



Relations between scripted online peer feedback processes and quality of written argumentative essay



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ABSTRACT

Teachers often complain about the quality of students' written essays in higher education. This study explores the relations between scripted online peer feedback processes and quality of written argumentative essay as they occur in an authentic learning situation with direct practical relevance. Furthermore, the effects of the online argumentative peer feedback script on students' written argumentative essay are studied. A pre-test, post-test design was used with 189 undergraduate students who were assigned to groups of three. They were asked to explore various perspectives, and the 'pros and cons' on the topic of 'Genetically Modified Organisms (GMOs)' in order to write an argumentative essay in the field of biotechnology. The findings reveal that successful students and groups differ in terms of their feedback quality than less-successful students and groups. This implies that when students engage in high-quality, elaborated and justified peer feedback processes, they write high-quality argumentative essays. Furthermore, the results show that the online argumentative peer feedback script enhances the quality of students' written argumentative essay. Explanations for these results, limitations, and recommendations for further research are provided.

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1. Introduction

Teachers often complain about the quality of students' written essays and claim that writing capacities of most undergraduate and even graduate students are insufficient (Cooper et al., 1984; Kellogg & Whiteford, 2009). This has convinced teachers to pay attention to the practices that enhance students' writing motivation and strategies that directly focus on improving their writing skills (Bruning & Horn, 2000; Stern & Solomon, 2006). Peer feedback is one of the most prominent instructional practices and strategies that teachers use to enhance both students' writing skills, their motivation, and also their learning in the particular content domain (Kluger & DeNisi, 1996; Nelson & Schunn, 2008). Peer feedback provides students with both informational value, in terms of supporting learning, and motivational value, in terms of stimulating effort resulting in the modification of student's cognition, motivation and/or behavior (Kluger & DeNisi, 1996; Shute, 2008).

Despite vast scientific research on the importance and the effects of peer feedback process on students' writing and learning (see Bayerlein, 2014; De Nisi & Kluger, 2000; Gabelica, Van den Bossche, Segers, & Gijssels, 2012; Nelson & Schunn, 2008), a crucial issue for the use of peer feedback that is left under investigated is the relation between peer feedback process and its outcomes. Whilst it is clear that there is

widespread applications of the peer feedback process for enhancing students' writing and learning in curricula all over the world and in various domains, there is a need for further research into the exploration of the relations between the peer feedback process and its outcomes. This study therefore explores whether and how the peer feedback process can be facilitated in such a way as to enhance students' outcomes such as writing argumentative essays.

1.1. Writing argumentative essays

Writing argumentative essays is a common practice for undergraduate students (Wu, 2006), for example in the field of biotechnology (the content domain of this particular study) covering a bunch of controversial issues such as 'Genetically Modified Organisms (GMOs)'. Students' essays often lack sound argumentation and depth of elaboration (Cooper et al., 1984) because they are either unaware of the features of a good quality argumentative essay or they have difficulty in transferring their argumentation knowledge into applications i.e. writing essays (Bacha, 2010; Noroozi, Teasley, et al., 2013). This is striking since argumentation is a key requirement of the essay (Wingate, 2012; Wu, 2006). Despite the recognition of argumentation as a key element of the essay, there is not yet a consensus among scholars and academic teachers in terms of characteristics of a high-quality argumentative essay. It is not fully clear "how does an argumentative essay should look like". Wingate (2012) argues that this lack of consensus comes from the fuzzy concept of the "essay" that is difficult to define as a genre because

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it is often used as an umbrella term for a variety of disciplines (see Johns, 2008). Various disciplines have different features of structure, discipline's value, epistemology, and argumentation (Andrews, 2010; Samraj, 2004). Therefore, specific requirements of the essay and presentation of the arguments in the essays should be taught to students in a given discipline by disciplinary experts (Wingate, 2012).

1.2. Features of argumentative essays

Undoubtedly, Toulmin's (1958) model of argument structure, which is based on the "grammar" of argument, is the most prominent framework for teaching and analysing argumentative text and essay writing. From Toulmin's point of view, every argument is composed of six interconnected parts: claim, data, warrant, backing, rebuttal, and qualifier respectively. Claim is an expression of the position that is advanced in the argument. The elements datum, warrant, and backing fall within the term grounds. Datum is the information that is expressed to support the acceptance of the claim. Warrant (often implicit) is a rule of inference that justifies the transition from the datum to the claim and reveals the relevance of the data for the claim. Backing is information such as reasonable evidence, statistics, or expert ideas that provide a rationale for a warrant. Qualifiers and their interrelated rebuttals are presented to qualify the relationship between claim and warrant.

Despite its vast popularity, the application of Toulmin's model at the macro level for writing long texts and essays is limited. Wingate (2012), for example, argues that the Toulmin's model renders itself to the analysis and construction of single claim and it is thus less helpful at the macro level. That is why even advocates of the Toulmin's model suggest additional methods and procedures to be combined with that model to address the large scale structure or macro level of the essay (Bacha, 2010; Davies, 2008; Wingate, 2012). This study therefore used a combined method to teach and analyse the students' argumentative essays using Toulmin's model as the basis and following scientific literature that suggest simple argumentative structure in the written argumentative essays (see Andrews, 1995; Qin & Karabacak, 2010). To comply with this, scientific literature suggests that in every argumentative essay a clear position needs to be presented followed by arguments and data to support that particular position. Furthermore, the argumentative essays should include possible counter-arguments and opposing points of view that need to be refuted. This would require 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 Andrews, 1995; Qin & Karabacak, 2010; Toulmin, 1958; Wood, 2001). These elements, as was discussed before, should be adjusted to particular content domain since writing argumentative essays differ from discipline to discipline (see Wingate, 2012).

This study used peer feedback approach to help students follow this structure of argumentative essay because feedback comments are the key factor for learning to write (see Hyland & Hyland, 2006; Noroozi, McAlister, & Mulder, 2016). The logic and rationale for choosing peer feedback over teacher feedback, besides scientific relevance, for teaching students how to write argumentative essays has to do with the time constraints of the teachers to provide feedback for all students' essays. From an educational practice perspective, providing feedback on students' written essays would be quite challenging for teaching staffs especially when class size increases, teachers become overloaded and possibilities for teacher-student interaction diminish (e.g. Boud & Molloy, 2013; Higgins, Hartley, & Skelton, 2002; Van Ginkel, Gulikers, Biemans, & Mulder, in press).

1.3. Importance of peer feedback

Peer feedback has been considered as a powerful instructional practice to enhance both students' writing skills and motivation (Brown, 2004; Gabelica et al., 2012; Kellogg & Whiteford, 2009) as well as their domain-specific learning performance and outcomes (Nelson &

Schunn, 2008). 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 Bayerlein, 2014; Crisp, 2007). Effective feedback can guide students to realize the gap between their own current and expected state, and provide them with advice on what to improve and how to improve (De Nisi & Kluger, 2000; Lizzio & Wilson, 2008). Peer feedback provides students with the opportunity to broaden and deepen their thinking and understanding when they compare their own writing processes and products with those of others (Yang, 2010). Peer feedback can thus provoke reflection on the content and the process of writing and deep thinking when students decide to accept or reject peers' revisions (Phielix, Prins, & Kirschner, 2010) or when they gain control of their own strategies in writing (Chee, 1995; Collins & Brown, 1988).

1.4. Challenges for peer feedback

Although scientific literature highlights the importance and the features of high-quality feedback for writing and learning (see Bayerlein, 2014; De Nisi & Kluger, 2000; Gabelica et al., 2012; Gabelica, Van den Bossche, De Maeyer, Segers, & Gijssels, 2014; Nelson & Schunn, 2008), there remains a challenge for students to construct high-quality feedback in collaborative settings (see Noroozi, Biemans, et al., 2013; Noroozi, Weinberger, et al., 2012). There could be several reasons for this:

First, providing peer feedback requires high-level cognitive processing (King, 2002) that does not happen intrinsically (Kollar & Fischer, 2010). Second, there are 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 (Andriessen, 2006), and perceiving critiques and counterarguments as personal attacks (Rourke & Kanuka, 2007). 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 (Nussbaum, Hartley, Sinatra, Reynolds, & Bendixen, 2004). Furthermore, less assertive students may avoid giving critical feedback just due to the (negative) competitive and disagreement aspects of the critiques (Nussbaum, Sinatra, & Poliquin, 2008). 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.

Third, scientific evidence has shown that students often struggle with the type and the nature of the feedback. While some students tend to focus on providing feedback on personal qualities, others tend to focus on the grading e.g. outcome-based feedback. Both of these feedback types may impede rather than improving learning. Feedback on personal qualities can be seen in the form of pure "praise, rewards and punishment" without task-related information (see Hattie & Timperley, 2007). Examples of such feedback messages include "You are a fantastic student", "Well-done", "Great job", and "That is a clever answer". Such feedback on personal qualities can only be beneficial for learning when accompanied by task-related information about the learning processes or performance (see Hattie & Timperley, 2007; Kluger & DeNisi, 1998). While feedback on personal qualities shift focus from instructional to social goals, outcome-based feedback lacks sufficient information to improve writing and learning (Hyland, 2000; Kluger & DeNisi, 1998; Muncie, 2000).

Last but not least, not all students fully trust in the competence of the learning peers to evaluate their work (Kaufman & Schunn, 2011). Distrust in learning peer's quality of feedback may not only impede learning but also create a negative perception that can even evoke negative emotional responses and further complications during peer feedback process (Cheng, Hou, & Wu, 2014; Hanrahan & Isaacs, 2001; Shute, 2008). All these difficulties imply the need for arranging learning environments for students to willingly and with a high degree of motivation engage in peer feedback process for learning and writing.

1.5. Online peer feedback

In scientific literature, various approaches have been proposed to motivate students engage in peer feedback process for writing essays (see Cheng, Liang, & Tsai, 2015 for an overview). The most prominent recent approach is the use of online peer feedback (see Chen & Tsai, 2009; Tseng & Tsai, 2007) that provide ample opportunities for enhancing the quality of peer feedback process (Mostert & Snowball, 2013). Online peer feedback settings allow for embedding instructional support and guidance e.g. hints and prompts that help students provide more relevant feedback of high quality to their peers (Mostert & Snowball, 2013; Noroozi, Biemans, Busstra, Mulder, & Chizari, 2011). Such structured online peer feedback settings can also remind students on the assessment quality criteria (e.g. in the form of rubrics or grids), thereby enhancing the quality of their assessments (Mostert & Snowball, 2013).

The use of online peer feedback has been realized in Web-Based Systems, Facebook, Blog, and Wiki environments. For instance, the use of a Web-Based System with structured peer feedback support was helpful with regard to promoting students' critical thinking and motivation to revise one's own and others' works and also for writing with higher argumentation quality (Tsai & Chuang, 2013). The use of a Wiki environment to support peer feedback process appeared to foster students' performance in writing and their satisfaction (Xiao & Lucking, 2008). The use of Facebook to support peer feedback process was helpful with regard to evoking students' interest, their motivation, writing skills and learning (Shih, 2011). The use of a Blog to support peer feedback process had a positive effect on students' writing and also on their perceptions of the use of technology (Ciftci & Kocoglu, 2012).

Based on these findings, conducting online peer feedback activities could result in positive influences on learners' writing performance. The reason behind this is that in online learning environments, students are able to submit their work, review learning peers' work, and also revise their work without any restriction (Lin, Liu, & Yuan, 2001) and with the flexibility to modify their feedback to peers or revise their work through the process as opposed to paper-based and face-to-face settings that provide less opportunities for enhancing the quality of peer feedback process (Mostert & Snowball, 2013; Yang, 2011). With the online peer feedback, students can re-construct their thoughts while formulating and organizing ideas and opinions and they can also re-read posted notes and feedback by looking at the conversation history. Written documents and feedback as well as re-reading and re-thinking those documents and notes are regarded as important tools for learning and knowledge construction (De Jong, Veldhuis-Diermanse, & Lutgens, 2002; Noroozi et al., 2011; Veerman, 2000). Despite positive impacts of the online peer feedback on students' writing performance, it does not entirely guarantee successful peer feedback learning. Additional instructional peer feedback support is needed in online peer feedback environments to fully safeguard effective peer feedback. Most of the previous studies (see Chen & Tsai, 2009; Shih, 2011; Tseng & Tsai, 2007) have focused on the role of peer feedback process on students' writing performance without explicit attention to the strategies that also enhance students' argumentative essay writing. This study therefore look for additional instructional peer feedback support that is beneficial for enhancing argumentative essay writing.

1.6. Argumentative scripting to support peer feedback

Scripting is one promising approach to safeguard effective peer feedback for both writing and learning. Examples of peer feedback support in online learning environments include provision of training to prepare students for giving high-quality feedback (Sluijsmans, Brand-Gruwel, van Merriënboer, & Bastiaens, 2002), guiding questions to provide relevant feedback (Gielen & De

Wever, 2012), peer feedback template to provide feedback and feed forward (Gielen & De Wever, 2015), sentence openers to stimulate interactions during feedback process (Noroozi, Weinberger, et al., 2013), and using multiple raters instead of one to minimize the risk of distrust in the peers (Cho & Schunn, 2007). All of the above mentioned peer feedback support options fall under the name "scripting".

Scripting in general provides detailed and explicit guidelines and role assignments for collaborative partners to clarify what, when, and by whom certain activities need to be executed during feedback process (Weinberger, Stegmann, Fischer, & Mandl, 2007). An argumentative feedback script in particular provides structure and guidelines for students to test, analyse, reflect, and reason the argumentative essays of the learning partners followed by practical suggestions to enhance the quality of their essays (Noroozi, Weinberger, et al., 2012, 2013; Weinberger et al., 2007). Furthermore, with the use of an argumentative feedback script, students will be given the direction on how to present their own position on the issue, support a position, consider and weigh arguments and counter-arguments, acknowledge alternative perspectives and qualifiers, respond to various counter-arguments and finally come to conclusion on the issue at stake (see Kuhn, 1991; Toulmin, 1958). The peer feedback support in current study was realized in a form of scripting in an online environment with guiding questions, templates, sentence openers, and the use of multiple raters. The rationale behind this scripting approach was to scaffold writing and learning in combination by guiding students on how to represent, structure, evaluate, and analyse their own and their learning partners' contributions.

1.7. Relations between peer feedback process and its outcomes

Most of the studies in this field of research have mainly focused on the outcomes of the peer feedback support that is writing, performance, motivation etc. (e.g. Tsai & Chuang, 2013; Xiao & Lucking, 2008). Furthermore, in most of the previous studies, learning processes and outcomes of the peer feedback support have been studied separately and not in combination, even though many scholars have argued that differences in learning outcomes are related to differences in learning processes and activities (e.g. Noroozi et al., 2011). Therefore, it is important to study peer feedback learning processes in relation to learning outcomes to reveal the connectivity between the two (Andriessen, Baker, & Suthers, 2003; Noroozi et al., 2011). This implies that to truly understand the learning that takes place, research on peer feedback should be both process-focused and result-focused (Noroozi et al., 2011; Noroozi, Busstra, et al., 2012). A crucial issue for the use of peer feedback that is left under investigated is the relation between peer feedback process and its outcomes. Whether and how the peer feedback process impact the learning outcomes? It is not clear whether successful and less-successful students and groups follow the same or different patterns during the peer feedback process in relation to their learning outcomes i.e. writing argumentative essays.

1.8. The objectives and research questions

This study aims to explore the relations between peer feedback learning processes and outcomes as they occur in an authentic learning situation with direct practical relevance. Furthermore, we aim to investigate the effects of an argumentative peer feedback script on students' written argumentative essay. The following research questions are formulated to address these issues:

1. What are the effects of an argumentative peer feedback script on students' written argumentative essay?
2. What are the relations between peer feedback process and the learning outcomes in terms of students' written argumentative essays?

2. Method

2.1. 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 189 BSc students who enrolled for the course “Introduction Molecular Life Sciences and Biotechnology”. This course is an introduction in the field of molecular life sciences and biotechnology. In this course, Dutch 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 19.20 ($SD = 1.84$) years. About 63% of participants were male and 37% were female. Participants were randomly divided into groups of three students. So, in total there were 63 groups of three students.

2.2. Materials and learning tasks

The topic was Genetically Modified Organisms (GMOs) with the focus on the use of “cultured meat manufacturing – insect cells”. Specifically, students were asked to write an argumentative essay 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 websites to further study the concept of the “cultured meat manufacturing – insect cells”. The students were asked to take into account the various perspectives on the need – or lack thereof – of using “cultured meat manufacturing – insect cells”.

2.3. Online learning environment

The three learning partners in each group were distributed over three different classrooms. 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 or materials that are relevant to them. The main feature of this digital learning module in the present study is the use of an argumentative peer feedback script. This module allows for scaffolding the peer feedback process and textual implementation of the argumentative feedback script.

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 along with role assignments for provoking and promoting students' reasoning and argumentative feedback processes and practices. In this study, during the peer feedback process students were given specific roles to carry out their assignment. More specifically, students were asked to play the role of assessor of the essays of the two learning partners in the group. The other two students in the group played the same role of assessing the essays of the learning partners. The structure of the argumentative peer feedback script was designed on the basis of the literature (see Andrews, 1995; Qin & Karabacak, 2010; Toulmin, 1958; Wood, 2001) and also characteristics for writing a complete and sound argumentative essay in the field of biotechnology.

Scientific literature suggests that the argumentative essay 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 Andrews, 1995; Qin & Karabacak, 2010; Toulmin, 1958; Wood, 2001). This structure was then adjusted to the field of the biotechnology since the nature of argumentative essays varies across disciplines (see Wingate, 2012). To do so, a series of meetings were held with the experts and teachers of the field to define the elements of a complete and sound argumentative essay for students in the field of biotechnology. The expert panel consisted of three experienced teachers who have taught this course for many years at Wageningen University and also at other higher education institutions, coordinators of various study programmes at Wageningen University that offer the course of “Introduction Molecular Life Sciences and Biotechnology” as an obligatory course such as the coordinator of biotechnology and the coordinator of molecular life sciences programmes, two researchers including the first author of this manuscript who have ample experience with research on peer feedback especially in the digital environments, and also a couple of students who had taken this course previously.

After several sessions of expert consultations, the experts reached consensus on the characteristics of argumentative essays in the field of biotechnology. While they agreed on the presence of the elements as suggested in the literature, the experts came to conclusions that there should be two more elements that need to be added to these elements including the intuitive opinions of the students and their final conclusion after integration of various pros and cons of the topic. Their reasoning was based on the sensitivity of the controversial topics in the field of biotechnology. The experts argued that in the field of biotechnology, all people including students have gut-feelings and intuitive opinions on the controversial issues in biotechnology even if they do not know anything about the topic. This intuitive opinion is not based on rational ideas and scientific facts in favour or against the topic. This is just based on their feelings and there are cases in which people are aware of the pros and cons and the scientific facts about a particular topic but still do not follow these facts and rely on their own gut-feelings. That is why, from these experts' points of view, argumentative essays in the field of biotechnology should always include students' intuitive opinions and feelings on the topic to see to what extent their essays follow their intuitive opinions. Furthermore, the experts agreed to include conclusions in the design of the peer feedback because, in many cases, students' final opinion about the controversial issues remains unclear for the readers. In most cases, students provide a list of arguments in favour and/or against the topic without any integration and final conclusion on the issue at hand. Argumentative essays should include conclusions that represent students' thoughts on the issue at hand that may come from their intuitive opinions and/or scientific facts and reasoning behind these facts. To conclude, they believe that an argumentative essay in the field of biotechnology should also include students' intuitive opinions and feelings on the topic followed by a conclusion that take scientific facts in favour and/or against the topic into consideration. Taking into accounts the scientific literature and also expert consultation on this particular content domain, a list of elements that should be included in the argumentative essays of students in the field of biotechnology was created (see Table 1 for this list).

The validity of this list of elements was again obtained through the panel of experts and the teachers of the course. We then designed our argumentative peer feedback script on the basis of this list and embedded that in the digital learning module using input text boxes and sentence openers and role assignments (see Table 1).

2.4. Procedure and Measurements

Overall, the session took about 4 h and consisted of four main phases. 1) During the introduction and pre-test phase, which took 30 min, students received introductory verbal explanations on the aims and the nature of the digital learning module and completed several questionnaires on demographic variables (gender, age, study programmes etc.) and their prior knowledge. 2) Then, in the individual

Table 1
Features of a high-quality argumentative written essay and argumentative peer feedback script.

Number	Features of a good reflection report by panel of experts and teachers in the field of biotechnology	Peer feedback scripting used in the current study
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?
2	The arguments in favour of the topic (pros).	To what extent your learning partner provide arguments in favour of the topic? To what extent your learning partner reflect the opinion of the advocates on the topic?
3	The scientific facts in favour of the topic (pros).	To what extent your learning partner provide scientific facts in favour of the topic?
4	The arguments against the topic (cons).	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?
5	The scientific facts against the topic (cons).	To what extent your learning partner provide scientific facts against the topic?
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?
7	The arguments and scientific facts (evidence, examples, figures, facts etc.) to support opinion with regard to integration of various pros and cons of the topic?.	To what extent your learning partner provide arguments and scientific facts (evidence, examples, figures, facts etc.) to support opinion with regard to integration of various pros and cons of the topic?
8	The final conclusion and statement on the topic.	Does your learning partner come to a conclusion based on his/her arguments? What do you think about his/her conclusion?

learning phase (50 min), students were asked to read theoretical text and articles, search the Internet in daily papers, periodic journals, and scientific papers. They were then asked to write an argumentative essay 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 (60 min), each student was asked to read the argumentative essay of the two learning partners and provide feedback on them for about 60 min (30 min per each argumentative essay) followed by a 10 min break. For each aspect of the peer feedback process (intuitive opinion, claims in favour of the topic, scientific facts in favour of the topic, claims against the topic, scientific facts against the topic, integration of pros and cons, conclusion, suggestions for improving writing), students were allowed to enter about 50 words. The system did not allow <40 words or >60 words. When students did not follow the rules for the number of words, the system alerted them that they needed to increase or decrease the number of words if they wanted to submit their feedback. 4) During the post-test and debriefing phase (80 min), students were asked to read the feedback and comments of the two learning partners and then revise their individual argumentative essay. In this phase, students were asked to write an individual argumentative essay for about 500 words. The system did not allow <450 words or >550 words. When this was the case, the system alerted the students that they need to increase or decrease the number of words if they want to submit their essays. Reading the feedback of the two learning partners and revising their argumentative essays lasted for about 55 min. Students were then asked to fill out several questionnaires to assess their learning after the assignment followed by debriefing (255 min).

2.4.1. Measurement of students' quality of written argumentative essays

A coding scheme was developed and used to measure quality of students' written argumentative essays on the GMOs topic. Both in the pre-test and post-test, each student was asked to write an argumentative essay on the following statement: "Insect-cell biomass infected with genetically modified baculovirus is a healthy meat alternative". This coding scheme was developed on the basis of the literature (see Andrews, 1995; Qin & Karabacak, 2010; Toulmin, 1958; Wood, 2001) and also characteristics for writing a complete and sound argumentative essay in the field of biotechnology as mentioned in Table 1. The validity of this coding scheme was obtained through the panel of experts and the teachers of the course by organizing a series of expert consultation meetings. Table 2 illustrates the features of this coding scheme in terms of variables, points, labels and corresponding descriptions. This coding scheme includes a series of variables that reflect the quality of students' argumentative essays. The following variables were extracted from the argumentative essays of each student both in the pre-test and post-test and labeled according to the coding scheme described in

Table 2. Intuitive opinion, Claims in favour of the topic, Justification for claim(s) in favour of the topic, Claims against the topic, Justification for claim(s) against the topic, Integration of pros and cons, and Conclusion. A single score was assigned for each of these variables both in the pre-test and post-test argumentative essays. Each student was given no point for each level 1 assessment (e.g. not mentioned), one point for each level 2 assessment (e.g. non-elaborated), and two points for each level 3 assessment (e.g. elaborated). Thus, for each variable, students could get a score of between zero and two. Subsequently, all points assigned to each student were added together and served as the final score indicating their quality of argumentative essays for both pre-test and post-test. Two trained coders coded 10% of the data both in the pre-test and post-test to evaluate the reliability index of inter-rater agreement. The main coder of this study was hired for the whole project. This coder had previous experience coding comparable online discussions in the context of other projects, especially for content analysis schemes. However, for the purposes of the current project and to assure reliability of the coding process, she received extensive extra training on applying various coding schemes as well as on the project's conceptual framework, coding rubrics, frequent misconceptions, and rules and instructions for the coding process. The coder was then given the opportunity to code 10% of the data separately without any supervision. The first author of this manuscript was the other coder who only coded the first 10% of the data. This resulted in identical scores in 98% of the contributions in the pre-test and 91% of the contributions in the post-test. Discrepancies were resolved through discussion before the final coding. Any problems they encountered in coding ambiguous texts during this round were discussed between the coders until agreement was reached on how to resolve them. When the team of researchers made sure that the main coder was competent for coding the data alone, the main coder was asked to code the other 90% of the data individually.

2.4.2. Measurement of students' feedback quality

A coding scheme was developed and used to assess the quality of students' feedback quality. This coding scheme followed the nature of the argumentative peer feedback script that was supposed to be used by students when giving feedback to the two learning partners on their argumentative essays. The validity of this coding scheme was obtained through the panel of experts and the teachers of the course by organizing a series of expert consultation meetings. Table 3 illustrates the features of this coding scheme in terms of variables, points, labels and corresponding descriptions. This coding scheme includes a series of variables that reflect the quality of students' feedback. The following variables were extracted from the feedback of each student and labeled according to the coding scheme described in Table 3. Intuitive opinion, Claims in favour of the topic, Justification for claim(s) in favour of the topic, Claims against the topic, Justification for claim(s) against the topic, Integration of pros and cons, Conclusion,

Table 2

Coding scheme to analyse the quality of students' argumentative essays with variables, points, labels and corresponding descriptions.

Variable	Points	Label	Description	Examples
Intuitive opinion	Zero	Not mentioned	No intuitive opinion is presented.	No intuitive opinion at all.
	One	Non-elaborated intuitive opinion	Intuitive opinion is presented but it is not discussed or elaborated on or it is discussed in an insignificant way.	I have nothing against eating insects and have always liked the idea of having tried mealworms crickets and scorpions.
	Two	Elaborated intuitive opinion	Intuitive opinion is presented and it is discussed or elaborated on in a significant way.	I admit that I am a bit uneasy with eating insect-cell biomass infected with genetically modified baculovirus. The words insect and virus sounds quite disgusting and creepy and I cannot imagine myself putting an insect in my mouth.
Claims in favour of the topic	Zero	Not mentioned	No claim is presented in favour of the topic.	No claim at all.
	One	Non-elaborated pro-claim	Only one claim is presented in favour of the topic.	The world population is increasing and the agriculture sector cannot keep up with that. Cultivated meat could be an alternative method.
	Two	Elaborated pro-claim	Multiple claims (two or more) are presented in favour of the topic.	The insect proteins are five times more than protein from normal meat. The baculovirus is harmless for people. With eating insects which are made by adult stem cells we don't need to slaughter animals.
Justification for claim(s) in favour of the topic	Zero	Not mentioned	No justification for pro-claim(s) is presented. None of the pro-claim(s) are justified. Pro-claim(s) are just being presented without any back up/support in terms of presenting scientific facts, evidence, examples, figures etc.	No justification at all.
	One	Non-elaborated justification for pro-claim(s)	Justification for pro-claim(s) is presented. Pro-claim(s) are being backed up/supported (with scientific facts, evidence, examples, figures etc.) but they are not strongly connected to the pro-claim(s). Justification for pro-claim(s) are not discussed or elaborated on in a significant way.	Scientific findings shows that the gene of the baculovirus makes the cell produce more valuable proteins that is completely harmless for humans.
	Two	Elaborated justification for pro-claim(s)	Justification for pro-claim(s) is presented. Pro-claim(s) are being backed up/supported (with scientific facts, evidence, examples, figures etc.) and they are strongly connected to the pro-claim(s). Justification for pro-claim(s) are discussed or elaborated on in a significant way.	Insect cells are good sources of proteins that are well digestible. Its fatty acid contents is comparable to fish or poultry. The sugar and mineral content of insect cells is higher than meat cells. The baculovirus is not harmful to humans and a genetically manipulated version can be used to optimize the amino acid content of the produced insect cells.
Claims against the topic	Zero	Not mentioned	No claim is presented against the topic.	No claim at all.
	One	Non-elaborated con-claim	Only one claim is presented against the topic.	GMO's escaping to the environment might form a hazard to the nature and the environment.
	Two	Elaborated con-claim	Multiple claims (two or more) are presented against the topic.	It will be a major cultural shock for Western countries eating insects. GMO foods may include antibiotic features built into them to make them immune or resistant to diseases or viruses. GMO foods cannot compete with the texture and structure of existing foods.
Justification for claim(s) against the topic	Zero	Not mentioned	No justification for con-claim(s) is presented. None of the con-claim(s) are justified. Con-claim(s) are just being presented without any back up/support in terms of presenting scientific facts, evidence, examples, figures etc.	No justification at all.
	One	Non-elaborated justification for con(s)-argument	Justification for con-claim(s) is presented. Con-claim(s) are being backed up/supported (with scientific facts, evidence, examples, figures etc.) but they are not strongly connected to the con-claim(s). Justification for con-claim(s) are not discussed or elaborated on in a significant way.	GMOs engineering could have a big unexpected environmental results. For example, breeding insects can lead to environmental problems similar to the problems in the cattle industry.
	Two	Elaborated justification for con(s)-argument	Justification for con-claim(s) is presented. Con-claim(s) are being backed up/supported (with scientific facts, evidence, examples, figures etc.) and they are strongly connected to the con-claim(s). Justification for con-claim(s) are discussed or elaborated on in a significant way.	GMO foods contain antibiotics to make them immune or resistant to diseases or viruses. When you eat them these antibiotic markers persist in your body and can make actual antibiotic medications less effective. Therefore, many people may resist to the use of such GMO foods as a source of protein when they are available in the market.
Integration of pros and cons	Zero	Not mentioned	No integration of pros and cons is presented.	No integration at all.
	One	Non-elaborated integration of pros and cons	Integration of pros and cons is presented but justification for the integration is not discussed or elaborated on or it is discussed in an insignificant way.	I think the production of such GMOs is safe and can solve the food shortage. The only real con is that we will have to change our food pattern but we will get used to that.
	Two	Non-elaborated integration of pros and cons	Integration of pros and cons is presented and justification for the integration is discussed or elaborated on in a significant way.	The pros outweigh the cons. Insects are interesting source of protein and minerals that is not a risk for the human being because it only protects the insect cells. However, more needs to be done for the general public who will have to make a switch in their attitude and appetite which is going to be hard.
Conclusion	Zero	Not mentioned	No conclusion is presented.	No conclusion at all.
	One	Non-elaborated conclusion	Conclusion is presented but it is not discussed or elaborated on or it is discussed in an insignificant way.	We need to enlighten people about GMO products so that it is less scary and more people are willing to use them once they are at the market.
	Two	Elaborated conclusion	Conclusion is presented and it is discussed or elaborated on in a significant way.	For cultivated meat production, 45% less energy is needed, 96% less greenhouse emissions are produced, and 99% less land and water are needed compared with traditional meat production. This all sounds very positive but we should consider what effect this has on our welfare, health, and economy and that there should be the guarantee that they are completely safe.

Table 3
Coding scheme to analyse the quality of students' feedback process with variables, points, labels and corresponding descriptions.

Variable	Points	Label	Description
Intuitive opinion	Zero	Not mentioned	No feedback on intuitive opinion is presented.
	One	Non-elaborated feedback on intuitive opinion	Feedback on intuitive opinion is presented but justification for the feedback is not discussed or elaborated on or it is discussed in an insignificant way.
	Two	Elaborated feedback on intuitive opinion	Feedback on intuitive opinion is presented and justification for the feedback is discussed or elaborated on in a significant way.
Claims in favour of the topic	Zero	Not mentioned	No feedback on pro-claim(s) is presented.
	One	Non-elaborated feedback on pro-claim(s)	Feedback on pro-claim(s) is presented but justification for the feedback is not discussed or elaborated on or it is discussed in an insignificant way.
	Two	Elaborated feedback on pro-claim(s)	Feedback on pro-claim(s) is presented and justification for the feedback is discussed or elaborated on in a significant way.
Scientific facts in favour of the topic	Zero	Not mentioned	No feedback on scientific facts in favour of the topic is presented.
	One	Non-elaborated feedback on scientific facts	Feedback on scientific facts in favour of the topic is presented but justification for the feedback is not discussed or elaborated on or it is discussed in an insignificant way.
	Two	Elaborated feedback on scientific facts	Feedback on scientific facts in favour of the topic is presented and justification for the feedback is discussed or elaborated on in a significant way.
Claims against the topic	Zero	Not mentioned	No feedback on con-claim(s) is presented.
	One	Non-elaborated feedback on con-claim(s)	Feedback on con-claim(s) is presented but justification for the feedback is not discussed or elaborated on or it is discussed in an insignificant way.
	Two	Elaborated feedback on con-claim(s)	Feedback on con-claim(s) is presented and justification for the feedback is discussed or elaborated on in a significant way.
Scientific facts against the topic	Zero	Not mentioned	No feedback on scientific facts against the topic is presented.
	One	Non-elaborated feedback on scientific facts	Feedback on scientific facts against the topic is presented but justification for the feedback is not discussed or elaborated on or it is discussed in an insignificant way.
	Two	Elaborated feedback on scientific facts	Feedback on scientific facts against the topic is presented and justification for the feedback is discussed or elaborated on in a significant way.
Integration of pros and cons	Zero	Not mentioned	No feedback on integration of pros and cons is presented.
	One	Non-elaborated feedback on integration of pros and cons	Feedback on integration of pros and cons is presented but justification for the integration is not discussed or elaborated on or it is discussed in an insignificant way.
	Two	Elaborated feedback on integration of pros and cons	Feedback on integration of pros and cons is presented and justification for the integration is discussed or elaborated on in a significant way.
Conclusion	Zero	Not mentioned	No feedback on conclusion is presented.
	One	Non-elaborated feedback on conclusion	Feedback on conclusion is presented but justification for the feedback is not discussed or elaborated on or it is discussed in an insignificant way.
	Two	Elaborated feedback on conclusion	Feedback on conclusion is presented and justification for the feedback is discussed or elaborated on in a significant way.
Suggestions for improving writing	Zero	Not mentioned	No feedback on suggestions for improving writing is presented.
	One	Non-elaborated feedback on suggestions for improving writing	Feedback on suggestions for improving writing is presented but justification for the feedback is not discussed or elaborated on or it is discussed in an insignificant way.
	Two	Elaborated feedback on suggestions for improving writing	Feedback on suggestions for improving writing is presented and justification for the feedback is discussed or elaborated on in a significant way.

and Suggestions for improving writing. A single score was assigned for each of these variables. Each student was given no point for each level 1 assessment (e.g. not mentioned), one point for each level 2 assessment (e.g. non-elaborated feedback), and two points for each level 3 assessment (e.g. elaborated feedback). Thus, for each variable, students could get a score of between zero and two. Subsequently, all points assigned to each student were added together and served as the final score for students' feedback quality. Since each student was asked to provide feedback on argumentative essays of the two learning partners in the group, the average scores of their feedback quality was calculated, indicating final mean score on their feedback quality. Two trained coders coded 10% of the data during feedback process to evaluate reliability index of inter-rater agreement. This resulted in identical scores in 85% of the data. The discrepancies were resolved through discussion.

2.4.3. Measurement of the relations between peer feedback process and its outcomes

In order to explore the relations between peer feedback process and its outcomes, the data collected for measuring quality of written argumentative essays and quality of their feedback were combined. To do so, the feedback quality was linked to the quality of the argumentative essays of students. Specifically, we first analysed the quality of the feedback of each student on the argumentative essays of the two learning partners to see whether and how the provision of the feedback was related to the learning outcomes i.e. quality of written argumentative essays. We then analysed the quality of the feedback that each student received from the two learning partners in the group to see whether and how the quality of the received feedback was related to the quality

of students' written argumentative essay. We then analysed quality of the feedback at the group level to see whether and how the quality of the peer feedback process at the group level can be related to the quality of students' written argumentative essay.

2.5. Analyses

ANOVA test for repeated measurement was conducted to determine the differences in quality of students' argumentative essays in the pre-test and post-test. Repeated measurement ANOVAs for each element of the students' argumentative essays (intuitive opinion, claims in favour of the topic, justification for claim(s) in favour of the topic, claims against the topic, justification for claim(s) against the topic, integration of pros and cons, conclusion) were then conducted as follow-up tests to the general ANOVA for repeated measurement.

We distinguished successful and less-successful students and groups, in order to measure the relations between peer feedback process (in terms of feedback on intuitive opinion, claims in favour of the topic, justification for claim(s) in favour of the topic, claims against the topic, justification for claim(s) against the topic, integration of pros and cons, conclusion, suggestions for improving writing) and the learning outcomes (in terms of the quality of students' written argumentative essays). Peer feedback process variables included both the mean quality scores of the feedback reports that each student provided for the two learning partners and also the mean quality scores of the two feedback reports that each student received from the two learning partners. Based on the mean quality scores of students' argumentative essays and using the median as the criterion, successful and less-

successful students and groups were classified. Next, the quality of the feedback of the successful and less-successful students and groups for each variable of the feedback process were compared. MANOVA was conducted to determine the differences in learning processes between successful and less-successful students both at the individual and group levels. ANOVAs for each aspect of the feedback process were then conducted as follow-up tests to the MANOVA both at the individual and group levels.

3. Results

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

3.1. Results for research question 1

This section presents the findings for the effects of the argumentative peer feedback script on quality of students' written argumentative essay. ANOVA test for repeated measurement showed that the average scores of students' written argumentative essay improved significantly from pre-test to post-test, $F(1, 187) = 11.16, p < 0.01, \eta^2 = 0.06$. This indicates the positive effect of the argumentative peer feedback script on mean quality scores of students' written argumentative essay. Students' mean quality scores for quality of written argumentative essay was 8.80 ($SD = 2.36$) for the pre-test and 9.56 ($SD = 2.42$) for the post-test.

Repeated measurement ANOVAs for various element of the students' argumentative essays showed a significant statistical difference between the pre-test and post-test measurements, Wilks $\lambda = 0.42, F(1, 187) = 35.37, p < 0.01, \eta^2 = 0.58$. Students in the pre-test and the post-test differed significantly with respect to their quality of claims against the topic, $F(1, 187) = 63.63, p < 0.01, \eta^2 = 0.25$, integration of pros and cons, $F(1, 187) = 106.37, p < 0.01, \eta^2 = 0.36$, and conclusion, $F(1, 187) = 51.80, p < 0.01, \eta^2 = 0.22$. Specifically, students scored higher in the post test compared with the pre-test with respect to the quality of their claims against the topic ($M1 = 0.91; M2 = 1.48$), and integration of pros and cons ($M1 = 0.61; M2 = 1.39$). Students scored

lower in the post test compared with the pre-test with respect to the quality of their conclusion ($M1 = 1.35; M2 = 0.83$). No significant differences in the pre-test and the post-test measurements was observed with respect to quality of intuitive opinion, $F(1, 187) = 0.01, p = 0.93$, claims in favour of the topic, $F(1, 187) = 5.50, p = 0.02$, justification for claim(s) in favour of the topic, $F(1, 187) = 1.09, p = 0.30$, and justification for claim(s) against the topic, $F(1, 187) = 3.05, p = 0.08$.

3.2. Results for research question 2

This section presents the findings for the relation between peer feedback quality (learning process) and quality of written argumentative essay (learning outcome).

MANOVA test showed that successful and less-successful students significantly differ with respect to mean quality scores of the received feedback from the two learning partners, Wilks $\lambda = 0.06, F(1, 187) = 362.51, p < 0.01, \eta^2 = 0.94$. As expected, successful individual students received higher quality feedback from the learning partners than less-successful individual students, $F(1, 187) = 4.59, p < 0.05, \eta^2 = 0.02$ (see Table 4). This difference was mainly due to the receptions of the more elaborated and justified feedback of successful individual students than less-successful individual students on the following feedback process variables; intuitive opinion, $F(1, 187) = 6.03, p < 0.05, \eta^2 = 0.03$, claims in favour of the topic, $F(1, 187) = 3.77, p < 0.05, \eta^2 = 0.02$, and justification for claim(s) in favour of the topic, $F(1, 187) = 8.72, p < 0.05, \eta^2 = 0.05$. Successful individual students appeared to have no difference with less-successful individual students in terms of quality of the received feedback from learning partners on the following feedback process variables: claims against the topic, $F(1, 187) = 0.98, p = 0.32$, justification for claim(s) against the topic, $F(1, 187) = 1.55, p = 0.21$, integration of pros and cons, $F(1, 187) = 1.58, p = 0.21$, conclusion, $F(1, 187) = 0.32, p = 0.57$, as well as suggestions for improving writing, $F(1, 187) = 0.70, p = 0.03$. Overall, successful individual students received more elaborated and justified feedback quality for their intuitive opinions, claims and their justifications in favour of the topic than less-successful individual students (see Table 4).

Table 4

Differences among successful and less-successful students in terms of mean quality feedback scores both at the individual and group level (max = 2; min = 0).

Variable	Label	Feedback reception individual		Feedback provision individual		Group feedback	
		Mean	SD	Mean	SD	Mean	SD
Intuitive opinion	Successful	1.43	0.47	1.40	0.50	1.28	0.40
	Less-successful	1.24	0.52	1.27	0.57	1.39	0.43
	Total	1.32	0.51	1.32	0.54	1.32	0.41
Claims in favour of the topic	Successful	1.19	0.47	1.19	0.59	1.22	0.37
	Less-successful	1.34	0.56	1.35	0.51	1.31	0.48
	Total	1.26	0.51	1.26	0.56	1.26	0.42
Scientific facts in favour of the topic	Successful	1.13	0.45	1.19	0.52	1.17	0.35
	Less-successful	1.33	0.49	1.25	0.54	1.29	0.44
	Total	1.22	0.48	1.22	0.52	1.22	0.39
Claims against the topic	Successful	1.23	0.48	1.22	0.50	1.21	0.37
	Less-successful	1.31	0.53	1.33	0.54	1.37	0.46
	Total	1.27	0.50	1.27	0.52	1.26	0.41
Scientific facts against the topic	Successful	1.00	0.53	1.00	0.62	0.97	0.45
	Less-successful	1.10	0.57	1.10	0.58	1.17	0.42
	Total	1.05	0.55	1.05	0.60	1.05	0.45
Integration of pros and cons	Successful	1.06	0.46	1.10	0.58	1.12	0.43
	Less-successful	1.20	0.53	1.20	0.51	1.19	0.41
	Total	1.14	0.49	1.14	0.55	1.15	0.42
Conclusion	Successful	1.13	0.38	1.13	0.40	1.16	0.27
	Less-successful	1.60	0.36	1.16	0.42	1.11	0.25
	Total	1.14	0.37	1.14	0.40	1.14	0.26
Suggestions for improving writing	Successful	1.06	0.39	1.06	0.45	1.06	0.32
	Less-successful	1.11	0.36	1.12	0.42	1.12	0.21
	Total	1.08	0.38	1.08	0.43	1.08	0.28
Mean score of the feedback quality (max = 15; min = 0)	Successful	9.11	2.63	9.16	3.14	9.20	2.42
	Less-successful	9.98	2.93	9.91	2.98	9.95	2.68
	Total	9.48	2.80	9.48	3.09	9.48	2.55

MANOVA test showed that successful and less-successful students slightly differ with respect to mean quality scores of the provided feedback for the two learning partners, Wilks $\lambda = 0.08$, $F(1, 187) = 274.70$, $p < 0.01$, $\eta^2 = 0.92$. Successful individual students appeared to provide higher quality feedback for learning partners than less-successful individual students, $F(1, 187) = 2.76$, $p < 0.1$, $\eta^2 = 0.02$ (see Table 4). Furthermore, successful individual students provided higher quality feedback for the claims of the learning partners in favour of the topic than less-successful individual students, $F(1, 187) = 4.14$, $p < 0.05$, $\eta^2 = 0.02$ (see Table 4). Successful individual students appeared to have no difference on the following feedback process variables than less-successful students: intuitive opinion, $F(1, 187) = 2.56$, $p = 0.11$, justification for claim(s) in favour of the topic, $F(1, 187) = 0.66$, $p = 0.42$, claims against the topic, $F(1, 187) = 2.31$, $p = 0.13$, justification for claim(s) against the topic, $F(1, 187) = 1.00$, $p = 0.32$, integration of pros and cons, $F(1, 187) = 1.57$, $p = 0.21$, conclusion, $F(1, 187) = 0.26$, $p = 0.61$, as well as suggestions for improving writing, $F(1, 187) = 0.78$, $p = 0.38$. Overall, successful individual students provided more elaborated feedback only with regard to the claims of the learning partners in favour of the topic than less-successful individual students (see Table 4).

MANOVA test also showed that successful and less-successful groups significantly differ with respect to their feedback quality, Wilks $\lambda = 0.04$, $F(1, 61) = 507.14$, $p < 0.01$, $\eta^2 = 0.96$. As expected, successful groups of students produced higher quality feedback than less-successful groups of students, $F(1, 61) = 3.97$, $p < 0.05$, $\eta^2 = 0.02$ (see Table 4). This difference was mainly due to higher feedback quality of successful groups of students than less-successful groups of students on the following feedback process variables; intuitive opinion, $F(1, 61) = 3.02$, $p < 0.1$, $\eta^2 = 0.02$, justification for claim(s) in favour of the topic, $F(1, 61) = 4.28$, $p < 0.05$, $\eta^2 = 0.02$, claims against the topic, $F(1, 61) = 7.14$, $p < 0.01$, $\eta^2 = 0.04$, and justification for claim(s) against the topic, $F(1, 61) = 8.63$, $p < 0.01$, $\eta^2 = 0.04$. Successful groups of students appeared to have no difference with less-successful groups of students in terms of quality of their feedback on the following feedback process variables: claims in favour of the topic, $F(1, 61) = 2.11$, $p = 0.15$, integration of pros and cons, $F(1, 61) = 1.58$, $p = 0.21$, conclusion, $F(1, 61) = 1.71$, $p = 0.19$, as well as suggestions for improving writing, $F(1, 61) = 1.61$, $p = 0.21$. Overall, successful groups of students produced more elaborated and justified feedback quality for their intuitive opinions, claims and their justifications in favour of and against the topic than less-successful groups of students (see Table 4).

4. Discussions

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

4.1. Discussions of results for research question 1

With implementation of an argumentative peer feedback script, students were able to improve the quality of their written argumentative essays as demonstrated in their post-test compared with pre-test. This is in line with previous studies that emphasize the positive effects of peer feedback on students writing skills (see Brown, 2004; Gabelica et al., 2012; Kellogg & Whiteford, 2009). The provided guidance and the design of the argumentative peer feedback script helped students provide high-quality feedback for the learning partners rather than superficial feedback such as feedback on personal qualities and/or outcome-based feedback that lack sufficient instructional value to improve writing (Hyland, 2000; Kluger & DeNisi, 1998; Muncie, 2000).

With the help of the argumentative peer feedback script, students were encouraged to provide high-quality feedback for their partners regardless of the psychological, emotional, and social barriers that are inherent to peer feedback process (see Nussbaum et al., 2004, 2008). The design of the argumentative peer feedback script helped students

understand that it is OK and even beneficial to sometimes when applicable oppose and disagree with the learning partners' arguments, to be challenged by learning partners, resulting in perceiving critical feedback and counter-arguments as constructive feedback rather than personal attack (see Rourke & Kanuka, 2007). This argumentative peer feedback script provided a safe and respectful environment for students to provide critical feedback without recourse to, or fear of, personal (ad hominem) statements.

One of the common challenges with regard to peer feedback is the extent to which students trust in the competence of the learning peers to evaluate their work (Kaufman & Schunn, 2011). This study tried to minimize the lack of trust among the learning partners by assigning and rotating the roles of students in the group that resulted in receiving two feedback reports instead of only one feedback. This reduced the provocation of the negative perceptual and emotional responses to the feedback that is a factor that impede learning (Cheng et al., 2014; Hanrahan & Isaacs, 2001; Shute, 2008).

Receiving two quality feedback reports from the learning partners along with the justifications of the arguments and also suggestions for improvements helped students realize the gap between their own current and expected level of the argumentative essays. Furthermore, comparing their own argumentative essays with those of the two learning partners and receiving detailed advice on what to improve and how to improve provoked students' reflection and deep thinking that is beneficial for improving the writing skills (Chee, 1995; Collins & Brown, 1988; De Nisi & Kluger, 2000).

Last but not least, the peer feedback script was designed in such a way as to explicitly show students what an argumentative essay should look like. As said before, this script was designed on the basis of the characteristics for writing a high quality argumentative essay in the field of biotechnology. During the peer feedback process, students were given the opportunity to not only learn the essential elements of an argumentative essay in their field but also practice those elements by receiving two quality feedback reports from the learning partners and also providing two feedback reports for the learning partners. So, in the post-test phase students knew what elements should be included in their essays as compared with the pre-test phase that they had no clue on how to write a high-quality argumentative essay. That is why, students performed better in the post-test than the pre-test with regard to argumentative essay writing.

4.2. Discussions of results for research question 2

The most important research question of the present study concerned the relations between peer feedback process variables and the learning outcomes (quality of written argumentative essay). This study revealed that successful students and groups differ in terms of their feedback quality than less-successful students and groups.

Students who received higher-quality feedback from the two learning partners wrote higher-quality argumentative essays compared with those students who received lower-quality feedback. The same pattern was true for providing feedback meaning that students who provided higher-quality feedback for the two learning partners wrote higher-quality argumentative essays compared with those students who provided lower-quality feedback. More specifically, students who received and provided more elaborated, justified and fruitful feedback scored higher with regard to quality of their argumentative essays compared with those students who received and provided less elaborated, justified and fruitful feedback.

This implies that in order to improve students' learning outcomes through the peer feedback process, one should pay explicit attention to the nature of the feedback process in terms of construction and reception of justified feedback and reasoned arguments. This is in line with previous research findings indicating that providing broader and deeper arguments that are supported with more elaborations and justifications lead to higher-quality of knowledge construction and domain-specific

learning than providing less elaborated and justified and more narrow and superficial arguments and contributions during peer feedback process (Munneke, Andriessen, Kanselaar, & Kirschner, 2007; Noroozi et al., 2011; Van Amelsvoort, Andriessen, & Kanselaar, 2007). The reasoning is that construction of arguments in reply to the various aspects of the argumentative essays of the two learning partners and qualifying and supporting these arguments along with consideration of multiple perspectives on the issue at stake are related to elaboration of deep cognitive processes, (see Baker, 2003; Stegmann, Wecker, Weinberger, & Fischer, 2012). Elaboration of deep cognitive processes can also happen when students analyse and evaluate the other two learning partners' arguments as reflected in the argumentative essays (Leitão, 2000; Stegmann, Weinberger, & Fischer, 2007). Analysing and evaluating quality of the argumentative essays of the two learning partners leads to construction of better arguments and enhancement of learners' knowledge as reflected in their own argumentative essays (see Noroozi, Weinberger, et al., 2013).

5. Conclusions, limitations, and suggestions for future research

This study contributes to accumulating empirical evidence that argumentative peer feedback script work well to facilitate peer feedback processes which in turn enhance learning outcomes (quality of written argumentative essay). This study used an argumentative peer feedback script to support peer feedback process and also to provoke students for engaging in high-quality feedback towards deeper reasoning resulting in the enhancement of learning outcomes. Such an argumentative peer feedback script guided the students to analyse and evaluate learning partners arguments on the controversial issue, express agreements/disagreements and integrate various points of views in their own argumentative essay. The current study also led to a more comprehensive picture of peer feedback process by linking feedback process variables to the learning outcomes. This integrative picture of learning process variables in combination with the learning outcomes made it possible to examine what kinds of peer feedback process appear to aid learning outcomes. Without appropriate support, one cannot expect that students will engage in a high-quality peer feedback process that is beneficial for learning and writing.

This study was conducted in an existing course in a real educational setting in the field of biotechnology with its own dynamics. This provided the opportunity to shed light on the peer feedback process and its relations with the learning outcomes as they occur in authentic learning situations (direct practical relevance). However, the authentic setting of this empirical study put some constraints and limitations that warrant discussions and recommendations for future research.

The lack of a control group condition could be regarded as the most important limitation of this study. We deliberately decided not to include a control group in this study for several reasons: First, we did not want to follow a rigid positivistic empirical approach at the expense of the ecological validity of the study. We care and strive for high practical relevance, which can only be achieved through studies that are conducted in real educational settings rather than control-based artificial settings. In general, teachers of such demanding courses as in our study are not much inclined to accept rigid positivistic empirical studies. Second, since the content of this digital learning module focusing on argumentation was directly related to the learning outcomes of the course and also would be reflected in students' final grade, we as researchers and also the teachers found it quite unjust and unethical to provide some students with specific support and to let others learn without any support. We wanted to provide equal opportunities for all students in the course with optimal attention to each of them without any bias. Third, a control group was not needed for the main purpose of this study (which was to answer the third research question). As a matter of fact, the focus of this study as its title suggests is on the relationship between scripted online peer feedback processes and quality of written argumentative essay. In order to find this relationship we did not need a

control group because the nature of the study was exploratory: We separated the successful students from less successful students to compare their learning processes and outcomes of this study. Having said that, we acknowledge that the results of this study in terms of the effects of the argumentative peer feedback script on students' written argumentative essay should be treated cautiously. With inclusion of the control group condition in future research, the real effects of the proposed script can be measured more reliably.

For this study, to analyse students' peer feedback process and also the quality of the argumentative essays, two new content analysis coding schemes were designed on the basis of the previous literature followed by adjustment and validation of the panel of teachers and experts in the field of biotechnology. Despite the fact that content analysis is a time-consuming process, it is one of the most frequently applied techniques for analysing written notes in online learning environments (see Noroozi et al., 2011). Although, a high inter-rater reliability values for these coding schemes were obtained, the outcomes of these coding schemes were not linked to the actual course exams and the knowledge gain as was obtained in this study. We therefore suggest that further research 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 coding schemes of this study. That would of course demand teachers and course coordinators to include open questions that require argumentation and elaboration. If they are not consistent, and the psychometric properties of the exams pass the minimum quality thresholds, further calibration of the coding schemes seems to be necessary.

The peer feedback process in this study was realized with three students in each group. Scientific literature suggests that the nature of peer feedback process differs depending on group size, since active participation and involvement can be much higher and easier in smaller than larger groups (see Noroozi, Weinberger, et al., 2012). Communication difficulties also increase with group size (Steiner, 1972). This is especially important with regard to free-riding and sucker influence, since they can happen much frequently in larger than smaller groups. This is why in the study by Michinov and Michinov (2009), dyads and triads differed in the way students performed in an online collaborative setting. It would be insightful to test the effects of such an argumentative peer feedback script on various group size (dyads, triads, large group) in order to maximize the likelihood of successful peer feedback process.

In line with the literature, both assessors and assessee benefited from the argumentative peer feedback script. Assessors learn by performing high-level cognitive activities such as reviewing, clarifying, explaining, comparing, contrasting, debugging, and revealing the missing information. Assessee learn by reviewing the feedback and making comparisons with their own performance, which also require high-level cognitive activities (Çevik, 2015; Li, Liu, & Steckelberg, 2010; Li, Liu, & Zhou, 2012; Topping, 2010). In this study, the effects of online scripted feedback on assessors were not as salient as the effects on assessee. This is interesting since intervention time for assessors and assessee was about the same. Other studies have shown that providing feedback is more beneficial than receiving feedback (Çevik, 2015; Cho & Cho, 2011; Cho & MacArthur, 2010; Nicol, Thomson, & Breslin, 2014). One plausible explanation is that in this particular study, students were more focused on improving their own essays rather than providing feedback for other students because of the limited time they had for completing their learning tasks. Another plausible explanation is that in this particular study the effects of providing feedback on argumentative essay writing were not examined independently of the effect of receiving feedback. This might explain why assessee benefited slightly more than assessors in this online scripted peer feedback setting. Further research is needed to shed more light on this issue and, depending on the results in comparable studies especially long duration ones, the improvement of the feedback design could be necessary.

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