Article

Design and Evaluation of a Digital Module with Guided Peer Feedback for Student Learning Biotechnology and Molecular Life Sciences, Attitudinal Change, and Satisfaction

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Abstract

This study aims to investigate the impacts of a digital learning module with guided peer feedback on students' domain-specific knowledge gain and their attitudinal change in the field of biotechnology and molecular life sciences. The extent to which the use of this module is appreciated by students is studied as well. A pre-test, post-test design was used with 203 students who were randomly assigned to groups of three. They were asked to work on the digital module with the aim of exploring various perspectives, and the "pros and cons" on the topic of "Genetically Modified Organisms (GMOs)." The results suggest that the module can be used to foster students' domain-specific knowledge gain and their attitudinal change. Furthermore, the module was evaluated positively in terms of students' motivation and satisfaction with the learning experiences.

Keywords: *attitudinal change; biotechnology; digital learning module; molecular life sciences; student satisfaction*

Introduction

While it is clear that there is widespread interest in the potential of digital learning modules in the field of biotechnology and molecular life sciences, there is a need for further research into the effectiveness of such digital modules in promoting domain-specific knowledge gain and attitudinal change, and a need to explore students' motivation and satisfaction with the learning experiences.

Digital learning modules are increasingly introduced in higher education, including in the field of biotechnology and molecular life sciences [1–3]. These modules can serve various purposes. Exercises in digital modules, for example, can increase students' motivation, their understanding and retention of knowledge [4], as well as facilitate the acquisition of domain-specific knowledge [5]. Embedding representational tools such as graphs, texts, diagrams, and pictures in digital learning modules can authenticate and visualize learning contexts [1, 2] which in turn help students acquire complex cognitive skills and perform deep learning [6, 7]. Digital learning modules provide students with various modes of information presentation, such as texts, exercises, graphs, diagrams, animations, pictures, and so forth, that can support students' learning [8–10].

Despite vast investments on digital learning modules, the use of such modules can still be challenging especially in real educational settings in which motivational aspects for learning are crucial. A promising approach to stimulate motivation for students to embrace such digital learning modules in their regular courses is to design and develop modules with peer feedback possibility that provide students with fun opportunities for learning. Receiving feedback from learning peers with the same motivational needs and also giving feedback to them in a reciprocal manner are important aspects of learning process (see refs. [[11] and [12]]). Effective feedback can guide students to realize the gap between their own current and expected, and provide them with advice on what to improve and how to improve [13, 14].

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Although scientific literature highlights the importance of feedback for learning as well as the features of high quality feedback (see refs. [[11] and [13]]), there remains a challenge for students to construct good quality (critical yet constructive) feedback in collaborative settings (see ref. 15). For various reasons, some students may avoid giving critical feedback to the learning peers while some others may prefer not to receive critical feedback from their learning peers. These reasons include psychological, emotional, and social barriers for giving and receiving critical feedback such as fear of losing face or getting into a fight with learning partners [16], and perceiving critiques and counterarguments as personal attacks [17]. For example, there are students who would be reluctant to oppose and disagree with their learning peers, while others may not appreciate being challenged themselves [18]. Furthermore, less assertive students may avoid giving critical feedback just due to the (negative) competitive and disagreement aspects of the critiques [19]. As a result, the feedback typically remains at the surface level and lack well-founded arguments for promoting critical thinking, and deep and elaborative learning. This is a striking omission since deep processing, critical thinking and logical reasoning are essential objectives in education that positively associate with learning performance (see ref. 15). Therefore, additional feedback support is needed if students are to willingly and with a high degree of motivation provide critical yet constructive feedback in such digital learning modules. This study provides such peer feedback support in a digital learning module to scaffold learning by guiding students on how to represent, structure, evaluate, and analyze their feedback for the learning partners.

To conclude, the importance of digital learning modules for learning is well researched, yet little empirical studies have addressed their combined effects on domain-specific knowledge gain, attitudinal change, and students' satisfaction. The picture is even more unclear when it comes to the features of these digital learning modules with regard to the peer feedback support. This study thus designs, implements, and evaluates a digital learning module with an intensified peer feedback support.

The goal of this study is to explore whether a digital learning module with guided peer feedback which encourages challenges and motivation support students' domain specific knowledge gain in the field of biotechnology and molecular life sciences. In addition, the extent to which the use of such a digital learning module is appreciated by students is studied as well. Furthermore, since interactions of students during peer feedback involve social process [20, 31] and facilitate consideration of alternative viewpoints [19, 31], it was examined whether the confrontation of viewpoints during peer feedback with learning partners leads to modification of students' conceptions and attitudinal change in a digital learning modules. Following research questions are formulated to address these goals:

What are the impacts of a digital learning module with guided peer feedback on students' domain-specific knowledge gain?

What are the impacts of a digital learning module with guided peer feedback on students' motivation and satisfaction with the learning experiences?

What are the impacts of a digital learning module with guided peer feedback on students' attitudinal change?

Method

Context and Participants

The study took place at Wageningen University in the Netherlands, with a focus on the Life Sciences, especially food and health, sustainability, and the healthy living environment. The participants were 203 B.Sc. students who enrolled for the course "BPE-10806; Introduction Molecular Life Sciences and Biotechnology." This course is an introduction in the field of molecular life sciences and biotechnology. In this course, students acquire insights into the ethical issues associated with activities in biotechnology and molecular life sciences and the significance of that for society. The mean age of the participants was 19.30 ($SD = 1.90$) years. About 63% of participants were male and 37% were female. Participants were divided into groups of three students. There were 67 groups of three students and one group of two students.

Materials and Learning Tasks

The topic for discussion was Genetically Modified Organisms (GMOs) with the focus on the use of "cultured meat manufacturing—insect cells." Specifically, students were asked to work on the following statement: "Insect-cell biomass infected with genetically modified baculovirus is a healthy meat alternative." They were provided with the description of the case and a summary of the theoretical text regarding the topic. They were also provided with some additional links to the websites to further study the concept of the cultured meat manufacturing—insect cells. Every student was then asked to read the learning materials and engage with the digital learning module in order to write an individual reflection report on the topic of the study. The peer feedback process then started in the digital learning module. Every student was then tasked with providing a structured feedback on the individual reflection reports of the two other learning partners in the group while receiving additional guidance. The students' task was to carefully read the reports of the two other members in the group and provide structured feedback on them while taking into account the various perspectives on the need—or lack thereof—of using cultured meat manufacturing—insect cells. The final task of every student was to revise his/her own individual report by applying the feedback of the other two learning partners in the group as the indicator of his/her own final individual report.

Learning Environment: A Digital Learning Module

The three learning partners in each group were distributed over different locations of a classroom. A digital learning module was designed and used in this study. This digital learning module is a web-enabled platform that provides students with various modes of information presentation, such as texts, exercises, graphs, diagrams, and pictures with the feedback features to stimulate interactions between members of a group in an active learning environment by getting them thinking together about topics, media or material that is relevant to them. The feedback features in this digital learning module is designed in such a way as to guide the interaction style for both synchronous and synchronous interactions—promoting reasoning, critical discussion, and justified arguments.

The main feature of this digital learning module is the use of guided peer feedback. This digital learning module provides the context and interaction style for reasoned and structured feedback, justified arguments and allowing the students to produce reusable content from their group experiences. This is done using a variety of input text boxes and sentence openers embedded in the platform for provoking and promoting students' reasoning, conceptual change, and argumentative feedback processes and practices. The structure of the guided peer feedback was designed on the basis of the literature and characteristics for writing a complete and sound reflection report in the field of Molecular Life Sciences and Biotechnology.

Scientific literature suggests that the reflection report should include a clear position on the topic, data to support the position, possible counter-arguments and opposing points of view, refutation of the counter-arguments and opposing points of view, and integration of the pros and cons of the topic by taking into consideration the opinions of the advocates and the opponents on the issue at hand (see refs. 21–24). This structure was then adjusted to the field of the molecular life sciences and biotechnology since the nature of reflection report varies across disciplines (see ref. 25). To do so, a series of meetings were held with the experts of the field and also the teachers of the course to define the elements of a complete and sound reflection report for students in the field of molecular life sciences and biotechnology. After several sessions of expert consultations, the experts reached consensus on the characteristics of argumentative essays in the field of molecular life sciences and biotechnology. These meetings were resulted in a list of items that should be included in the reflection reports of students. The feedback features and the learning activities of students were then designed on the basis of each element of a complete and sound reflection report to encourage constructive and useful feedback on this particular content domain (see Table I for the list of these items).

The validity of these items was obtained through circulating them among the experts and the teachers of the course. We then designed our guided peer feedback on the basis of these items (see Table I) and embedded them in the digital learning module using input text boxes and sentence openers.

Procedure

Overall, the session took about 4 hr and consisted of four main phases. 1) During the introduction and pre-test phase, which took 30 min, students received introductory verbal explanations and completed several questionnaires on demographic variables, their preliminary opinion on the GMOs, and their domain-specific prior knowledge. 2) Then, in the individual learning phase (50 min), students were asked to engage with the digital learning module, read theoretical text and articles (along with diagrams, pictures, graphs, etc.), search the Internet in daily papers, periodic journals, and scientific papers. They were then asked to write a reflection report (500 words) on the following statement: "Insect-cell biomass infected with genetically modified baculovirus is a healthy meat alternative" for about 20 min followed by a 10 min break. 3) During peer feedback phase (80 min), each student was asked to read the reports of two learning partners and provide guided feedback on them for about 80 min (40 min per each report) followed by a 10 min break. 4) During the post-test and debriefing phase (80 min), students were asked to read the comments of the two learning partners for about 15 min and then revise their individual report (500 words) for about 40 min. Students were then asked to fill out several questionnaires to assess their domain-specific knowledge gain, their shifts of opinions on GMOs, and their motivation and satisfaction with the learning experiences (25 min) followed by debriefing (5 min).

Measurement of Students' Domain-Specific Knowledge Gain

A pre-test–post-test questionnaire was used to measure students' domain-specific knowledge gain. This questionnaire consisted of 17 multiple-choice questions. Specifically, both in the pre- and post-test, each student was asked to answer these questions. Each correct answer was given one point and as a result each student could receive 17 points at maximum for both pre- and post-test. The data from post-test was compared with the pre-test data in order to come up with a single score for each student (T2-T1), indicating their domain-specific knowledge gain.

Measurement of Students' Attitudinal Change

A pre-test–post-test questionnaire was used to measure students' attitudinal change on the GMOs topic. This questionnaire consisted of eight questions on a five-point Likert scale ranging from "strongly disagree = 1," "disagree = 2," "neutral = 3," "agree = 4" through to "strongly agree = 5." Both in the pre- and post-test, each student was asked to indicate the extent to which s/he agreed with the GMOs statements (see Table II). The data from post-test was

TABLE I *Features of a good reflection report and guided peer feedback embedded in the digital module*

Number	Features of a good reflection report by panel of experts and teachers	Guided peer feedback embedded in the digital module using input text boxes and sentence openers
1	The intuitive opinion on the topic.	To what extent your learning partner present his/her intuitive opinion on the topic? Is that clear? Why or why not? (30 to 50 words).
2	The arguments in favor of the topic (pros).	To what extent your learning partner provide arguments in favor of the topic? To what extent your learning partner reflect the opinion of the advocates on the topic? (30 to 50 words).
3	The scientific facts in favor of the topic (pros).	To what extent your learning partner provide arguments against the topic? To what extent your learning partner reflect the opinion of the opponents on the topic? (30 to 50 words).
4	The arguments against the topic (cons).	To what extent your learning partner provide scientific facts in favor of the topic? (30 to 50 words).
5	The scientific facts against the topic (cons).	To what extent your learning partner provide scientific facts against the topic? (30 to 50 words).
6	The opinion on the topic taking into account various pros and cons.	To what extent your learning partner integrate various pros and cons of the topic? (30 to 50 words).
7	The arguments and scientific facts (evidence, examples, figures, facts, etc.) to support opinion.	Does your learning partner come to a conclusion based on his/her arguments? What do you think about his/her conclusion? (30 to 50 words).
8	The final conclusion and statement on the topic.	What are your suggestions for improving the quality of the reflection report of your learning partner? (30 to 50 words).

compared with the pre-test data in order to detect any shift of the student attitude towards GMOs statements. For each question, there could be a maximum of four-point shift (for example from strongly disagree to strongly agree and vice versa) on the GMOs statements on the basis of the Likert scale. The reliability coefficient was high for both pre- and post-test of this instrument (Cronbach $\alpha = 0.74$ and 0.69, respectively).

Measurement of Students' Motivation and Satisfaction with the Learning Experiences

A questionnaire designed by Mahdizadeh [26] was adapted to assess students' motivation and satisfaction with the learning experiences (see Table III). This questionnaire consisted of four main sections and 36 items in total on a five-point Likert scale ranging from "almost never true = 1," "rarely true = 2," "occasionally true = 3," "often true = 4" through to "almost always true = 5." The first section (6 items) assessed students' perceived effects of the domain-specific learning outcomes. The second section (10 items) assessed students' perceived effects of the domain-general learning outcomes. The third section (7 items) collected information on students' opinions on the ease of use of the module. The last section (13 items) assessed students' appreciation of the module. The reliability coefficient was high for all four scales of this instrument (Cronbach $\alpha = 0.87$, 0.91, 0.84, and 0.86, respectively).

Results

In this section, we present results for each research question in chronological order.

Results for Research Question 1

This section presents the findings for the effects of the digital learning module with guided peer feedback on students' domain-specific knowledge gain. Based on ANOVA test for repeated measurement, students' domain-specific knowledge improved significantly from pre-test to post-test, $F(1, 200) = 287.50$, $p < 0.01$, $\eta^2 = 0.59$. This suggests the positive effects of the digital learning module on the domain-specific knowledge gain of students. Students' mean quality scores for domain-specific knowledge was 9.37 (SD = 1.89) for the pre-test and 12.22 (SD = 1.76) for the post-test. So,

TABLE II *Pre-test–post-test questionnaire to measure students' attitudinal change on the GMOs topic*

Number	*Statements*
1	It is humane to humanize pigs by genetic modification to make their organs suitable for transplantation to humans (xenotransplantation).
2	GMO's are not a danger to biodiversity.
3	GM seeds should be further developed for the market to improve sustainability.
4	I will eat clone products such as genetically modified AquAdvantage-salmon as soon as they come on the market.
5	I have no objection against genetically modified pets such as hypoallergenic cats or fluorescing fish.
6	Insect-cell biomass infected with genetically modified baculovirus is a healthy meat alternative.
7	*In vitro* or cultured meat produced from genetically modified bovine muscle cells is a healthy meat alternative.
8	Overall, I am in favor of GMOs.

in average, the gain of knowledge for every student was 2.85 which is significant.

Results for Research Question 2

This section presents the findings for the effects of the digital learning module with guided peer feedback on students' motivation and satisfaction with the learning experiences. Students' motivation and satisfaction with the learning experiences appeared to be sufficiently high (around four on a five-point Likert scale) for all students. Specifically, the average score of students for "perceived effects of the domain-specific learning outcomes" was 3.82 on a five-point Likert scale higher (SD = 0.73). The average score of students for perceived effects of the domain-general learning outcomes was 3.26 (SD = 0.76). The average score of students for "the ease of use of the module" was 4.23 (SD = 0.63). The average score of students for "appreciation of the module" was 3.44 (SD = 0.62). During the plenary discussion sessions, students appreciated the module with regard to its dynamic nature, user-friendliness, and variation of the sentence openers. Furthermore, they said that the module was useful with respect to practicing, provoking and promoting their critical reasoning and argumentation skills.

Results for Research Question 3

This section presents the findings for the effects of the digital learning module with guided peer feedback on students' attitudinal change. A check was performed on students' attitudinal change on the GMOs from pre-test to post-test. Figure 1 depicts these results, showing the average Likert value for students for both pre- and post-test on the eight questions on the GMOs.

MANOVA test for repeated measurement showed that students significantly shifted their attitude towards GMOs from pre-test to post-test, *Wilks'* $\lambda = 0.24$, $F(1, 202) = 74.43$, $p < 0.01$, $\eta^2 = 0.76$. This was the case with all the eight questions with regard to students' positions on the GMOs. As can be seen in Fig. 1, there is an indication that the digital learning module with guided peer feedback affected students' attitude to the GMOs. While students in the pre-test were almost fully in favor of GMOs, the digital learning module and also the peer feedback from their learning partners shifted students' attitude towards being neutral (see Fig. 1). The results suggested that students GMOs' attitude can be shifted through argumentation and engagement in critical thinking and reasoning through engaging with the digital learning module supported with peer feedback.

Discussions

In this section, we explain and discuss the results of this study for each research question in chronological order.

Discussions of Results for Research Question 1

With implementation of a dialogue learning module, students were able to gain domain-specific knowledge as demonstrated in their post-test compared with pre-test. This is in line with previous studies that emphasize the positive effects of various representational tools, for example, textual and graphical implementation of the materials in the digital learning modules on students learning and knowledge construction (see refs. [2, 8, and [9]]). Following step-by-step guidelines and instructions embedded in the digital learning module seemed to help students acquire preliminary knowledge about the pros and cons of the controversial topic to be able to elaborate on that during the peer feedback process. The provided guidance and appropriate design of the guided peer feedback embedded in the module seemed to help students not only externalize their knowledge and information for their learning partners but also analyze the arguments of the learning partners.

The peer feedback support in the digital learning module was designed in such a way as to help students engage in deep cognitive processing for learning and discovering complementary knowledge of the two other learning partners in the group on the basis of their awareness of one another's specialized expertise (see refs. [[15] and [27]]). In this study, students benefitted from their partners'

TABLE III *Measurement of students' motivation and satisfaction with the learning experiences*

Perceived effects of the domain-specific learning outcomes	The module motivated me to learn about the topic.
	The module broadened my knowledge on the topic.
	The module deepened my knowledge on the topic.
	The module made me more interested in the topic.
	The module helped me learn pros and cons of various arguments for and against the topic.
	Overall, I am satisfied with my learning with this module.
Perceived effects of the domain-general learning outcomes	The module helped me learn how to form my opinion on the topic.
	The module helped me learn how to bring various pros and cons of the topic on the table.
	The module helped me learn how to benefit from the feedback of my learning partner.
	The module helped me learn how to bring my arguments on the table.
	The module helped me learn how to defend and support my opinion on the topic.
	The module helped me learn how to integrate various perspectives on the topic.
	The module helped me learn how to write a structured reflection report.
	The module helped me learn how to handle peer feedback.
	The module helped me learn essential elements of a sound argument for or against various perspectives on the topic.
	The module helped me learn how to critically yet politely, and respectfully provide constructive feedback for my learning partner.
Ease of Use of the module	Working on various parts of the module was easy, clear, and understandable.
	I had no technical problem working on the module.
	It took me only a short time to learn how to work with the module.
	It was easy to work with various functionalities of the module.
	It was easy to navigate through the module.
	Working on the module did not require too much technical computer literacy.
	Overall, the module was user-friendly.
Satisfaction with the Learning Task	I enjoyed working on the module.
	The description of the assignments was clear and understandable.
	The time allocated for carrying out various parts of the module was sufficient.
	The provided literature was useful for carrying out various parts of the module.
	The assignments in various phases of the module were clearly formulated.
	The provided literature was useful for learning about the topic.

TABLE III *(Continued)*

	The time given for practicing various exercises was helpful to learn how to work on the module.
	The instruction at the beginning of each assignment was helpful for working on the module.
	The workload of the module was adequate.
	The module was not boring.
	I would like to follow such a module to learn a range of subjects and topics.
	The use of such a module should be encouraged in education.
	Overall, I am satisfied with how much I learnt with this module.

knowledge and expertise by looking at two other group members' individual reports on the issue at hand. Specifically, analyzing their learning partners' reports and providing feedback on them raised group members' awareness of the topic. Awareness about various pros and cons of the controversial topic of the study enhanced students' knowledge awareness as was reflected in the post-test assessment of their domain-specific knowledge. Knowledge awareness in the group has been shown to be an important factor that foster students' knowledge construction [28, 29].

Discussions of Results for Research Question 2

Students appreciated the digital module, the textual and graphical representations of the information, and most importantly the peer feedback support that helped them write structured reflection report and gain domain-specific knowledge. Furthermore, they demonstrated that the module was useful with respect to practicing, provoking and promoting their critical reasoning and argumentation skills. This was documented through the survey at the end of the module.

It was apparently a challenging, yet pleasurable, learning opportunity for undergraduate students to follow a digital module for learning and sharing knowledge with fellow students over GMOs—one of the most controversial issues of the social and physical sciences. The use of guided peer feedback in the module was an encouraging opportunity for students to raise their awareness about the topic, express agreements/disagreements with the arguments of the two other learning partners, and integrate various points of view. The digital module seemed to provide students with a safe and respectful learning environment to practice their argumentation and exercise critical discussion and reasoning skills as well. The controversial issues of the GMOs caused quite passionate views on both side of the argument, increasing students willingness to outline their knowledge and externalize their information for others. It was also easy for students to quickly learn various functionalities of this digital module as demonstrated in their responses to the survey. Taking all together, the user-friendliness and the design of the module along with the guided peer feedback were positively reflected in the students' scores for motivation and satisfaction with the learning experiences.

Discussions of Results for Research Question 3

The digital learning module and the peer feedback support in this study caused most students to change their positions and shift their opinions, an outward sign that the activity initiated thinking, and rethinking, among the students. This has to do with the nature of argumentation that involves social process leading students' to consider alternative viewpoints and perspectives as well (see refs. [[19] and [20]]).

The results suggest that critical peer feedback of the module play a role for attitudinal change of students. The expectation was that the students would interact and be critical of their peers during the feedback process. As a result, it was also expected that they would be much susceptible to attitude shifts when they discover various perspectives and sides of the controversial issue. Through the peer feedback process, students were able to discover the knowledge distributed in the group and the pros and cons of the issue in order to revise, modify, and adjust their initial contributions on the basis of their learning partners' contributions (see refs. [[15] and [30]].

The change between being supportive of a proposal about GMOs to being neutral is in fact a relatively large change for a student studying the topic, so none of the attitude shifts recorded were trivial or unconsidered to the students involved. This study did not test conceptual change, but the equal frequency of attitude shifts, which indicate openness to persuasion, are at least likely to have implications for frequency of conceptual change also between the groups. However, we believe another factor that may be

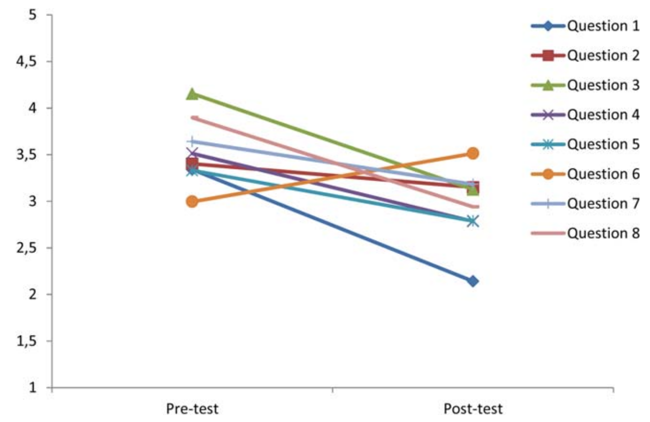

FIG 1 *The average Likert value means for attitudinal shift of students from pre-test to post-test on the basis of eight questions on GMOs' statements. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]*

involved in change of opinion is the strength or weakness of prior knowledge on the controversial issue. If prior knowledge is weak and the pre-test opinion is not firmly held, an opinion may be changed with relatively little argument.

Conclusions, Implications, Limitations, and Suggestions for Future Research

This study used a digital learning module that also supported peer feedback process to engage students in an intensified processes of learning and writing about a controversial topic. The module was designed in such a way as to provoke students for exchanging and directing diverse and multiple conflicting opinions towards deeper reasoning. While various information presentation of the digital learning module such as textual and graphical information, for example, texts, exercises, graphs, diagrams, pictures, and so forth, fostered domain-specific knowledge of the students, the use of peer feedback support seemed to promote and scaffold argumentation and critical reasoning enabling the students to provide constructive and critical feedback for their peers. The use of peer feedback support seemed to guide the students in appropriate ways to analyze learning partners arguments about the topic, express agreements/disagreements and when possible integrate various points of views in their own reflection report. This digital learning module seemed to provide a safe and respectful learning environment for students to also practice their argumentation and exercise critical discussion and reasoning skills without recourse to, or fear of, personal (*ad hominem*) statements, enhancing their awareness of the topic. Exchanging diverse and multiple conflicting opinions, analyzing one another arguments, and expressing agreements/disagreements supported with scientific facts, arguments, logical evidence and examples were then reflected in the attitudinal change of students towards the controversial topic of the GMOs from pre-test to post-test.

This study was embedded in an existing course in a real educational setting with its own dynamics. This means that there is a high level of ecological validity. However, the authentic setting of this study put some constraints on the possibilities to experiment. Further research under more stringent conditions (regarding pretesting, familiarization of students with the digital learning module, and use of various module functionalities) and in other sections of the same course, as well as in similar types of courses, is needed to test the extent to which the results can be generalized. The set-up and results of this study also point to the following issues and limitations that warrant discussions and recommendations for future research.

In this study, we used a multiple test measurement that was validated through a panel of experts and teachers to report the learning achievements of students. We did not shed light on the relationship between the course exams and the knowledge gain as was obtained in this study. Further analysis should be conducted to determine the extent to which the results of course exams (mid-term and final exam) are consistent with the scores obtained through the short-term multiple test measurements. If they are not consistent, and the psychometric properties of the exams pass the minimum quality thresholds, further calibration of the measurement is necessary. Therefore, we suggest that follow up research be aimed at this question.

Students in this study were free to navigate through the module with their own individual speed since it was an individual self-study module expect for the feedback process. They could have followed different routes. Practically, it was possible that some students skipped the information and the reading materials to immediately start with writing reflection report. Although this was quite unlikely, this could have influenced the results of this study. If that was the case, the research results presented would be of a conservative nature. Through our observations and also the survey, students followed the order corresponding with the module without skipping and deviations from the sequences in the module. In order to fully eliminate the risk of skipping and deviations from the module, in follow-up research we advise using logging facilities to register the way in which students go through the module, even if this is for self-study.

In this study, the effects of various aspects of the digital learning module on various dependent variables (domain-specific knowledge gain, students' satisfaction, and attitudinal change) were tested in combination and not separately. We are, therefore, not certain about the additive or interaction effects of each part of the module (textual and graphical information representations, reading materials, searching the internet, peer feedback support, etc.) on various dependent variables. For example, although we expect that peer feedback support is the main reason for attitudinal change of students or learning gains, it is still practically possible that the textual and graphical information representations, reading materials, searching the internet, and so forth, had effects on attitudinal change or learning gains, as well. We, therefore, advise that future studies focus on the interaction and/or additive effects of various independent and dependent variables of this study.

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