</sup>, and C. Svensen<sup>1</sup>

<sup>1</sup>Department of Arctic and Marine Biology, UiT The Arctic University of Norway, Tromsø, Norway

<sup>2</sup>Center for Teaching, Learning and Technology, UiT The Arctic University of Norway, Tromsø, Norway

\*Corresponding author. Email: monica.a.sundset@uit.no

---

**Abstract:** Feedback is defined as a process in which students can benefit from information about their own performance to improve the quality of their work and learning strategies. This case study examines how students in a bachelor-level physiology course experienced their learning when receiving formative feedback through digital multiple-choice questions (MCQs) in the web-based learning platform Canvas. The poorly attended colloquia in the course were replaced by a compulsory assignment comprising eight modules of MCQs. The MCQs could be repeated multiple times by the students providing ample low threshold, low risk opportunities to test knowledge and understanding and to receive feedback on whether they had achieved the learning objectives of the course (“*feedback loops*”). A student survey at the end of the course underlined the potential of using MCQs for automated feedback and learning. Thematic analysis of semi-structured one-on-one interviews with eight random students from the course identified two main themes related to student learning: the importance of the MCQs format and how student characteristics can affect MCQ-aided learning. Challenges were related to the formulations of the MCQs, and the feedback received, and to procrastination of the students' work with the MCQs reducing the learning outcome of the work. We discuss the potential of further developing and integrating online formative feedback loops through MCQs as a systematic approach to enhance learning and emphasize the importance of student and teacher feedback literacy when working with assessments tasks such as MCQs.

---

# 1 Introduction

Student learning is closely related to and affected by feedback and assessment practices (Gibbs, 1999; Scouller, 1998; Light and Cox, 2003; Gibbs and Simpson, 2004; Struyven et al., 2005; Pereira et al., 2016). Students often express that they lack sufficient and helpful feedback, while teachers feel they invest a lot of effort into providing feedback but that the students don't utilize this well (Boud and Molloy, 2013). Feedback can be a powerful tool enhancing student learning (Hattie and Timperley, 2007), provided that feedback practices are shifted towards a formative approach where students actively can participate and utilize the feedback to refine their learning strategies and improve their work (Hyatt, 2005; Price et al., 2010; Boud and Molloy, 2013; Ajjawji et al., 2022; Hansen and Ringdal, 2018).

Students and teachers share the responsibility of ensuring effective feedback processes (Nash and Winstone, 2017), requiring the development of feedback literacy (Carless and Boud, 2018; Carless and Winstone, 2023). For students, this involves the ability to seek, generate, and utilize feedback, as well as making academic judgements (Carless and Boud, 2018; Molloy et al., 2020). Teachers also need to develop a wide range of competencies to effectively incorporate feedback in their teaching and course planning. Boud & Dawson (2023) analyzed the competencies of feedback-literate teachers and developed a Teacher Feedback Literacy Competency Framework consisting of 19 different competencies split into three levels according to the scope of responsibility involved. The *macro-level* includes study program design and development. The *meso-level* includes course design and implementation. And the *micro-level* includes feedback practices relating to individual student assignments. Distinctions between these levels are not absolute, and most competencies could exist in some form at multiple levels.

Feedback is only effective when it helps students develop knowledge and learning. Hence, selecting the appropriate tools for feedback is crucial (Boud and Molloy, 2013). Practice testing (self-testing to enhance memory and comprehension of the to-be-learned material) and distributed practice (implementing a schedule of practice that spreads out study activities over time to enhance long-term retention) benefit learners and boost performance (Dunlosky et al., 2013).

Multiple-choice quizzes are a popular learning tool among students in higher education, and the multiple-choice questions (MCQs) format is also commonly used in exams (Struyven et al., 2005; Douglas et al. 2012; Butler and Roediger, 2008; Touissi et al., 2022). MCQs that are not followed up with feedback may endorse misunderstandings in cases where students wrongly think that they have given the correct answer (Roediger and Marsh, 2005). Computer-mediated feedback can act as a powerful form of feedback (Hattie and Timperley, 2007). Students can receive immediate automated feedback on the same task multiple times, in so-called "feedback loops", and use this feedback to make changes, fill knowledge gaps and make improvements to their work. Such feedback loops may highlight misconceptions and suggest areas for improvement (negative feedback loops) or acknowledge progress without addressing areas for improvements (positive feedback loops) (William, 2011). Developing question banks with MCQs for automated assessments or practice tests such as these requires a lot of effort from the teachers' side when it comes to quality assurance of the questions,

aligning them with intended learning outcomes, and providing feedback to support student self-regulated learning (Maarten 2023). Self-regulated learning processes entail students independently initiating and maintaining their cognitive, emotional, and behavioural activities in a purposeful manner aimed towards achieving their learning goals (Zimmerman and Schunk, 2011). The ability to self-regulate learning differs between learning environments and becomes even more important in emerging online learning settings (Viberg et al., 2020).

This project explores how students experience learning when receiving formative feedback working with online MCQs. The term *perceived learning* is in this paper used and understood as the students' self-reported and experienced learning through knowledge gained, generally based on introspection and reflections. Students have different preferred approaches to their studying and learning. An important distinction is, for example, between tendencies towards a "surface approach" focusing on recall and reproduce, or a "deep approach" focusing on understanding and meaning (Marton and Saljo, 1976; Biggs, 1979). Building on the evidence that assessment influences studying and learning, a third approach to learning was introduced where the student's intention was to achieve the highest possible grades through well-organized, conscientious study methods and efficient use of time (Entwistle and Ramsden, 1983; Entwistle et al., 2001; Struyvend et al. 2005). These different approaches are dynamic and constantly modified depending on the context and the tasks experienced by the student (Struyven et al. 2005).

We employed a case study design using data from a developing project in a bachelor-level course. The teachers in the course aimed to provide the students with multiple, low-risk opportunities to test their knowledge and understanding, and to encourage learning by working with digital MCQs. The MCQs were a mandatory, integrated part of the learning pathway closely linked to the teaching and the learning objectives of the course and providing the students with feedback regarding correct and incorrect answers (positive feedback loops).

The following research question was addressed: *How do students perceive their own learning when working with formative feedback through online MCQs?* We also highlight student and teacher feedback literacy in relation to working with mandatory assessment tasks and discuss how online formative feedback loops with MCQs can be developed and designed in a systematic approach to increase the learning outcomes.

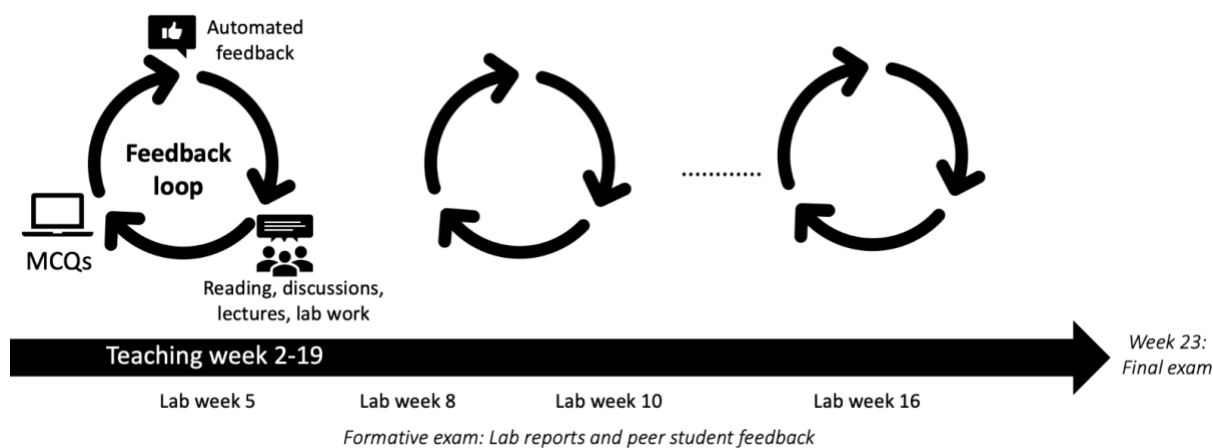
## 2 Methods

### 2.1 The context of the study

The context of this study was a 10 ECTS bachelor-level physiology course with an overall enrolment of ~80 students. The colloquia in the course had been designed to optimize student attendance, but turnout was still low. Student evaluations showed that students struggled to keep up with reading and consequently did not feel comfortable participating in the colloquia.

In spring 2022, the colloquia in the course were replaced by formative feedback loops including MCQs (Figure 1). The MCQs aimed to provide the students with low threshold, low risk opportunities to test their knowledge and receive feedback. The learning outcome descriptions of the course, teaching (two double lectures each week and four

practical classes with laboratory work), mandatory online work with MCQs and exams were all in constructive alignment according to Biggs (2003). The students could repeat the MCQs multiple times receiving automated feedback, and then redo the questions consulting the textbook, laboratory, and lectures notes, and discussing with teachers and fellow students. The linked assessment in the course consisted of a formative exam with lab reports and peer student feedback (worth 20%) and a summative written final exam (collectively worth 80%). In 2023, the format of the final exam was also changed to include MCQs in addition to the written exam questions.



**Figure 1.** Feedback loops with multiple-choice questions (MCQs) and linked assessment in the physiology course.

## 2.2 Developing online MCQs

The MCQs were closely linked to the teaching and the learning objectives of the course (Figure 1, Table 1), covering the fundamentals of the subjects in a scaffolding strategy (Vygotsky, 1978), to enhance engagement and support student-centred learning towards the final exam. The work with the MCQs was mandatory and had to be passed for the students to be able to take the final exam. The MCQs were developed in Canvas, an online learning platform used in the course to help guide the students through the curriculum, teaching modules and intended learning outcomes, submit assignments (MCQs, lab reports and peer student feedback), and access files and videos from lectures, questions, and discussions (Figure 1). The teaching in the course was conducted in both Norwegian and English. Textbooks and MCQs were also available in both languages. The students were presented to the project and the purpose of the assignment with the MCQs at the beginning of the course (via oral and written material). The setup of the MCQs was developed throughout the course and adjusted based on the ongoing dialogue between students and teachers regarding the format and how the MCQs functioned. The MCQs were published in parallel with the teaching in each module and kept open for the students to work on.

### 2.3 Student survey

The students in the course were invited to answer an online anonymous survey at the end of the teaching term. The survey included several aspects of teaching and assessment with a special focus on feedback. Data collected on the students' work with the MCQs are presented as part of this paper.

**Table 1.** Overview of the multiple-choice questions (MCQs) presented to the students in this current study. The MCQs were thematically aligned with the lectures, laboratory work and learning objectives in the different teaching modules of the course. The correct answers on the MCQs are not included in the table. Original questions were provided in Norwegian or English.

Module	Format	Example
Nerve physiology	22-item MCQs with 4-6 alternative answers to choose between	a) If the stimulus intensity of an axon is increased, then <ul style="list-style-type: none"> <li>• The amplitude of the action potential will increase</li> <li>• The frequency of the action potential will increase</li> <li>• The duration of the action potential will increase</li> <li>• The conduction velocity of the action potential will increase</li> </ul>
Muscle physiology, the autonomous nervous system, and CNS	20-item MCQs with 4-5 alternative answers to choose between	b) Which of the following reflexes is monosynaptic? <ul style="list-style-type: none"> <li>• The withdrawal reflexes</li> <li>• Reflexive relaxation of opposing (antagonistic) muscles</li> <li>• The muscle spindle stretch reflex</li> <li>• All of the above</li> </ul>
Kidney physiology	23-item MCQs with 4-5 alternative answers to choose between	c) What is the main site of $K^+$ secretion in the tubular system during hyperkalaemia? <ul style="list-style-type: none"> <li>• Cortical collecting duct</li> <li>• Proximal convoluted tubule</li> <li>• Descending limb of the loop of Henle</li> <li>• Ascending limb of the loop of Henle</li> <li>• Bowman's capsule</li> </ul>
Sensory physiology	43-item MCQs with 2-5 alternative answers to choose between	d) What constitutes the border between the external ear and the middle ear? <ul style="list-style-type: none"> <li>• Cochlea</li> <li>• Oval window</li> <li>• Tympanic membrane</li> <li>• Eustachian tube</li> </ul>
Circulatory physiology	17-item MCQs and 3 calculation questions	e) Consider the equations for flow rate and resistance for blood vessels. What would happen to flow rate if you would decrease the radius? <ul style="list-style-type: none"> <li>• Flow rate decreases</li> <li>• Flow rate increases</li> <li>• Flowrate is unchanged</li> <li>• Flow rate does not depend on radius, only resistance does</li> </ul>

		f) Calculate the cardiac output. Assume a hearth rate of 50 beats / minute and a stroke volume of 0.05 litre / beat.
Respiratory physiology	16-item MCQs, 1 question matching terms with definitions, and 1 calculation questions	g) What is the initial response to low-land adapted humans that go to high-altitude environments? <ul style="list-style-type: none"> <li>• Increased ventilation</li> <li>• Increased haemoglobin concentration</li> <li>• Increased plasma volume</li> <li>• Decrease in the gas exchange barrier</li> </ul> h) Match the different kinds of hypoxia to their definition: hypoxic hypoxia, anaemic hypoxia, ischemic hypoxia, histotoxic hypoxia <ul style="list-style-type: none"> <li>• Reduction in oxygen partial pressure</li> <li>• Normal partial pressure but reduced oxygen content</li> <li>• Low blood flow to tissue</li> <li>• Cell unable to utilize oxygen</li> </ul> i) Calculate the partial pressure of oxygen for an atmospheric pressure of 400 mmHg. Assume an oxygen concentration of 21% within the atmosphere.
Endocrinology and reproduction	20-item MCQ	j) Which of the following statements is <i>FALSE</i> ? <ul style="list-style-type: none"> <li>• Leydig cells secrete testosterone</li> <li>• Spermatogonia are derived from primordial germ cells</li> <li>• Spermatogenesis takes place in the seminiferous tubules</li> <li>• Spermatogenesis produces diploid gametes</li> </ul>
Digestive physiology	42 true or false statements with clues	k) CCK stimulates the contraction of the gall bladder <ul style="list-style-type: none"> <li>• True</li> <li>• False</li> </ul>

## 2.4 Interviews with the students

Semi-structured interviews were conducted with eight of the students from the course (Norli 2023). Five female and five male students were randomly selected and received an email with information about the research project associated with the implementation of the MCQs asking if they would participate. A reminder was sent out after a week when only two students had responded. Ten additional randomly selected students were invited, maintaining equal gender distribution. Finally, a total of four female and four male students agreed to an interview that was conducted within two weeks, representing about 10% of the student population in the course.

The students were enrolled in different educational programs at the same university. At the day of the interview, each student was informed about the project and given a consent form to sign before starting the audio recording. The information sheet stated that participating in the project was voluntary, provided contact information, and assured students that they would withdraw from the project at any time without any negative consequences. None of the students chose this option.

The semi-structured interviews (~60 min) focused on six different topics and were conducted by one of the authors. They began with open-ended questions connected to the students' previous experiences regarding feedback and MCQs in their educational journey. The students were asked about the significance of the MCQs tasks and the feedback for their own learning in the course, their experiences during the semester, their motivation for their learning work, and any other questions that arose based on what the students discussed in relation to the research question. Audio recordings were conducted through the University of Oslo's online system, where the "online form voice recorder app" form was utilized along with the "Voice Recorder" app for the actual audio recording. This setup was chosen to ensure security and privacy. Transcription of the interviews was performed using the "Dictate" function in "Word" and quality-checked against the audio recordings by listening to the recordings while reading the transcriptions.

Thematic analysis (Braun and Clarke, 2012) was applied to analyse the transcribed interviews (68K words, 240 pages). One author had the main responsibility for the analysis, consisting of a stepwise approach to identify and organize thematic patterns in relation to the research question. The five phases of this work included 1) a first read of the transcribed interviews; 2) starting to code and interpret findings and wordings of potential relevance to the research question; 3) identifying patterns from the codes; 4) reviewing the potential themes in relation to coded data and the entire data set; and 5) identifying and naming themes. The analysis was discussed and refined in conversation with the other authors, through the stages of the analysis. Quotes were also selected to illustrate the themes. At the end of the process, another author read through all transcripts, checked the correspondence with the themes and selected quotes, and suggested a moderate revision of the themes, which the research team agreed upon.

## 2.5 Data handling

All data presented in this paper were collected in line with national regulations for data handling. Data collection from the interviews was approved by the Norwegian Agency for Shared Services in Education and Research (Sikt) Permit number 908555. Stored data have been anonymised and will be deleted at the completion of the project.

# 3 Results

## 3.1 Student survey: Working with the MCQs contributed to increased learning

In total, 35% and 40% of the students responded to the survey in 2022 and 2023, respectively (Table 2). Most of the respondents reported that the work with the MCQs had increased their learning and helped clarify the learning objectives of the course. Most of the students had worked independently to solve the MCQs instead of collaborating with fellow students. The MCQs were meant to help the students avoid procrastination working through the curriculum of the course. About half the students started working on the MCQs as soon as they became available. Hence, many also waited to the end of the

semester to solve the MCQs. The students could repeat the MCQs unlimited times, but most of the students were able to obtain the required 60% correct answers without re-doing the MCQs.

**Table 2.** Results from an anonymous student survey 2022 (first year with MCQs in the course) and 2023 (MCQs improved with more detailed instructions). The original survey was provided in Norwegian.

Questions	2022		2023	
	Agree	Disagree	Agree	Disagree
I started working on the MCQs as soon as they became available in Canvas	50% (14)	50% (15)	67% (20)	40% (12)
I solved the MCQs at the end of the course	68% (19)	36% (10)	57% (17)	47% (14)
I repeated the MCQs many times until I got 60% correct answers	36% (10)	75% (21)	47% (14)	53% (16)
The work with the MCQs inspired me to work harder with the course	61% (17)	46% (13)	53% (16)	47% (14)
The work with the MCQs contributed to increased learning	71% (20)	29% (8)	73% (22)	30% (9)
The MCQs helped clarify learning objectives	68% (19)	32% (9)	63% (19)	40% (12)
I solved the MCQs on my own	92% (22)	29% (8)	77% (23)	23% (7)
I solved the MCQs in collaboration with one or more fellow students	39% (11)	71% (20)	33% (10)	70% (21)
I would have liked to have colloquia in addition to the MCQs	57% (16)	46% (13)	73% (22)	23% (7)

## 3.2 Student interviews

Through the thematic analysis of the interviews, two main themes were identified for how students perceived their own learning when working with the MCQs (Table 3).

### 3.2.1 Formats of MCQs and feedback affected learning

The first main theme is related to the format of the MCQs and includes two subthemes: The phrasing of the MCQs and the format of the feedback provided. Concerning the wording of the MCQs, the students preferred that the questions covered and tested both the curriculum and elaborated on broader and deeper understanding of the physiological mechanisms. They reported limited learning from working with the MCQs, and felt that the learning achieved was more towards details in the curriculum rather than the overall understanding of the different topics and mechanisms:

*‘Multiple-choice questions narrow down so specifically to one small answer, you lose the entire picture on many things. Yes, there is little learning output (...) You feel like you don’t get the overview ... you only get to the depth on that specific thing...’*

One student stated that they would have been unable to answer some of the questions without the answer alternatives. Also, several of the students stated that they tended to rely on guessing rather than actual knowledge or understanding when answer choices were written in such a way that they led to recognition or elimination strategies (Quote



(Q 1, see Table 3). Furthermore, the students pointed out that many of the MCQs and their corresponding learning outcomes were difficult to understand due to complicated language (Q2). Consequently, they also gave many wrong answers, leading to frustration and turning the focus towards getting the answers right instead of increasing their learning. Some students also reported that struggling to understand the questions made the work even more time-demanding and this lowered their motivation. In addition, the use of English versus Norwegian vocabulary led to misunderstandings and confusion (Q3). Several of the students conveyed that the learning outcome depended on the quality or formulation of the questions. Some of them also had high expectations regarding the learning outcome from working with the MCQs, and they felt that the quality of the questions should have been better to meet their expectations:

*‘I think that the quality of the multiple-choice questions should have been better (..) it is perhaps more the way the question is formulated....’*

The format of the feedback also affected the perceived learning of the students (Table 3). All the eight students considered good feedback important, making them aware of what they are doing right, how they can improve and hence increase their learning outcome. They had previous experience with written and oral feedback, and feedback on MCQs (right or wrong, automated comments). In this current course, the students experienced three different forms on feedback on the MCQ. The first type of feedback gave the students the correct answer when ticking the wrong answer. This resulted in minimal learning (Q4), although one student commented that the responsibility for benefiting from working with the quizzes largely relied on what each individual student chose to put into their work. The second type of feedback provided the students with the number of correct answers after having finished the MCQs but did not identify which of the answers were correct. This created much frustration, anger and demotivation among the students interviewed (Q5). Several of the students experienced that the MCQs became very time-consuming when they had to be repeated many times, not knowing what answers were right or wrong. They felt unsure of themselves, and perceived learning was low. These two initial feedback formats were not intentional from the teachers' side but caused by an error in the programming of the initial quizzes in Canvas. The error was corrected in dialogue with the students and in the following quizzes the students received feedback with information on which of the MCQs had been correctly answered. This third type of feedback gave the highest perceived learning (Q6). However, the students also felt that they would have liked an automated comment or hint to explain *why* the answer was wrong (Q7).

### *3.2.2 Student characteristics affected learning*

The second main theme identified was connected to experiences of how personal characteristics affected student learning working with MCQs and included three subthemes: work ethics and motivation; study strategies and time managements; and perception of the MCQs as a learning tool (Table 3).

The students expressed that work ethics (work habits, self-discipline, diligence and attitude) and motivation influenced their studying. Several of the students were focused on performing well in university and achieving good grades (Q8), aiming to use their time well, and experiencing greater learning outcomes and knowledge acquisition:

*‘.. I wanted all my answers to be right, or at least know the answers to all of them...’*

Some started working with the MCQs as soon as they became available and tried making the most out of the work. The MCQs gave them a reason to read the curriculum and the students felt that the exercise affected their learning:

*‘I had to do it, and then I might as well do it properly because then I’ll get more out of it than just going through it mechanically...’*

Opinions varied about the level of motivation derived from working with the MCQs (Q9, Q10). None of the students experienced increased motivation. One pointed out that motivation arises when the work and the learning feels relevant. And motivation seemed significant in determining whether they procrastinated the work with the MCQs or not. The students had to finish all the MCQs by the end of the semester and some students expressed that it was easy to postpone the work. Then, they experienced less learning because they ended up doing it all in one big effort just in time for the deadline. The students also expressed that their own study technique affected when and how they chose to work with the MCQs. For instance, one of the students followed up the MCQs to learn more:

*‘And it became more than just completing the tasks. Of course, some of it provided better understanding and allowed me to review things, but I prefer delving into a deep understanding of things. I believe that we learn best by answering questions of why and how. How do things happen? Why do they happen? And it’s not always easy, in my impression, to capture that in multiple-choice questions...’*

Study strategies (Q11) and time management (Q12) were also reported to affect learning. Some students prepared their own questions and memory cards to learn the curriculum. Students using these techniques had a positive approach to the MCQs and felt that they were helpful tools on their learning journey. Other students felt that they learned more from lectures and making their own notes, and that the MCQs were an additional task they had to complete before they could continue to using their own preferred study technique. Work effort and learning output from the MCQs was consequently low for some students.

**Table 3.** Main themes and subthemes identified using thematic analysis of interviews with eight students focusing on how they experienced their learning when working with and receiving feedback through digital, automated MCQs.

Main themes	Subthemes	Relevant quotes (Q) associated with the themes
Experiences of how the MCQ format affects student learning	Formulation of the MCQs	<p><b>Q1:</b> “(..) at the same time, I find it to be a weakness in multiple-choice questions because I feel that one (..) relies more on recognizing the correct answers rather than being able to extract them independently (..) I feel that it’s very easy for me to simply recognize the answer instead of reasoning my way to it in some manner.”</p> <p><b>Q2:</b> “You had to read the question many times to really understand them (..) the complexity of what they were asking. It was just complicated questions, so it would have been nice if they were a bit simpler and focused on basic facts. But also, some questions that tested understanding.”</p> <p><b>Q3:</b> “If you learn the vocabulary in both Norwegian and English, what I remember is that there was lot of mixing. It was the same word actually - but we had learned it in</p>

		<i>Norwegian and in English - and it took time before we realized it was the same.”</i>
	Formulation of the feedback	<p><b>Q4:</b> “So, it’s kind of like, yeah, I know that this one is correct, but it doesn’t necessarily help me.”</p> <p><b>Q5:</b> “Yeah, or no information about why what I had chosen was wrong or could be more correct, or any hints or something (..), and that was actually quite frustrating (..) I mean, those were the ones I spent extra time on.”</p> <p><b>Q6:</b> “I think it was useful because it provides feedback on what one has mastered, as well as what one does not master.”</p> <p><b>Q7:</b> “But if you choose the wrong answer (..) it would have been helpful if there could be a hint, either a page number or just a comment, that automatically appears when you select the wrong option. This would provide some guidance on what you have actually misunderstood...”</p>
Experiences of how individual characteristics affect student learning working with MCQs	Work ethics and motivation	<p><b>Q8:</b> “(..) very structured, and I am very focused at doing well in school.”</p> <p><b>Q9:</b> “(..) if I did not manage to answer the multiple-choice questions, it became very demotivating, and I was thinking – Well, now I don’t feel like doing it anymore. I’d rather do something else.”</p> <p><b>Q10:</b> “I don’t like multiple-choice tasks myself (...) usually, the answer options are so similar!”</p>
	Study strategies and time management	<p><b>Q11:</b> “I enjoy tests during the semester (..) to find out what I don’t master, but also to keep things fresh in my mind.”</p> <p><b>Q12:</b> “(..) when we were sort of done with all the work with the bachelor’s thesis... we actually started studying properly (..) in terms of the multiple-choice tasks, they were probably all done on the same day.”</p>
	Perceptions of the MCQs as a learning tool: Overview and repetition tool or imposed tool	<p><b>Q13:</b> “I thought it was relevant. The good thing about those quizzes was that I easily found out what I didn’t know or... Because when going through them, there would be a question where I would just go: ‘Oops! No, I don’t know this’. Then I understood that, okay, I need to study more on that topic, and I could make some notes... that it was covered... so I focused more on it. It became sort of... some kind of guideline... to what one should know.”</p> <p><b>Q14:</b> “I think that for all students, it is positive that they are ‘forced’ to (..) get familiar with the material (..) you have to put some effort into it. You can’t just let it pass by even if you don’t want to attend lectures (..) it requires you to engage to some extent.”</p> <p><b>Q15:</b> “Of course, when I was working with the assignments and had to flip through the book and all that, it gave me more insight into the topic ... when I later sat down to cram for the exam (..) During lectures and such, when I came across the topic that I had worked with in the multiple-choice tasks, it was like (..) this I know a bit better.”</p>

The students pointed out that other subjects and mandatory work coinciding with the physiology course influenced their efforts with the MCQs to a great extent. And that the late due date of the MCQs made it easier to down-prioritize the work with the quizzes compared to other shorter, more immediate deadlines and perhaps more time-consuming work, e.g., lab reports and peer feedback in the courses they were enrolled in. For instance, one student prioritized writing a bachelor thesis and postponed the work with the MCQs (Q12). Less time invested in the work with the MCQs affected the learning outcome since the students needed to complete them as fast as possible to meet the deadline.

The student's perception of the MCQs as a learning tool was identified as the third and last subtheme under characteristics affecting learning (*Table 3*). Some used the MCQs as a tool to get an overview of the curriculum and the intended learning outcome of the course (Q13). The quizzes became available at the beginning of a new teaching module and could be repeated multiple times. The students experienced that this was a useful method to refresh their knowledge, guiding them to the parts of the curriculum that they needed to focus on, helping them summarize the curriculum, and providing them with a starting point to focus on using own study techniques. This in turn helped them increase their learning outcome:

*'Although the multiple-choice tasks themselves don't contribute with a lot of knowledge directly, they do provide a good overview and help us understand the specific aspects of each topic....'*

One of the students explained that after completing the work with the MCQs, they wrote down the questions and answers. These were then used to explain and further study the subjects in the different modules by looking at the different answer alternatives, reading the book and attending the lectures. This student perceived a high learning outcome from the work. Several of the students commented that they viewed this work as mandatory studying (Q14) which was some form of learning in itself – but perhaps not the approach they would have chosen themselves. They had to sit down with the MCQs, going through the lectures and their notes again. The students expressed that they did learn from working with the MCQs, but whether this was the best form of learning outcome was arguable. One student was surprised in a positive way by this “mandatory learning” (Q15). This student had negative expectations regarding whether a high learning outcome could be achieved from working with the MCQs, but after having been forced to work hard with the assignment it became clear that these were the topics that the student ended up mastering the best. According to the students the MCQs themselves did not result in much learning but being required to sit down and focus on the curriculum resulted in a high learning outcome.

## 4 Discussion

Developing MCQ banks aligned with intended learning outcomes to support student self-regulated learning is laborious but allows flexible, time-efficient solutions for objective and immediate feedback that can be applied in both formative and summative assessment (Beerepoot, 2023). In this current study, more than seventy percent of the students who responded to our survey reported that the work with the MCQs had

increased their learning (Table 2). Thematic analysis of the interviews with the students identified two main themes related to student learning: the importance of the MCQs format and how individual characteristics can affect learning (Table 3). The characteristics of the students included their work ethics, motivation, study strategies, time management and their perception of the MCQs as a learning tool. Although the MCQs themselves did not result in much learning directly, the mandatory assignment forced them to work harder with the curriculum leading to a higher learning outcome. Some of the students also used the MCQs to refresh their knowledge and help focus their work using their own study techniques. In this sense the MCQs changed the behaviour of the students, with increased perceived learning as a result.

Challenges were related to the formulations of the MCQs and the feedback received, and to student procrastination with the MCQs, all of which could have reduced the learning outcomes (Table 3). The feedback was tailored to confirm if answers given to the MCQs were right or wrong and was meant to encourage the students to read the textbook, reinforce lecture and lab material, apply concepts, and discuss content with fellow students and teachers before repeating the MCQs (Figure 1). The teachers had to consider many aspects in the process of developing the mandatory assignments with the MCQs. Had the MCQs been suitably designed? Was the level of difficulty high enough? Did working with the MCQs help the students understand the subject - or just memorize information or guess the answers without reading up on the subjects when re-doing the MCQs? And did the work with the mandatory MCQs help the students structure their time better?

The interviews showed that several of the students had a “deep approach” to learning (Marton and Saljo, 1976; Biggs, 1979), and did not consider MCQs to be a good learning technique when it came to “*answering questions of why and how*”. They used their own alternative study techniques, preparing follow-up questions and memory cards. This motivated them to use their time efficiently and start working with the MCQs as soon as they became available, thus trying to increase the learning outcomes (Table 3). They also suggested that an automated comment explaining why the answer was wrong could have supported their learning (Q7). Some students had high expectations regarding their learning outcome, and if these were not met, they attributed this to poorly formulated questions. For example, it was perceived that the quizzes contained very specific questions that delved into a particular detail in the subject and did not provide a deeper understanding of the subject. The final exam consisted of seven problem-based essay questions and did not include MCQs. The students felt that they did not need to memorize specific details to do well at the exam as these could easily be solved using the textbook or internet, but rather needed a more holistic understanding of the topics. They believed that if the format, wording, and quality of the MCQs had been better, they would have been able to extract a higher learning outcome than what they felt they were left with. A possible approach for the teachers to further develop the course and boost the students’ learning could be to let the students themselves create MCQs with feedback. Developing MCQs as a learning method has a positive impact on both perception and performance, although some concerns are raised about the time and effort needed (Touissi et al., 2022).

Teachers and students have different roles that require different competencies in feedback processes (Carless and Boud, 2019; Molloy et al., 2020; Carless and Winstone, 2023; Boud and Dawson, 2023). Molloy et al. (2020) identified seven core features of

student feedback literacy: commits to feedback as improvement; appreciates feedback as an active process; obtains information to improve learning; processes feedback information; acknowledge and works with emotions; recognizes feedback as a reciprocal process; and enacts outcomes of feedback. Several of these competencies were evident in the interviews with the students working with the formative feedback loops in this current study. Online automated quizzes with instant feedback allows students to manage and develop their own independent learning, by taking the quizzes as many times as they like and administrating their own time use. The feedback loops were integrated into a learning management system (Figure 1) and provided the students with the opportunity to improve their performance. The interviewed students considered feedback important, appreciated the value of feedback and committed to feedback as improvement. They also appreciated feedback as an active process, using the questions and answers from the MCQs as a steppingstone to obtain more information, reading and learning more and employing their own learning strategies. Positive and negative emotions are also a natural part of the feedback and learning process, and it is important for students to acknowledge emotions and reactions they have to the feedback (Hill et al., 2021). The design of the feedback can be a crucial factor in the student's response and attitude towards the feedback (Hill et al., 2021).

The students were frustrated with the feedback received on the initial MCQs, as the MCQs had been set up in a wrong way. They were also frustrated about confusions arising due to unclear terminology. But positive feelings were also reported in relation to the learning gained from working with the quizzes. The interviews showed how student characteristics affected the learning when working with MCQs, suggesting that when introducing feedback loops with MCQs in a course it is also important to help the student build feedback literacy in relation to work ethics and motivation, study strategies, and time management, and how to use the MCQs as an efficient tool for learning.

Teachers play important facilitating roles in promoting student feedback literacy through curriculum design with feedback processes for student uptake, guiding and coaching (Carless and Boud, 2018; Carless 2023). Boud and Dawson (2023) identified and characterized feedback literacy competencies of university teachers pending on the scope of responsibility involved. They concluded that substantially increased levels of pedagogic competence and feedback literacy are needed to improve feedback and assist student learning. Working at the *meso-level* with course design and implementation requires that the teacher maximises effects of limited opportunities for feedback, designing feedback dialogues, constructing and implementing tasks with accompanying feedback processes, and utilizing technological aids to feedback as appropriate (Boud and Dawson, 2023). Adjusting and refining practices in the direction of more learning focused feedback processes as done by the teacher team in the development of the course in this study is indicative of reflective feedback literacy at the *meso-level*.

Earlier work has underlined the importance of providing students with the chance to enhance their future performance through the utilization of online quizzes facilitating instant feedback integrated into a learning management system (Jordan and Mitchell, 2009; Wong and Yang, 2017). Mandatory work with MCQs, the formative exam with lab reports, peer student feedback and feedback from the teachers in addition to discussions in lectures and during lab sessions, provided a range of different feedback opportunities for the students in this course (Figure 1), allowing the students to access

information in different ways and maximize their opportunities for important information to be understood and acted upon. When creating feedback opportunities, the teachers need to structure the course so that the students can optimise the use of the feedback from the different assignments. The work with the digital MCQs was aimed to capture sufficient student time and effort across the different modules and help the students manage, monitor and self-direct their learning. The MCQs were broken down into smaller modules connected to their individual defined learning outcome descriptions rather than one large module to help the students develop a better understanding of concepts and physiological mechanisms going through the curriculum.

Procrastination behaviour is quite common among students and correlates with performance (Hooshyar et al., 2019). We left the time management to the students with a deadline at the end of the course, and many of them tended to delay the work with the MCQs. Providing deadlines for the MCQs throughout the semester could help the students manage their time better and obtain more learning from the feedback.

Building on the data from the interview (Nordli 2023) and the survey several changes were made by the teacher team the following year. A detailed instruction was included along with each module of MCQs, linking the respective questions to relevant learning goals and guiding the students to where they could search for answers and learn more. The format of the quizzes was also made more uniform with respect to formulation and number of quizzes. Based on input from the students and discussions with the external sensor, the teacher team also changed the format of the final exam to include MCQs in addition to the longer written essay questions, for better alignment of the assignment with the end-of-course examination.

## 5 Conclusion

We examined students' perceived learning from working with formative feedback through online MCQs in a bachelor-level physiology course. We also discussed key aspects of feedback literacy involving receiving and acting upon feedback (students) and designing opportunities for students to act on feedback inputs in a learning-focused feedback process at the *meso-level* (teachers). Challenges identified included the format of the MCQs, the format of the feedback, and time management. The students expressed their appreciation for receiving feedback on their responses and a desire for more detailed feedback on the MCQs, with information that could aid and enhance their learning such as directions to find the right answer. Introducing multiple and dispersed deadlines for the assignments with the MCQs for the individual modules may help improve time-management for the students.

## Acknowledgements

Developing the teaching in the physiology course is a team effort. We are grateful to the teachers involved, and to the students that were interviewed and responded to the anonymous survey. This study is part of the project "*Developing feedback literacy for learning in biology*" led by M. A. Sundset and C. Svensen with strategic funding from UiT The Arctic University of Norway through The Program for Education Quality (Project

number 7-2021) and builds on data gathered through interviews conducted as part of the master degree project by Norli (2023).

## References

- Ajjawi, R., Kent, F., Broadbent, J., Tai, J. H.-M., Bearman, M., and Boud, D. (2022). Feedback that works: a realist review of feedback interventions for written tasks. *Studies in higher education (Dorchester-on-Thames)*, 47(7), 1343-1356. <https://doi.org/10.1080/03075079.2021.1894115>
- Beerepoot, M. T. P. (2023). Formative and summative automated assessment with multiple-choice question banks. *Journal of Chemical Education*, 100, 2947-2955. <https://doi.org/10.1021/acs.jchemed.3c00120>
- Biggs, J. B. (2003). Alinging teaching for construction learning. *Higher Education Academy*, 1(4), 1-4.
- Biggs, J. B. (1979). Individual differences in study processes and the quality of learning outcomes. *Higher Education*, 8, 381-394. <https://doi.org/10.1007/BF01680526>
- Boud, D., and Molloy, E. (2013). Rethinking models of feedback for learning: the challenge of design. *Assessment and evaluation in higher education*, 38(6), 698-712. <https://doi.org/10.1080/02602938.2012.691462>
- Boud, D., and Dawson, P. (2023). What feedback literate teachers do: an empirically-derived competency framework. *Assessment and evaluation in higher education, ahead-of-print(ahead-of-print)*, 48(2), 158-171. <https://doi.org/10.1080/02602938.2021.1910928>
- Braun, V., & Clarke, V. (2012). Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology, Vol. 2. Research designs: Quantitative, qualitative, neuropsychological, and biological* (s. 57–71). American Psychological Association. <https://doi.org/10.1037/13620-004>
- Butler, A. C., and Roediger, H. L. (2008). Feedback enhances the positive effects and reduces the negative effects of multiple-choice testing. *Memory & Cognition*, 36(3), 604-616. <https://link.springer.com/article/10.3758/mc.36.3.604>
- Carless, D. (2023). Teacher feedback literacy, feedback regimes and iterative change: towards enhanced value in feedback processes. *Higher Education Research & Development*, 42(8), 1890–1904. <https://doi.org/10.1080/07294360.2023.2203472>
- Carless, D., and Boud, D. (2018). The development of student feedback literacy: enabling uptake of feedback. *Assessment and evaluation in higher education*, 43(8), 1315-1325. <https://doi.org/10.1080/02602938.2018.1463354>
- Carless, D., and Winstone, N. (2023). Teacher feedback literacy and its interplay with student feedback literacy. *Teaching in higher education*, 28(1), 150-163. <https://doi.org/10.1080/13562517.2020.1782372>
- Douglas, M., Wilson, J., and Ennis, S. (2012). Multiple-choice question tests: A convenient, flexible and effective learning tool? A case study. *Innovations in Education and Teaching International*, 49(2), 111-121. <https://doi.org/10.1080/14703297.2012.677596>
- Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., and Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, 14(1), 4-58.
- Entwistle, N. J., and Ramsden, P. (1983). *Understanding student learning*. London: Croom Helm. <https://doi.org/10.4324/9781315718637>
- Entwistle, N. J., McCune, V., and Walker, P. (2001). Conceptions, styles and approaches within higher education: Analytical abstractions and everyday experience. In *Perspectives on cognitive, learning and thinking styles*. Sternberg, R. J., and Zhang, L. F. (Eds.), pp. 103-136. New York: Lawrence Erlbaum Associates.
- Gibbs, G. (1999). Using assessment strategically to change the way students learn. In *Assessment Matters in Higher Education: Choosing and using diverse approaches*. Brown, S. and Glasner, A. (Eds.), pp. 41-53. Buckingham: Open University Press. ISBN 0749411139.
- Gibbs, G., and Simpson, C. (2004). Conditions under which assessment supports students' learning. *Learning and Teaching in Higher Education*, 1, 3–31. <https://eprints.glos.ac.uk/3609/>
- Hansen, G., and Ringdal, R. (2018). Formative assessment as a future step in maintaining the mastery-approach and performance-avoidance goal stability. *Studies in Educational Evaluation*, 56, 59-70. <https://doi.org/10.1016/j.stueduc.2017.11.005>



- Hattie, J., and Timperley, H. (2007). The Power of Feedback. *Review of educational research*, 77(1), 81-112. <https://doi.org/10.3102/003465430298487>
- Hill, J., Berlin, K., Choate, J., Cravens-Brown, L., McKendrick-Calder, L., and Smith, S. (2021). Exploring the Emotional Responses of Undergraduate Students to Assessment Feedback: Implications for Instructors. *Teaching and learning inquiry*, 9(1), 294-316. <https://doi.org/10.20343/teachlearningqu.9.1.20>
- Hooshyar, D., Pedaste, M., and Yang, Y. (2020). Mining educational data to predict students' performance through procrastination behaviour. *Entropy*, 22(1). <https://doi.org/10.3390/e22010012>
- Hyatt, D. F. (2005). 'Yes, a very good point!': a critical genre analysis of a corpus of feedback commentaries on Master of Education assignments. *Teaching in higher education*, 10(3), 339-353. <https://doi.org/10.1080/13562510500122222>
- Jordan, S., and Mitchell, T. (2009). e-Assessment for learning? The potential of short-answer free-text questions with tailored feedback. *British Journal of Educational Technology*, 40(2), 371-385. <https://doi.org/10.1111/j.1467-8535.2008.00928.x>
- Light, G., and Cox, R. (2003). *Learning and teaching in higher education: The reflective professionals*. London: Sage.
- Marton, F., and Säljö, R. (1976). On qualitative differences in learning - II Outcome as a function of the learner's conception of the task. *British Journal of Educational Psychology*, 46, 115-127. <https://doi.org/10.1111/j.2044-8279.1976.tb02304.x>
- Molloy, E., Boud, D., and Henderson, M. (2020). Developing a learning-centred framework for feedback literacy. *Assessment and evaluation in higher education*, 45(4), 527-540. <https://doi.org/10.1080/02602938.2019.1667955>
- Nash, R. A., and Winstone, N. E. (2017). Responsibility-Sharing in the Giving and Receiving of Assessment Feedback. *Front Psychol*, 8, 1519-1519. <https://doi.org/10.3389/fpsyg.2017.01519>
- Norli, N. Q. B. (2023). *Formativ tilbakemelding gjennom digitale flervalgsoppgaver i Canvas: En kvalitativ studie av studentenes læringserfaring gjennom arbeid med flervalgsoppgaver i et fysiologi-emne på bachelor nivå* (MSc thesis), UiT The Arctic University of Norway. (in Norwegian)
- Pereira, D., Flores, M. A., and Niklasson, L. (2016). Assessment revisited: A review of research in Assessment and Evaluation in Higher Education. *Assessment and Evaluation in Higher Education*, 41(7), 1008-1032. <https://doi.org/10.1080/02602938.2015.1055233>
- Price, M., Handley, K., Millar, J., and O'Donovan, B. (2010). Feedback: all that effort, but what is the effect? *Assessment and evaluation in higher education*, 35(3), 277-289. <https://doi.org/10.1080/02602930903541007>
- Roediger, H. L., III, and Marsh, E. J. (2005). The positive and negative consequences of multi-testing. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 31, 1155-1159. <https://doi.org/10.1037/0278-7393.31.5.1155>
- Scouller, K. (1998). The influence of assessment method on students' learning approaches: Multiple choice question examination versus assignment essay. *Higher Education*, 35, 453-472. <https://doi.org/10.1023/A:1003196224280>
- Struyven, K., Dochy, F., and Janssens, S. (2005). Students' perception about evaluation and assessment in higher education: A review. *Assessment and Evaluation in Higher Education*, 30(4), 325-341. <https://www.tandfonline.com/doi/epdf/10.1080/02602930500099102>
- Touissi, Y., Hjej, G., Hajjioui, A., Ibrahim, A., and Fourtassi, M. (2022) Does developing multiple-choice questions improve medical students' learning? A systematic review. *Medical Education Online*, 27(1). <https://doi.org/10.1080/10872981.2021.2005505>
- Viberg, O., Khalil, M., and Baars, M. (2020). Self-regulated learning and learning analytics in online learning environments: A review of empirical research. In *LAK '20: Proceedings of the Tenth International Conference on Learning Analytics & Knowledge* (pp. 524-533). <https://doi.org/10.1145/3375462.3375483>
- Vygotsky, L. S. (1978). *Mind in society: The development of higher mental process*. Cambridge: Harvard University Press.
- Wong, G. K.-W., and Yang, M. (2017). Using ICT to Facilitate Instant and Asynchronous Feedback for Students' Learning Engagement and Improvements. In *Emerging Practices in Scholarship of Learning and Teaching in a Digital Era* (pp. 289-309). Singapore: Springer Singapore. [https://doi.org/10.1007/978-981-10-3344-5\\_18](https://doi.org/10.1007/978-981-10-3344-5_18)
- Zimmerman, B., and Schunk, D. (2011) *Handbook of self-regulation of learning and performance*. New York: Routledge.