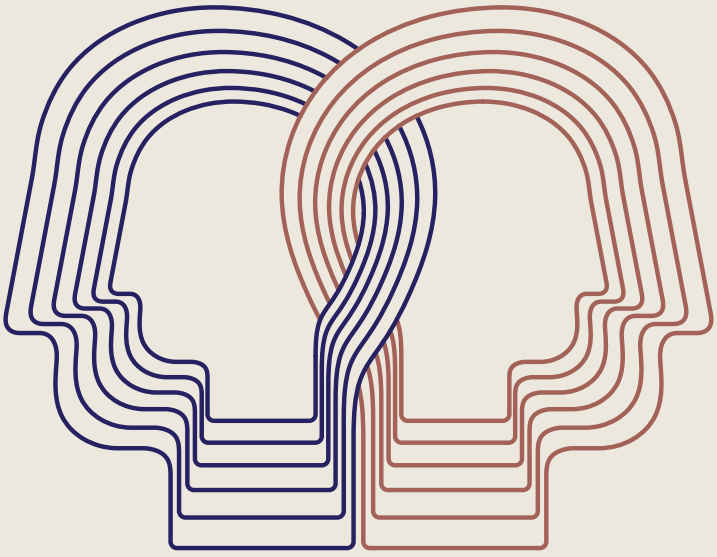
Fostering Argumentation with Online Learning Systems in Higher Education



Anahuac Valero Haro

Propositions

1. Argumentation scaffolds are essential to foster argumentation competence (this thesis)
2. The degree of expertise of domain-specific knowledge influence the quality of the argumentation behavior.
3. Researchers from 'hard science' disciplines are not aware of the complexity and implications of the human factor.
4. All it takes to advance significantly educational technology is a pandemic.
5. Resistance to new technology is taken away by providing good support.
6. The ethical behavior of multi-national companies dilutes as soon as they cross the borders of developing countries.

Propositions belonging to the thesis, entitled

Fostering Argumentation with Online Learning Systems in Higher Education

Anahuac Valero Haro
Wageningen, 27 June 2022

Fostering Argumentation with Online Learning Systems in Higher Education

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Fostering Argumentation with Online Learning Systems in Higher Education

Anahuac Valero Haro

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Anahuac Valero Haro

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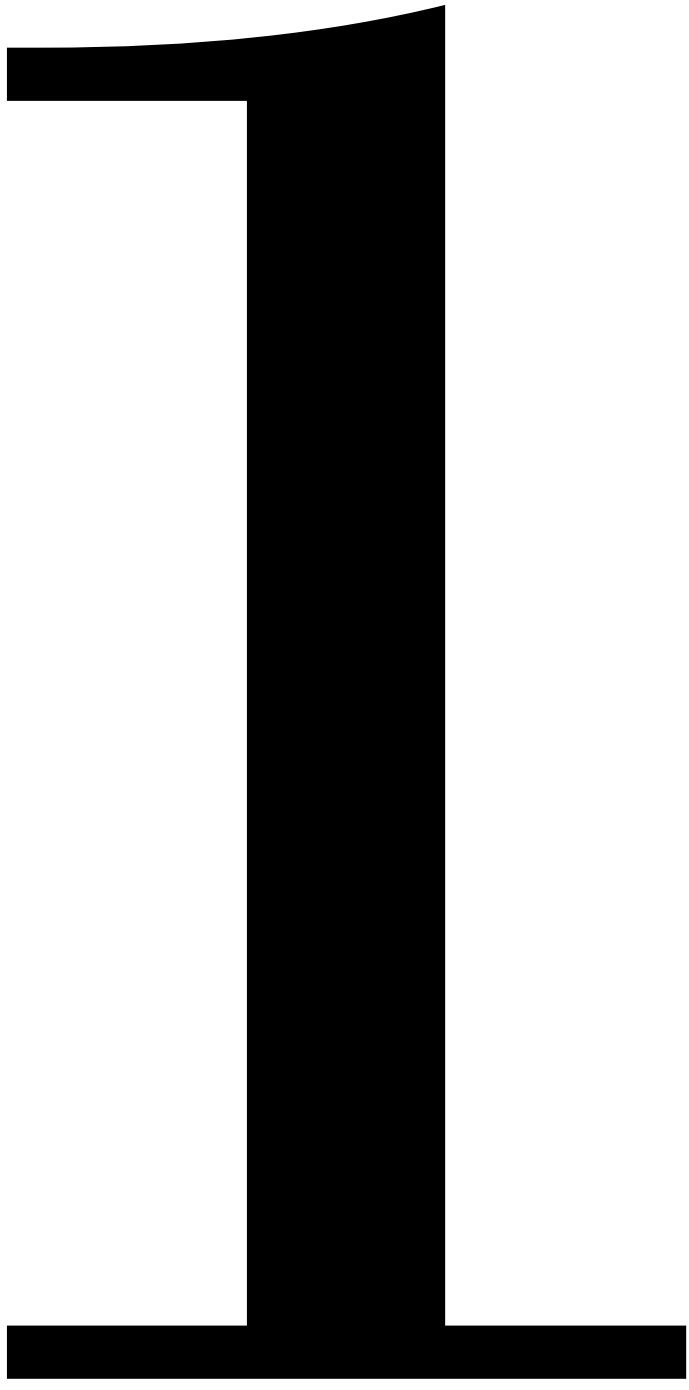


Chapter 1

General Introduction

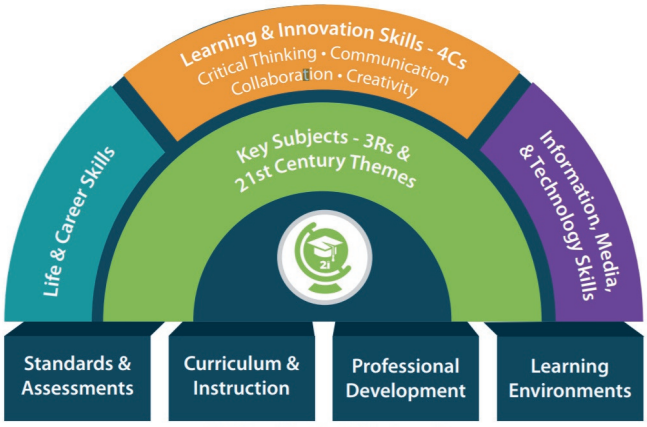
1.1 Background

Online technology is typically associated with innovation and is seen as a prominent driving force in both industry and education that can revolutionize both the work environment and the classroom. In the context of education, it is possible to identify three important shifts where technology reoriented education. The first was the introduction and use of personal computers, when they became sufficiently affordable in the 1970s and early 1980s. As the number of computers increased in schools, the idea of individualized and new ways of learning through the use of computer applications, programming, computer tutors, and computer games also increased (Howard & Mozejko, 2015). The second shift began in the 1990s with the introduction of the Internet and connected digital technologies. Computers and other devices started to connect through local networks, and the Internet enabled something that was not possible before, that is, accessing information and knowledge from around the world. At that point in time, online resources were static (e.g., plain webpages), but in the early 2000s, these resources became dynamic, allowing for the creation of content, such as wikis, and enabling online interaction through online groups and discussion boards (Howard & Mozejko, 2015). The third shift is currently ongoing. It began with how the forms of interaction on the Worldwide Web evolved, and how they are continuing to change (e.g., social networks, video conferencing, geo-tagging and mapping, and cloud computing). Initially, this led to rapid growth and widespread accessibility. In education, networked technologies led to the idea of group and collaborative online learning made possible thanks to the sophisticated communication, sharing, and potential content creation capabilities the technologies made available. The swift growth of communication and mobile digital technologies also stimulated the creation of large amounts of information, resulting in the so-called Information Age (Voogt & Knezek, 2008) and the Knowledge Economy, where the main sources of economic growth are products and services based on knowledge-intensive activities (Powell & Snellman, 2004). The latter is leading towards a new fourth swift in education where learning analytics (Leitner, Khalil, & Ebner, 2017; Viberg, Hatakka, Bälter, & Mavroudi, 2018), artificial intelligence (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019), an adaptive learning (Noroozi, Kirschner, Biemans, & Mulder, 2018) are gaining more relevance.

The swift evolution of technology has affected society significantly. It has meant that professionals in all fields are now confronted with global, complex, and cross-disciplinary challenges. Dealing with these challenges and problems demands for either T-shaped or π-shaped professionals. T-shaped professionals have deep expertise, combined with broad knowledge, allowing them to see the bigger picture, while π-shaped professionals have double-stemmed skills sets (e.g., data science and educational science, or design and development) that can cope with the fast, iterative, prototype-and-learn way of working

that is becoming more predominant in industry. Moreover, professionals should be able to find, assess, interpret, and represent new information quickly. Similarly, they need to be able to communicate and collaborate with others in multidisciplinary groups, but, most importantly, they need to think and learn for themselves. The latter means that professionals and students require new and different skills, the so-called "21st Century Skills" (Partnership for 21st Century Learning, 2015). Among these skills, four are related to learning and innovation, and they have been repeatedly recognized as the ones that set students who are better prepared to cope with the complex 21st century work environment apart from those who are not. The four skills in question are critical thinking, communication, collaboration, and creativity. Figure 1 shows the Partnership for 21st Century Learning (P21) Framework that illustrates the skills, knowledge, expertise, and support systems that students need to succeed in work, life, and citizenship.

Figure 1 The P21 Framework for 21st Century Learning illustrates the skills, knowledge, expertise, and support systems that students need to succeed in work, life, and citizenship.



In education, critical thinking plays a significant role in the acquisition of scientific knowledge, which is built on logical reasoning and argumentation. Similarly, professionals from different disciplines should acquire critical thinking skills and argumentation competence to analyze, conceptualize, synthesize, and cope with the global, complex, and cross-disciplinary challenges of the 21st century (Noroozi, Dehghanzadeh, & Talaee, 2020; Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2012; Scheuer, Loll, Pinkwart, & McLaren, 2010). It follows that many professional situations and learning activities in education require students to work together and solve argumentative tasks in teams with partners who have different perspectives on and knowledge conceptions

about the issues at hand (Noroozi et al., 2012). In such situations, students need to build upon, relate to, and refer to what has been said by their peers in order to learn and co-construct knowledge (Noroozi et al., 2018; Noroozi et al., 2012). As students build on, relate to, and refer to each other's knowledge to complete learning activities, students engage in argumentative discourse that is associated with deep and meaningful learning (Nussbaum, 2008; Weinberger & Fischer, 2006). Hence, the 21st Century skills communication, collaboration, and creativity are intrinsically connected to argumentation and collaborative learning.

Argumentation also offers an analytic framework for evaluating the quality of discourse (see Weinberger & Fischer, 2006), and it helps learning partners grasp, comprehend, and acknowledge different viewpoints and opinions, and to refine their own opinions by considering and integrating other perspectives on the issue at hand into account (Noroozi et al., 2018; Toulmin, 1958; van Bruggen & Kirschner, 2003). As such, fruitful discussions require students to be able to argue, think critically, and reason logically to explain their decisions, points of view, opinions, and feedback (Andriessen, 2006; Kuhn, 1991; Latifi, Noroozi, Hatami, & Biemans, 2021; Noroozi & Hatami, 2019; Noroozi, Hatami, et al., 2020). Hence, fostering the development of students' argumentation competence (i.e., students' ability to argue, consisting of their knowledge on argumentation, argumentation behavior, and attitude toward argumentation) is a matter of great importance.

To foster students' argumentation competence, multiple user interface affordances – such as texts, diagrams, and pictures – can be used to guide and prompt students toward desired learning and productive activities (Fischer, Kollar, Stegmann, & Wecker, 2013; Suthers, 2003). As such, researchers and practitioners have designed and embedded diverse instructional scaffolds, like visual representations and scripts, in learning modules of both web-based and computer applications, to facilitate, coordinate, and orchestrate a variety of student roles, interaction patterns, and activities (Kirschner, Buckingham Shum, & Carr, 2003; Noroozi et al., 2018; Noroozi et al., 2012; Scheuer et al., 2010; Tsovaltzi, Greenhow, & Asterhan, 2015). Learning together, or peer learning, is one of the means of interaction that can be facilitated through such instructional scaffolds. Peer learning has been successfully used to improve students' learning (K. M. Baker, 2016; Banihashem, Farrokhnia, Badali, & Noroozi, 2021; Boud, Cohen, & Sampson, 1999; E. G. Cohen, 1994; P. Dillenbourg, 1999; Topping, 2005), since giving and receiving peer feedback is a powerful learning practice (Gabelica, Bossche, Segers, & Gijselaers, 2012; Hattie & Timperley, 2007; Kluger & Denisi, 1996; Latifi, Noroozi, Hatami, et al., 2021; Latifi, Noroozi, & Talaee, 2021; Van der Kleij, Feskens, & Eggen, 2015).

Writing argumentatively and engaging in fruitful argumentative discourse with peers

are complex tasks for students since argumentation itself is complex and multi-faceted (Lynch, Ashley, Pinkwart, & Aleven, 2009; Scheuer et al., 2010). For example, Cooper et al. (1984) and Kellogg and Whiteford (2009) indicate that the argumentative essay writing of both undergraduate and graduate students is often below the quality level required for writing tasks at both school and the workplace. As mentioned above, argumentation skills are essential for professionals and students, and they are closely linked to the 21st Century skills of critical thinking, communication, collaboration, and creativity, skills that are essential to be able to solve the global, complex, and cross-disciplinary challenges of the Information Age and Knowledge Economy. Hence, it is important for practitioners, researchers, and society at large to further investigate argumentation, its constituent elements, and its relationships with domain-specific knowledge, as well as the scaffolding of argumentative learning activities for fostering both the acquisition of domain specific knowledge and argumentation competence.

This PhD thesis contributes to the existing body of knowledge in Computer-Supported Collaborative Argumentation (CSCA) literature by providing an overview of the effects of instructional scaffolds, specifically of scaffolding on the various aspects of argumentative discourse activities that can result in deep and meaningful learning. This thesis also explores the relationships between the components that comprise argumentation competence and between this and domain-specific knowledge as these are the basis for designing and evaluating argumentation scaffolds. Next, the thesis delves into the design and evaluation of argumentation scaffolds by investigating the effects of scripting in an online learning environment by means of worked examples and peer feedback on the learning outcomes of students' argumentative essay writing. Finally, the thesis investigates the design and evaluation of argumentation scaffolds by investigating the effects of scripting various peer feedback types in an online learning environment on the learning outcomes of students involved in argumentative essay writing.

1.2 Problem Statement, Research Questions, and Overview of the Thesis

Argumentation is an important competence in many parts of academic, professional, and personal life. Despite the relevance of argumentation, students often struggle to argue in a reasoned way in academic settings (Noroozi, Dehghanzadeh, et al., 2020; Noroozi, Teasley, Biemans, Weinberger, & Mulder, 2013). Students struggle with the intricate, non-linear, and ill-structured character of argumentation, among other aspects (Lynch et al., 2009; Scheuer et al., 2010), with generating, analyzing, and evaluating arguments based on rules of logic (Kuhn, 1991), and with dealing with different interpretations of "facts" (Scheuer, McLaren, Weinberger, & Niebuhr, 2013). Such issues make it

difficult to teach and learn the rules of argumentation, the construction of arguments and counterarguments (Toulmin, 1958), and to engage in sequential discourse (Leitão, 2000). In addition, argumentation is often excluded from curricula, so argumentation competence is often a by-product that develops indirectly and informally in the classroom (Driver, Newton, & Osborne, 2000; Osborne, 2010).

To foster argumentation competence, researchers and practitioners have conceived multiple learning systems, such as graphical-based systems to support the argumentation process, discussion-based systems to support dialogical argumentation, and knowledge representation systems to support the (co-)construction of arguments. Various kinds of argumentation scaffolds have been embedded into these systems, like argumentation scripts to orchestrate argumentation or interaction between learners and feedback agents that provide argumentation feedback to learners in real time, on demand, or delayed. However, empirical research on CSCA presents ambiguity with respect to the intentions and effects of the argumentation scaffolds (Rapanta, Garcia-Mila, & Gilabert, 2013). On the one hand, the aim of argumentation scaffolds can be to facilitate students' argumentative discourse activities to enable them to acquire domain-specific knowledge or skills (e.g., European e-commerce law or writing legal documents); this is called first-order argument-scaffolding. On the other hand, the argumentation scaffolds can be designed to foster students' argumentation competence such that they can learn to handle comparable tasks themselves without external support in the same or a similar domain; this is called second-order argument-scaffolding. However, more research is needed into the effects of the variables that can influence the design and implementation of argumentation-scaffolds, such as educational level (i.e., Higher Education and Secondary Education), communication form (i.e., synchronous and asynchronous), and group size (e.g., dyads and triads) (Noroozi et al., 2012; Rapanta et al., 2013). The paucity of literature on this accounts for the first research question of this thesis addressed in Chapter 2, which reads as follows: *What are the effects of first-order and second-order argument-scaffolding in Higher Education (HE) and Secondary Education (SE), and how does one way of scaffolding influence the other?*

In view of this, a systematic search strategy was defined to identify relevant literature in four online bibliographic databases; namely the Web of Science, Scopus, PsycINFO, and ERIC. Inclusion criteria comprising different constraints were defined to limit the scope of the search and ensure the quality of the literature selected. First, a set of previously used concepts related to CSCA were used; namely *learning, argumentation, collaboration*, and *computer support* (see Noroozi et al., 2012). Then, this set was complemented by the concepts *scaffolding* and *empirical study* as the interests of this study lay in empirical research on CSCA scaffolding. Next, a list of similar terms was defined for each of these concepts to increase the inclusion of relevant articles. The systematic search produced

527 articles which, after screening, resulted in 19 relevant articles. The systematic review reports the effects of CSCA argument-scaffolding on the acquisition of argumentation and domain-specific knowledge, and argumentation behavior in terms of the educational level of the participants – Higher Education (HE) and Secondary Education (SE) – the communication form (synchronous or asynchronous), and group size used in the studies.

To successfully design argumentation scaffolds, it is necessary to define the concept of argumentation competence and its comprising components first. This is difficult, as there is no consistent definition of argumentation competence among researchers (Rapanta et al., 2013). The lack of a consistent definition is a clear indicator that further research is needed to understand the relationships between the various components of argumentation competence (i.e., students' knowledge on argumentation, argumentation behavior, and attitude towards argumentation), and between these components and domain-specific knowledge. As such, it is necessary for both educational research and practice to understand the relationships between the components of argumentation competence, and their relationships with domain-specific knowledge. The aforementioned gap in the literature accounts for the second research question, addressed in Chapter 3: *What are the relationships between students' knowledge on argumentation, argumentation behavior, attitude towards argumentation, and domain-specific knowledge?*

In view of this, an exploratory study with a pre- and post-test design was conducted in an authentic educational setting. The pre- and post-test design allowed us to relate the various components of argumentation competence to domain-specific knowledge gain between pre- and post-test, with the argumentation activities carried out in between. The first part of the chapter presents how argumentation competence is defined in the literature, followed by a definition of argumentation competence that was conceived based on the literature. Regarding the empirical part of the study, one class of Bachelor's students attending a law course – i.e., on Global and EU Environmental Law & Policy – participated. The learning topic was on the context of World Trade Organization (WTO) law and its application to authentic cases. Different aspects of students' argumentative activities were analyzed, such as the quality of the construction of single arguments (Weinberger & Fischer, 2006), the quality of the construction of argumentative sequences (Leitão, 2000), and the quality of transactivity (Noroozi, Teasley, et al., 2013; Weinberger & Fischer, 2006), i.e., the ability to "reason operating on the reasoning of the other" (Teasley, 1997). The results report on the relationships between the components comprising argumentation competence (knowledge, behavior, and attitude), and between such components and domain-specific knowledge. The differences in argumentation behavior between successful and less successful students, in terms of domain-knowledge gain between pre-test and post-test are also reported.

With the intentions and effects of argumentation scaffolds investigated in Chapter 2 and the relationships between the components of argumentation competence and domain-specific knowledge acquisition explored in Chapter 3, it is important to delve into the design and evaluation of argumentation scaffolds. Previous research has suggested that the combination of online learning environments together with worked examples (also known as example-based learning) (Schwonke et al., 2009; Sweller, van Merrienboer, & Paas, 1998; Wittwer & Renkl, 2010) and peer feedback (Hattie & Timperley, 2007; Kluger & Denisi, 1996) are a promising solution for fostering the quality of argumentative essay writing. Previous research has investigated the effects of argumentative peer feedback scripts on the quality of argumentative essays and the acquisition of domain-specific knowledge (Noroozi, Biemans, & Mulder, 2016). However, it is unclear if the combination of worked examples and peer feedback have a positive effect on the learning outcomes of argumentative essay writing. This ambiguity drives the third research question addressed in Chapter 4: *Is there potential in an online learning environment with worked examples and peer feedback on students' argumentative essay writing and domain-specific knowledge acquisition?*

In view of this, a study with a pre- and post-test design was conducted in an authentic educational setting. Bachelor's students enrolled in an introductory biotechnology course wrote an argumentative essay on Genetically Modified Organisms (GMOs). Next, students provided their peers with feedback, after having been presented with the theory on how to write an argumentative essay and an example of an argumentative essay, and revised their essays. The preliminary results show the potential of combining worked examples and peer feedback to foster the quality of argumentative essay writing and the acquisition of domain-specific knowledge. However, it should be noted that further research with a control group is needed to examine possible causal relationships.

Argumentation scaffolds, such as peer feedback, have proven a successful approach for fostering argumentative essay writing skills and acquiring domain-specific knowledge. Peer feedback is a complex construct and it seems plausible to adjust its comprising elements to obtain a different effect on the learning outcomes. Hence, it is important to investigate the effects of various types of peer feedback on argumentative essay writing. Argumentative essays are one of the most common types of assignments for undergraduate students (Mei, 2006). Argumentative essays typically require students to investigate, gather and compare evidence, and write a clear and concise essay with sound reasoning (see Latifi, Noroozi, Hatami, et al., 2021; Noroozi et al., 2016). Argumentation is an essential element of such essays (Mei, 2006; Noroozi et al., 2016; Wingate, 2012), yet sound argumentation and depth of elaboration are frequently underdeveloped in students' essays (Cooper et al., 1984; Kellogg & Whiteford, 2009). Possible reasons for this are that students are unaware of the characteristics of good argumentative essays

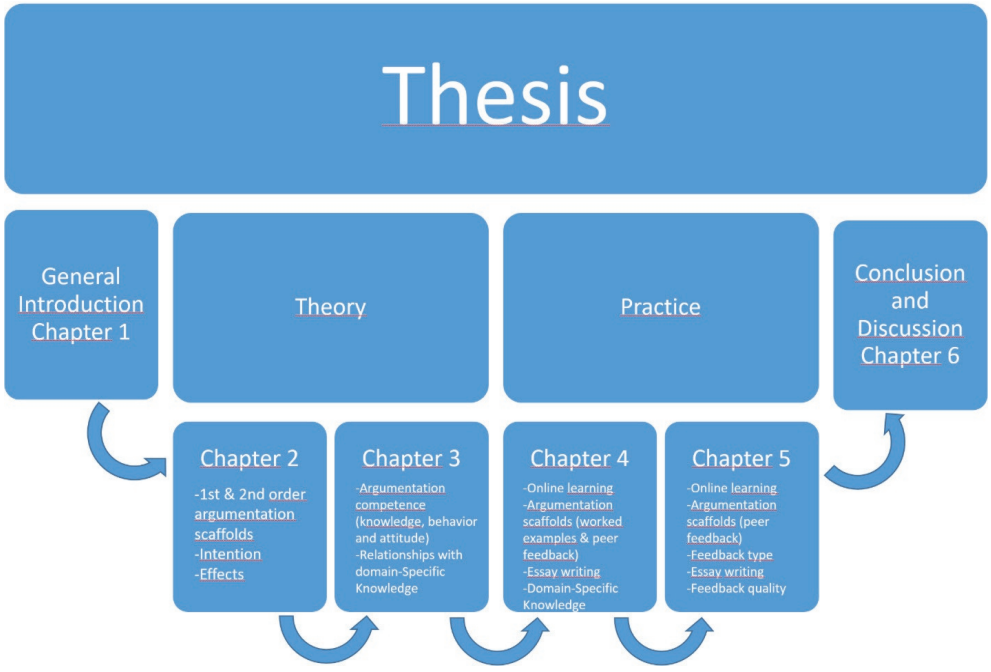
(Bacha, 2010), or that students struggle to put their argumentation knowledge into practice (Noroozi, Teasley, et al., 2013). Similarly, feedback is an important part of the learning process. Peer feedback facilitates the understanding of differences between the current and the expected state, and facilitates receiving advice on what and how to do it to make greater progress (DeNisi & Kluger, 2000; Hattie & Timperley, 2007; Latifi, Noroozi, Hatami, et al., 2021; Latifi, Noroozi, & Talaee, 2021; Lizzio & Wilson, 2008). Similarly, peer feedback can work in both small and large courses, so is an approach that can scale and allow the continuous provision of qualitative feedback to students. Comparatively, teachers' ability to continuously provide feedback decreases as the number of students increases. Despite its relevance, the provision of peer feedback can be both difficult and problematic since students may experience psychological, social, and motivational problems that can influence the peer feedback process and its outcomes. Previous academic research has investigated the effects of peer feedback on argumentation-based learning (Noroozi & Hatami, 2019), collaborative writing (Alvarez, Espasa, & Guasch, 2012), and argumentative essay writing (Noroozi et al., 2016). However, no research has yet been conducted into the effects of different feedback types (i.e., undirected feedback, standard feedback, feedforward, and combinations) on the quality of argumentative essays and the acquisition of domain-specific knowledge. This paucity of literature accounts for the fourth research question, addressed in Chapter 5: *What are the effects of different peer feedback types on the quality of writing argumentative essays?*

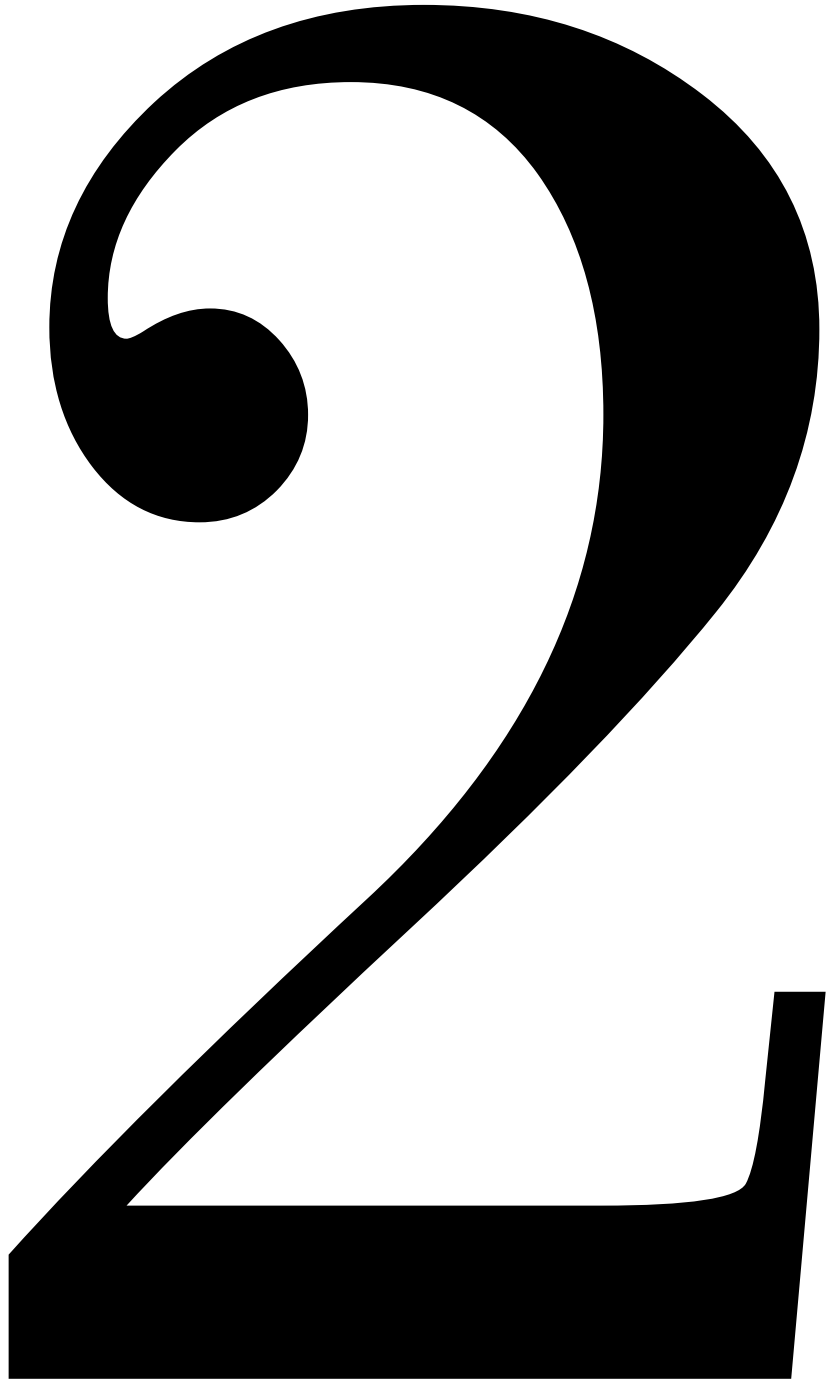
In view of this, an exploratory study with a pre- and post-test design was conducted in an authentic educational setting (Chapter 5). Bachelor students engaged in discussions about the pros and cons of 'Genetically Modified Organisms (GMOs)', provided feedback to peers, and wrote an argumentative essay regarding the topic. The study had four conditions, namely standard feedback, feedforward, standard feedback with feedforward, and undirected feedback. All participants received argumentative essay writing theory and an example of what a good argumentative essay should look like. The difference between the conditions concerned the structure and guidance provided by the peer feedback script during the feedback provision process. Results report the effects of the different peer feedback types on the student's peer feedback quality, on the quality of writing argumentative essays, and on domain-specific knowledge acquisition.

Finally, in Chapter 6, the overall conclusions are presented and discussed. The first part of the chapter is devoted to a summary of the main findings. Next, findings of the various studies are discussed in relation to each other. Afterwards, the strengths and weaknesses of the studies in this PhD dissertation are discussed, including methodological and theoretical issues. The last parts of the chapter concern recommendations for future research and implications for theory and practice. Figure 2 is a visualization of how this

thesis is composed and the relationships between the chapters comprising it.

Figure 2 Visualization of the relationships between the chapters of this thesis





Chapter 2

First- and second-order scaffolding of argumentation competence and domain-specific knowledge acquisition: a systematic review*

*This chapter is published as:

Valero Haro, A., Noroozi, O., Biemans, H., & Mulder, M. (2019). First- and second-order scaffolding of argumentation competence and domain-specific knowledge acquisition: a systematic review. *Technology, Pedagogy and Education, 28*(3), 329-345. doi:10.1080/1475939X.2019.1612772

2.1 Abstract

Results of research on intentions and effects of first- and second-order argument scaffolding of computer-supported collaborative argumentation competence development and domain-specific knowledge acquisition are ambivalent. A systematic review of research in Secondary and Higher Education (SE and HE) has been conducted to clarify and synthesize these intentions and effects, thereby differentiating between communication type (synchronous–asynchronous) and group size. Empirical research with pre-post-test designs was included only. Using specific search terms, 527 articles were found; 19 of these met pre-set selection criteria. Results indicate that HE studies intended to foster argumentation knowledge and domain-specific knowledge acquisition (i.e. knowledge construction), and reported significant effects for both types of knowledge. SE studies however, intended to foster argumentation behavior and domain-specific knowledge acquisition (i.e. learning by doing), and showed significant effects regarding the latter only. HE studies predominantly used asynchronous, and SE studies synchronous communication. Choice of group size was not explicitly justified.

2.2 Introduction

Diverse argumentation scaffolds, like visual representations and scripts, have been designed and embedded in web-based systems, including social networking sites, to facilitate, coordinate and orchestrate diverse roles, interaction patterns and activities of students (Kirschner et al., 2003; Noroozi et al., 2012; Scheuer et al., 2010; Tsovaltzi et al., 2015). Such scaffolds could have been designed as first-order scaffolds, to acquire domain-specific knowledge, or as second-order scaffolds, to acquire argumentation competence (i.e., students' argumentation knowledge, argumentation behavior and attitude towards argumentation). Nevertheless, empirical research on Computer-Supported Collaborative Argumentation (CSCA) presents unclarity with respect to the intention and effects (whether they were found or not) of first- and second-order argument scaffolding on argumentation competence and domain-specific knowledge. This review not only aims to clarify and synthesize such intentions and effects (whether they were found or not) in terms of the educational level of the participants (Higher Education (HE) and Secondary Education (SE)), but also reports on the communication form (synchronous or asynchronous), and group size used in the studies.

2.2.1 Argumentation

Argumentation is a key competence across domains and in different aspects of daily life. In the particular context of education, students are typically encouraged to work together and solve tasks in teams with partners holding various perspectives and knowledge conceptions about an issue (Noroozi et al., 2012). In such scenarios, students need to build upon, relate to, and refer to what has been said by their peers to learn and co-construct knowledge (Noroozi et al., 2018; Noroozi et al., 2012). Argumentation facilitates the comprehension of differing meanings, the acceptance, consideration and integration of others' perspectives and opinions of the problem at stake, and reflection (Toulmin, 1958; van Bruggen & Kirschner, 2003). Despite the importance of argumentation competence and the attempts to offer argumentation courses to students, argumentation competence is regularly developed indirectly and informally in the classroom (Driver et al., 2000; Osborne, 2010). When argumentation is considered in the classroom, a teacher can effectively provide individualized support, supervision and tutoring to one student or a small group of students (Bloom, 1984). However, this type of support falls short if the number of students increases, since the teacher will not be able to thoroughly supervise and tutor the argumentative activities of all students during peak times (Loll, Scheuer, McLaren, & Pinkwart, 2010). Similarly, students struggle to argue in a reasoned way in academic settings (Noroozi, Teasley, et al., 2013) due to different factors. Students struggle, among others factors, with the intricate, non-linear and ill-structured character of argumentation (Lynch et al., 2009; Scheuer et al., 2010), to generate, analyze and evaluate arguments based on rules of

logic (Kuhn, 1991), and to deal with different interpretations of "facts" (Scheuer et al., 2013). The latter makes argumentation difficult to teach, learn and follow its rules regarding the construction of arguments and counter-arguments (Toulmin, 1958), and to engage in sequential discourse (Leitão, 2000).

2.2.2 Argumentation Competence

This study considers that argumentation competence is comprised of students' argumentation knowledge, argumentation behavior and attitude towards argumentation, since these components are related and thus influence the learning outcome of the discourse (Noroozi et al., 2018). Moreover, argumentation competence is not only considered as the capacity to argue, think critically and reason logically to explain one's informed opinions, positions and decisions in contrast to other's viewpoints and opinions, but also as the capacity to handle equivalent tasks and continue learning in the future. In contrast, there is no homogenous definition of argumentation competence among researchers (Rapanta et al., 2013). Scientific evidence shows that researchers tend to measure argumentation competence by focusing mainly on the skills that individuals manifest during discourse (Rapanta et al., 2013), or by measuring students' knowledge on argumentation prior to and after collaborative discourse activities (Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2013). This is striking, since in many situations student's actual argumentation knowledge is not reflected in their argumentation behavior during discourse activities. For example, in several studies by Stegmann, Weinberger, and Fischer (2007), Stegmann, Wecker, Weinberger, and Fischer (2012), Kollar, Fischer, and Slotta (2007), as well as Noroozi, Weinberger, et al. (2013), although individual students showed to have knowledge for construction of formal quality of single arguments, they were not able either to put their knowledge in practice during discourse or in a similar argumentation task. Therefore, one should not only rely on students' argumentation knowledge but also their behavior during actual discourse (see also Andrew & McMullen, 2000). Furthermore, students' psychological, emotional, motivational, and social barriers may also affect their argumentative discourse activities. For instance, some individuals might hold emotions like nervousness or anxiety while providing a claim or receiving a question (Gilbert, 2004), or may perceive peer feedback as critiques and personal attacks (Rourke & Kanuka, 2007). Also, students emotionally attached to the topic of discussion can make argumentation unfruitful, complicated, or even impossible (Baumeister & Scher, 1988; Leith & Baumeister, 1996). Therefore, next to students' knowledge and behavior, their attitude toward argumentation (e.g. psychological, emotional, motivational, and social barriers) should also be considered. Moreover, being competent not only implies the capacity to apply a given competence in new situations possibly taking place in a different context, but also learning from the given problem and further developing the competence (M. Mulder, 2014).

One way to foster the acquisition of argumentation competence and domain-specific knowledge is to use computer-based learning systems and instructional scaffolds

2.2.3 CSCA, Scaffolding and its Effects

Previous research has found that CSCA can facilitate constructing, representing and sharing arguments in diverse formats (Noroozi et al., 2012; Scheuer et al., 2010). Similarly, CSCA environments are considered important instructional tools to scaffold and structure students' argumentative learning (Jeong & Lee, 2008), promote in-depth discussions (Andriessen, Baker, & Suthers, 2003), and in consequence facilitate in-depth understanding and the construction of productive arguments (Buckingham-Shum, 2003). In addition, CSCA systems make possible the scaffolding of important discourse and argumentation processes (Jeong & Lee, 2008).

To support learners in focusing on specific content, argumentation must be framed, scaffolded and guided by external representations (e.g. Belland, Glazewski, & Richardson, 2008; Mirza, Tartas, Perret-Clermont, & De Pietro, 2007). Many studies have shown the benefits and advantages of ABCSCL in terms of constructing knowledge, gaining a comprehensive understanding, cognitive development, and solving complex problems (e.g. Andriessen et al., 2003; Kirschner, Buckingham-Shum, & Carr, 2003). In addition, CSCA systems make possible the scaffolding of important discourse and argumentation processes (Jeong & Lee, 2008). Scaffolding can be defined as any kind of support that facilitates students' participation or acquisition of skills or knowledge during a task or activity which, otherwise, they could not have completed or acquired on their own (Belland, 2010; Hannafin, Land, & Oliver, 1999; D. Wood, Bruner, & Ross, 1976). Therefore, the design of scaffolds is based on the identification of problematic areas that impede learners from performing a given task independently (Lepper, Drake, & O'Donnell-Johnson, 1997).

In CSCA, many instructional scaffolds have been designed and integrated in web-based systems using graphical representations in the form of diagrams formed by nodes and links, tables, and visualizations, or in a more text-based representation in the form of hints, prompts, or scripts. Such scaffolds are designed to facilitate and orchestrate diverse roles, interaction patterns and activities of students at the individual and group level (Kirschner et al., 2003; Noroozi et al., 2012; Scheuer et al., 2010) and could have been designed as first-order or second-order scaffolding. In the first case, the scaffolds are designed to stimulate students' argumentative discourse activities for acquiring domain-specific knowledge within a specific domain (e.g. Dutch labor law), or learning complex skills (e.g., collaborative learning) within the domain being taught (e.g. patient care for professional medical practice). In the second case, the scaffolds are designed for acquiring argumentation competence such that students are able to handle equivalent

tasks themselves and continue learning in the future (van Merriënboer & Kirschner, 2012) in the same or similar domain. Nevertheless, it is not clear what the effects of first-order and second-order scaffolding on argumentation competence and domain-specific knowledge acquisition are, or how acquiring argumentation competence influence the acquisition of domain-specific knowledge.

2.2.4 Educational Level, Communication Form and Group Size

Scientific research indicated that different variables such as educational level of the participants, communication form used and group size (Noroozi et al., 2012; Rapanta et al., 2013) could influence the outcomes of CSCA. However, such variables were not the main interest in those studies even though they may play a role and thus influence the learning outcomes of CSCA.

Regarding the educational level, we focused on Higher Education (HE) and Secondary Education (SE) as our interest lies on these levels.

2.2.4.1 Educational level (HE and SE)

There is no simple definition of higher education. The Association des États Généraux des Étudiants de l'Europe (AEGEE) indicates that the international definition of HE, tertiary (post school) education, divides HE into two parts, namely Type A (Higher Education) and Type B (Further Education). The definition provided by the AEGEE is as follows:

"... It will have a theoretical underpinning, it will be at a level which would qualify someone to work in a professional field and it will usually be taught in an environment which also includes advanced research activity. Shortly, higher education mainly and generally means university level education... Further education generally includes post graduate studies in where you can gain your Master and Doctorate degrees."[1]

Moreover, HE is more abstract, theoretical, demands analytical skills and asking questions. Students are expected to take learning decisions, and carry out significant unsupervised work on which they receive fewer substantial feedback (Macdonald, 2000). Thus, HE is more about the "why".

Based on the International Standard Classification of Education (ISCED)[2], SE can be defined as education typically designed to prepare students for tertiary education, or provide skills relevant to employment, or both. Instruction is more varied, specialized and in-depth than programmes at ISCED level 2. Programmes are more differentiated, with an increased range of options and streams available. In contrast to HE, SE tends to be more concrete and practical, learning decisions are barely left to the students, the

work is mainly supervised and students receive more substantial feedback (Macdonald, 2000). Thus, SE typically focuses on the "how". The latter suggests that students in HE and SE not only differ substantially in the way they perform self-regulated learning and construct knowledge, but also in the level of complexity and cognitive workload required for their respective tasks. Therefore, scaffolds should consider the educational level of the target audience in their design such that they provide task support to students rather than cognitive overload.

2.2.4.2 Communication Form

Regarding the communication form, asynchronous communication provides time to reflect and better analyze information (A. L. Veerman, Andriessen, & Kanselaar, 2000); time to read assignments and to prepare for deliberations that is necessary to generate complex discussions (Dysthe, 2002; Salmon, 2002). Yet, asynchronous communication presents non-serial messages, time lag between messages, and requires participants to be aware of the thread (Khine, Yeap, & Chin Lok, 2003). In contrast, synchronous communication allows to work on a common shared artifact which facilitates a higher degree of elaboration and construction of arguments (de Vries, Lund, & Baker, 2002; Janssen, Erkens, & Kanselaar, 2006), facilitates higher-order thinking and discussion (A. Ravenscroft, McAlister, & Baur, 2006), and stimulates conceptual development (A. Ravenscroft, Wegerif, & Hartley, 2007). Hence, the design of scaffolds should take into account the characteristics of the task at stake as they may affect the learning outcomes.

Finally, regarding group size, the review of Noroozi et al. (2012), indicates that students are typically grouped in dyads, triads and larger groups, yet the reasoning behind the group size setting and the effects it entails are unclear. According to previous research, students in groups learn more than individuals (Dochy, Segers, Van den Bossche, & Gijbels, 2003). In contrast, working in groups may reduce team performance due to socio-psychological effects such as social loafing, e.g., free-riding and the sucker effect (Salomon & Globerson, 1989). Therefore, the size of groups may improve or reduce the learning outcomes.

1 Higher Education: What does it mean? https://www.wg.aegee.org/ewg/higheredu.htm

2 Statistical framework for organizing information on education maintained by UNESCO (ISCED 2011)

2.2.5 Research Questions

The aforementioned paucity in the literature drives this review in the form of the following research questions (RQ):

1. What are the effects of first-order and second-order argument-scaffolding on the elements of argumentation competence and domain-specific knowledge acquisition in HE and SE, and how does one way of scaffolding influence the other?

2. Which argumentation competence components (students' knowledge, behavior and attitude toward argumentation) have been considered for the provision of first-order and second-order argument-scaffolding in HE and SE?

3. What is the communication form used during the provision of first-order and second-order argument-scaffolding in HE and SE?

4. What is the group size used for the provision of argument-scaffolding in HE and SE?

2.3 Method

2.3.1 Development of a Search Strategy

To identify relevant literature a systematic search strategy was executed between December 2014 and February 2015 in the bibliographic databases Web of Science, Scopus, PsycINFO, and ERIC. Inclusion criteria was defined to limit the scope and ensure the quality of the literature. First, a set of concepts related to CSCA was defined, namely *learning, argumentation, collaboration* and *computer support* (Noroozi et al., 2012), which was complemented with the concepts *scaffolding* and *empirical study* as the interest of this study is in empirical research on CSCA scaffolding. To increase the inclusion of relevant articles a list of similar terms was created for each of the concepts, see Table 1. Second, only articles written in the English language were considered since research on CSCA is commonly published in international journals written in English. Third, only articles from peer reviewed journals were considered to guarantee a high level of quality. No time frame was defined. Table 1 shows the final search strategy.

Table 1 Search strategy

Concept	Search term
Argumentation	argument* OR e-argumentation
	AND
Scaffolding	scaffold* OR support* OR moderat* OR script* OR guid* OR facilitat* OR affordance* OR peer-scaffolding
	AND
Computer	computer* OR virtual-environment OR online-environment* OR online OR e-discussion* OR web-based OR hypermedia OR technology-mediated OR technological-setting OR technology-enhanced
	AND
Collaboration	collaborat* OR cooperat* OR team* OR group* OR CSCL OR CABLE OR ABCSL
	AND
Learning	learn* OR practic* OR construct OR refle*
	AND
Empirical Study	empirical OR study OR experiment* OR observation* OR behavioral-assessment OR qualitative* OR quantitative* OR practical
	AND
Other	Document Type = peer-reviewed article AND Language = english

*Wildcard: represents zero or more characters.

2.3.2 Identification of Relevant Articles

Relevant articles were identified using a systematic set of steps. First, the titles and abstracts of articles matching the search criteria were read and checked against pre-determined criteria for eligibility and relevance. Articles had to focus on computer-supported/assisted/based argumentation, address educational purposes, investigate argument-scaffolding, should not be focused on mere collaborative learning (i.e., argumentation was not used to resolve differences of opinion collectively) and were not of a conceptual or review nature. In case of doubt the article was carried forward to the next step. The interrater agreement of two coders (i.e., the first and second author) was calculated by randomly selecting 10% of the articles. To assure reliability of the coding process, coding rubrics were created and the second author was trained on the rubrics and the process. Then, the first author and the coder independently coded 10% of the data. Discrepancies were resolved through discussion until agreement was reached on how to resolve them. Afterwards, the first author coded the remaining data.

Then, the methodology section of the articles matching the criteria was read and labeled as experimental, quasi-experimental, non-experimental, or other. In this review, an *experimental study* has a pre- and post-test design, a control group and at least one treatment group, random assignment of study participants to groups (i.e., comparable

groups) and random assignment of treatment to groups. A *quasi-experimental study* has a pre- and post-test design and two or more comparable groups, or assurances are provided to guarantee that the groups are comparable. A *non-experimental study* lacks one or more design elements of a quasi-experimental study, is a qualitative study, or a study where the researcher starts from the effect/outcome of an observed phenomenon and attempts to determine what caused it (Kumar, 2011). The coding procedure was similar to the one used before for coding for the relevance of articles but was conducted by the main author. To assure reliability of the coding process the following actions were conducted: creating coding rubrics, defining coding process, coding 10% of randomly selected data, adjusting rubrics with further coding criteria after consultation of the co-authors and adding examples to facilitate the resolution of discrepancies. Afterwards, the first author coded the remaining data. Next, low internal validity articles were discarded (i.e., non-experimental and other). Similarly, non-topic related articles identified during this step were labeled as *other* and were discarded as well. Afterwards, the relevance of the articles was re-checked by reading their full text. This step was performed by one researcher. Then, articles not conducted in Higher Education (SE) or Secondary Education (SE) were discarded. Elementary school was not considered in this review as the learning environment differs substantially from HE and SE. In addition, our particular interest lies on HE and SE. Finally, a mapping comprised of multiple codes related to the relevant variables was defined, see Table 2. The study's intention was obtained from the research questions, the educational goals, the research goals or from the article's text. The data extraction and coding were conducted using coding rubrics, with review guidelines containing definitions and hints for applying the codes. Articles not considering any of the variables were discarded. To assure reliability of the data extraction and coding process, the extraction and coding were conducted by the main author following the same coding procedure used for the coding of the study design. First creating coding rubrics, defining coding process, coding 4 randomly selected articles, adjusting rubrics with further coding criteria after consultation of the co-authors and adding examples to facilitate the resolution of discrepancies. Afterwards, the first author coded the remaining data. The outcome of the process was a systematic map.

Table 2 Independent variables

Name	Description	Example
1st order scaffolding	The argumentation-scaffolds are designed to stimulate students' argumentative discourse activities for learning complex skills, or acquiring DK within a specific domain.	"…to guide and support students' argumentative interactions…with collaboration scripts to foster students' meaningful science learning and retention"

2nd order scaffolding	The argumentation-scaffolds are designed for acquiring AC such that students are able to handle equivalent tasks and continue learning in the future in the same and similar domains.	"…the system's impact on their (students) argumentation ability"
1st & 2nd order scaffolding	The argumentation-scaffolds are designed to stimulate students' argumentative discourse activities for learning complex skills, acquiring DK, and for learning AC.	"…explore the extent to which…micro-script influences domain-specific and domain-general knowledge "

2.4 Results and Discussion

2.4.1 Results of the Systematic Search

The total number of hits was 527, published in the years 1982-2015, including duplicates (214) and book chapters or books (3), or 310 relevant records. Table 3 shows the hits per database, while Table 4 shows the overlap between databases.

Table 3 Number of hits per database

Database name	Number of hits
Web Of Science	149
PsycINFO	104
Scopus	162
ERIC	112
	527

Table 4 Overlap between databases

	WebOfScience	PsycINFO	Scopus	ERIC
WebOfScience	-	54	90	46
PsycInfo	54	-	52	41
Scopus	90	52	-	48
ERIC	46	41	48	-

Screening based on titles and abstracts resulted in a set of 84 relevant articles and a set of 58 articles which could not be identified as being relevant or not and thus they were carried forward to the next step. The interrater agreement on the relevance of articles, considering titles and abstracts, was substantial (Cohen's Kappa = 0.731) according to Landis and Koch (1977), while the overall percent agreement was 0.87. Discarded articles fell in the categories different topic (159), conceptual (4), and reviews (5). Next, the main author labelled and screened the articles based on their study design, namely

experimental (10) quasi-experimental (18), non-experimental (77), and other (37). In case of doubt, the second author was consulted. After this, the full text of articles was read by the main author, and articles were coded as relevant (20), not investigating argument-scaffolding (3), focusing on mere collaborative learning (3), elementary school (1) and pre- and in-service teachers (1). Finally, one article not considering any of the dependent variables was discarded. The final number of relevant articles is 19, published in the years 2005-2014. Finally, the 19 articles were coded on the study design and variables by the main author supported by the other authors as described in the previous section. The outcome of the process was a systematic map.

2.4.2. Research Questions

In this section the research questions are addressed.

2.4.2.1 RQ1 - What are the effects of first-order and second-order argument-scaffolding on the elements of argumentation competence and domain-specific knowledge acquisition in HE and SE, and how does one way of scaffolding influence the other?

The following numbers consider the multiple conditions that some studies had, HE (13) and SE (10). In HE 38% of the studies reported significant effects in the acquisition of domain-specific knowledge, 53% of the studies found significant effects on acquisition of argumentation knowledge, and 15% of the studies reported significant effects facilitating argumentation behavior. Meanwhile, attitude towards argumentation was not considered at all, see Table 5. Successful argumentation scaffolds regarding the acquisition of domain-specific knowledge are a collaborative argumentation script and a concept map (Marée, van Bruggen, & Jochems, 2013), group awareness and an argumentation script to annotate general argument types (ontology) (Tsovaltzi, Puhl, Judele, & Weinberger, 2014; Weinberger, Stegmann, & Fischer, 2010). Regarding acquisition of argumentation knowledge, Stegmann et al. (2007) reported that either a script for the construction of single arguments, a script for the construction of argumentation sequences, or both (additive effect) facilitated argumentation knowledge specific to the scaffold intention. The effect of the script for the construction of single arguments was later confirmed in another study (Stegmann et al., 2012). Meanwhile, Bouyias and Demetriadis (2012), Noroozi, Weinberger, et al. (2013) and Weinberger et al. (2010) reported significant effects on both argumentation knowledge and domain-specific knowledge by using a peer-monitoring and a script for the construction of single arguments, a transactive discussion script, and a script for the construction of single arguments in combination with the learning arrangement respectively. In HE, the results indicate that argumentation scaffolds have been mostly successful facilitating the acquisition of argumentation knowledge and domain-specific knowledge.

With respect to SE, 50% of the studies reported significant effects in the acquisition of domain-specific knowledge. Significant effects on acquisition of argumentation knowledge were reported by 30% of the studies, while an additional 20% of the studies reported partial effects in only one of multiple indicators of argumentation knowledge measured, or within a specific subgroup of a treatment group. Successful argumentation scaffolds in terms of domain-specific knowledge are the "conflict schema" script and personally-seeded discussions (D. B. Clark, D'Angelo, & Menekse, 2009), the structuredness of scripts, for the construction of single arguments and argumentative sequences (Kollar et al., 2007), and the use of external representations (i.e., argumentative diagram, argument list and matrix) (van Drie, van Boxtel, Jaspers, & Kanselaar, 2005). In terms of argumentation knowledge, a successful argumentation scaffolds are the scripts for the construction of evidence-based arguments (Belland, Glazewski, & Richardson, 2011). Moreover, Yeh and She (2010) and Chen and She (2012) reported significant effects on both argumentation knowledge and domain-specific knowledge by using an script to annotate general argument types using an ontology, and sentence openers. Effects on attitude towards argumentation were not reported at all. Table 6 shows that research on argumentation scaffolds in SE has been mostly successful facilitating the acquisition of domain-specific knowledge. Two studies, Kollar et al. (2007), and Yeh and She (2010), supported the acquisition of domain-specific knowledge and argumentation knowledge by 1) formally explaining to students argumentation theory, e.g., Toulmin's model of argumentation and/or Leitão's argumentative sequences, 2) supporting the construction of arguments, and 3) facilitating argumentative discourse. In contrast, almost all the rest of the studies supported the acquisition of argumentation knowledge by 1) supporting the construction of arguments without providing argumentation theory (it was not reported), and 2) facilitating argumentative discourse. The exceptions were Weinberger, Marttunen, Laurinen, and Stegmann (2013), Weinberger and Fischer (2006), and D. B. Clark et al. (2009). Finally, Slof, Erkens, and Kirschner (2012) used "representational tools" to facilitate the construction and adjustment of students' representations.

2.4.2.2 RQ2 - Which argumentation competence components (students' knowledge, behavior and attitude toward argumentation) have been considered for the provision of first-order and second-order argument-scaffolding in HE and SE?

The following numbers consider the multiple conditions that some studies had, HE (13) and SE (10). Pre- and post-test measurements on the components of argumentation competence were considered 21 times (HE = 14, SE = 7), more specifically: argumentation knowledge 16 times (HE = 10, SE = 6), argumentation behavior five times (HE = 4, SE = 1), and attitude towards argumentation zero times. In line with this, pre- and post-test measures on a single component of argumentation competence were exclusively focused on argumentation knowledge (HE = 6, SE = 5). Two components, argumentation knowledge and argumentation behavior, were measured only five times (HE = 4, SE = 1).

2.4.2.3 RQ3 - What is the communication form used during the provision of first-order and second-order argument-scaffolding in HE and SE?

Table 5 shows that HE studies were typically conducted using asynchronous communication; this is clear when we consider that 77% of the studies employed this communication form. In contrast, as shown in Table 6, SE studies were commonly conducted using synchronous communication, that is, 80% of the studies used such communication form. The aforementioned results show that HE (asynchronous) and SE (synchronous) studies differ substantially in the communication form they used.

2.4.2.4 Research Question 4

None of the studies explicitly provided a reason for using a given group size. Nevertheless, we present the group sizes found. Roughly half of the studies present an homogeneous group size in the form of dyads (6) and triads (5), while others present an heterogeneous group size (e.g., groups with different sizes, a combination of dyads and triads or groups ranging from three to six students). In general, HE and SE studies considered grouping students in dyads or triads. Nevertheless, studies in HE are stricter in the group size as they tended to enforce only a specific number of participants. In contrast, studies in SE presented more flexibility as the group size could vary among groups (see Table 5 and Table 6).

Table 5 Scaffold, order, intention, measures, effects, communication and group size of HE studies

Higher Education			Intention				Measures (pre- & post-test)				Effects (pre- & post-test)				Com	Group size
			Arg				Arg				Arg					
Reference	Scaffold	Order	K	B	A	DK	K	B	A	DK	K	B	A	DK		
Marée, van Bruggen, and Jochems (2013)	collaborative argumentation script and concept map(ESCoM)	1st				1				1				1	sync	2
Weinberger, Marttunen, Laurinen, and Stegmann (2013)	peer-critique collaboration script (conflict script)	1st				1				1					async	3
Bouyias and Demetriadis (2012)	script for the construction of single arguments continuous (control)	both	1	1		1	1	1		1						
	script for the construction of single arguments fading		1	1		1	1	1		1		1			async	2
	peer-monitoring w/script for the construction of single arguments continuous		1	1		1	1	1		1	1	1		1		
Loll and Pinkwart (2013)	argument representations (different ontologies) and collaborative vs. individual use	both	1	1		1	1			1					sync	3
Noroozi, Weinberger, Biemans, Mulder, and Chizari (2013)	transactive discussion script	both	1	1		1	1	1		1	1			1	async	
Stegmann, Weinberger, and Fischer (2007)	script for the construction of single arguments	both	1			1	1			1	1					
	script for the construction of argumentation sequences		1			1	1			1	1				async	3
	both		1			1	1			1	1					
Stegmann, Wecker, Weinberger, and Fischer (2012)	script for the construction of single arguments	both	1			1	1			1	1				async	3
Tsovaltzi, Puhl, Judele, and Weinberger (2014)	group awareness and argumentation script to annotate general argument types (ontology)	both	1	1		1				1				1	async	n
Weinberger, Stegmann, and Fischer (2010)	script for the construction of single arguments and the learning arrangement (individual and collaborative)	both	1			1	1			1	1			1	async	3 vs 1

Table 6 Scaffold, order, intention, measures, effects, communication and group size of SE studies

Secondary Education			Intention				Measures (pre- & post-test)				Effects (pre- & post-test)					
			Arg				Arg				Arg				Com	Group size
Reference	Scaffold	Order	K	B	A	DK	K	B	A	DK	K	B	A	DK		
Belland (2010)	scripts for construction of evidence-based arguments in PBL	2nd	1				1				p				async	2-3
Belland, Glazewski, and Richardson (2011)	scripts for construction of evidence-based arguments in PBL	2nd	1	1			1				1				async	2-3
Slof, Erkens, and Kirschner (2012)	representational tools	1st				1				1					sync	3
Chen and She (2012)	script to annotate general argument types (ontology) and sentence openers	both	1			1	1			1	1			1	sync	ca. 6
Clark, D'Angelo, and Menekse (2009)	"conflict schema" script and personally-seeded discussions	both		1	1	1				1				1	sync	3-5
Kollar, Fischer, and Slotta (2007)	structuredness of scripts - construction of single arguments and argumentative sequences	both	1	1		1	1	1		1				1	sync	2
Lund, Molinari, Sejourne, and Baker (2007)	argumentation diagram - to debate or to represent a debate	both		1		1	1				p				sync	2
van Drie, Van Boxtel, Jaspers, and Kanselaar (2005)	external representations - argumentative diagram, argument list and matrix	both		1		1				1				1	sync	2
van Drie, Van Boxtel, Erkens, and Kanselaar (2005)	external representations - argumentative diagram and argument list	both		1		1				1					sync	2
Yeh and She (2010)	script to annotate general argument types (ontology) and sentence openers	both	1	1		1	1			1	1			1	sync	ca. 5

Intention	of the study	Com	Communication
Arg	Argumentation	Async	Asynchronous
K	Knowledge	Sync	Synchronous
B	Behavior	p	Partial result. Significant only in one element out of multiple measured
A	Argumentation attitude	1	Existence of
DK	Domain-specific knowledge		

2.4.3 Discussion

Our findings contribute in at least two ways to the field of CSCA. First, the results lead to a clearer idea of the effects (whether they were found or not) of first-order and second-order argument scaffolding in HE and SE. Second, they offer guidance to practitioners and researchers in the field of CSCA in terms of successful approaches of argument scaffolding and communication form in HE and SE.

The findings regarding the argument scaffold, intention, measures, and effects are diverse, yet interesting patterns were found. An unanticipated finding was the general lack of consideration of attitude towards argumentation. Such finding is not only inconsistent with our definition of argumentation competence, but also with previous research where it was demonstrated that students' psychological, emotional, motivational, and social barriers may affect argumentative discourse activities (Baumeister & Scher, 1988; Gilbert, 2004; Leith & Baumeister, 1996; Rourke & Kanuka, 2007). Similarly, studies rarely measured argumentation behavior. The latter contrasts with previous research where individuals holding argumentation knowledge were not able to put their knowledge in practice during discourse (dialogical) or in a similar argumentation task (monological) (Kollar et al., 2007; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007). The aforementioned results suggest that argumentation competence has not been considered as a composite of diverse elements, such as students' argumentation knowledge, argumentation behavior and attitude towards argumentation, but rather as a single element either argumentation knowledge or argumentation behavior. Therefore, argumentation competence has been mostly considered as skills that individuals manifest during discourse (Rapanta et al., 2013), or as the knowledge on argumentation that students have prior to and after collaborative discourse activities (Noroozi, Weinberger, et al., 2013).

It was also found that studies in both HE and SE aim to obtain first- and second-order scaffolding effects. Therefore, such studies strive to develop both argumentation competence and domain-specific knowledge. In line with this, it was found that a couple of studies, Kollar et al. (2007) and Yeh and She (2010), supported the acquisition of argumentation knowledge and domain-specific knowledge by providing students with argumentation theory before engaging in argumentative discourse activities. According to research on the field, students constructing arguments in interaction with their learning partners acquire argumentation knowledge and domain-specific knowledge (Andriessen, Baker, & Suthers, 2003). Moreover, *argumentative knowledge construction* assumes that knowledge acquisition is related to the frequency with which students engage in specific discourse activities (Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007; Weinberger & Fischer, 2006). Argumentative knowledge construction suggests that if students lack the theoretical knowledge underpinning

the construction of arguments (Toulmin, 1958), the construction of argumentation sequences (Leitão, 2000), or the ability to "reason operating on the reasoning of the other" (transactivity) (Teasley, 1997), then students may acquire such knowledge by "learning by doing" in an scaffolded environment, i.e., arguing-to-learn (Andriessen et al., 2003; Jiménez-Aleixandre, 2002; von Aufschnaiter, Erduran, Osborne, & Simon, 2008; Zohar & Nemet, 2002). The latter suggests that students learning would be more mechanical, concrete and practical, thus it would be focused on the "how". In contrast, students receiving argumentation theory before engaging in CSCA would internalize better the theory by practicing. Such students would be aware of how to successfully construct knowledge individually (i.e., constructing single arguments), and how to co-construct knowledge collaboratively (i.e., constructing argumentation sequences and operating in a transactive way). Moreover, such practice may trigger the application of theoretical concepts in the problem space and the construction and internalization of relations between the two (Palincsar, Anderson, & David, 1993). The latter suggests that students may be able to transfer and apply this knowledge to future problem cases in the same or similar context (Vygotsky, 1978). The second approach strives not only to foster conceptual understanding and learning, i.e., arguing-to-learn, but also fosters learning of argumentation, i.e., learning-to-argue (Kelly, Druker, & Chen, 1998; Kuhn, 2005; Osborne, Erduran, & Simon, 2004; Reznitskaya et al., 2001). This learning seems to be more abstract, theoretical, analytical, and about knowledge construction, more about the "why".

It was also hypothesized that if second-order scaffolding has first-order effects as well, research on argument-scaffolding should be centered on second-order scaffolding approaches. Nevertheless, this hypothesis cannot be confirmed nor refuted as most of the studies, in both HE and SE, have intention to achieve both first- and second-order scaffolding.

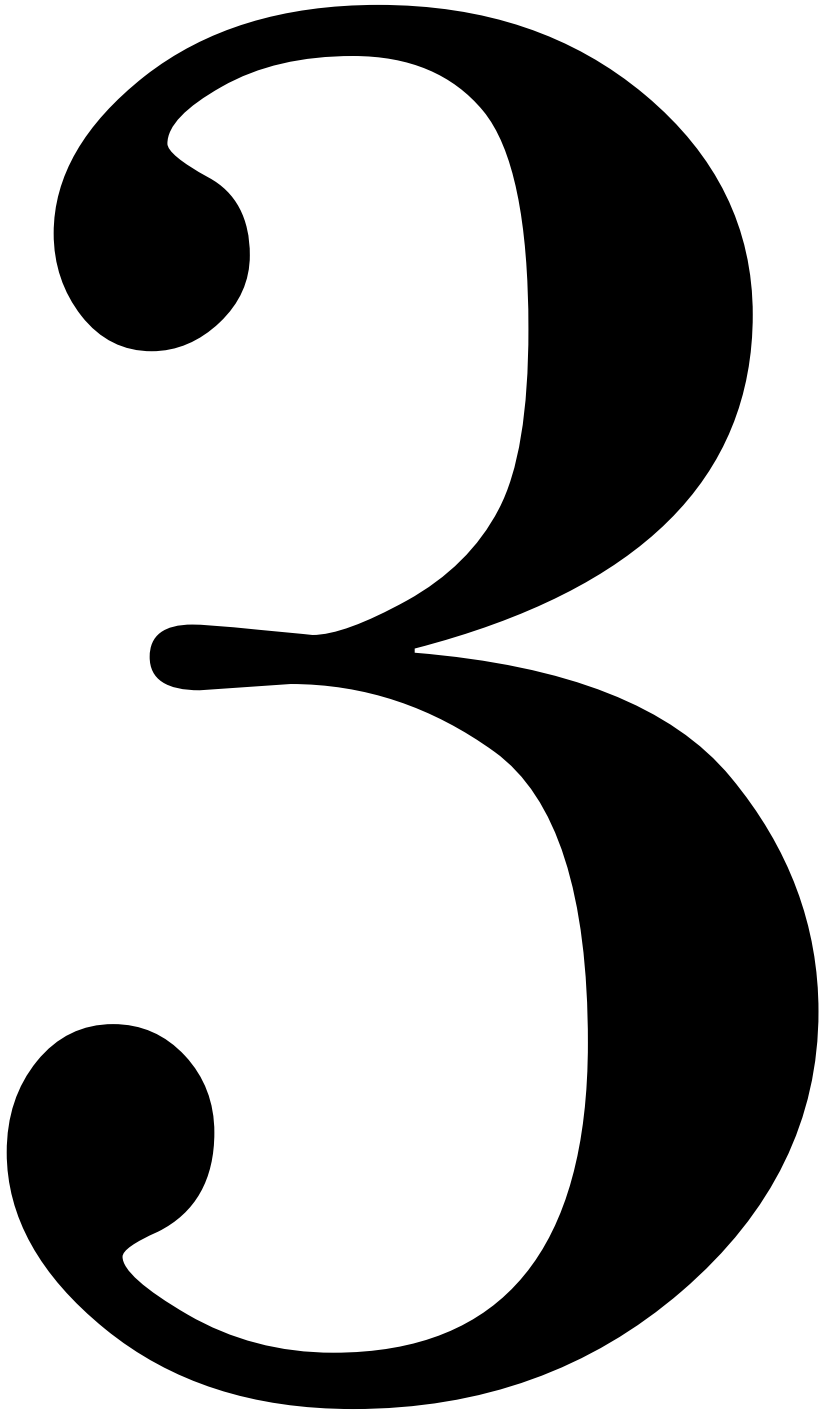
Regarding the communication form, it was found that HE studies (asynchronous) differ substantially from SE studies (synchronous). The difference in communication can be explained if we consider the complexity and cognitive workload required for the tasks in each level. Asynchronous communication is a good approach if we consider that the complexity and cognitive workload of the task in question is high. Asynchronous communication provides time to reflect and better analyze information (A. L. Veerman et al., 2000), to read assignments (Dysthe, 2002; Salmon, 2002), to construct well-conceived and complex arguments, and it also allows equitable participation (Schellens & Valcke, 2006), and can also generate critical dimensions of learning and higher cognitive levels of knowledge construction (Andresen, 2009; Schellens & Valcke, 2006). Nevertheless, asynchronous communication presents some drawbacks such as non-serial messages, time lag between messages, and demands participants to be aware

of the thread (Khine et al., 2003). In contrast, synchronous communication can deliver a higher degree of elaboration and construction of arguments as students can work in a shared workspace (de Vries et al., 2002; Janssen et al., 2006). Additionally, previous research indicated that synchronous communication supports higher-order thinking and discussion (A. Ravenscroft et al., 2006), and conceptual development (A. Ravenscroft et al., 2007). The previous arguments would imply that the design of scaffolds takes into account the context where they are to be used, and thus be tailored to such context.

Finally, the articles reviewed did not present the reason behind their choice of group size, typically dyads or triads. Previous research suggests that students learn more in groups than individually (Dochy et al., 2003), and that learning partners may be also beneficial for motivation and social skills (Johnson & Johnson, 1994). Yet, group size choice may affect collaboration and learning. Thus, a choice of small size groups may not only avoid free-riding and the sucker influence, but also may facilitate participation, turn taking, discussion, common ground and consensus.

2.4.4 Conclusions, Limitations, and Suggestions for Future Research

Our article's main contribution is shedding light on the intention and presence or not of effects of first- and second-order argumentation-scaffolds in terms of argumentation knowledge, argumentation behavior, attitude towards argumentation, and domain-specific knowledge (presented in Table 5 and Table 6) by means of a systematic approach to select, code and cluster the studies, and their effects. The findings serve as guidelines for future researchers and practitioners that want to achieve specific effects with argumentation-scaffolds. The criteria to only consider articles with an (quasi-) experimental design substantially reduced the number of articles under consideration, yet such design provides certainty on the effects of argumentation-scaffolds in educational settings. Finally regarding to future research, we suggest to broaden the spectrum of the dependent variables and to take all elements of argumentation competence, as well as domain-specific knowledge into account. Also, future research should explore the extent to which the provision of theoretical knowledge on argumentation before engaging students in CSCA affects the acquisition of argumentation knowledge and domain-specific knowledge. Furthermore, future research should investigate if second-order scaffolding has first-order effects as well, since this hypothesis could neither be confirmed nor rejected in our study. Last but not least, the design of argumentation-scaffolds should consider the identification of problematic areas that impede learners from performing a given task independently, as well as the context where they are to be used, and thus be tailored to such context.



Chapter 3

Argumentation Competence: Students' Argumentation Knowledge, Behavior and Attitude and their Relationships with Domain-Specific Knowledge Acquisition *

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3.1 Abstract

Following constructivist paradigms for learning, this article explores the relationships between the components of argumentation competence (knowledge, behavior and attitude), their relationships with domain-specific knowledge acquisition, and the differences in argumentation behavior between successful and less-successful students. An exploratory study, with a pre- and post-test design, in an authentic, non-scaffolded, online learning environment was conducted. Contrary to our expectations, no significant relationships between the components of argumentation competence were found. Nevertheless, a significant relationship between argumentation behavior and domain-specific knowledge acquisition was found. Moreover, results suggested that the capacity of students to transfer argumentation behavior to similar argumentation tasks can be related to students' domain-specific knowledge acquisition. Finally, successful students in terms of domain-specific knowledge acquisition scored higher regarding their argumentation behavior than less-successful students. These findings are discussed followed by theoretical and practical implications and suggestion for future work.

3.2 Introduction

In constructivist paradigms for learning, learners of all ages are supposed to engage in discussions and argumentation with their peers, take positions, negotiate meaning and understand various perspectives of issues which would also lead to co-constructing knowledge and solving authentic tasks (Noroozi et al., 2018). Engaging in collaborative argumentation is important for higher education students to manage today's complex issues and actively participate in the knowledge society. The dialogic dimension of argumentation is related to the socio-constructivist and socio-cognitive theory (Coffin & O'Halloran, 2008), in which argumentation is considered as part of a dialogic process between learners with their peers. This dialogic process followed by reasoned debate is considered central to the process by which higher-order mental thinking, critical reasoning, and reflection is developed (Noroozi et al., 2012).Learning processes and outcomes for students who are asked to collaborate and engage in argumentation with peers have been of interest to many researchers in higher education. Given the increasingly global nature of the controversial issues and the need for domain-specific and domain-general expertise to solve today's complex issues, helping higher education students learn to work together in groups to share their knowledge, expertise, and experiences from different perspectives is a priority for higher education.

Argumentation and domain-specific knowledge acquisition have been facilitated using diverse instructional scaffolds integrated in online learning environments (Noroozi et al., 2012; Scheuer et al., 2010). Yet, according to the meta-analysis review of Rapanta et al. (2013), there is no homogenous definition of argumentation competence among researchers nor standardized instrument to analyze and assess argumentation competence components. Moreover, there is a lack of knowledge in the literature in terms of the relationships between various components of argumentation competence, and between such components and domain-specific knowledge. Therefore, it is important, for both educational research and practice, to address such gap in the literature.

This exploratory study aims to expand our understanding on the relationships between the components of argumentation competence, and their relationships with domain-specific knowledge in an authentic, non-scaffolded, online learning environment. In addition, this study explores the differences in argumentation behavior between successful and less-successful students in terms of domain-specific knowledge gain.

3.2.1 Argumentation Competence

Higher education students are commonly required to solve complex problems in teams, within which team members may have a different perspective on the issue at hand, and different disciplinary backgrounds (Noroozi et al., 2012). In such scenarios,

students should be able to present their opinion, think critically, argue, and reason logically, to reach conclusions and make critical decisions (Andriessen, 2006; Kuhn, 1991). Argumentation facilitates the grasping of meanings and different perspectives, the resolution of discrepant opinions, reflection, and the acknowledgement and the integration of multiple perspectives of the problem at hand (Toulmin, 1958; van Bruggen & Kirschner, 2003). Different types of instructional scaffolds have been used in online learning environments to facilitate the acquisition of argumentation and domain-specific knowledge acquisition (Noroozi et al., 2012; Scheuer et al., 2010) despite the lack of a clear definition of the concept of argumentation competence, its comprising components and their relationships with domain-specific knowledge (Rapanta et al., 2013). Rapanta et al. (2013, p. 488)'s definition of argumentation competence comprises "the different types of skills related to argumentation that are manifested in a person's performance in both monological (individual) and dialogical (peer-to-peer) contexts".

In line with the lack of a homogenous definition of argumentation competence among researchers, there is no standardized instrument to analyze and assess argumentation competence components (Rapanta et al., 2013). Researchers typically measure argumentation competence in terms of the skills students manifest during argumentative discourse activities, e.g., argument form, use of strategies or achievement of specific argumentation goals (Rapanta et al., 2013), or by tests of argumentation knowledge prior to and after collaborative discourse activities (Noroozi, Weinberger, et al., 2013). Nevertheless, in some situations, students' actual knowledge on argumentation is not reflected in their behavior during argumentative discourse activities. For example, in several studies (Kollar et al., 2007; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007), students demonstrated knowledge regarding the construction of single arguments, but failed to apply such knowledge in argumentative tasks, such as discourse. Therefore, a reliable measurement of argumentation competence should rely on both students' argumentation knowledge and their behavior during actual discourse (see Andrew & McMullen, 2000). Furthermore, students' argumentative discourse activities may be affected by psychological-, emotional-, motivational-, and social factors (Polo, Lund, Plantin, & Niccolai, 2016). For instance, some students may present emotions, such as nervousness or anxiety, while presenting a claim or receiving a question (Gilbert, 2004). Similarly, students may perceive constructive feedback from peers as critique or personal attacks (Rourke & Kanuka, 2007). In addition, if students are emotionally attached to the topic under discussion (e.g., controversial issues like genetically modified food, animal testing or politics), argumentation may prove unfruitful, complicated, or even impossible (Baumeister & Scher, 1988; Leith & Baumeister, 1996). In contrast, emotions may also result in successful and fruitful argumentation as students use their emotions as a resource to argue (Polo et al., 2016; Polo, Plantin, Lund, & Niccolai, 2017) or operate on the reasoning of their learning

partners to highlight or make more salient socio-cognitive conflicts on their individual positions regarding the controversial issue at stake (Fischer, Bruhn, Gräsel, & Mandl, 2002; Roschelle & Teasley, 1995a; Weinberger, Ertl, Fischer, & Mandl, 2005).

Based on the aforementioned evidence, we argue that argumentation competence is comprised of students' knowledge on argumentation, argumentation behavior and attitude toward argumentation, since these components appear to be interwoven and, thus, may influence the learning outcomes of the discourse. Argumentation competence, therefore, encompasses the capacity to argue, think critically and reason logically to explain one's informed opinions, positions and decisions in contrast to others' viewpoints and opinions, and the capacity to handle equivalent tasks and continue learning in the future (Noroozi et al., 2018). Argumentation competence is crucial for writing argumentative essays and learning in collaborative environments, in which students must engage in collaborative knowledge construction in a transactive manner, e.g., build upon, relate to, and refer to, what has been said by their learning partners (Noroozi et al., 2018; Noroozi et al., 2012). In the following sections, we discuss argumentative essay writing, collaborative argumentation, and transactivity as three main aspects of students' argumentation-based learning.

3.2.2 Writing Argumentative Essays

Undergraduate students are typically required to complete assignments in the form of writing opinion papers and argumentative essays (Mei, 2006). Examples include students following courses on law or sociology, who learn diverse topics, such as 'Global and EU Environmental Law' or 'Sociology of Violence'. In such courses, the assignments require students to investigate a topic, gather and evaluate evidence, and write a clear and concise report in the form of an argumentative essay. The latter requires students to develop a clear theory supported by sound reasoning. In such assignments, argumentation has an essential role for writing argumentative essays (Mei, 2006; Wingate, 2012).

Unfortunately, students' essays rarely present sound argumentation and depth of elaboration (Cooper et al., 1984). There could be multiple reasons that may cause the aforementioned issues such as the lack of diverse general and context-specific language skills (Kelly & Bazerman, 2003), because students do not know the features of good argumentative essays (Bacha, 2010), or because they struggle in transferring their knowledge to applications, such as writing argumentative essays (Noroozi, Teasley, et al., 2013).

The features of a good argumentative essay can be described in terms of macro- and micro levels (Noroozi et al., 2016). At the macro level, a good argumentative essay is composed of a) a clear position, b) arguments and data in favor of the position,

c) arguments and data that are against or weaken the position, d) integrations of arguments and data in favor and against the topic, and e) a conclusion (Noroozi et al., 2016). While at the micro level, argumentative essays are composed of single arguments according to Toulmin's 'model of argumentation' (see below section "Construction of single arguments").

If students struggle to transfer their knowledge into applications such as writing argumentative essays, it is necessary to provide a learning activity where students can further develop their subject knowledge and argumentation competence. One option is collaborative argumentation.

3.2.3 Collaborative Argumentation

In collaborative argumentation (CA), learners engage in argumentative knowledge construction which involves reasoning processes and collective exploration of the dialogical space (Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007; Weinberger & Fischer, 2006). According to Munneke, Andriessen, Kanselaar, and Kirschner (2007), CA fosters reasoning and construction of knowledge since students can consider different viewpoints of a topic, and can question, clarify and explain to their learning partners, conceptions, doubts, beliefs and issues related to the topic. Similarly, CA facilitates deep elaboration of domain content, which is related to the acquisition of more and better organized domain knowledge (Jermann & Dillenbourg, 2003). In CA, students build up a shared understanding of the issue at stake (M. Baker, 2009), which is different from the 'win-lose' debate-type argumentation (Pinkwart, Aleven, Ashley, & Lynch, 2006, 2007), in which argumentation is employed to compete and/or convince others (Andriessen, 2006; Asterhan & Schwarz, 2009).

According to Weinberger and Fischer (2006), knowledge acquisition is directly related to the frequency with which learners engage in discourse and perform specific activities that can span multiple process dimensions. Weinberger and Fischer (2006) differentiated four specific processes of argumentative discourse activities, namely a participation dimension (quantity and heterogeneity of participation), an epistemic dimension (whether learners contributions are on- or off-task), an argument dimension (structural composition of arguments and their sequences) and a dimension of social co-construction or transactivity (to what extent learners refer to contributions of their learning partners).

This study focuses on the participation dimension, the argument dimension and transactivity. Such dimensions not only depict students' argumentation behavior at the macro- , i.e. transactivity and participation, and micro levels, i.e. argumentation, but also across social planes, i.e. individual and collaborative. The epistemic dimension

[see Weinberger and Fischer (2006)] was deliberately not considered, because some epistemic activities were not captured by the nature of the study. In contrast to solving a task collaboratively, solving a task individually and discussing the answer collaboratively may trigger different epistemic activities that can require a different analysis and further elaboration, making it worth of a detailed investigation in future research.

3.2.3.1 Participation dimension

The participation dimension depicts if students participate, and if they participate on an equal basis (Weinberger & Fischer, 2006) and is given by the quantity of participation and the heterogeneity of participation. The quantity of participation indicates to what extent learners contribute during the task, which is deemed as an important indicator of knowledge construction, and can be measured by the number of words students produce. The heterogeneity of participation tells us if students' participation is homogeneous. When participation is homogeneous, all students within the group may benefit from knowledge co-construction and the chance that students are left behind is reduced. Highly heterogeneous participation has been associated with 'social loafing' (Latané, Williams, & Harkins, 1979) or 'free riding' (Kerr & Bruun, 1983). Weinberger and Fischer (2006) argue that heterogeneity may be reduced if students collaborate in small groups, as their chance to participate in whole classroom settings proves rather difficult. Next to the participation dimension, the construction of single arguments and argumentative sequences is also deemed relevant.

3.2.4 Argumentative Knowledge Construction

Students should be able to argue, think critically and reason logically, as such abilities are core objectives in education. In argumentative knowledge construction, learners engage in collaborative argumentation, which involves reasoning processes and collective exploration of the dialogical space (Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007; Weinberger & Fischer, 2006). According to Munneke et al. (2007), collaborative argumentation fosters reasoning and construction of knowledge since students can consider different viewpoints of a topic, and can question, clarify and explain to their learning partners, conceptions, doubts, beliefs and issues related to such a topic. Similarly, collaborative argumentation facilitates deep elaboration of domain content, which is related to the acquisition of more and better organized domain knowledge (Jermann & Dillenbourg, 2003). In collaborative argumentation, students build up a shared understanding of the issue at stake (M. Baker, 2009), which is different from the 'win-lose' debate-type argumentation (Pinkwart et al., 2006, 2007), in which argumentation is employed to compete and/or convince others (Andriessen, 2006; Asterhan & Schwarz, 2009). Collaborative argumentation can be facilitated by instructional scaffolds that can be integrated in web-based systems (Noroozi et al., 2012; Scheuer et al., 2010), typically known as Computer-Supported Collaborative

Argumentation (CSCA).

According to Weinberger and Fischer (2006), knowledge acquisition is directly related to the frequency with which learners engage in discourse and perform specific activities that can span over multiple process dimensions. Weinberger and Fischer (2006) differentiated four specific processes of argumentative discourse activities, namely participation dimension (or quantity and heterogeneity of participation), epistemic dimension (or whether learners contributions are on- or off-task), argument dimension (or structural elements of single arguments and argumentative sequences) and dimension of social model of co-construction (or to what extent learners refer to contributions of their learning partners). The later dimension was refined and regarded as transactivity by Noroozi, Weinberger, et al. (2013). This study focuses on participation dimension, argument dimension and transactivity. Such dimensions not only depict students' argumentation behavior at the micro-, i.e. argumentation dimension, and macro levels, i.e. transactivity and participation dimension, but also across social planes, i.e. individual and collaborative levels. The epistemic dimension, as presented by Weinberger and Fischer (2006), was not deliberately considered, because some epistemic activities were not captured by the nature of the study. In contrast to solving a task collaboratively, solving a task individually and discussing the answer collaboratively may trigger different epistemic activities that can require a different analysis and further elaboration, making it worth of a detailed investigation in future research.

3.2.4.1 Participation dimension

The participation dimension depicts if students participate, and if they participate on an equal basis (Weinberger & Fischer, 2006). The latter is given by the quantity of participation and the heterogeneity of participation. The quantity of participation informs us to what extent learners contribute during the task, which is deemed as an important indicator of knowledge construction, and can be measured by the number of words students actually produce. The heterogeneity of participation tells us if students' participation is homogeneous. When participation is homogeneous, all students within the group may benefit from knowledge co-construction and the chance that students are left behind is reduced. Highly heterogeneous participation has been associated with 'social loafing' (Latané et al., 1979) or 'free riding' (Kerr & Bruun, 1983). Weinberger and Fischer (2006) argue that heterogeneity may be reduced if students collaborate in small groups, as their chance to participate in whole classroom settings proves rather difficult. Next to the participation dimension, the construction of single arguments and argumentative sequences is also deemed relevant.

3.2.4.2 Argument dimension

The argument dimension comprises the structural elements of single arguments (Kollar

et al., 2007; Stegmann et al., 2012; Stegmann et al., 2007) and argumentative sequences (Leitão, 2000).

3.2.4.2.1 Construction of single arguments

The construction of single arguments is based on Toulmin's 'model of argumentation' (Toulmin, 1958). Toulmin's model complements the traditional model of argument (based on premises-conclusion or data-claim), by further distinguishing more elements, namely *warrant*, *backing*, *qualifier* and *rebuttal*. Table 7 provides a definition and example of the elements of the Toulmin's 'model of argumentation' (Kollar et al., 2007; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2007; Weinberger & Fischer, 2006).

Table 7 Construction of single arguments based on Toulmin's 'model of argumentation'

Element	Definition	Example
Claim	A statement expressing the position on an argument	"The earth spins around"
Datum	Factual information supporting the acceptance of the claim	Observations and experiences, e.g. "so we have day and night"
Warrant	A rule of inference or logical connection indicating how the datum is supporting the claim	definitions, theories, codes, laws, and rules
Backing	Factual information	Statistics or expert opinions, grounding the warrant
Qualifiers	Used to limit the validity or scope of the claim. Specifically, a qualifier indicates the degree of certainty about the validity of the claim	Typically formed by using modal adverbs, such as 'perhaps', 'maybe', and 'probably'
Rebuttal	Depicts the circumstances under which the claim is invalid	'provided that…', and 'if and only if…'

Toulmin's model can be complex due to the relationships between its components or their ambiguity (Noroozi, Weinberger, et al., 2013; Stegmann et al., 2007). Moreover, all elements of the model rarely appear together in everyday language arguments (Stegmann et al., 2007). Therefore, Toulmin's model has been simplified in multiple studies to the elements: claim, grounds and qualifications (M. Baker, 2003; Kollar et al., 2007; Leitão, 2000; Noroozi, Weinberger, et al., 2013; Simon, 2008; Stegmann et al., 2012; Stegmann et al., 2007). The elements datum, warrant, and backing of Toulmin's model are grouped together under the element *grounds* (Stegmann et al., 2007). Similarly, Toulmin's model fails to capture and recognize the dynamic process of collaborative discourse, the dependencies and relationships of moves among participants (Andrews, 1995), or the opponent's part in the argumentation process (Andriessen, 2006). Therefore, the argumentative sequences during collaborative argumentation should be considered.

3.2.4.2.2 Construction of argumentative sequences

In dialogical argumentation, proponents express their opinions through discourse, then opinions are clarified, contested, and refined by the means of critical dialogue (Andrew Ravenscroft, 2011). Walton and Krabbe (1995) recognized six basic types of dialogue that the pair proponent-opponent may follow to reason collectively, namely persuasion (resolve or clarify issue), inquiry (prove or disprove a hypothesis), negotiation (reasonable settlement both can live with), information-seeking (exchange information), deliberation (decide best available course of action), and eristic (reveal deeper basis of conflict). Similarly, diverse dialogical models of argumentation have been proposed, e.g., formal-dialectics (Barth & Krabbe, 1982), pragma-dialectics (van Eemeren, Grootendorst, Johnson, Plantin, & Willard, 1996; van Eemeren, Grootendorst, & Kruiger, 1987) and Rescher's-dialectics (Rescher, 1977), yet all coincide in the importance of both arguments and counterarguments. Leitão (2000)'s *argumentative sequences* consist of specific sequences of *arguments*, *counterarguments*, and *integrations*, with an emphasis on the dynamic character of dialogical argumentation at a macro-level, to facilitate knowledge acquisition. *Argument* is defined as a statement favoring a specific proposition. *Counter-argument* is an argument opposing a preceding argument, and supporting an opposite proposition. Finally, *integration* is a statement aiming to balance and advance a preceding argument and counterargument (Stegmann et al., 2007; Weinberger & Fischer, 2006). Dialogic argumentation can be also described in terms of transactivity or the degree to which students refer to the contributions of their learning partners (Weinberger & Fischer, 2006), such co-construction of knowledge has been related to knowledge acquisition (Teasley, 1997).

3.2.4.3 Transactivity

Transactivity is connected to the level of cognitive elaboration and individual knowledge construction, and depicts the extent to which students build upon, relate to, and refer to what has been said by their learning partners during collaboration. The term transactive discussion was first adopted by Berkowitz and Gibbs (1983). Later the term transactivity was coined and introduced to collaborative learning by Teasley (1997). Transactivity means 'reasoning operating on the reasoning of the other' (Berkowitz & Gibbs, 1983, p. 402). According to Teasley (1997), the benefit from learning together is directly related to the extent to which students build on the reasoning of their learning partners. Students not building upon their learning partners' reasoning may accept their learning partners' contribution too quickly and thus they will not engage in both critical and transactive discussions. Such acceptance depicts the lowest level of transactivity which is known as *quick consensus building* (Weinberger & Fischer, 2006). In contrast, in *integration-oriented consensus building* students operating on the reasoning of their learning partners integrate each other's opinions. In this situation, students revise, modify and adjust their opinions and ideas taking as basis their learning partners' contributions (Noroozi,

Weinberger, et al., 2013; Weinberger & Fischer, 2006). There are also situations in which students engage in transactive discussions and critical argumentation with their learning partners. In such situations, students operate on the reasoning of their learning partners as there are socio-cognitive conflicts regarding their individual positions on the solution of the issue at stake. This situation is referred as *conflict-oriented consensus building*, and is considered to lead to successful and fruitful collaborative learning (Fischer et al., 2002; Weinberger et al., 2005).

3.2.5 Research Questions

Up until now, limited attempts have been made to examine the relationships between various aspects of argumentation competence (students' knowledge on argumentation, argumentation behavior and attitude toward argumentation) and also their relationship with domain-specific knowledge in an authentic, non-scaffolded, educational setting. Although Zohar and Nemet (2002) reported a positive impact of argumentation on domain-specific knowledge acquisition, argumentation was treated as a whole and the comprising elements of argumentation competence were not studied. Similarly, Noroozi et al. (2012) reported positive impact of argumentation on domain-specific knowledge acquisition, but the relationship of student's argumentation competence and the learning outcomes was not explored. Therefore, it is a crucial issue, and is imperative, for both educational research and practice, to clearly define the concept of argumentation competence, the relationships between its comprising components, and between these components and domain-specific knowledge. The aforementioned gap in the literature drives this study in the form of the following research questions:

1. What are the relationships between students' argumentation knowledge, behavior, and attitude and their relationship with domain-specific knowledge acquisition?

2. What are the differences in argumentation behavior between successful and less-successful students in terms of domain-specific knowledge gain?

3.3 Method

3.3.1 Context and Participants

This exploratory study with a pre- and post-test design was conducted at a university in the Netherlands. One class following a law course in environmental law and policy at the Bachelor Degree level participated in the study. The class was comprised of 57 students. The mean age of the participants was 22.67 years (SD = 2.89, MIN = 20, MAX = 36). The numbers of Dutch (54.4%) and foreign students (44%) were roughly equal. Female students represented 58% of the participants as opposed to 42% male students.

Students were not graded for the assignments as the activity was not an obligatory part in the course description. However, to motivate students' participation, the submission of the assignments was required by students to be able to participate in the final exam.

3.3.2 Learning Materials

The particular topic to be learned was World Trade Organization (WTO) law and its application to authentic cases. WTO law regulates trade between participating countries and consists of two major parts. One part is a framework to negotiate trade agreements, the other is a dispute resolution process used to enforce participants' adherence and compliance to WTO agreements. The materials used were developed by the course coordinator. The students' task was to use WTO law (presented during class by the teacher) to answer different questions about a real life case. This case was about a country that has put in place measures concerning the import of agricultural products, primarily poultry, for two reasons: a) to avoid the spread of avian influenza, or bird flu, from other countries due to trade, b) to protect an endemic rooster from cross-breeding with chickens imported from abroad, because they are particularly important as a symbol of national pride. The following is a brief description of the questions/activities asked of students during each assignment: 1) find a WTO case that has already dealt with a similar measure, 2) Consider the case to answer the following questions as a member of the WTO tribunal that has to hear the case: Is the country's measure with regards to avian influenza (AI) in compliance with a) Arts. 2.2, 5.1 and 5.2 of the Sanitary and Phytosanitary Measures (SPS) agreement? b) Arts. 3.1 and 3.2 of the SPS agreement? 3) Reason on the scope of WTO law in terms of the case, 4) reflect if WTO should regulate more strongly environmental law and food safety issues. The learning task was authentic and complex, as it required students to individually investigate a topic, gather and evaluate evidence and applicable law, and write a solution presenting a position supported by sound reasoning, and a clear and concise conclusion. Moreover, students had to analyze, discuss and provide feedback to each other's solutions in triads on the basis of the theoretical background (conceptual space). The goals were to: 1) argue in a specific domain, 2) argue in an individual and collaborative fashion, 3) share knowledge, and 4) learn from others.

3.3.3 Online Platform

The "*group discussion boards*" or forums with threaded discussions of the Blackboard learning management system were used in this study. The forums were private, only group members were able to see and make contributions. As Blackboard was user-friendly and the students were familiar with it, it was not necessary to spend much time explaining to students how to carry out the activities. The later aspect is important, as online learning systems demand user-friendly platforms (Noroozi et al., 2012).

3.3.4 Procedure

The class was randomly divided into groups of three students. All students received the same instructions and materials. The study consisted of six phases that took place over a period of three weeks, see Table 8.

Phase 1 consisted of an intake questionnaire on the following areas: socio-demographic information, domain-specific knowledge, attitude towards argumentation and argumentation knowledge. Phase 2 to Phase 5 were assignments related to an overarching WTO law case, each assignment was comprised of one or two questions/ activities (see section Learning Materials). During phases 2 to 5, students needed to: a) write an answer, in the form of an argumentative essay, b) post their answer, to seed the discussion, c) discuss in groups each other's answers (60 min for a, b and c), and d) revise original answer (45 min). Phase 6 consisted of an exit questionnaire that was the same as the intake questionnaire.

Table 8 Study phases descriptions

		Assignments				
Phase	**Pre-test**	**Assignment 1**	**Assignment 2**	**Assignment 3**	**Assignment 4**	**Post-test**
Activities	- Introduction - Intake questionnaire	- Write individual answer at home - Post individual answer to the discussion forum - Discuss answers with two learning partners (posting at least three relevant and meaningful contributions)(collaboratively at class) - Revise original answer (individually at class)				- Exit questionnaire - Debriefing
Time (min)	120min	105min	105min	105min	105min	120min

During the collaborative phase, students were asked to make at least three relevant and meaningful contributions, but this was not enforced. The students groups remained the same during the whole study. For this study, we only analyzed the pre- and post-tests and one assignment, namely the second assignment (Phase 3). The second assignment was deliberately selected because 1) students were already familiar with the activities of the assignment, and 2) it contained vast information, as students had to a) individually investigate, gather and evaluate evidence and applicable law, and write a solution, b) collaboratively analyze, discuss and provide feedback in triads on the basis of the theoretical background c) revise their original answer taking into account the feedback and arguments of their learning partners.

3.3.5 Instruments, Data Sources and Measurements

A revised version of the questionnaire and test employed by Noroozi, Weinberger, et al. (2013) and Noroozi, Teasley, et al. (2013) was used to gather socio-demographic

information (e.g., age gender, nationality), argumentation knowledge, and attitude towards argumentation. A questionnaire for domain-specific knowledge was developed by the course coordinator. Moreover, students' original and revised answers for each of the assignments, and discussions during collaboration were also collected. The coding scheme, coding rubrics, and rules for the coding process were obtained from previous studies (Noroozi, Teasley, et al., 2013; Noroozi, Weinberger, et al., 2013). The main author has previous coding experience, and was responsible for coding all the data in this study. The coding process reliability was assured by creating coding rubrics, defining a coding process, coding 10% of randomly selected data, and revising the rubrics with further criteria and examples, to facilitate the resolution of discrepancies, after consultation with the co-authors. Afterwards, the main author coded the remaining data.

3.3.5.1 Assessing and measuring argumentation behavior

The argumentation behavior of students was measured individually (i.e., original and revised answers of the assignment) and collaboratively (i.e., students' discussion during the collaborative learning phase). The data were analyzed following the coding schemes developed by Weinberger and Fischer (2006), Noroozi, Teasley, et al. (2013) and Noroozi, Weinberger, et al. (2013). In particular, the assignment was analyzed for the quality of the construction of single arguments, while students' discussions were analyzed for the quality of the construction of single arguments, the quality of the construction of argumentative sequences, and the quality of transactivity. The unit of analysis for the construction of single arguments was a sentence, delimited by a period '.'. Yet, preceding- and succeeding sentences were considered when deemed relevant (e.g., serving as grounds or qualifiers), as sometimes students do not connect them explicitly. The unit of analysis for argumentative sequences and transactivity was defined at the message level, which is all the text provided in one contribution. In summary, individual argumentation behavior is given by the score on the construction of single arguments, while collaborative argumentation behavior is the sum of the scores of construction of single arguments, argumentative sequences and transactivity.

3.3.5.1.1 Assessing and measuring quality of construction of single arguments

To measure the quality of the construction of single arguments, the messages were segmented. Then, the segments were coded as *simple claims*, *qualified claims*, *grounded claims*, *grounded and qualified claims* and *non-argumentative* moves following Weinberger and Fischer (2006), see Table 9. We assigned points to each segment as described in Table 9. Then, for each student, we counted and summed the points (Kollar et al., 2007; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007).

Table 9 Assessing and measuring quality of construction of single arguments

Segment type	Definition	Example	Points
simple claims	Statements that advance a position and are not supported by grounds or limited by qualifications. Segment is a claim if it does not function as grounds or qualifiers for other claims.	"The measures taken by India are not based on international standards, guidelines or recommendations."	1
qualified claims	Present a limitation of the validity of the claim (a qualifier) but do not present grounds. Common keywords: 'if', 'maybe', 'under the circumstances', 'perhaps', 'probably', 'provided that…', 'subject that…', and 'if and only if…'.	"However, they are deemed to be necessary to protect human and animal life and health and may be allowed, if they are based on appropriate risk assessments."	2
grounded claims	Grounds warranting/supporting the claim but do not present limitations of their validity. Grounds can be data (e.g., case description information), warrants (e.g., definitions, theories, codes, laws, and rules), or backing (e.g., evidence, such as statistics or expert opinions). Common keywords: 'because', 'since', 'due to the fact that', etc.	"According to WTO (2015), the measures are inconsistent with both Art. 3.1 and Art. 3.2 because they aren't based on 'the relevant international standard' according to Chapter 10.4 of the OIE terrestrial code"	2
grounded and qualified claims	Claims present both grounds and limitations of its validity (qualification).	"Furthermore, if you regard the risk assessment as a source of 'relevant scientific evidence' for the justification of a ban, I argue that India has no sufficient scientific evidence to justify its SPS measures and is therefore not in compliance with 2.2 ."	3
non-argumentative moves	Comprise questions, coordinating moves, and meta-statements on argumentation.	"What do you think about article 5.2?", "We could start with article 5.1", and "I really like your answer"	0

3.3.5.1.2 Assessing and measuring quality of argumentative sequences

To measure the quality of the construction of argumentative sequences, each student message was coded following Leitão (2000). The coding process distinguished between *arguments*, *counterarguments*, *integrations*, and *non-argumentative moves* (Kollar et al., 2007; Leitão, 2000; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2007; Weinberger & Fischer, 2006). To address the problem of messages with two or more segments presenting different argumentative sequence codes, a weight-based hierarchy based on the elements' sequence order was used to decide the code with more weight, see Table 10. We assigned points to each message as described in Table 10. Then, for each student we counted and summed the points.

Table 10 Assessing and measuring quality of argumentation sequences

Type	Definition	Example	Points/weight
arguments	A statement put forward in favor of a specific proposition that comprises claims that have not been discussed previously.	Student 1 "That means that can have higher level of protection, which could we see as a right to ban importing of chicken from other countries, where they had AI? What is your opinion?"	1
counterarguments	An argument that opposes or attacking a preceding argument, or an argument favoring an opposite proposition of a preceding argument	Student 2 "good job, you say 'precautionary principle', so for the protection, they have the available evidence, but for the whole trade, they do not, so they just can follow the precautionary action, means that is a kind of temporary action, they cannot restrict the trade for a very long time."	2
integrations	A statement that aims to balance, integrate, and advance a preceding argument and counterargument on a higher level. Counterarguments and integrations can refer to learning partners' arguments or to own arguments.	Student 3 "I believe they can protect themselves by imposing a higher standard, but indeed, for a short amount of time because of the precautionary principle."	3
non-argumentative moves	Comprised questions, coordinating moves, and meta-statements on argumentation.	"What is your opinion?" (see example for arguments)	0

3.3.5.1.3 Assessing and measuring quality of transactivity

To measure the quality of transactivity, student's contributions were coded using the *social mode dimension* following Noroozi, Teasley, et al. (2013) and Weinberger and Fischer (2006). The process of coding differentiated between six social modes: *externalization*, *elicitation*, *acceptance*, *integration*, *conflict* and *no-reaction*. To address the problem of messages with two or more segments presenting different social modes, a weight-based hierarchy, based on Teasley (1997)'s scale of transactivity, was used to decide the most transactive code (Noroozi, Teasley, et al., 2013). The hierarchy, from most to least transactive, is as follows: conflict, integration, elicitation, acceptance, externalization, and no-reaction. We assigned points to each message as described in Table 11. Then, for each student we counted and summed the points. In addition, we calculated for each student the proportion of conflicts, integrations, elicitations, acceptances, externalizations, and no-reactions with respect to his/her total amount of messages.

Table 11 Assessing and measuring quality of transactivity

Segment type	Definition	Example	Points/weight
externalization	When students expose thoughts to the group without reference to previous messages, such as the first discussion post or when students juxtapose externalizations, that is, students reply to previous externalizations by a further externalization.	"Your structure is indeed very clear, by the way!"	1
acceptance	When a) students agree to what has been said without further elaboration, b) students agree to what has been said by only repeating what has been said, c) students accept what has been said in order to move on with the task. This does not mean that they are convinced or agree with what has been said, and may not indicate a chance of opinion, but is rather a coordination move.	"Thanks, I will do that in my revised version" "Very clear reasoning and use of sources. Nothing to add!"	1
elicitation	When students ask for, or invite, a reaction from their learning partners. Elicitation aims at receiving information from the learning partners.	"What make you think India's measure was in concordance?"	2
integration	When students adopt their learning partners' perspectives and reason on this basis. This implies that students revise or change their opinion.	"So, it looks like India thought it complied to the int. standards but the panel consulted the OIE and found it was not sufficient."	3
conflict	When students present alternatives, reject, deny, modify, replace, or give a negative answer or evaluation to what has been said by the learning partner.	"But I say India didn't comply to international guidelines, and you say they did. So maybe we have an interesting discussion here"	3
no-reaction	When a) students do not respond to questions or other forms of elicitation from their learning partners, or b) students reply to a (parent) message of the learning partner without referring to what the learning partner has said in the message being replied.	Student 1 "The AB says that the Panel hasn't considered the arguments and evidence put forward by India. And that India only bans products from countries with AI, so that it's based on evidence (bluntly stated). And indeed only not a good risk assessment." Student 2 "By the way, the discussion is officially till 9.45 and the revising is from 9.45-10.15 :)"	0

3.3.5.2 Assessing and measuring individual acquisition of domain-specific knowledge

The intake questionnaire and the revised assignment were used to measure the individual acquisition of domain-specific knowledge. The intake questionnaire, the original assignment and the revised assignment were scored considering seven points provided by the course coordinator, covering theoretical concepts, problem case facts and their relation. Students received a score-point for each solution-point they covered. The indicator of domain-specific knowledge for each participant was then the sum of points in a given assignment. The overall knowledge gain was calculated as the difference between the intake questionnaire and the revised assignment. The median (med= 3) of the overall domain-specific knowledge gain was used as criterion to differentiate between successful and less-successful students. Three students in the less-successful group were moved to the successful group as they were holding the same gain as 14 students in such group. Thus, we had 30 successful and 24 less-successful students.

3.3.5.3 Assessing and measuring argumentation knowledge

Students' knowledge of argumentation was measured in the intake and exit questionnaires using tests designed and employed previously by Noroozi, Weinberger, et al. (2013). The test was comprised of two tasks. Firstly, students had to identify the best argumentative texts and provide explanations and arguments supporting their selection. Students could receive a maximum of five points, two for selecting the correct text, and a maximum of three for the explanations and arguments supporting their selection. Secondly, students' individual knowledge of the quality of single arguments and argumentative sequences was measured in the intake and exit questionnaires. A student could obtain a maximum of fourteen points. Both the points were converted to a decimal scale, then the average was calculated and used as indicator of argumentation knowledge. The gain of knowledge from pre-test to post-test was calculated and used as an indicator for the acquisition of argumentation knowledge.

3.3.5.4 Measurement of attitude towards argumentation

Students' attitude towards argumentation was measured using a revised version of the questionnaire designed and employed previously by Noroozi, Biemans, Weinberger, Mulder, and Chizari (2013). The questionnaire was comprised of 20 items on a five-point Likert scale ranging from 'Strongly disagree' to 'Strongly Agree'. The items asked in the questionnaire aimed to ascertain students' attitudes towards argumentation. For example, students were asked to rate themselves on statements such as 'argumentation fosters learning', 'argumentation adequately addresses critical assessment of each other's work', 'learning should involve social negotiation', 'I try to avoid conflicts with my learning partners to keep away from discussions', etc. The reliability coefficient was sufficient (Cronbach $\alpha = .80$).

3.3.5.5 Measurement of participation dimension

The quantity of participation was measured by counting the number of words in the assignments using the count word function of word-processing software. Similarly, the heterogeneity of participation was obtained by counting the number of contributions during collaboration for each student.

3.4 Analysis

We used correlations to determine the relationships between students' knowledge, behavior and attitude towards argumentation. The Pearson product-moment correlation coefficient was used to determine the aforementioned relationships if the assumptions of normality, linearity and homoscedasticity were met. Otherwise, Kendall's tau was used. One-way analysis of variance (ANOVA) tests were used to compare mean differences of argumentation behavior between successful and unsuccessful students. Furthermore, factorial repeated measures ANOVA tests (or mixed between-within subjects or Split-Plot) were used to compare argumentation behavior of successful and less-successful students over time.

3.5 Results and Discussion

In this section, we present the results for each of the research questions.

Research Question 1: What are the relationships between students' argumentation knowledge, behavior, and attitude and their relationship with domain-specific knowledge acquisition?

The results are presented in Table 12. Students' knowledge, behavior and attitude towards argumentation did not present significant relationships either at the pre-test and post-test. However, domain-specific knowledge (pre-test) presented small significant relationships with argumentation behavior (pre-test) and with the construction of single arguments (collaboration). Similarly, domain-specific knowledge (post-test) presented a medium significant relationship with argumentation behavior (post-test). The latter results suggest that the more students know and understand about the topic, the more they will present arguments without regard for the application or the social plane.

Argumentation behavior at pre-test presented small and medium significant relationships with the construction of single arguments, transactivity and argumentation behavior at collaboration. Similarly, the construction of single arguments, transactivity and argumentation behavior at collaboration presented small significant relationships with argumentation behavior at post-test (see Table 12). The latter suggest that students were able to transfer their argumentation behavior from the individual level to the collaborative level and back to the individual level.

Table 12 Correlations between argumentation knowledge, argumentation behavior, attitude towards argumentation and domain-specific knowledge

			Pre				Collaboration				Post			
	Variable		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Pre	1 ArgAttitude	ρ	-											
		Sig.	-											
		N	-											
	2 ArgKnow	ρ	0.138	-										
		Sig.	0.315	-										
		N	55	-										
	3 DomainKnow	ρ	-0.031	0.128	-									
	(assignment)	Sig.	0.825	0.351	-									
		N	55	55	-									
	4 ArgBehavior/	τ	0.03	0.16	.282**	-								
	SimpleArg	Sig.	0.754	0.092	0.005	-								
		N	55	55	57	-								

Collaboration	5 SimpleArg	τ	-0.006	0.069	.283**	.290**	-						
		Sig.	0.948	0.474	0.006	0.003	-						
		N	55	55	57	57	-						
	6 Transactivity	ρ	-0.001	0.234	0.078	.334**	.397**	-					
		Sig.	0.993	0.086	0.563	.000	.000	-					
		N	55	55	57	57	57	-					
	7 ArgSequence	τ	-0.044	0.055	0.068	0.187	.508**	.341**	-				
		Sig.	0.653	0.58	0.513	0.058	.000	0.001	-				
		N	55	55	57	57	57	57	-				
	8 ArgBehavior	τ	-0.005	0.121	0.159	.339**	.726**	.659**	.589**	-			
	(5+6+7)	Sig.	0.959	0.203	0.114	.000	.000	.000	.000	-			
		N	55	55	57	57	57	57	57	-			
Post	9 ArgAttitude	ρ	.666**	0.183	0.077	-0.017	0.127	0.025	0.009	0.106	-		
		Sig.	.000	0.204	0.587	0.868	0.206	0.862	0.93	0.285	-		
		N	50	50	52	52	52	52	52	52	-		
	10 ArgKnow	ρ	0.181	.679**	0.194	0.157	0.092	0.186	0.023	0.138	0.104	-	
		Sig.	0.214	.000	0.172	0.112	0.36	0.192	0.824	0.161	0.467	-	
		N	49	49	51	51	51	51	51	51	51	-	
	11 DomainKnow	ρ	-0.027	0.115	.864**	.305**	.262*	0.08	0.189	0.174	0.129	0.145	-
		Sig.	0.849	0.414	.000	0.003	0.012	0.564	0.077	0.088	0.372	0.32	-
		N	53	53	55	55	55	55	55	55	50	49	-
	12 ArgBehavior/	τ	0.097	0.114	.260*	.669**	.214*	.223*	0.186	.233*	0.026	0.074	.368**	-
	SimpleArg	Sig.	0.314	0.239	0.011	.000	0.028	0.022	0.062	0.015	0.795	0.463	.000	-
		N	53	53	55	55	55	55	55	55	50	49	55	-

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Variable	Description	Variable	Description
ArgAttitude	Attitude towards argumentation	DomainKnow	Domain-specific knowledge
ArgKnow	Knowledge on argumentation	SimpleArg	Construction of simple arguments
ArgBehavior	Argumentation behavior	ArgSequence	Construction of argumentative sequences
Pre	Pre-test	Post	Post-test
ρ	Pearson	τ	Kendall's tau

Research Question 2: What are the differences in argumentation behavior between successful and less-successful students in terms of domain-specific knowledge gain?

On average, successful students did better than less-successful students in terms of argumentation behavior in the original answer, the revised answer and also during collaboration (see Table 13). However, ANOVA tests indicated that the difference was only significant in the revised answer, $F(1, 52) = 4.43$, $p = .04$, $\eta^2 = .078$, $\omega^2 = .059$, with a moderate effect (J. Cohen, 1988, pp. 284-287; Kirk, 1996).

Factorial repeated measures ANOVA tests on argumentation behavior of successful and less-successful students over time indicated that there was a significant large effect of time on argumentation behavior, *Wilks' Lambda = .703, F(1, 52) = 21.95, p < .001,* $\eta 2 = .297$. Such result indicates that the argumentation behavior of both successful and less-successful students improved over time. Also, there was no statistically significant difference between the two student types, i.e. successful and less-successful students. Finally, the interaction effect was not significant, *Wilks' Lambda = .929, F(1, 52) = 3.99, p = .051,* $\eta^2 = .071$. However, results suggest that successful students gained more from the task.

Finally, successful students wrote more words on average than less-successful students in both the original (369 vs. 296 words) and revised answers (443 vs. 336 words), but the difference was not statistically significant in either case. Regarding heterogeneity, successful students contributed slightly less (4.47 times) on average than less-successful students (4.58 times), but the difference was not significant (see Table 13).

Table 13 Descriptive statistics for behavior, assignment's words & score (domain knowledge), and contribution (during collaboration)

		Successful		Less-successful		Total (group)		
		M	SD	M	SD	M	SD	Test
Pre	ArgBehavior	16.87	10.23	14.17	7.78	15.67	9.24	F(1, 52) = 1.14, p = .29
	DomainKnow	3.27	1.26	1.46	1.25	2.46	1.54	
	No. of words	369	232	296	206	337	222	
Post	ArgBehavior	21.53	10.55	16.04	8.04	19.09	9.83	F(1, 52) = 4.43, p = .04, η2= .078, η2= . 059
	DomainKnow	3.7	0.91	1.46	1.22	2.7	1.54	
	No. of words	443	226	336	234	396	234	
Collaboration	Contributions	4.47	2.2	4.58	2.5	4.52	2.32	
	SimpleArg	6.4	6.02	5.08	5.76	5.81	5.89	
	Transactivity	8.33	4.14	8.54	4.08	8.43	4.08	
	ArgSequence	3.1	2.63	2.46	2.6	2.81	2.61	
	ArgBehavior	17.83	10.42	16.08	10.68	17.06	10.47	F(1, 52) = .368, p = .547

3.5.3 Discussion

In our theoretical framework, we defined argumentation competence as an integrated capability, in which its comprising elements, i.e. argumentation knowledge, argumentation behavior and attitude towards argumentation, are intrinsically interwoven. Such a statement suggests the existence of relationships between the comprising elements. Therefore, the present exploratory study aimed to investigate if such relations exist in a regular, online learning environment, in which students' learning activities are not scaffolded at micro- or macro levels. We opted for such a setting, because scaffolding can facilitate students' participation, acquisition of skills or knowledge during a task or activity (Belland, 2010; Hannafin et al., 1999; D. Wood et al., 1976), which may influence the outcomes (Noroozi et al., 2012; Scheuer et al., 2010). Following, the results of each research question are discussed.

Contrary to our expectations, students' knowledge, behavior and attitude towards argumentation did not present significant relationships at pre-test or post-test. It is striking that attitude towards argumentation was not related to knowledge and behavior, as previous research indicates that students' attitude (e.g., psychological, emotional, motivational, and social barriers) may affect argumentative discourse activities (Baumeister & Scher, 1988; Gilbert, 2004; Leith & Baumeister, 1996; Polo et al., 2016; Polo et al., 2017; Rourke & Kanuka, 2007). Similarly, the (lack of) compensation participants receive for their participation may play a role. Students receiving compensation, e.g., a grade or money, may be extrinsically motivated by the reward and, thus, may perform better as participants without such an incentive. Beers, Kirschner, Boshuizen, and Gijselaers (2007, p. 539), conducted their study 'under highly regulated circumstances with highly motivated participants' to reduce the effects of social processes. Therefore, the lack of compensation and less controlled nature of the present study context may explain the lack of relation between attitude towards argumentation and both argumentation knowledge and argumentation behavior. Moreover, students' argumentation knowledge and argumentation behavior were not significantly related. Such a result is in line with previous findings in the literature, in which students with knowledge of the construction of single arguments were not able to put their knowledge into practice during discourse or in a similar argumentation task (Kollar et al., 2007; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007). The results suggest that students present problems in externalizing their argumentation knowledge both at the individual (argumentative essay) and collaborative levels (argumentative discourse), and that they need to further develop their argumentation competence. Therefore, the design, implementation and evaluation of instructional scaffolds to support and facilitate students' participation, externalization of current knowledge, and acquisition of skills or knowledge during collaborate learning (Belland, 2010; Hannafin et al., 1999; D. Wood et al., 1976; Zohar

& Nemet, 2002) or the specific instruction of argumentation is required (Zohar & Nemet, 2002). For example, argumentation scaffolds can facilitate the construction of arguments, and can guide and engage students in fruitful argumentative discourse activities (Noroozi et al., 2018). Similarly, argumentation scaffolds can also facilitate the writing and the provision of peer-feedback to argumentative essays (Noroozi et al., 2016). An overview of research literature on argumentation scaffolds on online learning systems, e.g., graphical representations (diagrams formed by nodes and links, tables, and visualizations), or text-based representations (hints, prompts, or scripts), can be found in Noroozi et al. (2012), Scheuer et al. (2010) and Kirschner et al. (2003).

An interesting result was the significant relationship between argumentation behavior at pre-test and argumentation behavior at collaboration, and the significant relationship between argumentation behavior at collaboration and argumentation behavior at post-test, that is across different applications and social planes. Such relationships suggest that students' argumentation behavior is not dependent of the application, e.g., argumentative essay or argumentative discourse, or the social plane, e.g., individual or collaborative, and that student's argumentation behavior can operate back and forth between applications and social planes. The aforementioned relationships may be explained by the positive relationship between domain-specific knowledge and argumentation behavior. Students having more domain-specific knowledge may be able to present a clearer position with data supporting or opposing it, or to consider or refute the point of view of their learning partners. The latter is in line with what the results from von Aufschnaiter et al. (2008, p. 1) suggested, that is "the main indicator of whether or not a high quality of argument is likely to be attained is students' familiarity and understanding of the content of the task". In contrast to previous research (Belland, 2010; Kollar et al., 2007; Noroozi, Teasley, et al., 2013; Noroozi, Weinberger, et al., 2013; Rapanta et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007; Weinberger et al., 2005; Weinberger et al., 2013), the relationships of argumentation behavior across different applications and social planes highlights the importance of measuring argumentation knowledge and argumentation behavior before and after collaborative discourse, and argumentation behavior during the latter.

Results indicated that on average, successful students presented a higher quality of argumentation behavior in the original answer, the revised answer and during collaboration. However, the difference was only significant in the revised answer.

Results showed that argumentation behavior of successful and less-successful students increased over time. The improvement in the quality of argumentation behavior is in line with the claims from several authors on the field who argued that Computer-Supported Collaborative Learning (CSCL) has a positive effect on learning outcomes (Andriessen et al.,

2003; Kollar et al., 2007; Noroozi et al., 2016; Noroozi, Biemans, et al., 2013; Noroozi, Teasley, et al., 2013; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007; Weinberger et al., 2005; Weinberger et al., 2010).

The improvement in quality may be related to different factors. For instance, students seeding the discussion with their original solution allowed them to explicate their knowledge and contrast their ideas and knowledge conceptions with those of their learning partners (Weinberger & Fischer, 2006). Awareness of learning partners' knowledge may lead to the use of their partners as a resource by asking questions (P Dillenbourg, Baker, Blaye, & O'Malley, 1995). Also, students may engage in a process of negotiation to reach common ground (H. H. Clark, Brennan, Resnick, Levine, & Teasley, 1991). The negotiation process may engage students in argumentative discourse, which may lead to integration of each other's ideas, perspectives and conceptions (Roschelle & Teasley, 1995b; Weinberger & Fischer, 2006). The negotiation process can also lead to conflict and critique, which has been deemed important in collaborative learning (Teasley, 1997). Students facing critique may be urged to evaluate others perspectives or to create better arguments to support their positions (Chan, Burtis, & Bereiter, 1997; Weinberger & Fischer, 2006). Providing a critique requires pointing out specific aspects of the partner's contributions, thus, students have to operate on the partner's reasoning on detail (Weinberger & Fischer, 2006). The aforementioned process of transactivity has been related to knowledge acquisition (Noroozi, Teasley, et al., 2013; Noroozi, Weinberger, et al., 2013; Teasley, 1997; Weinberger & Fischer, 2006).

The learning environment can also be related to the improvement in argumentation behavior. The threaded forum allowed students to keep track of the discussion, facilitated going back and forth to re-read the contributions, and made salient the relationships between contributions and replies. Moreover, CSCL environments can facilitate the generation of arguments, the discussion, elaboration, exchange and integration of ideas and knowledge, which could likely lead to a deeper understanding of the topic (Marttunen & Laurinen, 2001; A.L. Veerman, 2001; Veldhuis-Diermanse, 2002) and the development of higher-order thinking (Jong, Veldhuis-Diermanse, & Lutgens, 2002).

Finally, successful students wrote more words on average than less-successful students in the original assignment (pre-test) and in the revised assignment (post-test). The previous results suggest that successful students made more substantial or meaning-level changes (K. M. Baker, 2016; Faigley & Witte, 1981) as they may be more skilled (Sommers, 1980). Yet, this cannot be confirmed as our analyses did not cover such level.

3.5.4 Conclusions, Limitations, and Suggestions for Future Research

This article explored the relationships between argumentation competence components (knowledge, behavior and attitude) and domain-specific knowledge, and the differences

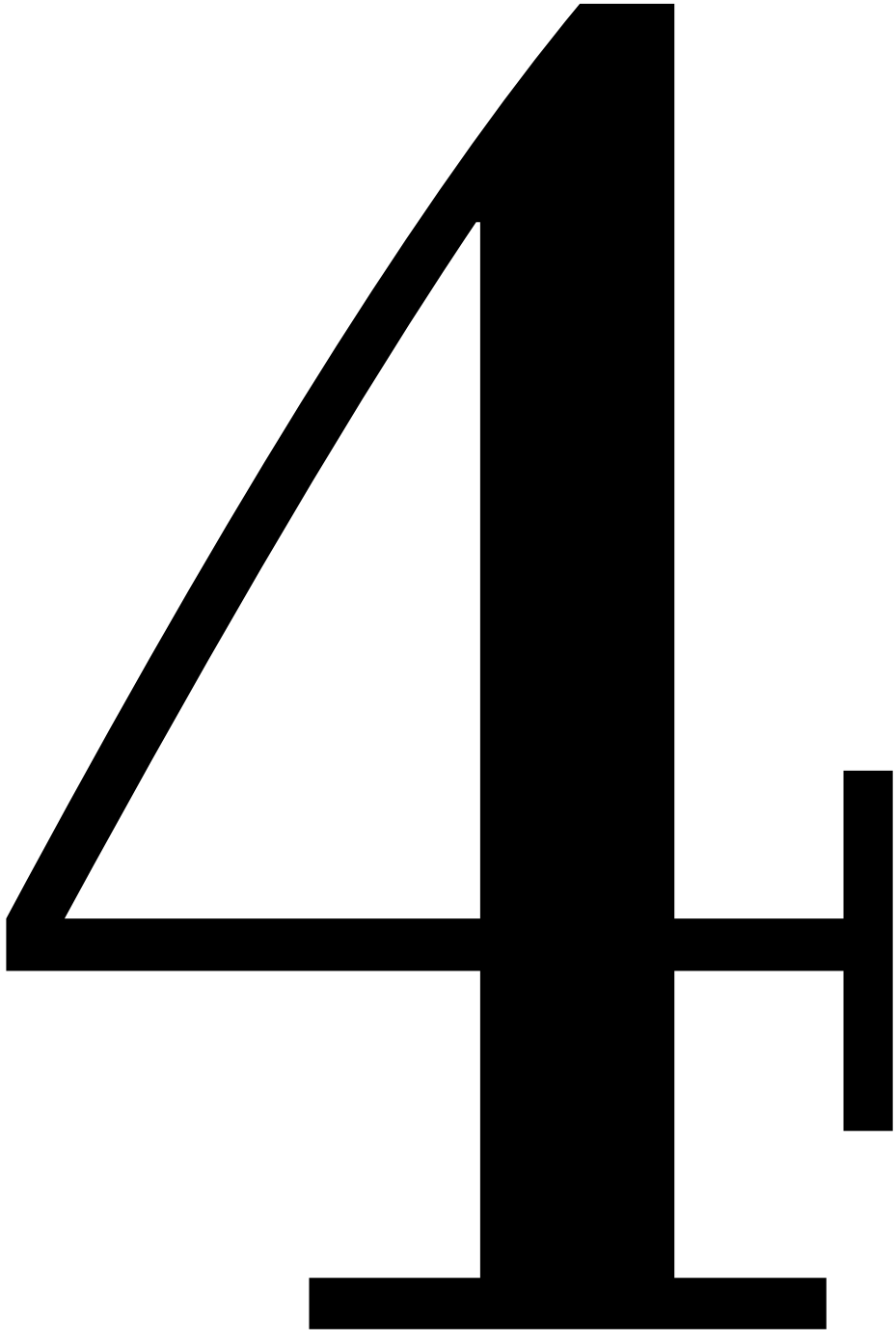
in argumentation behavior between successful and less-successful students, in terms of domain-knowledge gain. The study setting provided direct practical relevance of a learning scenario without argumentation scaffolds. Based on the results, it was suggested that the lack of relation between attitude towards argumentation and both argumentation knowledge and argumentation behavior may be related to the lack of compensation and less controlled nature of the present study. Additionally, based on the current study results, we argued the need to design, implement and evaluate argumentation scaffolds to facilitate the writing of argumentative essays, and to guide and engage students in fruitful argumentative discourse, since students struggle to transfer argumentation knowledge to applications. Moreover, relationships between argumentation behavior at individual and collaborative levels suggested that students' argumentation behavior can operate back and forth between different applications and social planes. The latter may be explained by the relationship between students' argumentation behavior and their knowledge on the topic; the more students know and understand about the topic, the more they will present arguments without regard of the application or the social plane. Furthermore, although the argumentation behavior of successful and less-successful students increased over time, the former did better on average. The improvement in the quality of argumentation behavior contributes to empirical evidence that CSCL has a positive effect on the learning outcomes. Contrary to our expectations, no significant relationships were found between the elements of argumentation competence at pre-test or post-test. Such results suggest the need to design, implement and evaluate instructional scaffolds to foster students' argumentation competence.

We made the deliberate choice of not having a control condition as the goal of the present study was not related to an intervention, but rather to the understanding of argumentation competence and the relationships between its comprising elements in a real un-scaffolded educational setting. The setting of the present study offered some constraints and limitations that serve as starting point for future research recommendations. Real educational settings, as in this study, offer high practical relevance (high ecological validity). In the present study, students' participation was motivated by requiring submission of the assignments to take the final examination. Furthermore, students were not graded on the assignments, as that was not described in the course description. Not grading students' assignments may lure students to put less effort into the activities, which may produce different results due to possible variations in students' attitude and behavior. To achieve an authentic behavior from the students, it is necessary to treat experimental course content as regular content, that is, to grade it and count it towards the final grade. However, it is difficult to convince teachers to conduct experiments in their classes, and is even more difficult to have such content graded and counted towards the final grade because teachers are afraid of negative course evaluations from the students. Therefore, teachers are only willing to change course

content once educational innovations have been tested and results are positive. The latter implies that integration of new course content features requires an iterative process that may be long and bureaucratic, which may hinder innovation.

This study analyzed students' assignments and discussions in terms of construction of single arguments, construction of argumentation sequences, transactivity, and the participation dimension. Yet, it lacks an analysis on content improvement in terms of surface- and meaning-level changes and their relation to student's argumentation competence.

Future research should further investigate the relationship between argumentation behavior and domain-specific knowledge, e.g., if higher domain-specific knowledge implies better argumentation behavior. Furthermore, research should be conducted to assert the effect of highly-controlled environments and rewards in the relations between the elements of argumentation competence and domain-specific knowledge.



Chapter 4

Students' argumentative essay writing and domain-specific knowledge acquisition in the field of biotechnology: Towards understanding the possible potential of an online learning environment with worked examples and peer feedback*

*This chapter is based on:

Valero Haro, A., Noroozi, O., Biemans, H. J. A., & Mulder, M. (2019). The effects of an online learning environment with worked examples and peer feedback on students' argumentative essay writing and domain-specific knowledge acquisition in the field of biotechnology. *Journal of Biological Education, 53*(4), 390-398. doi:10.1080/00219266.2018.1472132

4.1 Abstract

The present study investigated the effects of an online learning environment supported with worked examples and peer feedback on students' argumentative essay writing and domain-specific knowledge acquisition in the field of biotechnology. As part of a bigger project, a pre- and post-test study design was used with 45 bachelor students who were randomly grouped in pairs. Students were asked to analyze a case and write an argumentative essay taking into account the advantages and disadvantages of genetically modified organisms. The results showed that students' quality of argumentative essay writing and acquisition of domain-specific knowledge increased from pre-test to post-test. At this point, however, it should be noted that further research with a control group is needed to examine possible causal relationships. Implications, suggestions, and future research are discussed.

4.2 Introduction

Biotechnology is making a large and rapid impact on society, and new advances typically present socio-scientific issues that divide the public's opinion (van Lieshout & Dawson, 2016). Therefore, students should be aware of the practical applications, and the ethical and societal aspects and implications of biotechnology to make well-informed ethical decisions (Dawson & Schibeci, 2003). One potential way to facilitate students learning on biotechnology is using online learning environments. In the particular field of biotechnology, online learning environments have been designed to, among others, develop students' laboratory skills (Hsiu-Ping, Tzy-Ling, Weijane, & Horn-Jiunn, 2014), or acquire domain-specific knowledge (Cheaney & Ingebritsen, 2005; Noroozi & Mulder, 2017; van Seters, Wellink, Tramper, Goedhart, & Ossevoort, 2012). Online learning environments offer multiple advantages such as adapted or personalized instruction to students with varying prior knowledge (van Seters et al., 2012), fostering domain-specific knowledge acquisition (Diederen, Gruppen, Hartog, Moerland, & Voragen, 2003), or promoting active learning, providing individualized feedback, or reducing cognitive load (Busstra, Feskens, Hartog, van't Veer, & Kok, 2008). Online learning environments can include multiple user interface affordances such as texts, diagrams and pictures to guide and orchestrate the student toward productive activities and learning (Fischer et al., 2013; Suthers, 2003).

In the context of science, argumentative essay writing is crucial. Students should think critically and reason logically to justify and argue they decisions, point of views and opinions in contrast to the ones of others (Noroozi et al., 2018). However, the argumentative essay writing aptitude of undergraduate and graduate student's is typically below the level necessary to accomplish writing tasks of sufficient quality at school or the workplace (Cooper et al., 1984; Kellogg & Whiteford, 2009). This is striking since writing 'is an important tool for thinking, learning and domain-specific knowledge creation' (Dysthe, 2007, p. 237), and is also a good predictor of success during the first year of higher education (Geiser & Studley, 2002). Insufficient argumentative essay writing skills can be related to insufficient practice at school/universities (Kellogg & Whiteford, 2009), the enormous efforts required from teachers to grade the essays and provide feedback to students (K. M. Baker, 2016; Cooper et al., 1984), and the fact that argumentation competence is regularly developed indirectly and informally in the classroom (Driver et al., 2000; Osborne, 2010). Scientific literature suggests that the use of online learning environments along with worked examples (also known as example-based learning) (Schwonke et al., 2009; Sweller et al., 1998; Wittwer & Renkl, 2010) and peer feedback (Hattie & Timperley, 2007; Kluger & Denisi, 1996) can be considered as a promising approach to facilitate argumentative essay writing.

Feedback is characterized as an action where an external agent, e.g., a peer or a computer system, provides information concerning one or more aspect(s) of our performance in a task or our understanding (Hattie & Timperley, 2007; Kluger & Denisi, 1996). The main ideas behind peer-learning are that peers' social status is the same, and to cut down immediate teacher intervention and allow students to learn with and from each other (Boud et al., 1999, p. 413). Receiving and giving feedback from and to peers, i.e., peer feedback, with comparable motivations is a relevant element of the learning process (Bayerlein, 2014; Crisp, 2007) because feedback can orchestrate and guide students' learning (Crisp, 2007; Orsmond, Merry, & Reiling, 2005) and increase learning (Hattie & Gan, 2011; Hattie & Timperley, 2007; Shute, 2008). Similarly, students may learn during and from the discussion itself (Knight & Wood, 2005; Smith et al., 2009) since students facing critique may consider the peer's perspective and may construct better arguments to support their own perspective taking the peer's perspective into account (Chan et al., 1997; Weinberger & Fischer, 2006). According to Winne and Butler (1994), the information contained in a peer feedback event can contain information that can help the learner to confirm, complement, overwrite, or restructure students' domain-specific knowledge, meta-cognitive knowledge, beliefs or cognitive tactics and schemas.

An instruction method that has been extensively researched is learning from worked examples (Wittwer & Renkl, 2010) where students learn by studying from fully worked examples, i.e., examples with solutions steps and the final solution (Ayres, 2012). Its effect is known as the *worked example effect*, and is among the best established findings in cognitive load theory (Schwonke et al., 2009; Sweller et al., 1998). However, worked examples typically include only *product-oriented information*, e.g., the solutions steps and the final solution, thus they are not particularly effective facilitating the process of acquisition of meaningful and flexible knowledge (Van Gog, Paas, & Van Merriënboer, 2004). Therefore, worked examples should also include *process-oriented information*, that is, the rationale of why certain solution steps should be followed (Wittwer & Renkl, 2010). Providing the rationale behind the steps or tasks that need to be conducted is supposed to facilitate the internalization of the process. The latter may support students to: a) provide high-quality feedback which is beneficial to enhance their writing skills (DeNisi & Kluger, 2000), and b) provide on-task feedback rather than off-task feedback on personal evaluations of the learning partner which is less effective (Hattie & Timperley, 2007).

As such, the combination of theory or instructional explanations with worked examples facilitates understanding and impedes the creation of misconceptions and inconsistencies (Wittwer & Renkl, 2010). Furthermore, including problems to be solved increases the effectiveness of example-based learning (Ayres, 2012; Pashler et al., 2007). However,

there are situations that may affect the effectiveness of work examples. For instance, work examples effectiveness decreases as students gain experience, such effect is known as the *expertise-reversal effect* (Kalyuga, Ayres, Chandler, & Sweller, 2003). Similarly, experienced students may invest cognitive resources in instructional support that may be redundant, i.e., the *redundancy effect* (Sweller, 2005; Sweller et al., 1998). The latter, may inhibit student's self-regulation and learning.

In previous research, the quality of argumentative essays and the acquisition of domain-specific knowledge have been successfully supported by argumentative peer feedback scripts (Noroozi et al., 2016). However, it is unclear if combining worked examples and peer feedback can improve the learning outcomes. Hence, this study aimed to investigate the effects of example-based learning and peer feedback on students' domain-specific knowledge acquisition and argumentative essay writing on the field of biotechnology in the form of the following research questions:

Is there potential in an online learning environment with worked examples and peer feedback on students' domain-specific knowledge acquisition?

Is there potential in an online learning environment with worked examples and peer feedback on students' argumentative essay writing?

4.3 Method

4.3.1 Context and Participants

A study with a pre- and post-test design with participants randomly grouped in pairs was conducted in September 2016 at a university in the Netherlands specialized in life sciences. The participants were 45 Bachelor of Science (BSc.) students registered in a course aimed at introducing students to the domain of biotechnology. The course covers diverse ethical issues relevant to the practice of biotechnology and their significance to society. The mean age of the participants was 18.11 years (SD = .65, MIN = 17, MAX = 20). Students were mostly Dutch (97.8 %). About two-thirds of the students were male and a third female.

4.3.2 Materials, Learning Tasks and Online Learning Environment

The learning topic was "insect-cells for cultured meat manufacturing" which falls under the overarching theme of Genetically Modified Organisms (GMOs). Specifically, students were asked to write an argumentative essay on the statement: 'Insect-cell biomass infected with genetically modified baculovirus is a healthy meat alternative'. To compose the essay, students received a case description, a summary of theory about the topic,

hyperlinks to scientific publications, and freedom to do further investigation on the Internet. Students were asked to consider various views and opinions on whether or not using 'insect-cells for cultured meat manufacturing' is a necessity or a fad (see Noroozi et al., 2016). All the instructions were embedded in an online learning environment that was designed and implemented for the study. The learning environment offered information in different forms such as texts, diagrams, and pictures. Additionally, the learning environment provided students theory and a worked example on how a good argumentative essay should look like. According to Noroozi et al. (2016), argumentative essays should include a clear position followed by arguments and evidence in favor of the position, and arguments weakening or against the position. Next, essays should take into account and refute the opponents' opinions, integrate arguments in favor and against the topic, and formulate a conclusion. Finally, essay elements' specifics should be adjusted to the respective discipline because there are variations between disciplines. The learning environment also facilitated the peer feedback process by assigning roles to students, i.e., assessor and assesse, and orchestrating the interaction of the learning partners, e.g., feedback provision, with scripts (Fischer et al., 2013). Finally, the learning environment allowed students to revise their essays considering the peer feedback received. A timer with the expected completion time was available for each of the different parts of the learning environment. Similarly, a word counter for each input box was available.

4.3.3 Procedure

The study consisted of four phases that took place over a period of four consecutive days. Students had the freedom to complete all the phases from their preferred location within the stipulated time frame. On day one, an introduction to the learning environment was given during class time (20min). Next, students logged in to the learning environment and completed a questionnaire on domain-specific knowledge (15 min). On day two, students, individually, read a theoretical text and scientific publications on the learning topic, with instructions indicating the most relevant parts (30 min), searched on the Internet for more information and sources (e.g., daily papers, periodic journals, and scientific papers) (30 min), and wrote an argumentative essay of ca. 500 words (min. 450, max. 550 words) individually (45min). On day three, students read a theoretical text on how to write an argumentative essay and received an example of an argumentative essay. Then, each student provided peer feedback to his or her learning partner (90 min). The peer feedback form was a single text field where students had to give feedback (ca.400, min. 350, max. 450 words) to the argumentative essay of their learning partner. The learning environment checked that the answers' word count were within the lower and upper bounds, if the requirements were not met, the learning environment showed textual and visual feedback. Next, students revised their own argumentative essay based on the feedback from their learning partner. Finally, students completed questionnaires on domain-specific knowledge (the same as the pre-test) (15 min), and were debriefed

(5 min). The total time for the study was 335min. approximately.

4.3.4 Measurements

The quality of student's written argumentative essays, i.e., the original and the revised, was measured using the coding scheme developed by Noroozi et al. (2016). The scheme considers the features of a complete and sound argumentative essay within the context of biotechnology and was developed in conformity with the literature (Andrews, 1995; Qin & Karabacak, 2010; Toulmin, 1958; N. V. Wood, 2001). The scheme was validated using a series of consultation meetings and discussions with a panel comprised of experts and teachers.

The coding scheme contains different elements with multiple levels. Every level is comprised of a label, a description, points, and examples to make the coding process easy and unambiguous. A score, between zero and two, was assigned for each of the following elements of the student's argumentative essays: a) Intuitive opinion, b) arguments in favor of the topic or pro-arguments, c) scientific facts in favor of the topic or pro-facts, d) arguments against the topic or con-arguments, e) scientific facts against the topic or con-facts, f) opinion on the topic considering various pros and cons or integration of pros and cons, g) scientific facts to support opinion on the topic after integration of pros and cons or integration of pro- and con-facts, and h) conclusion. The assessment scores were given as follows: two points for level 2 or elaborated, one point for level 1 or non-elaborated, and zero points for level 0 or not mentioned. Therefore, the student's quality score of writing argumentative essays is the sum of all points of an essay, with a maximum of 16 points.

The interrater agreement was sufficient (Cohen's Kappa = 0.873) according to Landis and Koch (1977). The interrater agreement with two coders (i.e., the first author and a trained coder) was obtained by randomly selecting 5% of the original and revised assignments. To guarantee reliability, the coder was trained on the coding process and the coding rubrics. Next, the first author and the coder coded 5% of the data independently. The coding discrepancies were resolved through discussion until agreement was reached. Finally, the trained coder coded the rest of the data.

Domain-specific knowledge was measured during pre- and post-test using a questionnaire developed by the course coordinator. This questionnaire was comprised of 17 multiple-choice questions and one open question, e.g., 'What is a continuous animal cell line?', 'Insects that are commercially cultivated include…', 'A baculovirus is…', 'What is a "master cell bank"?' For each question students received a point, for a total of 18 points. Then, the domain-specific knowledge score was calculated for each student on a scale from 0 to 1 (#points/18) and then multiplied by 10 to have scores on a scale from 0 to

10. The result was used as the domain-specific knowledge score for the given test.

4.4 Results and Discussion

The Following, the results of each research question are presented.

4.4.1 Research Question 1

A one-way repeated measures ANOVA test indicated that students' domain-specific knowledge improved significantly from pre-test to post-test, *Wilks' Lambda =.465, F(1, 40) = 46.06, p < .001,* $\eta 2 = .535$. As such, the online learning environment presented a positive effect on student's domain-specific knowledge acquisition. Students' mean quality scores for domain-specific knowledge increased from pre-test to post-test, see Table 14. Student's average gain on domain-specific knowledge was one point on a 10-point scale.

Table 14 Student's pre-test and post-test mean scores for domain-specific knowledge and quality of writing

	Pre-test	Post-test	
Domain-specific knowledge	M = 4.91, SD = .93	M = 5.9, SD = 1.28	p < .001
Quality of writing	M = 10.17, SD = 2.09	M = 11.37, SD = 2.63	p < .005

4.4.2 Research Question 2

According to a one-way repeated measures ANOVA test, students' quality of writing argumentative essays improved significantly from the original to the revised essay, *Wilks' Lambda =.80, F(1, 44) = 10.59, p = .002,* $\eta 2 = .194$. The results suggests that the online learning environment had a positive effect on the student's quality of writing argumentative essays. Students' mean quality scores for writing argumentative essays increased from pre-test to post-test, see Table 14. Student's average gain on essay quality was 1.2 points on a scale from 0 to 16.

4.4.3 Discussion

In this section, the results of the research questions are discussed.

Students were able to improve the quality of their argumentative essays and also gained domain-specific knowledge, from pre-test to post-test, using an online learning environment which combined worked examples and peer feedback. The results sheds light on the positive combined effect of worked examples and peer feedback on the learning outcomes. The aforementioned results are in line with previous research

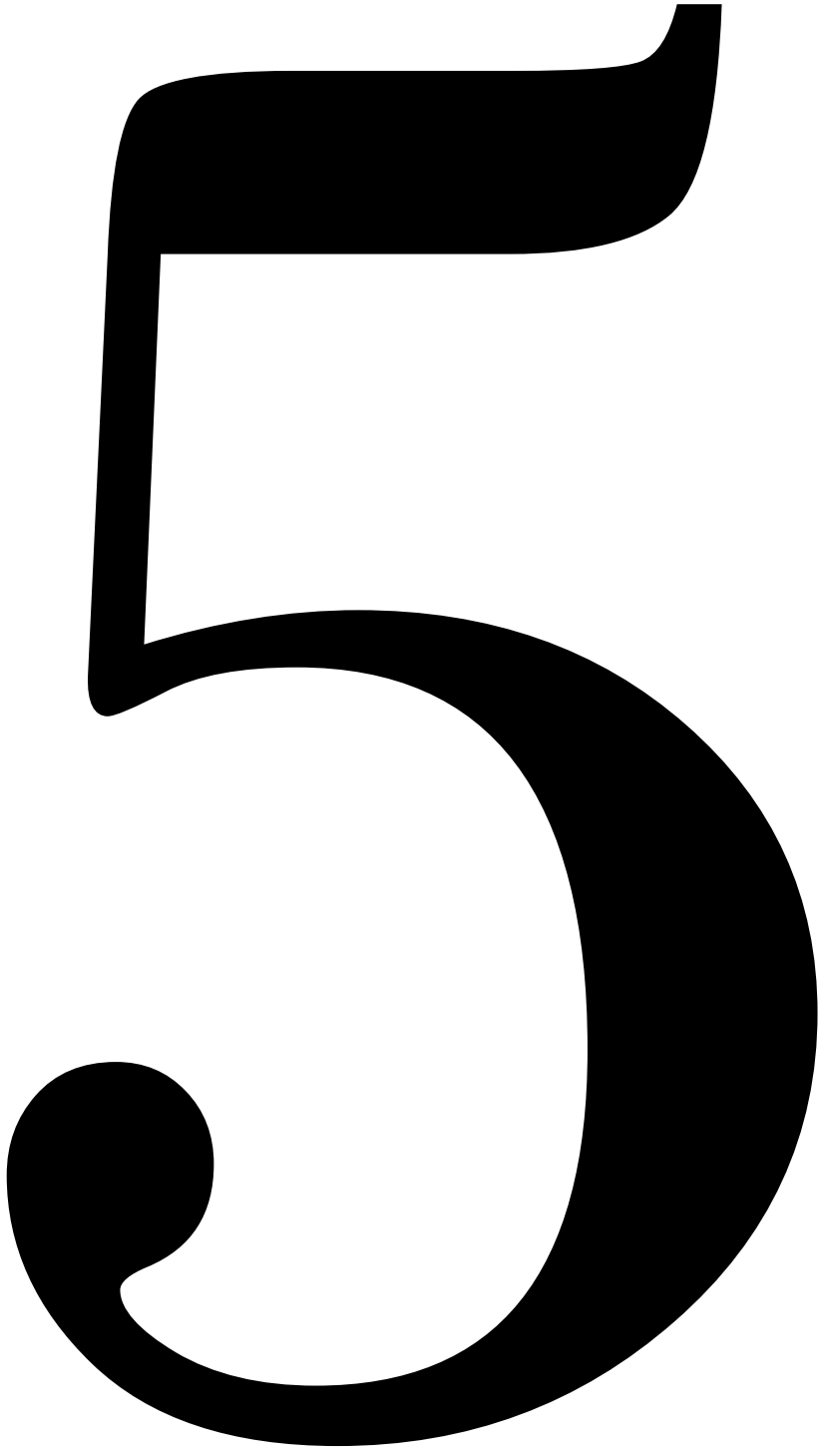
claiming positive effects of worked examples (Ayres, 2012; Schwonke et al., 2009; Sweller et al., 1998), theory or instructional explanations (Van Gog et al., 2004; Wittwer & Renkl, 2010) and practice (Ayres, 2012; Pashler et al., 2007). Similarly, providing multiple affordances such as texts, diagrams and pictures intended to direct students toward productive activities and learning (Fischer et al., 2013; Noroozi & Mulder, 2017; Suthers, 2003). In addition, by facilitating the peer feedback process (Hattie & Timperley, 2007; Kluger & Denisi, 1996), students were supported to provide valuable feedback to their learning partners related to the understanding of the topic and the writing of argumentative essays. The feedback content was facilitated by instructing students to first get themselves informed on the topic under discussion by reading a theoretical text on the topic and scientific articles, and by providing theory and a worked example on how a good argumentative essay should look like. The peer feedback process allows students to confirm, complement, overwrite, or restructure their knowledge conceptions (Winne & Butler, 1994, p. 5740), and to identify and rectify mistakes and misconceptions (Shute, 2008; Van der Kleij et al., 2015), to comprehend the differences between the actual and the desired state, and to receive advice on what to do and how to do it to make better progress (DeNisi & Kluger, 2000; Hattie & Timperley, 2007; Lizzio & Wilson, 2008). Hence, analyzing and contrasting the work of the learning partner during the feedback process triggers reflection (Phielix, Prins, & Kirschner, 2010), and broadens and deepens students' reasoning and understanding (Yang, 2010). Finally, the online learning environment was designed to facilitate and promote the development of students' argumentative writing skills, and in consequence to foster student's argumentation competence. Argumentation competence is essential for students in academic settings as they are typically required to work in groups, and to write argumentative essays (Noroozi et al., 2018; Noroozi et al., 2012). The aforementioned situations require students to think critically and reason logically to argue in favor of their opinion, to reach conclusions, and to take important decisions (Andriessen, 2006; Kuhn, 1991). Argumentation competence allows students to contrast, acknowledge and take into account or refute the opinions of others (Toulmin, 1958; van Bruggen & Kirschner, 2003).

4.4.4 Conclusions, Limitations, and Suggestions for Future Research

In this study an online learning environment which combined worked examples and peer feedback was used to improve the quality of argumentative essay writing and support domain-specific knowledge acquisition in the field of biotechnology. The use of worked examples and peer feedback seems to have improved student's argumentative essays quality and domain-specific knowledge acquisition. Furthermore, the peer feedback process allowed students to provide feedback related to the topic and the writing of argumentative essays. Similarly, the peer feedback process was designed to facilitate learning as students received feedback on their current state and suggestions on what

they should do and how they should do it to make progress and reach a desired state. The peer feedback process seemed to allow students to contrast each other's work, which in turn, could trigger the validation and the restructuring of knowledge conceptions, and the identification and rectification of errors and misconceptions. Meanwhile, the design of the online learning environment aimed to facilitate and promote the development of students' argumentation competence (see the previous note on examining possible causal relationships on pg. 60). Students had the convenience and flexibility to work on the assignment during and from their preferred time and location within the stipulated time frame. Similarly, the online learning environment allowed to present information in different forms, e.g., texts, diagrams and pictures, and to structure student's interactions to facilitate productive activities and learning.

This study was conducted in a real educational setting. Such setting offers advantages and disadvantages. An advantage is that the practical relevance and ecological validity of the study are high. The reasoning behind this is that students' engagement in the task in a real educational setting is intrinsically driven by the students' motivation to learn and pass the course rather than by monetary rewards which are typically received upon successful completion of laboratory tasks. Therefore, laboratory settings may produce unrealistic data that produce biased research. A clear limitation of this study was the lack of a control condition to allow us to disregard the effects of variables other than the independent variable and to assert causality. However, we made the deliberate choice of not having a control condition because the revised essay was graded and some students in a control condition might have been in disadvantage. In addition, we were not able to investigate the separate effects of the different instructional scaffolds, i.e., the worked examples and the peer feedback, on the learning outcomes. The latter could be considered as a second limitation of the present study. Thus, further research is needed to investigate whether the scaffolds have a summative effect or lessen the learning outcomes. Moreover, future longitudinal research should be conducted to assess the effectiveness of the instructional scaffolds, but should control for the *expertise-reversal effect* (Kalyuga et al., 2003) and the *redundancy effect* (Sweller, 2005; Sweller et al., 1998) which can inhibit student's self-regulation and learning.



Chapter 5

Exploring the Effects of Various Feedback Types on the Feedback Quality and the Learning Outcomes*

*This chapter is based on a manuscript that has been submitted for review.

5.1 Abstract

This study explored the effectiveness of various peer feedback types in an online learning environment in terms of the feedback quality and the learning outcomes (i.e., argumentative essay writing and acquisition of domain-specific knowledge). The study used a pre- and post-test design with four conditions (undirected feedback, standard feedback, feedforward and a combination of both). In this study, 221 undergraduate students, who were randomly assigned to dyads, engaged in discussions about the pros and cons of 'Genetically Modified Organisms (GMOs)', provided feedback to peers, and wrote an argumentative essay regarding the topic. Results indicated significant differences between the conditions in terms of the quality of feedback provided. This implies that the peer feedback quality can be enhanced or diminished by guiding the feedback type. Similarly, results revealed an increase in the learning outcomes of all students without significant differences among conditions. We discuss how such increase in the quality of the learning outcomes might be related to the power of peer feedback regardless of the feedback type. We also discuss why using multiple instructional scaffolds may result in over-scripting that may diminish the power of peer feedback and the effects of the scaffolds themselves in online learning environments.

5.2 Introduction

Argumentation competence comprehends the capacity to argue, think critically and reason logically for justifying and contrasting our positions and opinions against the positions and opinions of others. In addition, argumentation in academic settings encompasses the capacity to carry out comparable tasks and continue learning in the future (Noroozi et al., 2018). Acquiring argumentation competence is crucial for students, especially in collaborative learning environments where they build upon, relate to, and refer to what has been said by others to co-construct knowledge (Noroozi et al., 2018; Noroozi et al., 2012). According to the literature, undergraduate and graduate student's argumentative essay writing skills are typically below the proficiency level required to deliver writing tasks, at school or the workplace (Cooper et al., 1984; Kellogg & Whiteford, 2009). Cooper et al. (1984) argue that the root of the problem is insufficient task practice in the secondary and higher education curriculum, along with the considerable time and effort required in grading essays to provide feedback to students. Similarly, Driver et al. (2000) and Osborne (2010) argue that another problem cause is that argumentation is frequently developed in an indirect and informal fashion in the classroom. Even when argumentation is considered in the classroom, a teacher can only offer individualized support, supervision and tutoring to a single or a small group of students (Bloom, 1984). To address the issue of insufficient argumentative essay writing skills, researchers, teachers and practitioners have looked for instructional practices to foster student's writing motivation and strategies that improve the quality of essay writing and the acquisition of domain-specific knowledge (Bruning & Horn, 2000; Noroozi et al., 2016; Stern & Solomon, 2006). Learning together or peer learning supported by computers, such as digital learning environments, is one of the most relevant instructional practices and strategies to improve students' essay writing capacities (K. M. Baker, 2016; Boud et al., 1999; E. G. Cohen, 1994; P. Dillenbourg, 1999; Topping, 2005). In peer learning, both face to face and in digital learning environments, the provision of peer feedback is a powerful instructional practice to foster learning (Gabelica et al., 2012; Hattie & Timperley, 2007; Kluger & Denisi, 1996; Van der Kleij et al., 2015). Our interest lies in computer-supported peer feedback and feedforward, where students in a digital learning environment engage in reflective criticism of the work and/or performance of their peers using given criteria and providing feedback or feedforward to them (Falchikov, 2001; Gielen & De Wever, 2015a; Noroozi et al., 2016). The standard feedback provides information on the actual task with respect to the actual performance (Hattie & Timperley, 2007). In contrast, feedforward provides information on possible directions or strategies to pursue to reach a desired goal (Hattie & Timperley, 2007). The feedback event can contain information about the peers' actual work and/or performance (standard feedback - how am I going/doing?), or indicate a direction by delineating a goal to be achieved (feedforward - where to next?) (Hattie

& Timperley, 2007). Research on peer feedback and feedforward on student's writing include perceptions, relevance, process, effects on the performance and learning, and the relation between the process and the outcomes (K. M. Baker, 2016; Bayerlein, 2014; Gielen & De Wever, 2015a, 2015b; R. A. Mulder, Pearce, & Baik, 2014; Nelson & Schunn, 2009; Noroozi et al., 2016). Scripts are a form of scaffolding that can be used to structure and direct the feedback process and orchestrate students' interactions. Previous research has shown that such instructional support can foster the quality of writing (Gielen & De Wever, 2015a; Noroozi et al., 2016). Similarly, when students engage in high quality feedback processes, they write high-quality argumentative essays (Noroozi et al., 2016). However, it is yet unclear if the provision of directed feedback (standard feedback, feedforward or a combination of both) is more effective than undirected feedback in fostering argumentative essay writing. Hence, this study used a digital learning environment to explore the implications of scripting the provision of directed (standard feedback, feedforward and a combination of both) and undirected feedback on students' learning outcomes.

5.2.1 Argumentative Essay Writing

Argumentative essay writing is an essential competence across domains and aspects of daily life. In the workplace, a myriad of professionals such as lawyers, instructional designers, politicians, researchers, etc. need to regularly produce work artifacts that employ argumentative writing. Similarly, argumentative essays form part of the regular assignments for undergraduate students (Mei, 2006). Clear examples are students following courses on sociology, law, or biotechnology (the content domain of the present study) covering diverse controversial issues such as "Sociology of Violence", "EU and US Law", and "Genetically Modified Organisms (GMOs)". Such assignments generally require students to investigate a topic, gather and evaluate evidence, and write a clear and concise essay that includes a clear theory supported by sound reasoning, acknowledgment of possible counter-arguments, integrations of the arguments and a general conclusion (see Noroozi et al., 2016). Hence, good argumentation is a fundamental element of an essay (Mei, 2006; Noroozi et al., 2016; Wingate, 2012). Unfortunately, sound argumentation and depth of elaboration are rather infrequent in students' essays (Cooper et al., 1984; Kellogg & Whiteford, 2009). The reasons behind are that a) students ignore what the characteristics of a good argumentative essay (Bacha, 2010), or b) students struggle to put their argumentation knowledge into practice such as writing argumentative essays, that is, transferring argumentation knowledge to argumentation behavior (Noroozi, Teasley, et al., 2013). The features of an argumentative essay vary from discipline to discipline (Andrews, 1995; Samraj, 2004; Wingate, 2012). Hence, domain experts should teach students the specifics of the essay and the presentation of the arguments in their domain (Wingate, 2012).

5.2.2 Argumentative Essay Features

This study follows the method to teach and analyze students' argumentative essays in the context of biotechnology developed by Noroozi et al. (2016). The method uses Toulmin's model of argumentation (Toulmin, 1958) as the basis, and a simple argumentative structure based on the scientific literature. Toulmin's model comprises the traditional model of argument based on premises-conclusion (data-claim), by distinguishing more elements, namely *warrant*, *backing*, *qualifier* and *rebuttal* (see Toulmin, 1958). Regarding the structure of the essay, Noroozi et al. (2016)'s suggestion contrasts the standard structure by including students' intuitive opinion and a final conclusion. Therefore, the structure of the argumentative essay should present the students' intuitive opinions and feelings on the topic. The reasoning behind is, that students, and most people, possess gut-feelings and intuitive opinions on the various controversial issues of biotechnology, notwithstanding they are not familiar with the topic (Noroozi et al., 2016). Students' opinion is followed by arguments and data supporting them. Moreover, essays should incorporate arguments opposing or weakening the opinion (counter-arguments), and consider and refute the point of view of opponents. Next, the arguments in favor and against the topic should be integrated considering the opinions of the advocates and the opponents of the topic in question (Andrews, 1995; Noroozi et al., 2016; Qin & Karabacak, 2010; Toulmin, 1958; N. V. Wood, 2001). After the integration, students should provide their conclusions since it is common that students' final opinion on the topic remains unclear after arguing in favor and against the topic (Noroozi et al., 2016). Finally, the presentation and specifics of the aforementioned elements should be tailored to the domain in question as variations exist from domain to domain (Wingate, 2012). According to the literature, the process of receiving and giving feedback to learning partners with similar interests and motivational needs is an important aspect of the learning process (Bayerlein, 2014; Crisp, 2007) as feedback guides student learning (Crisp, 2007; Orsmond et al., 2005).

5.2.3 Peer Feedback

In peer learning "students learn with and from each other without the immediate intervention of a teacher" (Boud et al., 1999, p. 413). Peers are individuals with the same social standing that can provide peer feedback. Peer feedback is defined as the action taken by a peer to provide information regarding some aspect(s) of one's task performance or understanding (Hattie & Timperley, 2007; Kluger & Denisi, 1996). The information contained in a feedback event may not only refer to the correctness of an answer, but it may also contain information about precision, timeliness, learning guidance, motivational messages, lesson sequence advisement, critical comparisons, and learning focus (Mory, 2004). Such information allows students to confirm, add, delete, overwrite, correct and restructure their domain- or meta-cognitive knowledge, beliefs, cognitive tactics and strategies (Winne & Butler, 1994, p. 5740). Therefore,

peer feedback is seen as one of the most important instructional practices to increase students' learning (Hattie & Gan, 2011; Hattie & Timperley, 2007; Shute, 2008), such as writing skills and motivation (K. M. Baker, 2016; Brown, 2004; Gabelica et al., 2012; Kellogg & Whiteford, 2009; Nelson & Schunn, 2009; Topping, 1998), and domain-specific knowledge (Nelson & Schunn, 2009). Students involved in peer feedback may be able to identify and rectify mistakes and misconceptions, and enhance their problem-solving skills and self-regulation (Shute, 2008; Van der Kleij et al., 2015). Peer feedback enables students to grasp and understand the differences between their current and the expected state, and to receive advice on what and how needs to be done to make better progress (DeNisi & Kluger, 2000; Hattie & Timperley, 2007; Lizzio & Wilson, 2008). Furthermore, during peer feedback, students contrast their solutions with the ones from their learning partners; Such process triggers student's reflection on both the content and the writing process (Phielix et al., 2010) and allows students to broaden and deepen their knowledge, reasoning and understanding (Yang, 2010). Similarly, Nicol, Thomson, and Breslin (2014, p. 102) claim that during the feedback provision process students actively evaluate and judge both the work of their learning partners and their own work, the latter through a reflective process.

Since feedback plays an important role on learning and achievement (Hattie & Timperley, 2007), different characteristics and aspects of a feedback intervention have been investigated. For example, type of information content, amount of information (load), complexity (how much and what information), timing (immediate, delayed, on request), type and analysis of errors, type of learning outcome, and motivational aspects (Mory, 2004). The characteristics and aspects of a feedback event including, but not limited to, type, timing, content and the way it is given can affect the feedback's effectiveness. The influence of such characteristics and aspects invites to investigate and understand the extent to which the feedback type, directed (standard feedback, feedforward and a combination of both) or undirected, can influence argumentative essay writing and domain-specific knowledge acquisition. Therefore, it is important to determine which type of feedback is most effective.

5.2.3.1 Feedback type

According to Sadler (1989), the information contained in a feedback event needs to be related to the learning task or process that can take the student from the current state to the desired state of understanding. Such state change can be achieved through different cognitive processes, such as restructuring understandings, providing information on correctness, indicating the lack or need of more information, suggesting directions to follow, and/or suggesting other possible strategies to understand a particular information or complete a particular task (Hattie & Timperley, 2007). Hattie and Timperley (2007, p. 89) indicate that "feedback is effective when it consists of information about progress,

and/or about how to proceed". Thus, a peer feedback event can provide standard feedback, feedforward or both. Standard feedback aims to provide information related to the actual task and/or desired performance with respect to an expected standard, prior performance, and/or success or failure on (part of) the task (How am I going/doing?). However, the answer to the question "how they are going?", is not always welcome by students (Hattie & Timperley, 2007). In contrast, feedforward points to possible directions to pursue or indicates alternative strategies to follow (Where to go next?). Feedforward can derive in self-regulation, greater fluency and automaticity, more strategies and processes to work on the tasks, deeper understanding, and awareness on the current and the desired state of understanding (Hattie & Timperley, 2007). However, the peer feedback provision process faces challenges that are discussed in the following paragraph.

5.2.3.2 Challenges for peer feedback

Although standard feedback and feedforward can significantly enhance learning processes and outcomes (Shute, 2008), under certain conditions it can be detrimental to performance (Kluger & Denisi, 1996). Working in collaborative environments and providing feedback to learning partners can be difficult and problematic for students as psychological, social and motivational factors may play a role in the process and its outcomes. For instance, the information contained in a feedback event can be perceived by students as criticism and attacks to the person rather than as constructive feedback to the work (Rourke & Kanuka, 2007). Similarly, some students may not like to be questioned, or struggle to present a different opinion or contradict others ideas (Nussbaum, Hartley, Sinatra, Reynolds, & Bendixen, 2004). Furthermore, students may be reluctant to conceptual change or may just ignore the learning partner's feedback (Nussbaum, Sinatra, & Poliquin, 2008), while others may not provide critical feedback to avoid conflict or adversarial interaction (Nussbaum & Jacobson, 2004). Such problems may derive in surface level feedback that may result in minor revisions that only modify or clarify the writing (Faigley & Witte, 1981). In contrast, high quality feedback may trigger reasoning, critical thinking, and deep and elaborative learning, which may result in major revisions that change the essay substantially such as presenting new (counter) arguments, evidence, or even revising the complete essay (Faigley & Witte, 1981). Likewise, some students provide feedback related to praise, rewards and punishment (e.g., "Great answer", "I like your answer", "Well done") rather than on-task feedback and advice on how to do it better (Hattie & Timperley, 2007). Yet, the former is only effective when on-task feedback follows (Hattie & Timperley, 2007; Kluger & Denisi, 1998). Finally, a major issue can be the distrust in the competence of the learning partner to provide good feedback. If distrust exists, feedback may be disregarded, in contrast, feedback from a trustworthy source, e.g., a teacher, may be taken into account (Kaufman & Schunn, 2011; Shute, 2008). The aforementioned difficulties, demand the

design of leaning environments that motivate student's participation, and support the standard feedback and feedforward provision process to foster learning in digital peer learning environments.

5.2.3.3 Scripting the peer feedback process

According to Weinberger et al. (2005), learning in collaborative environments is frequently unsatisfactory regarding how students work on the concepts to be learned and how they collaborate with their learning partners. Therefore, instructional scaffolds have to be designed to facilitate students' participation, provision of peer feedback, and acquisition of skills or knowledge in collaborative environments (Belland, 2010; Hannafin et al., 1999; D. Wood et al., 1976). Instructional scaffolds in the form of scripts are one promising approach to facilitate and direct the provision of useful peer feedback to foster writing and learning. Scripting can facilitate and orchestrate diverse roles and interactions patterns at the individual and group level such that students are aware of what, when, and by whom specific activities related to the feedback process need to be performed (Weinberger, Stegmann, Fischer, & Mandl, 2007). Peer feedback scripts are designed, among other things, to structure and guide students' analysis of the argumentative essays of learning partners, to trigger reflection and reasoning, and to direct the feedback type (Noroozi et al., 2016; Noroozi et al., 2012; Noroozi, Weinberger, et al., 2013; Weinberger et al., 2007). In addition, with the provision of peer feedback on argumentative essays, students will be introduced to the process of writing and the elements of a good argumentative essay, namely providing a clear position, arguments and data supporting the position, arguments opposing or weakening the opinion, integrations of arguments an data in favor and against the topic, and a conclusion (Andrews, 1995; Noroozi et al., 2016; Qin & Karabacak, 2010; Toulmin, 1958; N. V. Wood, 2001). However, the use of scripts also present challenges. For example, providing too much external support, i.e., excessive scripting, may cause a negative effect such as *over-scripting* (P. Dillenbourg, 2002), that may even inhibit the student's self-regulated application of the internal script (Fischer et al., 2013).

The directed peer feedback script in the present study was embedded in a digital learning environment and was comprised of guiding questions. The script encourages and guides students to provide feedback with a specific type and to address the different elements of an argumentative essay.

5.2.4 Research Questions

Feedback is an important component of the learning process. Yet, the provision of peer feedback can be difficult and problematic for students since psychological, social and motivational factors may influence the peer feedback process and its outcomes. Similarly, the use of scripts may be beneficial or counter-productive, thus it is crucial

to get more insight regarding their use to structure and guide the peer feedback process and its outcomes. Up until now, it is not clear if directed feedback is more effective than undirected feedback to foster the quality of written argumentative essays and domain-specific knowledge acquisition. The aforementioned gap in the literature drives this study in the form of the following research questions:

1. What are the effects of a directed peer feedback script on student's peer feedback quality?

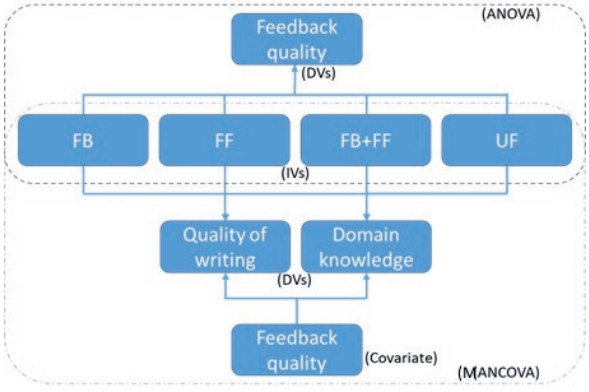
2. What are the effects of a directed peer feedback script on the quality of writing argumentative essays while controlling for the quality of feedback received?

3. What are the effects of a directed peer feedback script on domain-specific knowledge acquisition while controlling for the quality of feedback received?

5.3 Method

An exploratory study with a pre- and post-test design was conducted. The major independent variable, *feedback script type*, had four levels, namely, standard feedback (FB), feedforward (FF), standard feedback with feedforward (FB+FF), and undirected feedback (UF). Similarly, the dependent variables were: student's feedback quality, quality of writing argumentative essays and domain-specific knowledge acquisition. The covariate for the last two variables was the quality of feedback received, see Figure 3.

Figure 3 Design of the study. An ANOVA test was used to compare mean differences of students' feedback quality. A MANCOVA test was used to compare the effectiveness of the directed peer feedback script on the quality of students' written argumentative essays and domain-specific knowledge acquisition.



All conditions received theory on argumentative essay writing, including the rationale behind the structure of an argumentative essay, and an example on how a good argumentative essay should look like (both were embedded in the digital learning environment). The difference between the conditions was the structure and guidance provided by the directed peer feedback script during the feedback provision process.

The design of our directed peer feedback script is based on the argumentative script of Noroozi et al. (2016). However, the script used in the current study was further elaborated to guide the feedback process and facilitate the provision of directed (standard feedback, feedforward and a combination of both) and undirected feedback. In addition, the script was designed according to the characteristics of a complete and sound argumentative essay in the context of biotechnology (Noroozi et al., 2016). Considering the elements of the essay, we designed four different versions of the directed peer feedback script (see also Table 15). The standard feedback (FB) version of the script directs the feedback to address the progress that has been made toward the goal (i.e., How am I going/doing?). Likewise, the feedforward (FF) version of the script directs the feedback to provide advice on activities that need to be undertaken to make better progress (i.e., where to go next?). Similarly, the standard feedback with feedforward (FB+FF) version of the script combines the two aforementioned versions, that is, it directs the provision of feedback to both the progress made and advice on activities to make better progress (Hattie & Timperley, 2007). Finally, the undirected feedback (UF) version of the script does not guide or direct the feedback, thus it is left up to the student. The essay structure is comprised of the student's a) intuitive opinion on the topic, b) arguments and data in favor, c) counter-arguments and opposing points of view (if existing) and data against, d) an integration of the pros and cons considering the opinions of advocates and opponents of the topic, and e) a final conclusion. The essay structure was the result of multiple consultation meetings with a panel comprised of experts and teachers on the field, researchers in education and argumentation and students who followed the course previously (Noroozi et al., 2016).

5.3.1 Context and Participants

The study took place in September 2016 at a university in the Netherlands specialized in life sciences. The participants were 221 Bachelor of Science (BSc) students enrolled in a face to face (traditional) course named "Introduction to Molecular Life Sciences and Biotechnology". Besides introducing students to the aforementioned field, the course addresses diverse ethical issues associated with the practice of biotechnology and its relevance for society. The mean age of the participants was 18.42 years (SD = 1.34, MIN = 16, MAX = 28). Students were mostly Dutch (97 %). About 70% of participants were male and 30% female. Participants were randomly grouped in pairs and assigned to the different conditions.

5.3.2 Materials and Learning Tasks

The digital module assignment formed part of the course curricula. Therefore, it was a required activity and took place during the fourth week of the period (which is comprised of six weeks of classes).

The topic in question was "insect-cells for cultured meat manufacturing" which is part of the overarching theme of Genetically Modified Organisms (GMOs). Students had to write an argumentative essay on the statement: "Insect-cell biomass infected with genetically modified baculovirus is a healthy meat alternative". To accomplish the task, students received a description of the case, a summary of the theoretical text about the topic, links to scientific publications, and freedom to search online. Students were asked to consider different views on the advantages (pros) and disadvantages (cons) of using "insect-cells for cultured meat manufacturing" (see Noroozi et al., 2016). All the instructions were embedded in the digital learning environment.

5.3.3 Digital Learning Environment

The digital module was a regular assignment that was redesigned and implemented as a digital learning environment for this study. The module presents information in different formats such as texts, diagrams, and pictures. In addition and serving as a baseline, the module offered to all students argumentative essay theory and an example on how a good argumentative essay should look like. Yet, the most relevant characteristic of the module is the use of a directed peer feedback script to structure and guide the peer feedback process.

The learning module facilitates and guides the provision of directed feedback, and allows students to revise their work taking into consideration the feedback received and the learning from the feedback provision process. This is achieved by scripting the provision of feedback, defining roles for the learning partners (i.e., assessor and assesse), and scripting the interaction of the learning partners to promote reasoning and directed feedback processes and practices. A timer with the expected time for each part of the module was available along with a word counter for each input box.

Table 15 Elements of a high-quality essay in the field of biotechnology (left). Directed peer feedback script for standard feedback "FB" (center), feedforward "FF" (right) and their combination, standard feedback with feedforward "FB+FF" (center and right).

	Elements of high-quality essay	Standard feedback (FB)	Feedforward (FF)
1	Intuitive opinion on the topic	Did your learning partner present his/her intuitive opinion on the topic? Please explain.	What is your advice to your learning partner to (better) present his/her intuitive opinion on the topic? Please explain.
2	Arguments in favor of the topic (pros)	Did your learning partner provide arguments in favor of the topic? Please explain.	What is your advice to your learning partner to (better) provide arguments in favor of the topic? Please explain.
3	Scientific facts in favor of the topic (pros)	Did your learning partner provide scientific facts (evidence, examples, figures, etc.) in favor of the topic? Please explain.	What is your advice to your learning partner to (better) provide scientific facts (evidence, examples, figures, etc.) in favor of the topic? Please explain.
4	Arguments against the topic (cons)	Did your learning partner provide arguments against the topic? Please explain.	What is your advice to your learning partner to (better) provide arguments against the topic? Please explain.
5	Scientific facts against the topic (cons)	Did your learning partner provide scientific facts against the topic? Please explain.	What is your advice to your learning partner to (better) provide scientific facts against the topic? Please explain.
6	Opinion on the topic considering various pros and cons.	Did your learning partner take into account the integration of various pros (arguments in favor of the topic) and cons (arguments against the topic) in forming his/her opinion of the topic? Please explain.	What is your advice to your learning partner to (better) form his/her opinion of the topic taking into account the integration of various pros (arguments in favor of the topic) and cons (arguments against the topic)? Please explain.
7	Scientific facts to support opinion regarding the integration of various pros and cons of the topic	Did your learning partner provide scientific facts to support his/her opinion on the integration of various pros and cons of the topic? Please explain.	What is your advice to your learning partner to (better) provide scientific facts to support his/her opinion on the integration of various pros and cons of the topic? Please explain.
8	Conclusion and statement on the topic	Did your learning partner come to a conclusion on the topic based on his/her arguments? Please explain.	What is your advice to your learning partner to (better) come to a conclusion on the topic based on his/her arguments? Please explain.

5.3.4 Procedure and Measurements

During the study, students were grouped in pairs, but they conducted the tasks individually in an asynchronous fashion. Therefore, students had the convenience of completing each phase from any location at any time within the stipulated time frame. In addition, students' identity was anonymous within the system as usernames were generic (e.g., "Student 1").

The study was comprised of four main phases over a period of four consecutive days, see Table 16. On the first day, students received a verbal introduction to the module during class time (20min), and completed questionnaires on socio-demographic information and domain-specific knowledge (35 min). On the second day, students had to individually read theoretical texts and scientific publications (30 min), search online for more information sources such as daily papers, periodic journals, and scientific papers (30 min), and write an individual argumentative essay (45min) of ca. 500 words (min. 450, max. 550 words).

Table 16 Outline of the online learning module

Phase	Estimated time	Start date	Deadline
Introduction	20 min	Sep 20th	
Pre-test	20 min	Sep 20th	Sep 20th
Write report	105 min	Sep 21st	Sep 21st
Peer feedback	90 min	Sep 22nd	Sep 22nd
Revise report, post-test and debriefing	100 min	Sep 23rd	Sep 23rd
Total	350 min		

On the third day, students had to read a text about "How to write an argumentative essay" followed by an example of an argumentative essay. After this, each student had to provide feedback to his/her learning partner using a feedback form (90 min). The scripted feedback form for students in the FB and FF condition had a question and a text field of ca.50 words (min. 40, max. 60 words) for each element of a high-quality essay, see *Table 15* for more information. Students in the FB+FF condition, received a feedback form comprising both the FB and the FF forms. In contrast, the feedback form for students in the UF condition was comprised of a request to provide feedback and a text field to write their feedback of ca.400 words (min. 350, max. 450 words). Next, on the fourth day students had to read the feedback from their learning partner (15 min), and then revise their individual argumentative essay (45 min), ca. 500 words (min. 450, max. 550 words). In all cases, the system checked that the amount of words were within the lower and upper bounds, if that was not the case, the system provided textual and visual feedback. In addition, each text field had a word counter. Finally, students

completed questionnaires on domain-specific knowledge (equal to pre-test) (35 min). Finally, students were debriefed (5 min). The total time was ca. 335min.

5.3.4.1 Measurement of student's feedback quality

The coding scheme developed by Noroozi et al. (2016) was used to assess the quality of the feedback given by the students. The scheme was in line with the peer feedback script that students used to provide directed or undirected feedback to their learning partner's argumentative essay. Noroozi's coding scheme was developed according to the literature (Andrews, 1995; Qin & Karabacak, 2010; Toulmin, 1958; N. V. Wood, 2001) and the characteristics of a complete and sound argumentative essay in the context of biotechnology (see also Table 15). The scheme validity was obtained from a series of consultation meetings with a panel of experts and teachers (Noroozi et al., 2016). The scheme is comprised of a set of variables with different levels of proficiency that describe the quality of the student's feedback. Each level has a label, points and description. The feedback given by all students were coded and scored in terms of the variables: Intuitive opinion, claims in favor of the topic, justification for claim(s) in favor of the topic, claims against the topic, justification for claim(s) against the topic, integration of pros and cons, integration of pro- and con-facts, and conclusion. A score, between zero and two, was given for each of the aforementioned variables as follows: zero points if feedback was not present, one point for non-elaborated feedback, and two points for elaborated feedback. Hence, the student's feedback quality is given by the sum of all points obtained in the feedback assessment process. The interrater agreement with two coders (i.e., the first author and a trained coder) was calculated randomly selecting 5% of the student's feedback (equally distributed for FB, FF, FB+FF and UF conditions). To assure reliability of the coding process, the coder was trained on such process including the coding rubrics. Then, the first author and the coder independently coded 5% of the data. The interrater agreement was substantial (Cohen's Kappa = 0.68) according to Landis and Koch (1977). Discrepancies were resolved through discussion until agreement was reached on how to resolve them. Afterwards, the coder coded the remaining data.

5.3.4.2 Measurement of student's quality of writing argumentative essays

The quality of students' written argumentative essays on the topic was measured using the coding scheme developed by Noroozi et al. (2016). The coding scheme validity was obtained in the same way as the validity of the scheme to measure student's feedback quality, that is, from a series of consultation meetings with a panel of experts and teachers (Noroozi et al., 2016). The scheme consist of a set of variables with various levels of proficiency that depict the quality of the student's argumentative essay. Each level is defined a label, points, description and examples to facilitate the coding. The original and revised essays of all students were coded in terms of the variables: Intuitive opinion,

arguments in favor of the topic (pro-arguments), scientific facts in favor of the topic (pro-facts), arguments against the topic (con-arguments), scientific facts against the topic (con-facts), opinion on the topic considering various pros and cons (integration of pros and cons), scientific facts to support opinion regarding the integration of various pros and cons of the topic (integration of pro- and con-facts), and conclusion. A score of zero, one or two was given for each of the aforementioned variables. The assessment was done as follows: zero points were given if the element was not mentioned, one point if the element was non-elaborated, and two points if the element was elaborated. The student's quality of writing argumentative essays at a certain point (pre-test or post-test) is then given by the sum of all points obtained in the corresponding essay. The gain on the quality of students' written argumentative essays was the difference between the revised assignment and the original assignment. The interrater agreement was calculated following the same process used before to calculate the interrater agreement for the quality of student's feedback. The interrater agreement for the student's quality of writing argumentative essays was almost perfect (Cohen's Kappa = 0.873) according to Landis and Koch (1977). Discrepancies were resolved through discussion until agreement was reached on how to resolve them. Then, the coder coded the rest of the data.

5.3.4.3 Measurement of domain-specific knowledge

Domain-specific knowledge was measured before and after the intervention using a questionnaire developed by the course coordinator. The questionnaire contained 17 multiple-choice questions and one open question, e.g., 'What is a continuous animal cell line?', 'Insects that are commercially cultivated include…', 'A baculovirus is…', 'What is a "master cell bank"?' A point was given for each correct answer, for a maximum of 18 points per test. Afterwards, the average was calculated and used as the score for the respective test. The gain on the domain-specific knowledge was the difference between the pre- and post-tests.

5.3.5 Analyses

A one-way analysis of variance (ANOVA) test was used to compare mean differences of students' feedback quality, see Table 17. Post hoc comparisons were done using Bonferroni's test.

A one-way multivariate analysis of covariance (MANCOVA) was conducted to compare the effectiveness of the directed peer feedback script on the quality of students' written argumentative essays and the domain-specific knowledge acquisition. Such omnibus test was used to avoid getting and artificially inflated alpha as a result of conducting multiple statistical tests on the same sample. The independent variable (IV) was the feedback script type (standard feedback, feedforward, a combination of both and undirected feedback), and the dependent variable (DV) was the gain on the quality of students'

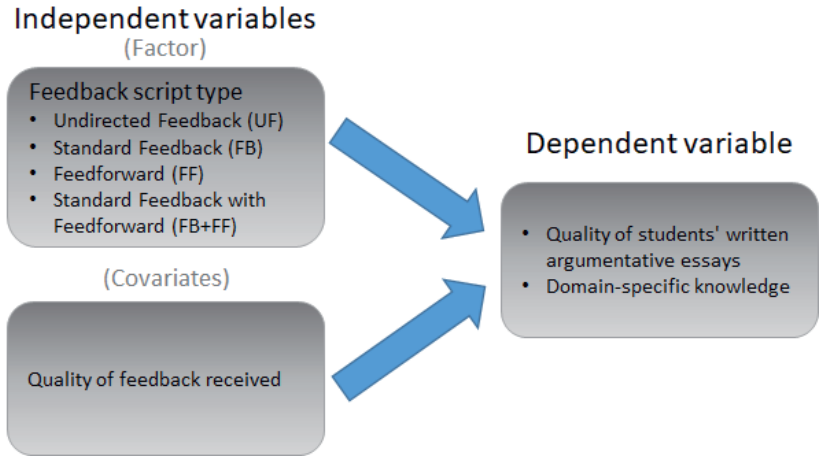
Table 17 ANOVA design

Independent variable (Feedback script type)	Dependent variable (Students' feedback quality)
Undirected Feedback (UF)	X
Standard Feedback (FB)	X
Feedforward (FF)	X
Standard Feedback with Feedforward (FB+ FF)	X

written argumentative essays. The quality of feedback received by students was used as the covariate in the analysis, see Figure 4. To remove the effect of the condition on the covariate, the covariate was corrected. The covariate corrected for a student is given by the quality of feedback received minus the feedback quality mean of the student group condition, that is, covariate corrected = $CC_{ij} = C_{ij} - \bar{C}_i$, where i is *i-th* condition and j is *j-th* student within the condition.

Finally, to reduce the impact of potential sources of bias we used the method of winsorizing, that is, outliers were substituted with the highest value that was not an outlier.

Figure 4 (in)dependent variables and covariate of the study



5.4 Results and Discussion

5.4.1 Research Question 1

ANOVA tests indicated a statistically significant difference in the quality of feedback provided for the four conditions, *Welch's F(3, 92.15) = 46.83, p < .005,* $\eta^2 = .39$, with a large effect (J. Cohen, 1988, pp. 284-287). Post hoc comparisons indicated that the mean score of the FB condition (M = 14.28, SD = 2.08) was significantly different from the FF condition (M = 7.95, SD = 3.75), the FB+FF condition (M = 11.25, SD = 2.75), and the UF condition (M = 9.09, SD = 3.45). Similarly, the FB+FF condition was significantly different from the FF and UF conditions. Finally, the UF condition was significantly different from the FF condition, see Table 18. Such result indicated that the directed peer feedback script was more effective supporting and directing the creation of standard feedback and a combination of standard feedback and feedforward. In contrast, the script was not very effective supporting and directing the creation of feedforward.

Table 18 Average scores of the quality of feedback provided per condition. Average scores are given for each of the elements comprising an argumentative essay

		Quality of feedback provided on								Quality of feedforward provided on							
Condition		Intuitive opinion	Pro-arguments	Pro-facts	Con-arguments	Con-facts	Integration of pros & cons	Integration of facts	Conclusion	Intuitive opinion	Pro-arguments	Pro-facts	Con-arguments	Con-facts	Integration of pros & cons	Integration of facts	Conclusion
UF	M	1.38	1.43	1.32	1.48	1.13	.74	.27	1.23	-	-	-	-	-	-	-	-
	SD	.78	.66	.8	.66	.88	.84	.62	.86	-	-	-	-	-	-	-	-
	N	44	44	43	43	43	43	43	43	-	-	-	-	-	-	-	-
FB	M	1.93	1.91	1.91	1.89	1.58	1.63	1.52	1.89	-	-	-	-	-	-	-	-
	SD	.32	.35	.28	.31	.77	.67	.78	.31	-	-	-	-	-	-	-	-
	N	46	46	46	46	46	46	46	46	-	-	-	-	-	-	-	-
FF	M	-	-	-	-	-	-	-	-	.91	.78	1.19	.93	1.19	1	.93	1
	SD	-	-	-	-	-	-	-	-	.8	.77	.79	.7	.77	.69	.79	.69
	N	-	-	-	-	-	-	-	-	47	47	47	47	47	47	47	47
FB+FF	M	1.92	1.77	1.82	1.77	1.82	1.6	1.05	1.57	1.22	1.07	1.47	1.17	1.32	1.15	.8	.92
	SD	.26	.47	.5	.53	.38	.67	.9	.67	.91	.85	.78	.84	.79	.89	.88	.85
	N	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40

UF	Undirected Feedback	M	Media
FB	Standard Feedback	SD	Standard deviation
FF	Feedforward	N	Number of participants
FB+FF	Standard Feedback with Feedforward		

5.4.2 Research Question 2

The covariate, the quality of feedback received, presented a small significant relationship with the quality of writing argumentative essays, $F(1, 165) = 4.14$, $p = .043$, $\eta 2 = .026$, indicating that the quality of writing argumentative essays is influenced by the quality of the feedback received. Moreover, there was not a significant effect of the directed peer feedback script on the quality of writing argumentative essays gain after controlling for the effect of the quality of feedback received, $F(3, 155) = .231$, $p = .875$, that is, the gain was similar for all the conditions. A comparison between the estimated marginal means, showed that the biggest gain, yet not significant, was obtained by the FB condition (M=1.98) followed by the FB+FF, FF and UF conditions (M=1.72, 1.71, 1.65 respectively)..

Table 19 Quality of writing argumentative essays scores for the original and revised essays for all conditions

		Original essay		Revised essay	
	N	M	SD	M	SD
Undirected Feedback UB	45	10.17	2.09	11.37	2.63
Feedback FB	47	8.87	2.63	10.61	2.67
Feedforward FF	48	8.79	2.39	10.47	2.36
Feedback and Feedforward FB+FF	44	9.65	1.79	11.15	1.86

5.4.3 Research Question 3

The covariate, the quality of feedback received, presented a small significant relationship with the acquisition of domain-specific knowledge, $F(1, 155) = 4.84$, $p = .02$, $\eta 2 = .03$, indicating that the acquisition of domain-specific knowledge is influenced by the quality of the feedback received. In addition, there was not a significant effect of the directed peer feedback script on domain specific knowledge acquisition after controlling for the effect of the quality of feedback received, $F(3, 155) = .38$, $p = .76$, indicating that the gain was similar for all the conditions. A comparison between the estimated marginal means, showed that the biggest gain, yet not significant, was obtained by the FF condition (M=11.4) followed by the UF, FB+FF and FB conditions (M=10.4, 9.6, 9.2 respectively).

Table 20 Domain-specific knowledge scores for the pre- and post-test for all conditions. Scores were transformed such that the maximum possible score was 100.

		Pre-test		Post-test	
	N	M	SD	M	SD
Undirected Feedback UF	41	49.17	9.35	59	12.86
Feedback FB	45	51.2	9.49	61.04	9.58
Feedforward FF	48	50.06	11.36	61.98	11.1
Feedback and Feedforward FB+FF	42	50.48	9.29	59.57	11.25

5.4.4 Discussion

Following, the results of the research questions are discussed.

5.4.4.1 Research Question 1

The results indicated that the directed peer feedback script was significantly better at supporting and directing the creation of standard feedback followed by the combination of standard feedback and feedforward. However, the script was not as effective supporting and directing the creation of feedforward. In general, the directed peer feedback script guided and helped students to provide high-quality feedback to their learning partners which is favorable to improve their writing skills (DeNisi & Kluger, 2000). In addition, the script supported the provision of feedback related to the task rather than on personal evaluations or affect about the learning partner which is consider to be less effective (Hattie & Timperley, 2007). Moreover, the script allowed the provision of structured and sequential feedback on each of the different elements of a high quality argumentative essay, thus facilitating the improvement of each of the elements of the argumentative essay. However, it is important to take into consideration that all students received argumentative essay theory and an example of an argumentative essay and that may have played a role in the feedback provision process. Such statement is supported by the fact that the UF condition, which was not scripted, outperformed the FF condition. The previous information suggests that scaffolding the feedback provision process with theory and examples is effective to foster high quality feedback, and a further combination with scripts to support and direct the feedback is even more effective. Yet, is necessary to understand why the script was not as effective in the FF condition. One possible explanation is that it is not customary for students to receive feedback containing possible directions to pursue or about alternative strategies to follow, but rather corrective feedback on their performance on the actual task. As such, it may have been difficult for the students to provide feedback containing alternative directions or strategies. To conclude, effective feedback should 1) reduce the gap between what is understood and what should be understood, and 2) increase student's effort, motivation,

and engagement to reduce such gap (Hattie & Timperley, 2007). In addition, effective feedback must include 1) information related to the actual task and/or performance taking as reference an expected standard, prior performance, and/or the success or failure on (part of) the task (How am I going/doing?), and 2) information related to possible directions or alternative strategies to follow (Where to go next?) (Hattie & Timperley, 2007).

5.4.4.2 Research Question 2 and 3

There were increases in the quality of writing argumentative essays and in domain-specific knowledge acquisition from pre-test to post-test in all the conditions. In addition, the quality of feedback received presented a small significant relationship with the quality of writing argumentative essays and the acquisition of domain-specific knowledge. Such results are in line with previous research claiming positive results of peer-feedback on writing skills (Brown, 2004; Gabelica et al., 2012; Kellogg & Whiteford, 2009; Noroozi et al., 2016) and domain-specific knowledge acquisition (Nelson & Schunn, 2009; Noroozi & Mulder, 2017). During the peer feedback process, students contrasted their solutions with the ones from their learning partners. As a result, students were able to identify and rectify mistakes and misconceptions (Shute, 2008; Van der Kleij et al., 2015), to broaden and deepen their reasoning and understanding (Yang, 2010), to understand the differences between the current and the expected state, and what to do and how to do it to improve and do better (DeNisi & Kluger, 2000; Hattie & Timperley, 2007; Lizzio & Wilson, 2008). Moreover, the peer feedback process guided students learning (Crisp, 2007; Orsmond et al., 2005), facilitated problem-solving skills and self-regulation (Shute, 2008; Van der Kleij et al., 2015), and triggered reflection (Phielix et al., 2010).In this particular study no significant differences were found between directed (i.e., FB, FF, and FB+FF) and undirected (i.e., UB) feedback in terms of the quality of writing argumentative essays and domain-specific knowledge acquisition. Such results differ with previous literature indicating that the effectiveness of feedback is influenced by its type and the way it is provided (Hattie & Timperley, 2007). Our results, may be explained if we consider that all conditions received theory on the composition of an argumentative essay and an example of an argumentative essay. In previous studies on argumentation scaffolds to foster argumentation knowledge and domain-specific knowledge acquisition, students received argumentation theory before engaging in argumentative discourse activities, but the effects of providing theory were not investigated (Kollar et al., 2007; Yeh & She, 2010). Therefore, it is important to put in context the effects of theory and examples on the learning outcomes. We believe, that the provision of theory and an example may have diminished the effect of the directed peer feedback script, and may have made the script redundant and even unnecessary. This reasoning is in line with educational psychology (Wittwer & Renkl, 2010) and cognitive load theory (CLT) (Sweller et al., 1998) literature indicating the positive

effects of theory, or instructional explanations, along with worked examples (also known as example-based learning). For instance, providing theory and examples can prevent misconceptions and inconsistencies, and facilitate understanding (Wittwer & Renkl, 2010). In addition, the theory-example combination can be effective at fostering the acquisition of meaningful and flexible knowledge (Van Gog et al., 2004) since both the *product-oriented information*, i.e., the how, and the *process-oriented information*, i.e., the rationale or the why some solution steps should be conducted (Wittwer & Renkl, 2010), are provided. Similarly, previous research found that example-based learning is more effective when it is accompanied with problems to be solved (Pashler et al., 2007). Therefore, students supported with instructional scaffolds that combine theory, examples and practice might profit more. Nevertheless, the effectiveness of worked examples is diminished as students get more experience, i.e., *expertise-reversal effect* (Kalyuga et al., 2003). In addition, experienced students might not need further instructional support, as they have to invest cognitive resources in redundant information. Redundant information might hamper learning as it might result in unnecessary overloading and in suboptimal learning processes due to the *redundancy effect* (Sweller, 2005; Sweller et al., 1998). The redundancy effect is line with the idea of *over-scripting* (P. Dillenbourg, 2002), which can occur due to too much scaffolding, or when the provision of external support inhibits the student's self-regulated application of the internal script (Fischer et al., 2013). Hence, the provision of instructional support should consider the student's internal script, and should be decreased over time to foster the learning of self-directed learning skills (Noroozi & Mulder, 2017; van Merriënboer & Kirschner, 2012). To conclude, we believe that providing theory and an example nullified the effects of the directed peer feedback script in this study. In addition, caution should be exercised while piling up or combining instructional scaffolds, as the effects of some scaffolds may be nullified of may result in suboptimal learning processes due to overloading, e.g., redundancy effect and over-scripting. Last, the theory-example combination seems to be a powerful instructional support to foster argumentative essay writing.

5.4.5 Conclusions, Limitations, and Suggestions for Future Research

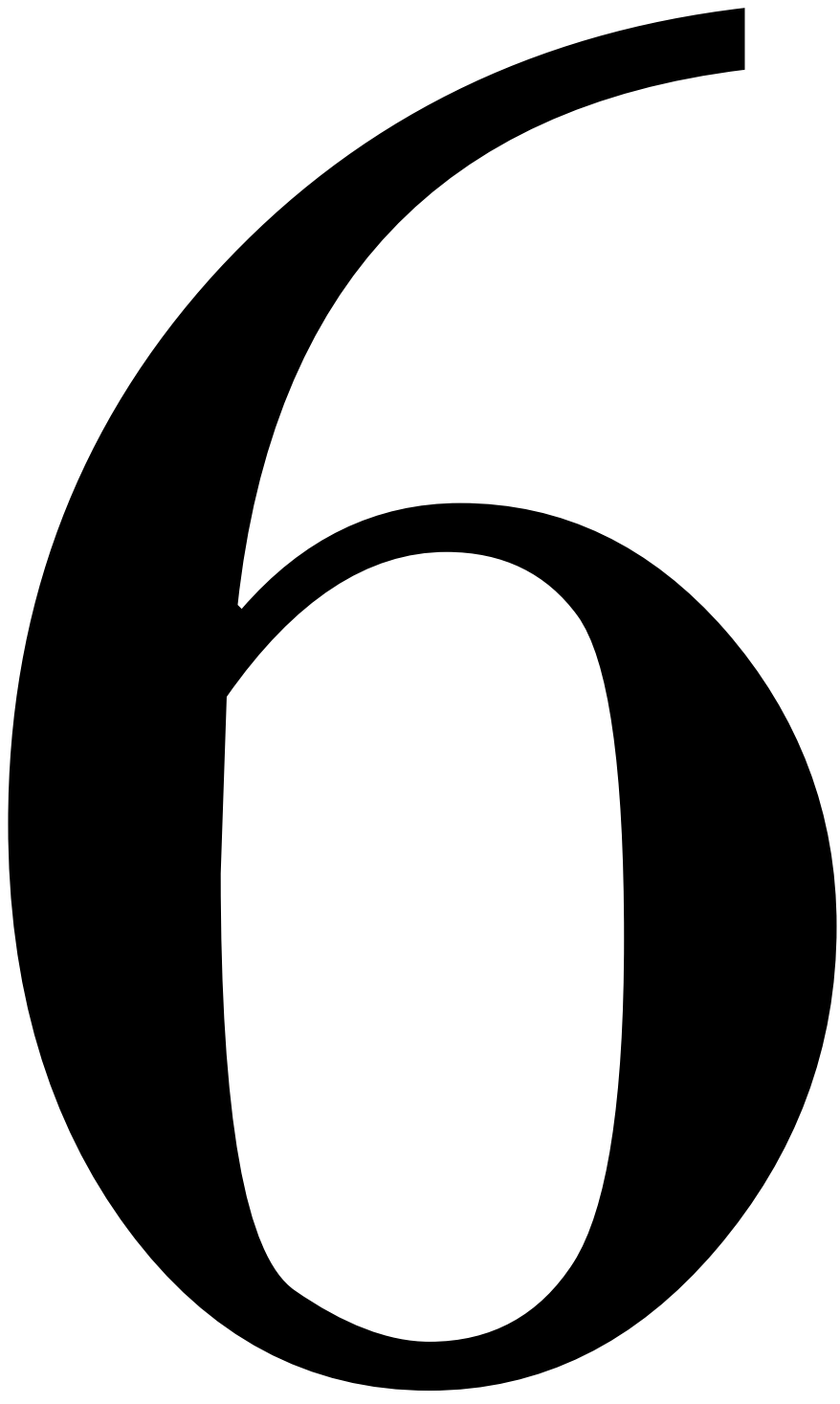
In this study we investigated the effects of directed feedback (standard feedback, feedforward or a combination of both) and undirected feedback on the performance of student's argumentative essay writing and domain-knowledge acquisition in a digital learning environment. Results indicate that the quality of feedback provided by students differed significantly between conditions. The directed peer feedback script is more effective supporting the provision of standard feedback and a combination of standard feedback and feedforward. In contrast, the script is less effective supporting and directing the creation of feedforward. Such results indicate that the quality of peer feedback can be enhanced or diminished by guiding the feedback type. Similarly, results indicate an increase in the quality of writing argumentative essays and in domain-specific knowledge

acquisition from pre-test to post-test in all the conditions. The increase is related, in part, to the quality of the feedback students received. Despite there are no significant differences between the different conditions in terms of the learning outcomes, possibly related to over-scripting, the peer feedback process guided students learning, facilitated problem-solving skills and self-regulation, and triggered reflection.

The study was conducted in vivo. Such setting provided advantages and disadvantages. An advantage, is the high practical relevance and high ecological validity of the study due to the real educational setting instead of laboratory settings in which motivational aspects may be affected due to synthetic learning environments and rewards upon successful completion of the tasks and activities. In contrast, to level the field of play for all the students, all the conditions received theory on the composition of an argumentative essay and an example of an argumentative essay. The latter, may have affected the effect of the directed peer feedback script, making the script redundant or even unnecessary. Therefore, we make a call to exercise caution while combining multiple instructional scaffolds, as some scaffolds may nullify others of may result in suboptimal learning processes due to overloading, e.g., redundancy effect and over-scripting.

Another possible criticism of the study is related to the scale and the coding scheme used to measure the quality of peer feedback. The scale, which was developed and successfully used before by Noroozi et al. (2016), has a scale ranging from 0 to 2. The scale may not offer a large spectrum of variation in contrast to a scale with more points, yet it is able to provide insight into the quality of peer feedback. Moreover, we created a rubric, and used examples (depicting the characteristics that should be met to assign a score) to ensure consistency of the measures and assess change equally well across the entire range of the construct. In addition, the coding process of the quality of feedback disregarded if the actual feedback provided by the student corresponded, either completely or partially, to the scripted feedback type. Such type of analysis may have influenced the results. Yet, we believe that analyzing the extent to which the feedback script fosters the provision of a given feedback type deserves a deeper analysis and thus further research to understand the possible reasons and processes behind such behavior.

Another criticism of the present study is that it only measured the effect of the intervention in the short term but not in the long term. Therefore, future research should investigate the effects of theory and worked examples in contrast to scripting (e.g., feedback type). In addition, the effectiveness of the aforementioned instructional scaffolds should be evaluated considering the educational level of the students as their expertise and cognitive capacity may play a role. Last, future studies should have a longitudinal design to assess student learning, internalization of the constructs, and its application in the same and different contexts.



Chapter 6

General Conclusions and Discussion

6.1 Introduction

This final chapter summarizes the results of the studies presented in chapters 2 to 5. It also discusses the main findings with respect to the literature, methodology, future research, and practical implications. First, the chapter offers a summary of the main findings, and reiterates the research questions formulated in Chapter 1 and how they were answered by the respective studies. Next, the relevance of the results is discussed from an integrated perspective. Afterwards, the strengths and weaknesses of the studies conducted during this PhD project are discussed. The next part of the chapter is devoted to suggestions for future research, taking into account the study's limitations. The last part of the chapter discusses implications for educational practice.

6.2 Main Findings of the Studies

6.2.1 Main Findings of Chapter 2

Students in higher education are often grouped in teams to solve complex problems. In these scenarios, students have to make critical decisions and reach conclusions that require them to share and co-construct knowledge, think critically, and argue. However, argumentation is not easy to learn or do due to its intricate, non-linear, and ill-structured character, and the complexity of generating, analyzing, and evaluating arguments based on the rules of logic (Kuhn, 1991; Lynch et al., 2009). To facilitate the development of argumentation competence, researchers and practitioners have developed multiple learning systems with diverse instructional scaffolds (Gyenes, 2017; Latifi, Noroozi, Hatami, et al., 2021; Scheuer et al., 2010). However, there is no clear overview or understanding of the intention and effects of argumentation scaffolds in the empirical research on Computer Supported Collaborative Argumentation (CSCA). The study presented in this chapter addressed the issue of ambivalently of research on intentions and effects of argumentation scaffolds. Argumentation scaffolds can be designed to: a) facilitate argumentative discourse activities that promote the acquisition of domain-specific knowledge or skills, or b) foster the development of argumentation competence regardless of domain or context. In addition, the possible effects of variables such as educational level, communication form and group size are not clear. These gaps in the literature initiated the first research question of this thesis: *What are the effects of first-order and second-order argument scaffolding in Higher Education (HE) and Secondary Education (SE), and how does one way of scaffolding influence the other?*

Chapter 2 addressed the research question mentioned above. It provided an overview of argumentation, followed by a definition of argumentation competence and its composite parts (i.e., argumentation knowledge, argumentation behavior, and attitude towards

argumentation). Next, based on the literature, the chapter elaborated on the variables of educational level, communication form, and group size, and how they play a role in the definition (e.g., the level of abstraction, guidance, and support), and thus in the effects of argumentation-scaffolds. A systematic review of the literature was conducted to answer the research question. This approach allowed for a systematic analysis of the intention and effects of argumentation scaffolds investigated in empirical studies into CSCA.

The quantitative analysis of the research on argument-scaffolding revealed that, of the studies that took place in HE, 38% found significant effects on the acquisition of domain knowledge, 53% found significant effects on acquisition of argumentation knowledge, and 15% reported significant effects facilitating argumentation behavior. Regarding studies conducted in SE, 50% found significant effects on the acquisition of domain knowledge, 30% found significant effects on the acquisition of argumentation knowledge, while an additional 20% reported partial effects in only one out of multiple indicators of argumentation knowledge measured, or within a specific subgroup of a treatment group. In general, attitudes towards argumentation were neglected by both HE and SE studies. Similarly, studies in both HE and SE aimed to obtain first- and second-order scaffolding effects, that is, they strove to facilitate both argumentation competence and domain knowledge acquisition. Unfortunately, it was not possible to confirm or refute whether second-order scaffolding has first-order effects, since most of the studies in both HE and SE were intended to achieve both first- and second-order scaffolding effects. Hence, there is no evidence in this study for recommending that the focus of research on argument-scaffolding should be centered on second-order scaffolding approaches.

The quantitative analysis also found information regarding the focus given to the different elements of argumentation competence during the provision of first- and second-order argument-scaffolding in HE and SE. Argumentation knowledge was typically the focus, with 76% of the occurrences, followed by argumentation behavior with 24%. Attitudes towards argumentation were disregarded. Next to the focus on the different elements of argumentation competence, information pertaining to communication form used during the provision of first- and second-order argument scaffolding in HE and SE was extracted. HE and SE studies differed significantly in this regard: while HE studies tended to employ asynchronous communication (77%), SE studies tended to employ synchronous communication (80%). The last piece of information extracted during the quantitative analysis was related to the group size used for the provision of argument-scaffolding in HE and SE. It is important to note that none of the studies offered an explanation of their group size choice. About half of the studies, regardless of educational level, opted for either dyads or triads. However, SE studies were more lenient, and

group size varied between groups. This review study led to an overview of the effects of first- and second-order argumentation scaffolds in terms of argumentation knowledge, argumentation behavior, attitude towards argumentation, and domain knowledge. The findings of this study do not show important differences between HE and SE because the studies did not explicitly indicate whether the educational level of the participants was considered in the design of the argumentation scaffolds. Similarly, the studies did not provide motivations behind the group size choices. Therefore, the choices could have been merely practical or part of the design of the learning activity based on the mastery level expected indicated in the learning outcome. Hence, the findings suggest that the CSCA field could benefit from more research where the effects of these variables (e.g., education level, communication form, and group size) on learning outcomes (e.g., quality of writing argumentative essays and domain-specific knowledge acquisition) are investigated. Similarly, the findings suggest that future studies should consider elaborating on the instructional design of the learning activities as the reasoning behind the design choices could contribute to and further the debate in the field. To conclude, the intention of argumentation scaffolds in HE and SE tend to achieve both first- and second-order argumentation effects. Similarly, it is not clear if and to what extent the context (e.g., educational level) and other design choices (e.g., communication form and group size) influence learning outcomes. The complete study was presented in Chapter 2 and includes a discussion and future research agenda.

6.2.2 Main Findings of Chapter 3

As presented in Chapter 1, the first step towards the successful design of argumentation scaffolds is defining the concept of argumentation competence and its composite parts. However, the literature presents diverse definitions of argumentation competence (Rapanta et al., 2013). Furthermore, there is a gap in the literature with respect to the relationships between the components of argumentation competence (i.e., students' knowledge of argumentation, argumentation behavior, and attitude towards argumentation), and between these components and domain-specific knowledge. Consequently, the second research question of this thesis was: *What are the relationships between students' knowledge on argumentation, argumentation behavior, attitude towards argumentation, and domain-specific knowledge?*

Chapter 3 dealt with this research question. As part of the theoretical framework, argumentation competence was defined as an integrated capability, in which its comprising elements – i.e., argumentation knowledge, argumentation behavior, and attitude towards argumentation – are intrinsically interwoven. The definition encompasses the elements that researchers typically measure, such as the skills students create and use during argumentative discourse (Rapanta et al., 2013) and argumentation knowledge (Noroozi, Weinberger, et al., 2013). In addition, the definition considers

students' attitudes towards argumentation since argumentative discourse activities may be affected by psychological, emotional, motivational, and social factors (Gilbert, 2004; Polo et al., 2016; Polo et al., 2017; Rourke & Kanuka, 2007).To answer the research question, an exploratory study with a pre- and post-test design was conducted in an authentic, online learning environment, in which the students' learning activities were not scaffolded at either micro or macro level. The study design let us link the components of argumentation competence to domain-specific knowledge gain between pre- and post-test with the argumentation activities executed in between. No significant relationships between students' knowledge, behaviors, and attitudes towards argumentation were found pre- or post-test. In contrast, domain-specific knowledge (pre-test) presented a small significant relationship with argumentation behavior (pre-test) and the construction of single arguments (collaboration). It was also found that domain-specific knowledge (post-test) presented a medium significant relationship with argumentation behavior (post-test), suggesting that the expertise in a topic facilitates the construction of arguments without regard of the application (i.e., the task at hand) or the social plane (i.e., individual or group level). The results suggested that students were able to transfer their argumentation behavior across social planes, that is, from the individual level to the collaborative level and back to the individual level. The study presented in Chapter 3 also investigated the differences in argumentation behavior between successful and less successful students in terms of domain-specific knowledge gains. On average, the argumentation behavior of successful students was better during the original answering (pre-test), the revised answering (post-test), and during collaboration. However, a significant moderate difference was only found in the revised answer. It was also found that the argumentation behavior of both successful and less successful students improved over time. However, the student type – i.e., successful and less successful – did not significantly affect the argumentation behavior score. The results also suggest that successful students profited more from the task, yet the interaction effect time-student type was not significant. Finally, a quantitative analysis indicated that, on average, successful students tend to write more words than less successful students, and that the level of heterogeneity was roughly similar.

In this study, no significant relationships between the elements comprising argumentation competence were found in the context of a non-scaffolded online learning environment. This result may be explained if it is considered that the activity was not obligatory and was not graded as it was not part of the course description. Hence, it is possible that students did not put the same effort as they would have if a grade were at stake. Similarly, students' argumentation knowledge and argumentation behaviors were not significantly related. In previous research (Kollar et al., 2007; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007), students failed to apply their argumentation knowledge during argumentative learning activities. The results

suggest that students struggle to externalize their argumentation knowledge no matter the social plane. However, the findings also report a positive relationship between domain-specific knowledge and argumentation behavior which suggests that students' abilities for putting their argumentation knowledge into practice is a direct result of their mastery or familiarity with the domain (see von Aufschnaiter et al., 2008, p. 1). Hence, more research is needed to shed light on how and the extent to which domain-specific knowledge is connected to students' argumentation knowledge and behavior. In a similar vein, more research is needed to determine how and to what extent a person's state of mind influences their behavior and thus their learning outcomes.

To conclude, this study further advanced the understanding of argumentation competence and the relationships between its comprising elements. Results suggest that the relationships between its comprising elements are affected by other variables (covariates), such as the mastery level of the domain or topic at stake. The complete study was presented in Chapter 3, along with a discussion and future research agenda.

6.2.3 Main Findings of Chapter 4

After exploring the effects of argumentation scaffolds in Chapter 2, defining the concept of argumentation competence, and exploring the relationships between its comprising elements in Chapter 3, it was then necessary to explore the effects of an online learning environment enriched with argumentation scaffolds. Online learning environments can support the acquisition of knowledge (Cheaney & Ingebritsen, 2005; Noroozi & Mulder, 2017; van Seters et al., 2012) and skills (Hsiu-Ping et al., 2014) if they are enriched with affordances in the user interface, in the form of texts, diagrams, and pictures (among other forms) that can guide and orchestrate students into productive activities (Fischer et al., 2013; Suthers, 2003). Among such activities is the writing of argumentative essays. Argumentative essay writing can be successfully supported by argumentative peer feedback scripts (Noroozi et al., 2016) or by worked examples (Ayres, 2012; Wittwer & Renkl, 2010). Scripts are instructional scaffolds that are used to facilitate and direct the provision of useful peer feedback. Scripting can facilitate and orchestrate student roles and interactions patterns to make them aware of what and when certain activities related to the feedback process should take place and who they should be administered by (Weinberger et al., 2007). Peer feedback is seen as one of the most important instructional practices for aiding students' learning (Hattie & Gan, 2011; Hattie & Timperley, 2007; Shute, 2008) as it provides to them with opportunities to learn from each other without immediate intervention from a teacher (Boud et al., 1999; Hattie & Timperley, 2007; Kluger & Denisi, 1996). The information (e.g., correcting the answer, timeliness, learning guidance, motivational messages) contained in a feedback event can prompt students to evaluate and revise their domain or metacognitive knowledge, beliefs, cognitive tactics, and strategies (Winne & Butler, 1994, p. 5740). Similarly,

worked examples are an instructional method where students learn by studying fully worked examples, that is, examples including solutions steps and the final solution (Ayres, 2012). Its effect, the *worked example effect*, is one of the best established findings in the literature on cognitive load theory (Schwonke et al., 2009; Sweller et al., 1998). Combining argumentative peer feedback scripts and worked examples is a promising approach to scaffolding students' writing of argumentative essays. Worked examples can be used to support students' understandings of expected outcomes, associated steps, and their rationale, while scripting can be used to guide and orchestrate students through the learning activity. However, it is unclear if combining worked examples and peer feedback can improve learning outcomes. Consequently, the third research question of this thesis was: *Is there potential in an online learning environment with worked examples and peer feedback on students' argumentative essay writing and domain-specific knowledge acquisition?*

Chapter 4 investigated the research question in the field of biotechnology. After introducing the benefits of online learning environments (Cheaney & Ingebritsen, 2005; Hsiu-Ping et al., 2014; Noroozi & Mulder, 2017; van Seters et al., 2012) and affordances embedded in their user interface on students learning (Fischer et al., 2013; Suthers, 2003), the chapter introduced peer feedback as one of the most compelling instructional practices for supporting learning (Hattie & Timperley, 2007; Kluger & Denisi, 1996). A feedback event provides information about the current task and/or desired performance on an expected standard. Similarly, the concept of worked examples was introduced as another approach to scaffold students learning. Moreover, the importance of providing worked examples with *product-oriented information* (i.e., the solutions steps and the final solution) and *process-oriented information* (i.e., the rationale of why the solution steps should be followed (Wittwer & Renkl, 2010)) on the internalization of the process was addressed. It was then argued that the internalization of the process may support students in: a) providing high-quality feedback, which is beneficial for enhancing their writing skills (DeNisi & Kluger, 2000), and b) providing on-task feedback instead of off-task feedback (Hattie & Timperley, 2007).

To answer the research question, an empirical study with a pre- and post-test design was conducted in an authentic learning environment. The learning activity involved the provision of feedback using an online learning environment with information in different forms such as texts, diagrams, and pictures. Similarly, the learning environment provided students with theory and a worked example depicting what a good argumentative essay should look like. The statistical analyses indicated that students' domain-specific knowledge and the quality of writing argumentative essays improved significantly from pre- to post-test, suggesting that the online learning environment had a positive effect on the learning outcomes. Similarly, the results suggest that combining

the two instructional scaffolds is an effective way of positively influencing the learning outcomes. On one hand, worked examples seemed to have successfully supported students' understanding of the expected outcome (i.e., an argumentative essay – product-oriented information), associated steps (i.e., the features of a complete and sound argumentative essay – product-oriented information), and their rationale (or the motivation behind each of the features if present – process-oriented information). On the other hand, argumentative peer feedback scripts seemed to have successfully guided the students' interactions and the provision of feedback during the learning activity. The preliminary results (see the previous note on examining possible causal relationships on pg. 60) suggest that the argumentation scaffolds complemented each other and did not provide redundant information. Redundant information may hinder learning as it can produce unnecessary overloading and suboptimal learning processes due to the *redundancy effect* (Sweller, 2005; Sweller et al., 1998) and over-scripting (P. Dillenbourg, 2002). Unfortunately, the design of the study did not shed any light on the effect size of each of the argumentation scaffolds.

To conclude, this study further advanced the understanding of the potential of argumentation scaffolds. It explicitly shed light on the possibilities of designing learning activities that can combine two scaffolds and that they can complement each other.

6.2.4 Main Findings of Chapter 5

Given the contents of the previous chapters, the next logical step was further exploring peer feedback and its effects. Building on the study presented in Chapter 4, the study presented in Chapter 5 went more in-depth by exploring whether feedback type influences learning outcomes. Peer feedback is a powerful instructional practice used to foster learning and that facilitate the writing of argumentative essays in digital environments where students engage in reflective criticism of the work and/or performance of their peers. However, it is yet unclear if the provision of directed feedback (standard feedback, feedforward, or a combination of both) is more effective than undirected feedback in fostering argumentative essay writing skills and domain-specific knowledge acquisition. Consequently, the fourth research question of this thesis was: *What are the effects of a various peer feedback scripts on the quality of writing argumentative essays and the acquisition of domain-specific knowledge?*

Chapter 5 addressed this question. The theoretical framework was comprised of different elements. Firstly, the concept of peer feedback was defined as the action taken by a peer to provide information regarding some aspect(s) of one's performance or understanding of the task in question (Hattie & Timperley, 2007; Kluger & Denisi, 1996). Secondly, the concepts of standard feedback and feedforward were introduced. Standard feedback provides information related to the actual task and/or desired performance with respect

to an expected standard (how am I doing?). In contrast, feedforward indicates possible lines of inquiry or indicates alternative strategies to pursue (where to go next?). Thirdly, scripts were introduced as an approach to facilitate and direct the provision of useful peer feedback to foster writing and learning. Finally, the study introduced the concept of a directed peer feedback script embedded in a digital learning environment. The directed peer feedback script was comprised of guiding questions designed to teach students to provide feedback of a specific type and to address the different elements of an argumentative essay. To answer the research question, an exploratory study with a pre- and post-test design was conducted in an authentic, online learning environment. The major independent variable, the *feedback script type*, had four levels: standard feedback (FB), feedforward (FF), standard feedback with feedforward (FB+FF), and undirected feedback (UF).

The statistical analyses indicated that the quality of feedback is influenced by the feedback script type; specifically, the directed peer feedback script was more effective for the creation of FB and FB+FF. However, the script was not very effective supporting and directing the creation of FF. This finding could be explained if we take into account that students are more familiar with the provision of standard feedback, that is, students' feedback typically provides information related to the actual task and/or desired performance, prior performance, and/or the success or failure of (part of) the task (how am I going/doing?) (Hattie & Timperley, 2007). In contrast, students are less familiar with the provision of feedforward. Unfortunately, the study did not validate whether the feedback provided was indeed of the form requested. Therefore, future studies involving feedforward should consider the use of worked examples (Ayres, 2012) to support the understanding of the expected outcome of the task at hand. In addition, the results indicate that the quality of writing argumentative essays and the acquisition of domain-specific knowledge are influenced by the quality of the feedback received, but there was not a significant effect of the feedback script type. This finding could be explained if we consider that the information contained in a feedback event could include information related to the correctness of the answer, critical comparisons among others (Mory, 2004). The information allows students to confirm, revise, and restructure their domain or metacognitive knowledge and their work (Winne & Butler, 1994, p. 5740).

To conclude, this study further advanced the understanding of argumentation scaffolds. It provides more insight into the design of argumentation scaffolds based on peer feedback scripting. Similarly, the discussion highlights the relevance of ensuring that students understand the task in question, and how understanding the task can influence the outcomes.

6.3 Research Findings in an Integrated Perspective

This thesis consists of four main studies including a review study and three empirical studies that were conducted in real educational settings. The studies contributed to the advancement of the body of knowledge on argumentation by investigating the use of online learning systems enriched with argumentation scaffolds that were designed to foster the acquisition of argumentation competence and domain specific knowledge. In this section, the main findings of these studies are discussed in combination.

The results of the review study presented in Chapter 2 shed light on the intentions and effects of first- and second-order argumentation scaffolds of CSCA in argumentation competence and domain-specific knowledge acquisition, and suggested areas for future research. Similarly, Chapter 2 served as framework of reference and inspiration for the studies presented in chapters 3, 4, and 5.

In Chapter 2, first-order scaffolds were defined as scaffolds designed to enable students to acquire domain-specific knowledge. In contrast, second-order scaffolds were defined as scaffolds designed to enable students to acquire argumentation competence (for an overview see Kirschner et al., 2003; Noroozi et al., 2012; Scheuer et al., 2010). The findings of this study supports the claims of Noroozi et al. (2018), who argue that most argumentation scaffolds have been designed to enable students to acquire domain-specific knowledge or a complex cognitive skill. Noroozi et al. (2018) argue that argumentation scaffolds should be designed as second-order, that is, the scaffolds should promote the acquisition and internalization of argumentation competence. The argumentation scaffolds employed in chapters 4 and 5 stimulated students' argumentative discourse activities for acquiring domain-specific knowledge and the acquisition of argumentation competence, so present a first- and second-order character. The acquisition was facilitated by guiding and orchestrating students throughout the learning activity, explaining the concepts and the associated reasoning, and facilitating the practice of argumentation competence (knowledge and skills).

The rationale was that acquiring argumentation competence and learning how to self-regulate argumentative activities in comparable situations results in acquisition of domain-specific knowledge and the development of the associated cognitive skills. Next to the intention and effects of argumentation scaffolds, it was deemed important to have a clear definition of the concept of argumentation competence and its comprising elements to have a real understanding of their intentions and effects. To provide a definition of argumentation competence (students' argumentation knowledge, argumentation behaviors, and attitudes towards argumentation) an integrative perspective on the literature was used. Rapanta et al. (2013) indicate that researchers typically measure

students' knowledge on argumentation prior to and after collaborative discourse activities. However, next to pre- and post-measurements, it is important to also consider students' behavior during actual discourse to assess their competence because students possessing argumentation knowledge are not necessarily able to put that knowledge in practice (Kollar et al., 2007; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007). Moreover, it is also necessary to consider students' attitudes toward argumentation since psychological, emotional, motivational, and social barriers in the form of nervousness, anxiety, or emotions can negatively influence argumentation activities or even make them impossible. Hence, next to knowledge and behavior, attitudes toward argumentation should also be considered.

The intention and effects of first- and second-order argumentation scaffolds and the definition of argumentation competence presented in Chapter 2 was the starting point for the empirical studies presented in chapters 3, 4, and 5. The study presented in Chapter 3 aimed at disentangling the relationships between the components of argumentation competence (knowledge, behavior, and attitude), and their relationships with the acquisition of domain-specific knowledge. The design of the study (i.e., a regular, online learning environment, in which students' learning activities were not scaffolded at micro (i.e., single arguments) or macro levels (i.e., essay composition/ structure) (Noroozi et al., 2016)) allowed for a further increase of the understanding of the process of acquiring skills and knowledge during a regular collaborative learning activity in an online learning environment. The statistical analyses executed as part of the second study did not find significant relationships between the comprising elements of argumentation competence. This finding seems to be a big contradiction to our theoretical framework and definition of argumentation competence. It was argued that students' knowledge on argumentation, argumentation behavior and attitude toward argumentation – which comprise their argumentation competence – appear to be interwoven and may influence the learning outcomes of the discourse. The finding can be explained if we consider Samarapungavan (2018) and Chinn and Duncan (2018) line of argumentation. Samarapungavan argues that students need to learn detailed and highly domain-specific patterns of reasoning and argumentation to reason and argue about topics within a particular domain. Similarly, Chin and Duncan argue that a successful performance on reasoning and argumentation on scientific problems require a degree of expertise for domain-specific aspects of reasoning and argumentation. The latter suggest that students gain argumentation competence as they gain expertise on reasoning and argumentation within a specific domain. Hence, it is possible that as the expertise increases, the relationships between the comprising elements of argumentation competence become more significant and prominent. Similarly, the design of argumentation scaffolds should take the degree of domain expertise of domain-specific aspects of reasoning and argumentation into account. If online learning systems are used,

then it is also possible to use adaptive fading to offer adaptive external support (Noroozi et al., 2018). Similarly, the findings indicate a positive relation between domain-specific knowledge and behavior suggesting that students' expertise on the domain or issue at hand facilitates the construction of arguments without regard of the application (e.g., argumentative essay or argumentative discourse) or the social plane (i.e., individual or groups). Moreover, the results suggest that students can transfer their argumentation behaviors across social planes. The relationships between argumentation behaviors across different applications and social planes emphasize the importance of measuring at different points; argumentation knowledge (before and after) and argumentation behavior (before, during, and after collaborative discourse).

In addition, the results suggest that students had problems externalizing their argumentation knowledge both at the individual (argumentative essay) and collaborative levels (argumentative discourse). These results are in line with previous literature in which students were not able to manifest their argumentation knowledge into argumentation behavior both at the individual and collaborative levels (Kollar et al., 2007; Noroozi, Weinberger, et al., 2013; Stegmann et al., 2012; Stegmann et al., 2007). A possible underlying reason for the externalization issue is that it could be a direct result of the students lack of mastery or familiarity with the domain (see von Aufschnaiter et al., 2008, p. 1) or a lack of domain expertise in domain-specific aspects of reasoning and argumentation (Chinn & Duncan, 2018). Hence, it is important to further investigate how individual and group learning activities enhanced with argumentation scaffolds can increase the quality of the argumentation. Similarly, it is important to design and conduct longitudinal studies to better evaluate the development of students' argumentation competence, and to determine whether the relationships between the components of argumentation competences get stronger and more significant as students' mastery increases over time.

The findings of Chapter 3 support the need to design, implement, and evaluate instructional scaffolds to support and facilitate students' acquisition of domain-specific knowledge and argumentation competence. In the present thesis, this need was considered and resulted in the design of the studies presented in chapters 4 and 5. Chapter 4 investigated the potential of worked examples and peer feedback in fostering argumentative essay writing skills. Combining worked examples and peer feedback seems to have potential to improve learning outcomes. Yet, further investigation is needed to determine implication. Worked examples can support the understanding of goals, necessary steps, and their rationale, that is, they promote argumentation knowledge and facilitate argumentation behavior by showing how knowledge should be transferred into behavior. Meanwhile, scripting peer feedback can guide and orchestrate students during the learning activity, thus promoting and eliciting students' argumentation behaviors

in executing tasks. Chapter 5 explored the effectiveness of various peer feedback types (undirected feedback, standard feedback, feedforward, and a combination of both) in an online learning environment in terms of feedback quality and learning outcomes (argumentative essay writing and the acquisition of domain-specific knowledge). Based on the theoretical framework presented in Chapter 2 and its intention (i.e., to facilitate the acquisition of domain-specific knowledge and argumentation competence), the argumentation scaffolds employed in the studies presented in chapters 4 and 5 have a first- and second-order character.

The results presented in Chapter 4 suggest that students were able to improve the quality of their argumentative essays and gained domain-specific knowledge from pre-test to post-test, using an online learning environment that combined worked examples and peer feedback. The results are in line with previous research arguing the positive effects of worked examples (Ayres, 2012; Schwonke et al., 2009; Sweller et al., 1998), theory, and instructional explanations (Van Gog et al., 2004; Wittwer & Renkl, 2010) and practice (Ayres, 2012; Pashler et al., 2007). The results also expand the body of knowledge of argumentation scaffolds as they suggest the combination of worked examples and scripted peer feedback may have a positive effect on the learning outcomes (see the previous note on examining possible causal relationships on pg. 60). Moreover, in Chapter 3, it was mentioned that "the main indicator of whether or not a high quality of argument is likely to be attained is students' familiarity and understanding of the content of the task" (von Aufschnaiter et al., 2008, p. 1). The latter is part of the reasoning behind the study design of the studies presented in chapters 4 and 5, that is, instructing students to learn about a topic by reading a theoretical text and scientific articles on it, and by providing theory and a worked example of what a good argumentative essay should look like. By doing so, students can increase their mastery or familiarity with the subject (see von Aufschnaiter et al., 2008, p. 1) and increase their subject expertise of domain-specific aspects of reasoning and argumentation (Chinn & Duncan, 2018).

The argumentation scaffolds employed in Chapter 4's study (i.e., peer feedback scripts and work examples) seem to have potential as successful instructional approaches. However, it was not clear whether feedback type could play a role in the learning outcomes of students supported with argumentation scaffolds in online learning systems. Therefore, in Chapter 5, the design and evaluation of argumentation scaffolds were also investigated. Results revealed significant differences between the conditions (i.e., standard feedback, feedforward, standard feedback with feedforward, and undirected feedback) in terms of the quality of feedback provided, implying that peer feedback quality can be enhanced or diminished by guiding the feedback type. In addition, and in line with the preliminary findings of the study presented in Chapter 4, facilitating the peer feedback process allows students to provide valuable feedback to their learning

partners about the topic in question (Hattie & Timperley, 2007; Kluger & Denisi, 1996). The study shed light on the implications of feedback type on the quality of the task, in this case peer feedback quality. As such, it is very important to pay attention to the design of argumentation scaffolds as they can not only influence learning positively, but a bad design can hinder it. Moreover, the results indicated an increase in the learning outcomes of all students without significant differences among conditions. Lastly, the increase in the learning outcomes is in line with previous research arguing the positive results of peer feedback on writing skills (Brown, 2004; Gabelica et al., 2012; Kellogg & Whiteford, 2009; Latifi, Noroozi, Hatami, et al., 2021; Noroozi et al., 2016) and domain-specific knowledge acquisition (Nelson & Schunn, 2009; Noroozi & Mulder, 2017).

6.4 Strengths, Weaknesses, and Suggestions for Future Research

This thesis contains a review study and three empirical studies conducted in authentic educational settings. The studies intend to further increase the body of knowledge on argumentation and the use of online learning systems enriched with argumentation scaffolds to support the acquisition of argumentation competence and domain specific knowledge.

The review study presented in Chapter 2 identifies two types of argumentation scaffolds, the ones designed as first-order scaffolds, to acquire domain-specific knowledge, or as second-order scaffolds, to acquire argumentation competence. The review shed light on the intention and presence or not of effects of first- and second-order argumentation scaffolds in terms of argumentation knowledge, argumentation behavior, attitude towards argumentation, and domain-specific knowledge on the context of HE and SE. This review study reported on argumentation scaffolds with significant effects in terms of first- and second-order argumentation scaffolds. However, the study did not report on the effect size. Therefore, it would be valuable to the field if another literature review on argumentation could report on the effect size, that is, the magnitude to which the first- and second-order argumentation scaffolds or their combination affected the learning outcomes and, based on that, provide recommendations for the most effective argumentation scaffolds for a given educational setting. Therefore, future research could conduct a quantitative meta-analysis on the topic to determine which argumentation scaffolds and under what conditions have the greatest effect size on domain-specific knowledge, argumentation competence or both. This would provide researchers with evidence for concluding if and how a given intervention has a real and, most importantly, a large effect on the dependent variable. Moreover, according to von Aufschnaiter et al.

(2008), students lack of mastery or familiarity with the domain, which can influence the learning outcomes; future research should explore if and to what extent the provision of theoretical knowledge on argumentation before engaging students in CSCA compares to other argumentation scaffolds in terms of the effects on the acquisition of argumentation knowledge and domain-specific knowledge. This will provide researchers with insight into the effectiveness of theoretical knowledge (Van Gog et al., 2004; Wittwer & Renkl, 2010) in comparison to argumentation scaffolds providing diverse affordances such as texts, diagrams and pictures intended to direct students toward productive activities and learning (Fischer et al., 2013; Noroozi & Mulder, 2017; Suthers, 2003).

The exploratory study in Chapter 3 provided a better understanding of the relationships between the components that comprise argumentation competence and domain-specific knowledge, and the differences in argumentation behavior between successful and less-successful students in terms of domain-knowledge gain. The study took place in an authentic educational setting, so offers high ecological validity. However, the nature of the study and the goal of understanding argumentation competence and the relationships between its comprising elements in an authentic un-scaffolded educational setting led to other research questions that could be addressed in future research. Future research could conduct a similar study, but in an experimental situation with un-scaffolded (control) and scaffolded (intervention) groups. Such research would shed light on how, which conditions, and to what extent an argumentation-scaffold may have a significant effect (and its magnitude) on the relationships between the components comprising argumentation competence and domain-specific knowledge. Furthermore, in this study, students were motivated to participate by requiring submission of the assignments to get admitted to the final examination; students' assignments were also not graded. Future research could validate the findings of this study by conducting an experimental study focusing on answering how and to what extent student motivation (e.g., grading vs not grading assignments) influences learning outcomes. In this study, students' assignments and discussions were analyzed in terms of construction of single arguments, construction of argumentation sequences, transactivity, and participation, but the improvement of content quality was not considered. Hence, future research could focus on determining the relationships between the components comprising argumentation competence and the improvement on the content quality in terms of surface- and meaning-level changes. In addition, future research could further investigate the relationship between argumentation behavior and domain-specific knowledge (e.g., if higher domain-specific knowledge implies better argumentation behavior). Such research could provide valuable evidence to investigate the design of argumentation scaffolds that vary on their support based on the student's domain specific knowledge mastery level. Furthermore, research could be conducted to assert the effect of highly controlled environments and rewards in the relationships between the elements of argumentation competence and

domain-specific knowledge. The results of such research could provide evidence for designing future experiments with high validity or better understanding the limitations and boundaries.

The study presented in Chapter 4 shed light on the potential positive effects of an online learning environment enriched with argumentation scaffolds, in the form of worked examples and peer feedback, designed to foster students' argumentative essay writing skills and domain-specific knowledge acquisition. The study took place in an authentic educational setting, which presented pros and cons. One of the positive aspects was that both the practical relevance and ecological validity of the study were high. Students completed the tasks in authentic educational settings and were intrinsically driven by their motivation to learn and pass the course. In contrast, students engaging in tasks in laboratory settings may produce unrealistic data that may result in unrealistic synthetic results, as students are typically driven by monetary rewards received upon successful completion of the tasks. The study presented one important limitation: the lack of an experimental design. As such, the lack of a control condition did not allow us to disregard the effects of variables other than the independent variable. In contrast, the choice of not having a control condition prevented a possible disadvantage for students, since their revised essays were graded, so the intervention could have played a role on the outcome. Moreover, the design and focus of the study prevented us from investigating the individual effects of the argumentation scaffolds (i.e., the worked examples and the peer feedback) on the learning outcomes and to draw causal conclusions. Therefore, further research should investigate the relationships between the argumentation scaffolds and if they have a summative effect. These results could provide focus to future research on combining argumentation scaffolds to increase the effect size. Similarly, the study presented the effects of argumentation scaffolds after the completion of only one task. Besides an experimental design, future research could also consider a longitudinal design for determining the effectiveness of the instructional scaffolds over a series of tasks. The experiment could also make provisions to control for the *expertise-reversal effect*, the decrease on the effectiveness of the scaffold as students gain experience (Kalyuga et al., 2003), and the *redundancy effect* (investing cognitive resources in instructional support that may be redundant (Sweller, 2005; Sweller et al., 1998)), which can affect the learning outcomes as they can inhibit students' self-regulation and learning.

The exploratory study in Chapter 5 shed light on the effects of a digital learning environment enhanced with argumentation scaffolds. Specifically, it reported the positive effects of argumentation scaffolds in the form of directed feedback (standard feedback, feedforward, or a combination of both) and undirected feedback on the quality of writing argumentative essays and in domain-specific knowledge acquisition. Similarly to the studies presented in chapters 3 and 4, this study was conducted in situ

and thus presents high practical relevance and high ecological validity. One of the areas of opportunity of the study is the number of argumentation scaffolds. In this study, next to the per-feedback script, students were also supported with theory on the composition of an argumentative essay and an example of an argumentative essay. The results suggest that the lack of significant differences between the different conditions in terms of the learning outcomes is related to over-scripting the learning activity. Thus, it is possible that one or more of the scripts was redundant or even unnecessary, and may have caused the *redundancy effect* (Sweller, 2005; Sweller et al., 1998) and cognitive overload. Therefore, future research should consider reducing the number of argumentation scaffolds per experiment to understand their individual and combined effects. Another criticism of this study is the scale and the coding scheme used to measure the quality of peer feedback. The scale ranges from 0 to 2 and was developed and used previously by Noroozi et al. (2016). However, the scale may not offer a sufficiently large spectrum of variation in contrast to a scale with more points. Another criticism of this study is that it only measured the effect of the intervention in the short term but not in the long term. Future research should focus on conducting a longitudinal study that can provide valuable evidence on how and to what extent students internalized the knowledge. Similarly, future research should investigate the effects of theory and worked examples (second-order scaffolds) in contrast to scripting (e.g., feedback type; first-order scaffold). Theory and worked examples promote argumentation knowledge and argumentation behavior by showing how to transfer knowledge into behavior in contrast to guiding and orchestrating students during learning activities, thus promoting and requiring students' argumentation behavior to execute a task. The results can support further research to investigate how, the extent to which, and the learning activities where different types of argumentation scaffolds are more effective.

6.5 Implications for Educational Practice

The results presented in the various chapters of this thesis have several important implications for educational practice. As stated in the introduction, today's students are part of the so-called Information Age (Voogt & Knezek, 2008) and the Knowledge Economy. Students and professionals alike are faced with global, complex, and cross-disciplinary challenges that demand professionals with cross-disciplinary knowledge. Similarly, professionals are expected to work with others in multidisciplinary teams and to train and develop while they work (i.e., continuous learning). Governments are even offering incentives to foster continuous learning, such as the "STAP budget" announced recently by the Dutch government[3]. All these means that professionals and students require to upskill, retrain, further develop, or acquire new sets of skills, such as the so-called 21st Century Skills (Partnership for 21st Century Learning, 2015).

Some of the 21st Century Skills are related to learning and innovation (i.e., critical thinking, communication, collaboration, and creativity). In the context of education, critical thinking provides the basis for the acquisition of scientific knowledge, which revolves around logical reasoning and argumentation. Students and professionals often solve argumentative tasks in conjunction with partners who have different backgrounds, perspectives, and knowledge about the challenge in question. To be able to successfully collaborate and solve the challenges at hand, students and professionals need to build upon, relate to, and refer to their peers' contributions so that they can learn and co-construct knowledge. Hence, it is important to support students in the acquisition and development of 21st Century Skills, such as critical thinking and its comprising skills such as logical reasoning and argumentation.

This PhD thesis offers various types of instructional approaches in the form of first- and second-order argumentation scaffolds to foster the acquisition of argumentation competence and domain-specific knowledge. The findings of the diverse studies suggest that designing learning activities enriched with argumentation scaffolds can facilitate the acquisition of critical thinking, communication, collaboration, and creativity, and thus, can prepare students to face today's global, complex, and cross-disciplinary challenges.

The results of the review study presented a clearer idea of the effects (e.g., whether they were found or not) of first- and second-order argument scaffolding in HE and SE. Similarly, it provided an overview of the intention of the argumentation scaffolds, the form of communication (asynchronous or synchronous), and the group size (e.g., dyads and triads). These results can inform and drive course developers during the design of learning activities aimed at fostering the acquisition of domain-specific knowledge and/or argumentation competence. To support the acquisition of argumentation competence, course designers can employ argumentation scaffolds designed to support learners to focus on specific content by means of external representations (e.g., Belland, Glazewski, & Richardson, 2008; Mirza, Tartas, Perret-Clermont, & De Pietro, 2007). Similarly, course designers can make use of first- and second-order argumentation scaffolds in the form of worked-examples and argumentation scripts to foster the acquisition of domain-specific knowledge and argumentative essay writing (see chapters 4 and 5). Argumentation scaffolds can also be used to construct knowledge, enable a comprehensive understanding, cognitive development, and complex problem solving (e.g., Andriessen et al., 2003; Kirschner, Buckingham-Shum, & Carr, 2003). However, next to defining the learning objective, the assessment format, and the learning activity, teachers and practitioners should identify problematic areas that impede learners from performing the given task or achieving the desired goal and select the right argumentation

3 https://business.gov.nl/subsidy/stap-budget-training-development/

scaffold(s).

The study presented in Chapter 3 provided direct practical relevance of a learning scenario without argumentation scaffolds. There is a need to design, implement, and evaluate argumentation scaffolds to facilitate the writing of argumentative essays, and to guide and engage students into fruitful argumentative discourse, since students struggle to transfer argumentation knowledge to applications. In addition, it seems that students' argumentation behavior can operate back and forth between different applications and social planes. Course designers can take this into consideration during the design of learning activities that are intended to evaluate students individually or as a group. Course designers and practitioners should be aware of the relationship between students' argumentation behavior and their knowledge on a given topic; the more students know and understand about the topic, the more they will be able to present arguments without regard to the application or social plane. Moreover, the successful performance of learning activities requiring reasoning and argumentation is dependent on the degree of domain expertise of domain-specific aspects of reasoning and argumentation. Hence, course designers and practitioners should design learning activities throughout the whole course and curriculum that, next to domain-specific knowledge, also consider the acquisition of argumentation practice.

The empirical studies presented in chapters 4 and 5 are directly relevant to course designers and practitioners. Both illustrate the possibility of using argumentation scaffolds in different domains such as biotechnology, microbiology, law, and science. In the context of biotechnology, online learning systems can be used to develop students' laboratory skills, acquire domain-specific knowledge, and to foster argumentative essay writing skills. Argumentative essay writing is an aptitude that undergraduate and graduate students across disciplines generally lack. Therefore, course designers and practitioners can use online learning environments combined with worked examples and peer feedback to improve the quality of argumentative essay writing and support domain-specific knowledge acquisition. Worked examples encourage students to study fully worked examples (i.e., examples with solutions steps and the final solution, and learn from them). Meanwhile, scripting peer feedback can direct, guide, and orchestrate the type and format of feedback that students provide to their peers. In addition, course designers and practitioners can use argumentation scaffolds in the form of peer feedback scripts to direct students into the provision of on-task feedback rather than off-task feedback. The peer feedback process allows students to compare each other's work, which in turn, triggers the validation and the restructuring of knowledge conceptions, and the identification and rectification of errors and misconceptions.

The study presented in Chapter 5 explored the effectiveness of various peer feedback types (undirected feedback, standard feedback, feedforward, and a combination of both) in an online learning environment in terms of the feedback quality and the learning outcomes (i.e., argumentative essay writing and acquisition of domain-specific knowledge). Course designers and practitioners can employ computer-supported peer feedback and feedforward to promote students engaging in reflective criticism of the work and/or performance of their peers using given criteria and providing feedback (on the actual task with respect to the actual performance) or feedforward (on potential directions or strategies to reach a desired goal) to them. Similarly, course designers and practitioners looking into increasing the quality of argumentative essay writing and into increasing domain-specific knowledge can employ peer feedback scripts to structure and guide students' analysis of the argumentative essays of learning partners, to trigger reflection and reasoning, and to direct the feedback type. Moreover, course designers and practitioners should exercise caution when combining multiple instructional scaffolds, as some scaffolds may nullify others as the result of suboptimal learning processes due to overloading (e.g., *redundancy effect* and over-scripting).

This PhD thesis may have implications for the design of online education, study programs based on Challenge Base Learning (CBL), or when exceptional emergency situations prevent face to face interaction between learners. In the case of CBL, students face cross-disciplinary challenges that they need to tackle, together with peers with different backgrounds. Hence, students need to develop argumentation competence to communicate, collaborate, and co-construct knowledge by building upon, relating to, and referring to what has been said by their peers to learn and co-construct knowledge (Noroozi et al., 2018; Noroozi et al., 2012). As students build upon, relate to, and refer to each other's knowledge to complete learning activities, students engage in argumentative discourse that is associated with deep, meaningful learning.

Argumentation competence is essential in both academic and professional life. We therefore encourage program directors and curriculum designers to consider the inclusion of argumentation competence as part of study program curricula. Argumentation competence should be one of the "professional skills" or "soft-skills" and be embedded as one of the learning activities students learn alongside course specific knowledge, rather than having a learning activity devoted entirely to it.

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English Summary

The growth of communication and mobile digital technologies has stimulated the creation of large amounts of information resulting in the so-called Information Age, and the Knowledge Economy where the main source of economic growth are products and services based on knowledge-intensive activities.

The evolution of technology has significantly affected society and the types of challenges that students and professionals face. Students and professionals in all fields are now confronted with global, complex, and cross-disciplinary challenges. Similarly, professionals need to cope with the fast, iterative, prototype-and-learn way of working that the industry is increasingly adopting. Moreover, professionals should be able to find, assess, interpret, and represent new information quickly, and communicate and collaborate with others in multidisciplinary groups, but most importantly, they need to think and learn for themselves. All this means that professionals need to acquire and develop new skills, namely the so-called 21st Century Skills. Among such skills, four are related to learning and innovation and are recognized as those that set apart students who are better prepared to cope with the complex 21st century work environments from those who are not. The four skills in question are critical thinking, communication, collaboration, and creativity. In the context of education, critical thinking plays an important role in the acquisition of scientific knowledge which is built on logical reasoning and argumentation. Students and professionals across disciplines should acquire and develop critical thinking and argumentation competence to analyze, conceptualize, synthesize, and cope with the challenges of the 21st century.

This thesis aim is to further expand the understanding of argumentation competence, its comprising elements, and the intention and design of argumentation scaffolds in online learning systems. To accomplish the aim, a multi-method approach was followed using a combination of review, exploratory, and experimental studies. The thesis is comprised of six chapters. Chapter 1 introduces the reader to the core concepts of this thesis. In Chapter 2, the following research question is addressed: *What are the effects of first-order and second-order argument-scaffolding in Higher Education (HE) and Secondary Education (SE), and how does one way of scaffolding influence the other?* The chapter provides an overview on argumentation, followed by a definition of argumentation competence and its comprising elements (argumentation knowledge, argumentation behavior, and attitude towards argumentation). Next, the chapter introduces and defines first-order scaffolds (i.e., scaffolds designed to acquire domain-specific knowledge) and second-order scaffolds (i.e., scaffolds to acquire argumentation competence). Then, based on the literature, the chapter introduces and describes the variables educational level, communication form and group size and how they can influence the definition and in

consequence the effects of argumentation-scaffolds. A systematic review of the literature was executed to answer the research question. The review permitted to analyze in a systematic fashion the intention and effects of argumentation scaffolds that have been investigated in empirical studies of Computer-Supported Collaborative Argumentation (CSCA). The review of the literature followed a systematic search strategy (527 articles were found) and considered specific inclusion criteria resulting in the selection of 19 articles which were then coded on the study design and variables. The studies varied in terms of educational level (HE or SE), the intention of the argumentation scaffolds, the effects on the acquisition of domain-specific knowledge, argumentation knowledge, and argumentation behavior, the communication form (synchronous or asynchronous), and group size (dyad, triad, etc.). Then, a systematic map was created. The study synthesizes the findings, suggests areas in which more research is required, and offers guidance to practitioners and researchers in the field of CSCA in terms of successful approaches of argument scaffolding and communication form in HE and SE.

In Chapter 3, the second study is presented. The study explores the relationships of the components comprising argumentation competence and between these components and the learning outcomes. The aim of the study is then presented in the form of the following research question that reads: *What are the relationships between students' knowledge on argumentation, argumentation behavior, attitude towards argumentation, and domain-specific knowledge?* Firstly, as part of the theoretical framework, the concept of argumentation competence was defined as an integrated capability, in which it's comprising elements, i.e. argumentation knowledge, argumentation behavior and attitude towards argumentation are intrinsically interwoven. The definition comprises the elements that researchers commonly measure such as argumentation knowledge and the skill that students manifest during argumentative discourse(Noroozi, Weinberger, et al., 2013). Moreover, the definition considers students attitude towards argumentation because argumentative discourse activities may be affected by psychological-, emotional-, motivational-, and social factors. To address the research question, an exploratory study with a pre- and post-test design was conducted in a real educational setting. An online learning environment was used in which the learning activities of the students were not scaffolded at micro- (i.e., single arguments) or macro levels (i.e., essay composition/structure). The design of the study allowed us to connect the components of argumentation competence to domain-specific knowledge gain between pre- and post-test with the argumentation activities executed in between. Contrary to our expectations, no significant relationships between the elements comprising argumentation competence were found in the context of a non-scaffolded online learning environment. This finding seems to contradict our theoretical framework and definition of argumentation competence. The result may be attributed to different reasons such as the fact that the activity was not obligatory and not graded. Similarly,

another possibility is that each domain demands a certain degree of domain expertise of domain-specific aspects of reasoning and argumentation, that is, students need to learn detailed and highly domain-specific patterns of reasoning and argumentation to reason and argue about topics within a particular domain. The latter suggest that students' mastery on argumentation competence increase as students gain expertise on reasoning and argumentation within a specific domain. Hence, it is possible that as the expertise increases the relationships between the comprising elements of argumentation competence gets more significant and prominent. Next to that, more research is needed to shed light on the relationships of the components comprising argumentation competence and domain-specific knowledge acquisition. In addition, further research is needed to determine how, and to which extend a person's state of mind influence the behavior and thus the learning outcomes. This study advanced the understanding of argumentation competence and the relationships between its comprising elements. Similarly, the study results suggest that the relationships between its comprising elements is affected by other variables (covariates) such as the mastery level of the domain or topic at stake.

Based on the results of the review study (presented in Chapter 2) and the exploratory study (presented in Chapter 3), argumentation scaffolds were designed to foster argumentation competence and domain-specific knowledge acquisition in an online learning environment. The study, presenter in Chapter 4, explores the effects of an online learning environment supported with worked examples and peer feedback on students' argumentative essay writing and domain-specific knowledge acquisition. Online learning environments have been enhanced with affordances in the user interface (e.g., texts, diagrams, and pictures) that can guide and direct students to facilitate the acquisition of knowledge and skills such as writing argumentative essays. Argumentative essay writing can be successfully supported by argumentative peer feedback scripts or by worked examples. Scripts are instructional scaffolds that can be used to facilitate and direct the provision of useful peer feedback. Peer feedback can help to increase students' learning as it provides opportunities to students to learn from each other without the immediate intervention of the teacher. Meanwhile, worked examples is an instructional method where students learn by studying from fully worked examples. There is unclarity regarding the effects of combining argumentative peer feedback scripts and work examples on the learning outcomes. In consequence, the third research question of this thesis reads: *Is there potential in an online learning environment with worked examples and peer feedback on students' argumentative essay writing and domain-specific knowledge acquisition?* An empirical study with a pre- and post-test design was conducted in an authentic learning environment to answer this question. The results suggest that the online learning environment had a positive effect on the learning outcomes (students' domain-specific knowledge and the quality of writing argumentative essays improved). Moreover, the

results suggest that the combination of two instructional scaffolds is an effective way to positively influence the learning outcomes. Worked examples seemed to have supported students understanding of the expected goal, related steps, and their rationale. Similarly, argumentative peer feedback scripts seemed to have guided the students' interactions and feedback provision during the learning activity. The preliminary results of this study advanced the understanding of the potential of argumentation scaffolds and shed light on the possibility of combining two or more scaffolds and how they may complement each other in a given learning activity. The study also discusses possible issues that may occurs as the redundancy effect and over-scripting.

The study presented in Chapter 5 built on Chapter 4's study and its findings. The study goes one step deeper by exploring if the feedback type influences the learning outcomes. It is not clear if argumentation scaffolds in the form of directed feedback (standard feedback, feedforward, or a combination of both) are more effective than undirected feedback in fostering argumentative essay writing and domain-specific knowledge acquisition. Hence, the fourth research question of this thesis reads: *What are the effects of a various peer feedback scripts on the quality of writing argumentative essays and the acquisition of domain-specific knowledge?* To answer this question the theoretical framework is constructed around peer feedback, feedback type and scripting. Peer feedback is the action taken by a peer to provide information about one or more aspects of one's performance or understanding of the task at stake. After that, the concepts of standard feedback and feedforward were presented. Standard feedback focuses on the question h*ow am I going/doing?* Thus, it provides information related to the actual task and/or desired performance with respect to an expected standard. Meanwhile, feedforward centers on the question *where to go next?* Hence, it points to possible directions to pursue or indicates alternative strategies to follow. Next, the concept of scripts was introduced as an instructional scaffold that can be used to facilitate and direct the provision of peer feedback such that it is useful to foster argumentative writing and learning of domain-specific knowledge. Last, the concept of directed peer feedback script was introduced. A directed peer feedback script is comprised is comprised of guiding elements such as questions that are conceived to guide students in the provision of feedback with a specific type and to address the different elements of an argumentative essay. An exploratory study with a pre- and post-test design and 221 Bachelor of Science (BSc) students was conducted in real educational settings. The independent variable "feedback script type" had the following four levels: standard feedback (FB), feedforward (FF), standard feedback with feedforward (FB+FF), and undirected feedback (UF). The dependent variables were: student's feedback quality, quality of writing argumentative essays and domain-specific knowledge acquisition. Similarly, the quality of feedback received was a covariate for quality of writing argumentative essays and domain-specific knowledge acquisition. The study findings indicate significant differences between the different

conditions in terms of the quality of feedback provided. The latter implies that the use or argumentations scaffolds in the form of directed peer feedback scripts can affect the quality of the feedback that students provide to their peers. Moreover, results showed an increase in the learning outcomes of all students without significant differences among conditions. The increase might be related to the power of peer feedback regardless of the feedback type.

The results indicate that the feedback script type influences the quality of feedback. Similarly, the quality of the feedback received influences the quality of writing argumentative essays and the acquisition of domain-specific knowledge, but there was not a significant effect of the feedback script type

Chapter 6, summarizes and combines the results of the studies, and reflects on their strengths and weaknesses: Similarly, it proposes areas for future research and discusses implications for education practice. This thesis contributes mainly to the literature on argumentation and Computer-Supported Collaborative Argumentation (CSCA). However, it also contributes to the literature on online learning systems, Computer-Supported Collaborative Systems (CSCL), scripting, peer feedback, worked examples, and writing skills. *First*, this thesis addresses the issue of the intentions and effects of first- and second-order argument scaffolding of CSCA competence development and domain-specific knowledge acquisition and the effects of the educational level, communication form and group. And as such complements previous research that argues that argumentation scaffolds should be designed as second-order since the acquisition and internalization of argumentation competence can result in first-order effects. Similarly, it complements research looking into fostering the learning of detailed and highly domain-specific patterns of reasoning and argumentation to be able to reason and argue about topics within such domain. *Second*, it addresses the lack of a common definition of argumentation competence, and the relationships between its comprising elements, i.e., students' knowledge on argumentation, argumentation behavior, attitude towards argumentation, and their relationship with domain-specific knowledge. Thereby it provides valuable insights into if and the extent until which these components are related ad how they influence the acquisition of domain-specific knowledge. *Third*, it delves into the design, evaluation, and effect of argumentation scaffolds embedded in online learning systems to facilitate students' domain-specific knowledge acquisition and argumentative essay writing. It sheds light on the positive effects of combining argumentation scaffolds on the quality of feedback and how they can play a role on the learning outcomes. *Fourth*, it is known that peer feedback in digital environments is a powerful instructional practice that can foster learning and the quality of writing argumentative essays. However, little is known about the effects of the feedback type on the quality of writing argumentative essays and the acquisition of domain-specific

knowledge. This issue is addressed and thus complementing research on peer learning and its effects on the acquisition of domain-specific knowledge and skills.

With respect to future research on this topic, it is important to further investigate the effect size of interventions with argumentation scaffolds. Similarly, future research is needed to determine if and how second-order scaffolding has first-order effects as well. The findings of both will provide further insight and allow researchers and practitioners to focus their efforts on designing and refining second-order argumentation scaffolds to maximize their effect. Moreover, future research could further investigate the relationship between argumentation behavior and domain-specific knowledge (e.g., if higher domain-specific knowledge implies better argumentation behavior). Such research could provide valuable evidence to investigate the design of argumentation scaffolds that vary on their support based on the student's domain specific knowledge mastery level, i.e., fading. It is also important to know more about the relationships between argumentation scaffolds and if they have a summative effect. The findings could provide focus to future research and practice on combining multiple argumentation scaffolds to increase the effect size. In general, future research should strive to conduct longitudinal studies as they can provide important evidence on how and the extent to which students internalized the knowledge and develop argumentation competence.

There are multiple implications to be derived from our research with respect to the acquisition of argumentation competence and the use of online learning systems to achieve such goal. The findings of the various studies suggest that learning activities enriched with argumentation scaffolds can foster critical thinking, communication, collaboration, and creativity, which are important skills needed to face today's global, complex, and cross-disciplinary challenges. Course designers should take into consideration the use of first- and second-order argumentation scaffolds such as worked-examples, argumentation scripts, and peer feedback to facilitate the acquisition of domain-specific knowledge and argumentative essay writing.

Course designers and practitioners should consider the relationship between students' argumentation behavior and their knowledge on the subject; the more students know and understand about the topic, the easiest it will be for them to present arguments. In addition, learning activities that, next to domain-specific knowledge, also consider the acquisition of argumentation practice should be designed throughout the whole course and curriculum. The reason behind is that the successful performance of learning activities requiring reasoning and argumentation is influenced by the expertise of the domain and its specific aspects of reasoning and argumentation. Moreover, course designers and practitioners should exercise caution while combining more than one instructional scaffold, as scaffolds may nullify each other due to suboptimal learning

processes resulting of overloading (e.g., redundancy effect and over-scripting).

To conclude, we hope that this thesis encourages researchers to continue investigating how to promote the development and acquisition of argumentation competence. Furthermore, we hope that this research serves as inspiration and reference for practitioners to further integrate argumentation competence development in the curricula.

Sumario en Español

El crecimiento de las tecnologías digitales de la comunicación y la movilidad ha estimulado la creación de grandes cantidades de información dando lugar a la llamada Era de la Información (information age), y a la Economía del Conocimiento (knowledge economy) donde la principal fuente de crecimiento económico son los productos y servicios basados en actividades intensivas en conocimiento.

La evolución de la tecnología ha afectado significativamente a la sociedad y a los tipos de retos a los que se enfrentan los estudiantes y los profesionales. Los estudiantes y los profesionales de todos los campos se enfrentan ahora a retos globales, complejos e interdisciplinarios. Del mismo modo, los profesionales deben hacer frente al modo de trabajo rápido, iterativo y de prototipo-prendizaje que la industria está adoptando cada vez más. Además, los profesionales deben ser capaces de encontrar, evaluar, interpretar y representar nueva información con rapidez, y comunicarse y colaborar con otros en grupos multidisciplinarios, pero lo más importante es que necesitan pensar y aprender por sí mismos. Todo esto significa que los profesionales necesitan adquirir y desarrollar nuevas habilidades, las llamadas Habilidades del Siglo 21 (21st Century Skills). Entre dichas habilidades, cuatro están relacionadas con el aprendizaje y la innovación y son reconocidas como las que diferencian a los estudiantes mejor preparados para enfrentarse a los complejos entornos laborales del siglo XXI de los que no lo están. Las cuatro habilidades en cuestión son el pensamiento crítico, la comunicación, la colaboración y la creatividad. En el contexto de la educación, el pensamiento crítico desempeña un papel importante en la adquisición de conocimientos científicos que se basan en el razonamiento lógico y la argumentación. Los estudiantes y profesionales de todas las disciplinas deben adquirir y desarrollar un pensamiento crítico y competencia argumentativa para analizar, conceptualizar, sintetizar y hacer frente a los retos del siglo XXI.

El objetivo de esta tesis es ampliar la comprensión de la competencia argumentativa, los elementos que la componen y la intención y el diseño de andamiajes de la argumentación en los sistemas de aprendizaje en línea. Para lograr el objetivo, se siguió un enfoque multimétodo utilizando una combinación de estudios de revisión de la literatura, exploratorios y experimentales. La tesis consta de seis capítulos. El capítulo 1 presenta al lector los conceptos centrales de esta tesis. En el capítulo 2, se aborda la siguiente pregunta de investigación: ¿Cuáles son los efectos del andamiaje de la argumentación de primer y segundo orden en la Educación Superior (ESup) y en la Educación Secundaria (ESec), y cómo influye una forma de andamiaje en la otra? El capítulo ofrece una visión general de la argumentación, seguida de una definición de la competencia argumentativa y de los elementos que la componen (conocimiento de

la argumentación, comportamiento argumentativo y actitud hacia la argumentación). A continuación, el capítulo presenta y define los andamiajes de primer orden (es decir, los andamiajes diseñados para adquirir conocimientos específicos del dominio) y los andamiajes de segundo orden (es decir, los andamiajes para adquirir la competencia argumentativa). A continuación, basándose en la bibliografía, el capítulo introduce y describe las variables nivel educativo, forma de comunicación y tamaño del grupo y cómo estos pueden influir en la definición y, en consecuencia, en los efectos de los andamiajes de la argumentación. Se realizó una revisión sistemática de la literatura para responder a la pregunta de investigación. La revisión permitió analizar de forma sistemática la intención y los efectos de los andamiajes de argumentación que han sido investigados en estudios empíricos de la Argumentación Colaborativa Asistida por Ordenador (CSCA - Computer-Supported Collaborative Argumentation). La revisión de la literatura siguió una estrategia de búsqueda sistemática (se encontraron 527 artículos) y tuvo en cuenta criterios de inclusión específicos que dieron como resultado la selección de 19 artículos que fueron codificados en función del diseño y las variables del estudio. Los estudios variaron en cuanto al nivel educativo (ESup o ESec), la intención de los andamiajes de argumentación, los efectos sobre la adquisición de conocimiento específico del dominio, el conocimiento de argumentación y el comportamiento de argumentación, la forma de comunicación (síncrona o asíncrona) y el tamaño del grupo (díada, tríada, etc.). A continuación, se creó un mapa sistemático. El estudio sintetiza los resultados, sugiere áreas en las que se requiere más investigación y ofrece orientación a los profesionales e investigadores en el campo de la CSCA en términos de enfoques exitosos de andamiaje de la argumentación y la forma de comunicación en la ESup y la ESec.

En el capítulo 3 se presenta el segundo estudio. El estudio explora las relaciones de los componentes que conforman la competencia argumentativa y entre estos componentes y los niveles de aprendizaje. A continuación, se presenta el objetivo del estudio en la forma de la siguiente pregunta de investigación que dice así ¿Cuáles son las relaciones entre los conocimientos de los estudiantes sobre argumentación, el comportamiento argumentativo, la actitud hacia la argumentación y los conocimientos específicos del dominio? En primer lugar, como parte del marco teórico, se definió el concepto de competencia argumentativa como una capacidad integrada, en la que los elementos que la componen, es decir, el conocimiento de la argumentación, el comportamiento argumentativo y la actitud hacia la argumentación, están intrínsecamente entrelazados. La definición comprende los elementos que los investigadores suelen medir, como el conocimiento de la argumentación y la habilidad que los estudiantes manifiestan durante el discurso argumentativo (Noroozi, Weinberger, et al., 2013). Además, la definición tiene en cuenta la actitud de los estudiantes hacia la argumentación ya que las actividades del discurso argumentativo pueden verse afectadas por factores psicológicos, emocionales, motivacionales y sociales. Para abordar la pregunta de

investigación, se realizó un estudio exploratorio con un diseño de pre y post prueba en un entorno educativo real. Se utilizó un entorno de aprendizaje en línea en el que las actividades de aprendizaje de los estudiantes no estaban andamiadas a nivel micro (es decir, argumentos individuales) o macro (es decir, composición/estructura de ensayos). El diseño del estudio nos permitió relacionar los componentes de la competencia argumentativa con la ganancia de conocimientos específicos del dominio entre la pre y la post prueba con las actividades de argumentación ejecutadas en el medio. En contra de nuestras expectativas, no se encontraron relaciones significativas entre los elementos que componen la competencia argumentativa en el contexto de un entorno de aprendizaje en línea no andamiado. Este resultado parece contradecir nuestro marco teórico y la definición de competencia argumentativa. El resultado puede atribuirse a diferentes razones, como el hecho de que la actividad no era obligatoria ni estaba puntuada. Asimismo, otra posibilidad es que cada dominio exija un cierto grado de experiencia en aspectos específicos del razonamiento y la argumentación en dicho dominio, es decir, que los estudiantes necesiten aprender patrones de razonamiento y argumentación detallados y muy específicos del dominio para razonar y argumentar sobre temas dentro de un dominio concreto. Esto último sugiere que el dominio de la competencia argumentativa por parte de los estudiantes aumenta a medida que éstos adquieren experiencia en el razonamiento y la argumentación dentro de un dominio específico. Por lo tanto, es posible que, a medida que aumenta la experiencia, las relaciones entre los elementos que componen la competencia argumentativa sean más significativas y destacadas. Además, es necesario investigar más a fondo las relaciones entre los componentes de la competencia argumentativa y la adquisición de conocimientos específicos. Además, es necesario seguir investigando para determinar cómo y hasta qué punto el estado de ánimo de una persona influye en el comportamiento y, por tanto, en los niveles de aprendizaje. Este estudio ha permitido avanzar en la comprensión de la competencia argumentativa y de las relaciones entre los elementos que la componen. Asimismo, los resultados del estudio sugieren que las relaciones entre los elementos que la componen se ven afectadas por otras variables (covariables) como el nivel de dominio del dominio o tema en cuestión.

A partir de los resultados del estudio de revisión (presentado en el capítulo 2) y del estudio exploratorio (presentado en el capítulo 3), se diseñaron andamiajes de argumentación para fomentar la competencia argumentativa y la adquisición de conocimientos específicos del dominio en un entorno de aprendizaje en línea. El estudio, presentado en el capítulo 4, explora los efectos de un entorno de aprendizaje en línea apoyado con worked examples (ejemplos elaborados) y retroalimentación entre pares sobre la escritura de ensayos argumentativos de los estudiantes y la adquisición de conocimientos específicos del dominio. Los entornos de aprendizaje en línea han sido mejorados con affordances (ofrecimientos) en la interfaz del usuario (por ejemplo, textos, diagramas e

imágenes) que pueden guiar y dirigir a los estudiantes para facilitar la adquisición de conocimientos y habilidades como la escritura de ensayos argumentativos. La escritura de ensayos argumentativos puede ser apoyada con éxito mediante scripts (guiones) de retroalimentación argumentativa entre pares o mediante worked examples. Los scripts son andamios didácticos que pueden utilizarse para facilitar y dirigir la provisión de retroalimentación útil entre pares. La retroalimentación entre pares puede ayudar a aumentar el aprendizaje de los alumnos, ya que les da la oportunidad de aprender unos de otros sin la intervención inmediata del profesor. Por su parte, los worked examples son un método de instrucción en el que los alumnos aprenden estudiando a partir de ejemplos totalmente desarrollados. No hay claridad en lo que respecta a los efectos de combinar los scripts de retroalimentación argumentativa entre pares y los worked examples en los resultados del aprendizaje. En consecuencia, la tercera pregunta de investigación de esta tesis dice ¿Existe potencial en un entorno de aprendizaje en línea con worked examples y retroalimentación entre pares sobre la escritura de ensayos argumentativos de los estudiantes y la adquisición de conocimientos específicos del dominio? Para responder a esta pregunta se realizó un estudio empírico con un diseño de pre y post prueba en un entorno de aprendizaje auténtico. Los resultados sugieren que el entorno de aprendizaje en línea tuvo un efecto positivo en los resultados del aprendizaje (mejoraron los conocimientos específicos del dominio de los estudiantes y la calidad de la redacción de ensayos argumentativos). Además, los resultados sugieren que la combinación de dos andamios didácticos es una forma eficaz de influir positivamente en los niveles de aprendizaje. Los worked examples parecen haber ayudado a los estudiantes a comprender el objetivo esperado, los pasos correspondientes y su justificación. Del mismo modo, los scripts de retroalimentación argumentativa de pares parecieron haber guiado las interacciones de los estudiantes y la provisión de retroalimentación durante la actividad de aprendizaje. Los resultados preliminares de este estudio permiten comprender el potencial de los andamiajes de argumentación y arrojan luz sobre la posibilidad de combinar dos o más andamiajes y cómo pueden complementarse en una actividad de aprendizaje determinada. El estudio también analiza los posibles problemas que pueden producirse como el redundancy effect (efecto de redundancia) y el over-scripting (exceso de soporte).

El estudio presentado en el capítulo 5 se basa en el estudio del capítulo 4 y en sus conclusiones. El estudio da un paso más al explorar si el tipo de retroalimentación influye en los niveles de aprendizaje. No está claro si los andamiajes de argumentación en forma de retroalimentación dirigida (retroalimentación estándar, feedforward - hacia el objetivo, o una combinación de ambas) son más eficaces que la retroalimentación no dirigida para fomentar la escritura de ensayos argumentativos y la adquisición de conocimientos específicos del dominio. De ahí que la cuarta pregunta de investigación de esta tesis sea ¿Cuáles son los efectos de los distintos scripts de retroalimentación

entre pares sobre la calidad de la escritura de ensayos argumentativos y la adquisición de conocimientos específicos del dominio? Para responder a esta pregunta, el marco teórico se construye en torno a la retroalimentación entre pares, el tipo de retroalimentación y scripting. La retroalimentación de pares es la acción realizada por un compañero para proporcionar información sobre uno o más aspectos de la propia actuación o de la comprensión de la tarea en cuestión. A continuación, se presentan los conceptos de retroalimentación estándar y feedforward. La retroalimentación estándar se centra en la pregunta ¿cómo voy/lo hago? Por lo tanto, proporciona información relacionada con la tarea actual y/o el rendimiento esperado con respecto a un estándar previsto. Por su parte, el feedforward se centra en la pregunta ¿hacia dónde ir ahora? Por lo tanto, señala posibles direcciones a seguir o indica estrategias alternativas a seguir. A continuación, se introdujo el concepto de scripts como un andamio didáctico que puede utilizarse para facilitar y dirigir la provisión de retroalimentación entre pares, de manera que sea útil para fomentar la escritura argumentativa y el aprendizaje de conocimientos específicos del dominio. Por último, se introdujo el concepto de guión de retroalimentación entre pares dirigido. Un guión de retroalimentación entre pares dirigida se compone de elementos orientadores como preguntas que se conciben para guiar a los estudiantes en la provisión de retroalimentación con un tipo específico y para abordar los diferentes elementos de un ensayo argumentativo. Se llevó a cabo un estudio exploratorio con un diseño de pre y post prueba y 221 estudiantes de Licenciatura en Ciencias (Bachelor of Science - BSc) en entornos educativos reales. La variable independiente "tipo de guión de retroalimentación" tenía los siguientes cuatro niveles: retroalimentación estándar (FB), feedforward (FF), retroalimentación estándar con feedforward (FB+FF) y retroalimentación no dirigida (UF). Las variables dependientes fueron: la calidad de la retroalimentación del estudiante, la calidad de la escritura de ensayos argumentativos y la adquisición de conocimientos específicos del dominio. Asimismo, la calidad de la retroalimentación recibida fue una covariable para la calidad de la escritura de ensayos argumentativos y la adquisición de conocimientos específicos. Los resultados del estudio indican diferencias significativas entre las distintas condiciones en cuanto a la calidad de la retroalimentación proporcionada. Esto implica que el uso de andamiajes de argumentación en forma de guiones de retroalimentación dirigida entre pares puede afectar a la calidad de la retroalimentación que los estudiantes proporcionan a sus compañeros. Además, los resultados mostraron un aumento en los niveles de aprendizaje de todos los estudiantes sin diferencias significativas entre las condiciones. Este aumento podría estar relacionado con el poder de la retroalimentación entre pares, independientemente del tipo de retroalimentación.

Los resultados indican que el tipo de script de retroalimentación influye en la calidad de la misma. Del mismo modo, la calidad de la retroalimentación recibida influye en la calidad de la escritura de ensayos argumentativos y en la adquisición de conocimientos

específicos del dominio, pero no hubo un efecto significativo del tipo de script de retroalimentación.

El capítulo 6, resume y combina los resultados de los estudios, y reflexiona sobre sus puntos fuertes y débiles: Asimismo, propone áreas para futuras investigaciones y discute las implicaciones para la práctica educativa. Esta tesis contribuye principalmente a la literatura sobre argumentación y Computer-Supported Collaborative Argumentation (CSCA). Sin embargo, también contribuye a la literatura sobre sistemas de aprendizaje en línea, Computer-Supported Collaborative Systems (CSCL), scripting, retroalimentación entre pares, worked examples y habilidades de escritura. En primer lugar, esta tesis aborda la cuestión de las intenciones y los efectos del andamiaje de la argumentación de primer y segundo orden sobre el desarrollo de la competencia CSCA y la adquisición de conocimientos específicos del dominio y los efectos del nivel educativo, la forma de comunicación y el grupo. Y, como tal, complementa investigaciones anteriores que sostienen que los andamiajes argumentativos deben diseñarse como de segundo orden, ya que la adquisición e interiorización de la competencia argumentativa puede dar lugar a efectos de primer orden. Del mismo modo, complementa la investigación que estudia el fomento del aprendizaje de patrones de razonamiento y argumentación detallados y altamente específicos del dominio para poder razonar y argumentar sobre temas dentro de dicho dominio. En segundo lugar, aborda la falta de una definición común de competencia argumentativa y las relaciones entre los elementos que la componen, es decir, el conocimiento de los estudiantes sobre la argumentación, el comportamiento argumentativo, la actitud hacia la argumentación y su relación con el conocimiento específico del dominio. De este modo, proporciona información valiosa sobre si estos componentes están relacionados, y en qué medida, y cómo influyen en la adquisición de conocimientos específicos del dominio. En tercer lugar, se profundiza en el diseño, la evaluación y el efecto de los andamios argumentativos integrados en los sistemas de aprendizaje en línea para facilitar la adquisición de conocimientos específicos del dominio y la redacción de ensayos argumentativos por parte de los estudiantes. Aclara los efectos positivos de la combinación de andamios argumentativos en la calidad de la retroalimentación y cómo pueden influir en los resultados del aprendizaje. En cuarto lugar, se sabe que la retroalimentación entre pares en entornos digitales es una poderosa práctica instructiva que puede fomentar el aprendizaje y la calidad de la escritura de ensayos argumentativos. Sin embargo, se sabe poco sobre los efectos del tipo de retroalimentación en la calidad de la escritura de ensayos argumentativos y la adquisición de conocimientos específicos del dominio. Se aborda esta cuestión y se complementa así la investigación sobre el aprendizaje entre pares y sus efectos en la adquisición de conocimientos y habilidades específicas del dominio.

Con respecto a futuras investigaciones sobre este tema, es importante seguir investigando

el tamaño del efecto de las intervenciones con andamiajes argumentativos. Del mismo modo, es necesario investigar en el futuro si el andamiaje de segundo orden tiene también efectos de primer orden y de qué manera. Los resultados de ambas investigaciones proporcionarán más información y permitirán a los investigadores y profesionales centrar sus esfuerzos en el diseño y el perfeccionamiento de los andamiajes de argumentación de segundo orden para maximizar su efecto. Además, en futuras investigaciones se podría estudiar la relación entre el comportamiento argumentativo y el conocimiento específico del dominio (por ejemplo, si un mayor conocimiento específico del dominio implica un mejor comportamiento argumentativo). Dicha investigación podría proporcionar una valiosa evidencia para investigar el diseño de andamios argumentativos que varíen en su soporte en función del nivel de maestría del conocimiento específico del dominio del estudiante, es decir, el fading. También es importante saber más sobre las relaciones entre los andamios argumentativos y si tienen un efecto sumativo. Los resultados podrían servir de base para futuras investigaciones y prácticas sobre la combinación de múltiples andamiajes argumentativos para aumentar el tamaño del efecto. En general, las investigaciones futuras deberían esforzarse por realizar estudios longitudinales, ya que pueden aportar pruebas importantes sobre cómo y hasta qué punto los estudiantes interiorizaron los conocimientos y desarrollaron la competencia argumentativa.

Son múltiples las implicaciones que se derivan de nuestra investigación con respecto a la adquisición de la competencia argumentativa y al uso de los sistemas de aprendizaje en línea para lograr dicho objetivo. Los resultados de los distintos estudios sugieren que las actividades de aprendizaje enriquecidas con andamiajes de argumentación pueden fomentar el pensamiento crítico, la comunicación, la colaboración y la creatividad, que son habilidades importantes necesarias para afrontar los retos globales, complejos e interdisciplinarios de hoy en día. Los diseñadores de cursos deben tener en cuenta el uso de andamiajes argumentativos de primer y segundo orden, como los worked examples, los scripts argumentativos y la retroalimentación entre pares, para facilitar la adquisición de conocimientos específicos del dominio y la redacción de ensayos argumentativos.

Los diseñadores de cursos y los profesionales deben tener en cuenta la relación entre el comportamiento argumentativo de los estudiantes y sus conocimientos sobre el tema; cuanto más sepan y comprendan los estudiantes sobre el tema, más fácil les resultará presentar argumentos. Además, a lo largo de todo el curso y del plan de estudios deberían diseñarse actividades de aprendizaje que, además de los conocimientos específicos del tema, tengan en cuenta la adquisición de la práctica de la argumentación. La razón que subyace es que la realización con éxito de las actividades de aprendizaje que requieren razonamiento y argumentación está influida por los conocimientos del dominio y sus aspectos específicos de razonamiento y argumentación. Además, los diseñadores de cursos y los profesionales deben tener cuidado al combinar más de un andamio didáctico,

ya que los mismos pueden anularse mutuamente debido a procesos de aprendizaje subóptimos resultantes de la sobrecarga/saturación (por ejemplo, redundancy effect y over-scripting).

Para concluir, esperamos que esta tesis anime a los investigadores a seguir investigando cómo promover el desarrollo y la adquisición de la competencia argumentativa. Además, esperamos que esta investigación sirva de inspiración y referencia para que los profesionales sigan integrando el desarrollo de la competencia argumentativa en los planes de estudio.

Nederlandse Samenvatting

De groei van communicatie en mobiele digitale technologieën heeft de creatie van grote hoeveelheden informatie gestimuleerd, hetgeen heeft geleid tot het zogenaamde informatietijdperk en de kenniseconomie, waarin de belangrijkste bron van economische groei wordt gevormd door producten en diensten die zijn gebaseerd op kennisintensieve activiteiten.

De evolutie van de technologie heeft de samenleving en de soorten uitdagingen waarmee studenten en professionals worden geconfronteerd, aanzienlijk beïnvloed. Studenten en professionals in alle vakgebieden worden nu geconfronteerd met mondiale, complexe en disciplineoverschrijdende uitdagingen. Evenzo moeten professionals kunnen omgaan met de snelle, iteratieve, prototype-and-learn manier van werken die de industrie steeds meer hanteert. Bovendien moeten professionals in staat zijn om nieuwe informatie snel te vinden, te beoordelen, te interpreteren en weer te geven, en te communiceren en samen te werken met anderen in multidisciplinaire teams, maar het belangrijkste is dat ze zelf moeten kunnen denken en leren. Dit alles betekent dat beroepsbeoefenaren nieuwe vaardigheden moeten verwerven en ontwikkelen, namelijk de zogenaamde 21e-eeuwse vaardigheden. Vier van deze vaardigheden houden verband met leren en innovatie en worden erkend als vaardigheden die studenten die beter zijn voorbereid op de complexe werkomgevingen van de 21e eeuw, onderscheiden van studenten die dat niet zijn. De vier vaardigheden in kwestie zijn kritisch denken, communicatie, samenwerking en creativiteit. In de context van het onderwijs speelt kritisch denken een belangrijke rol bij de verwerving van wetenschappelijke kennis die is gebaseerd op logisch redeneren en argumenteren. Studenten en professionals in alle disciplines moeten de competentie kritisch denken en argumenteren verwerven en ontwikkelen om te analyseren, conceptualiseren, synthetiseren en om te gaan met de uitdagingen van de 21e eeuw.

Deze dissertatie beoogt het begrip van argumentatiecompetentie, de samenstellende elementen hiervan, en het doel en ontwerp van argumentatieondersteuning (scaffolding) in online leersystemen verder uit te breiden. Om dit doel te bereiken is een multi-method benadering gevolgd, waarbij gebruik is gemaakt van een combinatie van review, exploratief, en experimenteel onderzoek. Het proefschrift bestaat uit zes hoofdstukken. Hoofdstuk 1 introduceert de kernconcepten van dit proefschrift. In Hoofdstuk 2 wordt de volgende onderzoeksvraag behandeld: Wat zijn de effecten van eerste-orde en tweede-orde argumentatie-scaffolding in het Hoger Onderwijs (HO) en het Voortgezet Onderwijs (VO), en hoe beïnvloedt de ene manier van scaffolding de andere? Het hoofdstuk geeft een overzicht van argumentatie, gevolgd door een definitie van argumentatiecompetentie en de samenstellende elementen (argumentatiekennis, argumentatiegedrag, en

houding ten opzichte van argumentatie). Vervolgens introduceert en definieert het hoofdstuk eerste-orde scaffolding (d.w.z. scaffolding om domeinspecifieke kennis te verwerven en tweede-orde scaffolding (d.w.z. scaffolding om argumentatiecompetentie te verwerven). Vervolgens worden in dit hoofdstuk, op basis van de literatuur, de variabelen opleidingsniveau, communicatievorm en groepsgrootte geïntroduceerd en beschreven en hoe deze van invloed kunnen zijn op de definitie en daarmee de effecten van argumentatiescaffolding. Een systematisch literatuuronderzoek werd uitgevoerd om de onderzoeksvraag te beantwoorden. De review maakte het mogelijk om op een systematische manier de doelen en de effecten van argumentatiescaffolding te analyseren die onderzocht zijn in empirische studies naar Computer-Supported Collaborative Argumentation (CSCA). De literatuurstudie volgde een systematische zoekstrategie (er werden 527 artikelen gevonden) en kende specifieke inclusiecriteria, hetgeen resulteerde in de selectie van 19 artikelen die vervolgens werden gecodeerd op studieopzet en variabelen. De studies varieerden in termen van opleidingsniveau (HO of VO), het doel van de argumentatiescaffolding, de effecten op de verwerving van domeinspecifieke kennis, argumentatiekennis en argumentatiegedrag, de communicatievorm (synchroon of asynchroon), en groepsgrootte (dyade, triade, etc.). Vervolgens werd een systematisch overzicht gemaakt. De studie synthetiseert de bevindingen, suggereert gebieden waar meer onderzoek nodig is, en biedt richtlijnen voor praktijkprofessionals en onderzoekers op het gebied van CSCA voor succesvolle benaderingen van argumentatiescaffolding en communicatievormen in HO en VO.

In hoofdstuk 3 wordt de tweede studie gepresenteerd. Deze studie onderzoekt de relaties tussen de componenten waaruit argumentatiecompetentie bestaat en tussen deze componenten en de leeruitkomsten. Het doel van de studie is vertaald naar de volgende onderzoeksvraag: Wat zijn de relaties tussen argumentatiekennis, argumentatiegedrag, attitude ten opzichte van argumentatie, en domeinspecifieke kennis van studenten? Ten eerste wordt, als onderdeel van het theoretisch kader, het concept van argumentatiecompetentie gedefinieerd als een geïntegreerde vaardigheid, waarin de samenstellende elementen, d.w.z. argumentatiekennis, argumentatiegedrag en attitude ten aanzien van argumentatie intrinsiek met elkaar verweven zijn. De definitie omvat de elementen die onderzoekers gewoonlijk meten zoals argumentatiekennis en de vaardigheid die studenten ten toon spreiden tijdens argumentatieve communicatie (Noroozi, Weinberger, et al., 2013). Bovendien houdt de definitie rekening met de houding van studenten ten opzichte van argumentatie omdat argumentatieve communicatieactiviteiten beïnvloed kunnen worden door psychologische, emotionele, motivationele en sociale factoren. Om de onderzoeksvraag te beantwoorden, werd een exploratief onderzoek met een pre- en posttest design uitgevoerd in een authentieke onderwijssetting. Er werd gebruik gemaakt van een online leeromgeving waarin de leeractiviteiten van de studenten niet werden ondersteund op micro- (d.w.z. enkelvoudige

argumenten) of macroniveau (d.w.z. samenstelling/structuur van een essay). De opzet van de studie maakte het mogelijk om de componenten van argumentatiecompetentie te koppelen aan domeinspecifieke kenniswinst tussen pre- en post-test waarbij de argumentatieactiviteiten tussendoor werden uitgevoerd. In tegenstelling tot de verwachtingen werden er geen significante verbanden gevonden tussen de elementen waaruit argumentatiecompetentie bestaat in de context van een niet-ondersteunde online leeromgeving. Deze bevinding lijkt in tegenspraak te zijn met het theoretisch kader en onze definitie van argumentatiecompetentie. Dit resultaat zou kunnen worden toegeschreven aan verschillende redenen, zoals het feit dat de activiteit niet verplicht was en niet werd beoordeeld. Een andere mogelijkheid is dat elk domein een zekere mate van domeinexpertise vereist van domeinspecifieke aspecten van redeneren en argumenteren, dat wil zeggen dat studenten gedetailleerde en zeer domeinspecifieke patronen van redeneren en argumenteren moeten leren om te kunnen redeneren en argumenteren over onderwerpen binnen dat bepaalde domein. Dit laatste suggereert dat de beheersing van argumentatiecompetentie van leerlingen toeneemt naarmate leerlingen meer expertise verwerven over redeneren en argumenteren binnen een specifiek domein. Het is dus mogelijk dat naarmate de expertise toeneemt de relaties tussen de samenstellende elementen van argumentatiecompetentie significanter en prominenter worden. Daarnaast is meer onderzoek nodig naar de relaties tussen de componenten waaruit argumentatiecompetentie bestaat en domeinspecifieke kennisverwerving. Tenslotte is verder onderzoek nodig om te bepalen hoe en in welke mate iemands gemoedstoestand van invloed is op het gedrag en daarmee op de leerresultaten. Deze studie bevordert het begrip van argumentatiecompetentie en de relaties tussen de elementen waaruit deze bestaat. Ook suggereren de onderzoeksresultaten dat de relaties tussen de samenstellende elementen beïnvloed worden door andere variabelen (covariaten) zoals het beheersingsniveau van het domein of onderwerp waar het om gaat.

Op basis van de resultaten van de reviewstudie (gepresenteerd in hoofdstuk 2) en de verkennende studie (gepresenteerd in Hoofdstuk 3), werd argumentatiescaffolding ontworpen om argumentatiecompetentie en domeinspecifieke kennisverwerving in een online leeromgeving te bevorderen. De studie gepresenteerd in Hoofdstuk 4 onderzoekt de effecten van een online leeromgeving ondersteund met uitgewerkte voorbeelden en peer feedback op het schrijven van argumentatieve essays en het verwerven van domeinspecifieke kennis door studenten. Online leeromgevingen zijn verrijkt met 'affordances' in de gebruikersinterface (bijv. teksten, diagrammen en afbeeldingen) die studenten kunnen begeleiden en sturen bij het verwerven van kennis en vaardigheden, zoals het schrijven van argumentatieve essays. Het schrijven van argumentatieve essays kan met succes worden ondersteund door scripts voor argumentatieve peer feedback of door uitgewerkte voorbeelden. Scripts zijn scaffolds die kunnen worden gebruikt om het geven van nuttige peer feedback te vergemakkelijken en te sturen. Peer feedback kan het

leerproces van de leerlingen bevorderen omdat het leerlingen de kans geeft van elkaar te leren zonder de onmiddellijke tussenkomst van de leerkracht. Verder is het werken met voorbeelden een instructiemethode waarbij leerlingen leren te studeren aan de hand van volledig uitgewerkte voorbeelden. Er bestaat onduidelijkheid over de effecten van de combinatie van argumentatieve peer-feedback scripts en uitgewerkte voorbeelden op de leerresultaten. De derde onderzoeksvraag van dit proefschrift luidt dan ook: Is er potentie in een online leeromgeving met uitgewerkte voorbeelden en peer feedback gericht op het schrijven van argumentatieve essays en domeinspecifieke kennisverwerving door studenten? Een empirische studie met een pre- en post-test design werd uitgevoerd in een authentieke leeromgeving om deze vraag te beantwoorden. De resultaten suggereren dat de online leeromgeving een positief effect had op de leerresultaten (de domeinspecifieke kennis van studenten en de kwaliteit van het schrijven van argumentatieve essays verbeterden). Bovendien suggereren de resultaten dat deze combinatie van twee scaffolds een effectieve manier is om de leeruitkomsten positief te beïnvloeden. Uitgewerkte voorbeelden leken het begrip van studenten van het verwachte doel, gerelateerde stappen en hun beweegredenen te bevorderen. Op dezelfde manier leken argumentatieve peer-feedback scripts de interacties tussen de studenten en het geven van feedback tijdens de leeractiviteit te ondersteunen. De voorlopige resultaten van deze studie hebben geleid tot een beter begrip van de potentie van argumentatiescaffolding en werpen licht op de mogelijkheid om twee of meer vormen van scaffolding te combineren en hoe ze elkaar kunnen aanvullen bij een bepaalde leeractiviteit. De studie bespreekt ook mogelijke problemen die zich kunnen voordoen zoals het redundancy effect en overscripting.

De studie in hoofdstuk 5 bouwt voort op de studie in hoofdstuk 4 en de bevindingen daarvan. De studie gaat een stap dieper door te onderzoeken of het type feedback van invloed is op de leerresultaten. Het is niet duidelijk of argumentatiescaffolds in de vorm van gerichte feedback (standaard feedback, feedforward, of een combinatie van beide) effectiever zijn dan ongerichte feedback in het bevorderen van het schrijven van argumentatieve essays en domeinspecifieke kennisverwerving. Vandaar dat de vierde onderzoeksvraag van dit proefschrift luidt: Wat zijn de effecten van verschillende peer feedback scripts op de kwaliteit van het schrijven van argumentatieve essays en de verwerving van domeinspecifieke kennis? Om deze vraag te beantwoorden richt het theoretisch kader zich op peer feedback, feedbacktype en scripting. Peer feedback is de actie van een peer om informatie te geven over één of meer aspecten van iemands prestatie of begrip van de taak waar het om gaat. Daarna worden de concepten standaard feedback en feedforward gepresenteerd. Standaard feedback richt zich op de vraag hoe doe ik het?/gaat het goed? Het geeft dus informatie met betrekking tot de eigenlijke taak en/of de gewenste prestatie ten opzichte van een verwachte norm. Ondertussen richt feedforward zich op de vraag waar moet ik nu heen? Het wijst dus op mogelijke richtingen die moeten worden ingeslagen of geeft alternatieve strategieën aan die moeten worden

gevolgd. Vervolgens wordt het concept van scripts geïntroduceerd als scaffolding die kan worden gebruikt om het geven van peer feedback te vergemakkelijken en te sturen, teneinde argumentatief schrijven en het leren van domeinspecifieke kennis te bevorderen. Ten slotte wordt het concept van een gericht peer-feedback script geïntroduceerd. Een script voor gerichte peer feedback bestaat uit ondersteunende elementen zoals vragen die zijn ontworpen om studenten te begeleiden bij het geven van feedback van een specifiek type en om de verschillende elementen van een argumentatief essay te adresseren. Een verkennende studie met een pre- en post-test design en 221 Bachelor of Science (BSc) studenten werd uitgevoerd in een authentieke onderwijssetting. De onafhankelijke variabele "feedback script type" had de volgende vier niveaus: standaard feedback (FB), feedforward (FF), standaard feedback met feedforward (FB+FF), en ongerichte feedback (UF). De afhankelijke variabelen waren: de kwaliteit van de feedback van de student, de kwaliteit van het schrijven van argumentatieve essays en de domeinspecifieke kennisverwerving. De kwaliteit van de ontvangen feedback was een covariaat voor de kwaliteit van het schrijven van argumentatieve essays en de domeinspecifieke kennisverwerving. De bevindingen van de studie wijzen op significante verschillen tussen de verschillende condities wat betreft de kwaliteit van de gegeven feedback. Dit laatste impliceert dat het gebruik van argumentatiescaffolds in de vorm van gerichte peer feedback scripts de kwaliteit van de feedback die studenten aan hun peers geven kan beïnvloeden. Bovendien toonden de resultaten een toename in de leerresultaten van alle studenten zonder significante verschillen tussen de condities. De toename zou te maken kunnen hebben met de kracht van peer feedback, ongeacht het type feedback. De resultaten geven aan dat het feedback script type de kwaliteit van de feedback beïnvloedt. Ook de kwaliteit van de ontvangen feedback beïnvloedt de kwaliteit van het schrijven van argumentatieve essays en de verwerving van domeinspecifieke kennis, maar er was geen significant effect van het type feedback script.

In hoofdstuk 6 worden de resultaten van de studies samengevat en gecombineerd, en wordt gereflecteerd op sterke en zwakke punten. Daarnaast stelt het hoofdstuk terreinen voor toekomstig onderzoek voor en bespreekt het implicaties voor de onderwijspraktijk. Deze dissertatie draagt vooral bij aan de literatuur over argumentatie en Computer-Supported Collaborative Argumentation (CSCA). Het proefschrift draagt echter ook bij aan de literatuur over online leersystemen, Computer-Supported Collaborative Learning (CSCL), scripting, peer feedback, uitgewerkte voorbeelden, en schrijfvaardigheid. Ten eerste gaat deze dissertatie in op de doelen en effecten van eerste- en tweede-orde argumentatiescaffolding gericht op CSCA competentieontwikkeling en domeinspecifieke kennisverwerving en de effecten van het opleidingsniveau, de communicatievorm en de groep. Als zodanig is het een aanvulling op eerder onderzoek dat stelt dat argumentatiescaffolds als tweede-orde scaffolds moeten worden ontworpen omdat de verwerving en internalisering van argumentatiecompetentie kan resulteren

in eerste-orde-effecten. Op dezelfde manier vult het onderzoek aan dat gericht is op het bevorderen van het leren van gedetailleerde en zeer domeinspecifieke patronen van redeneren en argumenteren om te kunnen redeneren en argumenteren over onderwerpen binnen een dergelijk domein. Ten tweede gaat deze studie in op het gebrek aan een gemeenschappelijke definitie van argumentatiecompetentie, en op de relaties tussen de elementen waaruit deze competentie bestaat, namelijk de kennis van leerlingen over argumentatie, hun argumentatiegedrag, hun houding tegenover argumentatie, en hun relatie met domeinspecifieke kennis. Daardoor verschaft het onderzoek waardevolle inzichten in de vraag of en in welke mate deze componenten gerelateerd zijn en hoe ze de verwerving van domeinspecifieke kennis beïnvloeden. Ten derde gaat het onderzoek dieper in op het ontwerp, de evaluatie en het effect van argumentatiescaffolding ingebed in online leersystemen om de domeinspecifieke kennisverwerving en het schrijven van argumentatieve essays door studenten te bevorderen. Het werpt licht op de positieve effecten van het combineren van argumentatiescaffolds op de kwaliteit van feedback en hoe deze een rol kunnen spelen bij de leerresultaten. Ten vierde, het is bekend dat peer feedback in digitale omgevingen een krachtige instructiemethode is die het leren en de kwaliteit van het schrijven van argumentatieve essays kan bevorderen. Er is echter weinig bekend over de effecten van het type feedback op de kwaliteit van het schrijven van argumentatieve essays en de verwerving van domeinspecifieke kennis. Dit onderwerp is onderzocht en vormt daarmee een aanvulling op onderzoek naar peer learning en de effecten daarvan op de verwerving van domeinspecifieke kennis en vaardigheden.

Wat betreft toekomstig onderzoek naar dit onderwerp, is het belangrijk om de effectgrootte van interventies met argumentatiescaffolding verder te onderzoeken. Evenzo is toekomstig onderzoek nodig om te bepalen of en hoe tweede-orde scaffolding ook eerste-orde effecten heeft. De bevindingen van beide onderzoekslijnen zullen meer inzicht verschaffen en onderzoekers en praktijkprofessionals in staat stellen hun inspanningen te richten op het ontwerpen en verfijnen van tweede-orde argumentatiescaffolding om het effect te maximaliseren. Bovendien zou toekomstig onderzoek de relatie tussen argumentatiegedrag en domeinspecifieke kennis verder kunnen onderzoeken (bv. of kwalitatief hogere domeinspecifieke kennis leidt tot beter argumentatiegedrag). Dergelijk onderzoek zou waardevolle inzichten kunnen opleveren in het ontwerp van argumentatiescaffolds die variëren in hun ondersteuning op basis van het beheersingsniveau van de domeinspecifieke kennis van de leerling, m.a.w., fading. Het is ook belangrijk om meer te weten over de relaties tussen verschillende argumentatiescaffolds en of ze een summatief effect hebben. De bevindingen zouden richting kunnen geven aan toekomstig onderzoek en de praktijk van het combineren van meerdere argumentatiescaffolds om de effectgrootte te vergroten. In het algemeen zou toekomstig onderzoek moeten streven naar het uitvoeren van longitudinale studies, omdat die belangrijk bewijs kunnen leveren over hoe en in welke mate leerlingen de

kennis hebben geïnternaliseerd en argumentatiecompetentie hebben ontwikkeld.

Uit het onderzoek kunnen meerdere implicaties worden afgeleid met betrekking tot het verwerven van argumentatiecompetentie en het gebruik van online leersystemen om dat doel te bereiken. De bevindingen van de verschillende studies suggereren dat leeractiviteiten die verrijkt zijn met argumentatiescaffolds kritisch denken, communicatie, samenwerking en creativiteit kunnen bevorderen. Dit zijn belangrijke vaardigheden die nodig zijn om de globale, complexe en interdisciplinaire uitdagingen van vandaag het hoofd te bieden. Onderwijsontwerpers zouden rekening moeten houden met het gebruik van eerste- en tweede-orde argumentatiescaffolds zoals uitgewerkte voorbeelden, argumentatiescripts en peer feedback om de verwerving van domeinspecifieke kennis en het schrijven van argumentatieve essays te bevorderen.

Onderwijsontwerpers en praktijkprofessionals moeten rekening houden met de relatie tussen het argumentatiegedrag van studenten en hun kennis over het onderwerp; hoe meer studenten weten en begrijpen over het onderwerp, hoe gemakkelijker het voor hen zal zijn om argumenten te presenteren. Bovendien moeten leeractiviteiten die, naast domeinspecifieke kennis, ook rekening houden met de verwerving van argumentatiecompetentie, worden ontworpen voor de hele cursus en het hele curriculum. De reden hiervoor is dat de succesvolle uitvoering van leeractiviteiten die redeneren en argumenteren vereisen, beïnvloed wordt door de domeinspecifieke expertise en de specifieke aspecten van redeneren en argumenteren. Bovendien moeten onderwijsontwerpers en praktijkprofessionals voorzichtig zijn met het combineren van meer dan één scaffold, omdat scaffolds elkaar teniet kunnen doen door suboptimale leerprocessen die het gevolg zijn van overbelasting (bijv. redundancy effect en overscripting).

Concluderend hoopt dit proefschrift onderzoekers aan te moedigen om te blijven onderzoeken hoe de ontwikkeling en verwerving van argumentatiecompetentie kan worden bevorderd. Hopelijk dient dit onderzoek ook als inspiratie en referentie voor praktijkprofessionals om de ontwikkeling van argumentatiecompetentie verder te integreren in hun curricula.

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About the Author

Anahuac Valero Haro was born on November 23, 1981, in Guadalajara, Mexico. He obtained a Bachelor's degree in Computer Engineering at the Universidad de Guadalajara, Mexico. After working in the industry, he decided to further expand his knowledge and obtained a Master's degree in Computer Science at the Universität des Saarlandes, Germany. He gained interest in educational technology by working as student research assistant and completing his thesis in the DFKI (Deutsches Forschungszentrum für Künstliche Intelligenz). In 2013, he started his PhD trajectory on the topic of Computer-Supported Collaborative Argumentation at the Wageningen University. Anahuac currently works at the Education and Student Affairs (ESA) department of the Eindhoven University of Technology (TU/e) as educational adviser on educational technologies and digital assessment.

Peer reviewed articles: published and in press

Valero Haro, A., Noroozi, O., Biemans, H., & Mulder, M. (2019). First- and second-order scaffolding of argumentation competence and domain-specific knowledge acquisition: a systematic review. Technology, Pedagogy and Education, 28(3), 329-345. doi:10.1080/1475939X.2019.1612772

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Conference papers and presentations

Valero Haro, A., Noroozi, O., Biemans, H., & Mulder, M. (2016). The effects of first-order and second-order scaffolding on computer-supported collaborative argumentation - a systematic review. Paper presented at Competence 2016, Wageningen, The Netherlands.

Valero Haro, A., Noroozi, O., Biemans, H., & Mulder, M. (2017). Exploring the relationships between the components of argumentation competence and their relationships with domain-specific knowledge. Paper presented at EDULEARN17, Barcelona, Spain.

Training and Supervision Plan

in the context of the research school

Interuniversity Center for Educational Research

Wageningen School of Social Sciences

Anahuac Valero Haro

Wageningen School of Social Sciences (WASS)

Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
ICO National Fall School	ICO	2015	1
ICO International Fall School	ICO	2014	3
LearnLab summer school (ICT and Education)	Carnegie Mellon University	2015	3
Research methodology - Qualitative	ICO	2015	3
Competence theory research and practice	ICO/WASS	2014	3
B) General research related competences			
WASS Introduction Course	WASS	2013	1
From Topic to Proposal	WASS	2013	4
ICO Introductory Course	ICO	2014	5
Data Management Planning	Wageningen UR Library	2015	0.4
Information Literacy PhD including EndNote Introduction	Wageningen UR Library	2014	0.6
Reviewing a Scientific Paper	WGS	2015	0.1
'Argumentation competence: student's knowledge on argumentation, argumentation behavior and attitude towards argumentation, and their relationships with acquisition of domain-specific knowledge'	WASS PhD day	2017	1
High-Impact Writing in Science	WIAS	2017	1.3
Presenting with Impact	Wageningen in'to Languages	2017	1
Survival Guide to Peer Review	WIAS	2017	0.3
'The effects of first-order and second-order scaffolding on computer-supported collaborative argumentation - a systematic review'	Conference on Competence, theory, research and practice, Wageningen, The Netherlands	2016	1
'Exploring the relationships between the components of argumentation competence and their relationships with domain-specific knowledge'	Conference on Education and new learning Technologies, Barcelona, Spain	2017	1

C) Career related competences/personal development			
Scientific Integrity	WGS	2013	0.2
PhD committee	ECS/ELS	2013-2016	5
Organization BCCS day-out 2016			
Presenting research at chair group meetings/ seminar series			
Project and Time Management	WGS	2017	1.5
Total			36.4

*One credit according to ECTS is on average equivalent to 28 hours of study load

Colophon

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