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Flexible Scripting to Facilitate Knowledge Construction in Computer-supported Collaborative Learning

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Chapter 1
Learning 2.0

The 20th Century was a time of great innovation and change. One of the best examples of the emerging technology in this era was the World Wide Web, which was brought to life in the European Laboratory for Particle Physics in Geneva, Switzerland. This was an exciting place, where Tim Berners-Lee came up with his extraordinarily brief proposal to enable physics researchers from all over the world to organize, exchange and pool together scientific information by combining them in a web of hypertext documents (Berners-Lee 1989). This 'Vague, but exciting' proposal, as it is called by his boss, led to the creation of the World Wide Web. Soon after the first website http://info.cern.ch/ into the public eye in 1991, the number of websites had a dramatic growth first in the USA, and then all over the world.

With the rapid growth of Web 1.0, educators in the 1990s became aware of the importance of this new technology to support and facilitate teaching and learning activities. For example, Web 1.0 technologies made it possible to deliver expert knowledge in dynamic ways such as streaming video and online conferencing to not only appropriately equipped classrooms, but also thousands of remote sites. These technologies resulted in the boom of computer-mediated distance education in the past two decades.

Web 1.0 changed the way of information gathering, delivery, or in another word, human-information interaction. Web 2.0, however, changed the way of human-human interaction. The term Web 2.0 was first coined by O'Reilly (2005) and it was also referred to as the 'Read-Write Web' (Price 2006). Green (2010) described what he believed to characterize the differences between Web 1.0 and Web 2.0. According to his words, most Web 1.0 applications from the 1990s concerned primarily with the passive delivery of content, but less about interaction with users. Information was generated top-down for a mass audience and then the 'read-only' content broadcast from one to many. In contrast, Web 2.0 went beyond the relative static web pages to enable members of the general public to actively contribute and exchange information. Rather than being a one-way flow of information, Web 2.0 had the capacity for addressing today's diverse needs to be

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customized, personalized, and offering rich opportunities for social connection and interactivity.

Considering the changes of sharing knowledge through new information networks and socially interacting with others, some researchers are convinced that innovative use of Web 2.0 technologies can bring about quality change in the world of education (Kozma 2003). A question is therefore being asked by educators and researchers who perceive the changing trends and the potential of new technologies for connecting teachers, learners and resources: are we missing out on the chance to improve teaching and learning by utilizing the Web 2.0 tools available today? Compared with learners who accept and use new technologies without question, schools already lag behind (Solomon and Schrum 2007). Traditional teaching and learning environments are “presentation-driven”, which require students simply to follow directions (Solomon and Schrum 2007, p. 21). In contrast, the desired Learning in the digital age is collaborative, with information being shared, discussed, refined together with others.

However, learning in the digital age is not a simple summation of traditional learning methods and emerging technologies of the Web 2.0. It’s clear that no effect can be expected from simply using a computer or providing the Internet access. Efficiency depends on the software features and on the educational activities built around software (Dillenbourg and Schineider 2005). Therefore, we are going to address three key points with respect to the contemporary application in teaching and learning in this chapter: (i) What is the distinctive feature of learning in the Web 2.0 era; (ii) what is the theoretical mechanism underpinning the effective learning; and (iii) how to facilitate learning in the present and future practices.

1.1 A Current View: Emerging Needs of Learning 2.0

To enhance the effectiveness of technology-enhanced learning, we first need to know more about the features of learning with Web 2.0 technologies.

1.1.1 Collaborative and Interactive Learning

Unlike many traditional web-based technological applications which focus on the dissemination and delivery of contents, Web 2.0 applications are more driven by user contributions and interactions (Ferdig et al. 2007). Without being limited to formal school work, the habituated use of WWW involves participating in online communities, showing others what they can do, or voicing their opinions. In particular, the notion of Web 2.0 highlights the growing popularity of so-called ‘social software’ that allows users to communicate, work together and share their ideas in a variety of group interactions (Rollett et al. 2007). According to Anderson (2004, p. 42), “the greatest affordance of the Web for educational use is the profound and multifaceted increase in communication and interaction capability", which is even more evident in Web 2.0 when compared to the set of linked information sources that characterized 'Web 1.0'. The new media has helped create a culture for learning, where rather than some professors regurgitating facts and theories, students discuss and learn from each other. Oblingers (2005) observed that students in the digital age express a need for more varied forms of communication and report being easily bored with traditional learning methods. And the enhanced interactivity and connection with others can be enjoyable for learners.

'Today's students are no longer the people our educational system was designed to teach' (Prensky 2001). The 'new' students (some refer to them as Net Geners), are unique in that they are the first generation to grow up with digital and cyber technologies. Those digital kids learn differently from their predecessors with distinctive ways of thinking, communicating, and learning (Oblinger 2005). Nowadays we are immersed in the virtual world consisting of Wikipedia (the largest encyclopedia online written collaboratively by volunteers from all around the world), Facebook (an online social network that permits registered users to create profiles, upload photos and video, send messages and keep in touch with friends), YouTube (an online sharing service that allows users to watch and upload videos), Skype (a popular internet telephony application that offers free calling and further enables file transfers, texting, video chat and videoconferencing) and other social networks.

As social software tools seem to come out of nowhere, it is inevitable that the role of the Internet in the area of education is going to continue to grown at an ever increasing rate. Around 10 years ago, computer usage was already extreme high among college students (Jones 2002). According to the findings of surveys given to students at public and private colleges and universities in the continental United States, 86% have gone online. While students use the internet more often to communicate socially (42%) than to engage in work for classes (38%), an overwhelming number of students (nearly 79%) agreed or strongly agree that Internet use has had a positive impact on their college academic experience. And it is surprising to know that the majority of the college students (73%) said they use the Internet more than the library. Information technologies have become so pervasive; it is hard for us not to embrace them in the instructional process. While those tools were not developed specifically for educational applications, many of them are rooted in strong pedagogical underpinnings and possess many characteristics that could redefine the very possibilities of education (Ferdig et al. 2007).

However, collaborative learning in the classroom has continued to be largely ignored (Salomon and Perkins 1998). Most learning that occurs in the traditional classroom focuses on individual learning and consequently individual knowledge construction, assessed by results on standardized tests of academic achievement. Such an immediate academic success on traditional schooling scores is not everything. An employee in a real work environment is definitely not expected to follow what he or she is instructed in an isolated task to arrive at a 'single' correct answer. On the contrary, we need to be able to collaborate in groups to solve problems by canvassing information and resources from supervisors and peers.

To succeed in our struggle to provide the needed qualified workforce for the future, learning in the digital age includes the various innovative approaches that learners to master new technologies in order to participate in virtual communities where they exchange, criticize and present information and ideas. As a result, the goal of education in this new age is to prepare students to use their skills to communicate and collaborate. There are required skills for effective workers and citizens in the knowledge society of the 21st century and to 'participate in and make positive contributions' to the digital culture (OECD 2009). The development and implementation of instructional practices that will foster students' skills to communicate, think and reason effectively, make judgments about the accuracy of masses of information, solve complex problems and work collaboratively in diverse teams remains an important challenge for today's higher education (Pellegrino et al. 2001).

Currently, computer revolutions, multimedia advancement together with the combination of speedy, effective and barrier-free communication in relation with the tremendous amount of information have set a practical base for collaborative learning. Modes of learning about what we teach and how we teach have changed dramatically due to the numerous collaborative opportunities to increasingly enable and encourage social networking and interactive engagement (Rollett et al. 2007). Not only the daily observation and experiences, but scholarly traditions suggested that a certain amount of learning takes place beyond the confines of the individual mind (Salomon and Perkins 1998). Social mediation of learning, when well conducted, can be far more effective than its solo learning alternative. To reach the needs of the Net Generation more effectively, educators need to consider learning approaches that exploit the social networking skills which students exhibit outside of the classrooms.

1.1.2 Initiative and Self-Directed Learning

Another key feature of Web 2.0 is the concept of user add value, which means that users are integrated into the content creation process, thereby adding value to that process (Rollett et al. 2007). The relative horizontality of access to the Web has dramatically encouraged learning with an extremely high degree of self-organization.

The Net Generation exhibits great capacity in the use of the interactive technologies and tendency towards independence and autonomy in their learning (Oblinger 2005). They are described as self-reliant and curious information seekers (Tapscott 1998). Given these characteristics, it is obvious that this generation demands a new learning paradigm, different from the authoritarian, 'one size fits all' model of education (Brown 2005). Glenn (2000) further notes that Net Geners need self-directed learning opportunities, interactive environments, multiple forms of feedback, and assignment choices that use different resources to create personally meaningful learning experiences. The capacity of learning with new technologies is also defined as ‘21st Century Skills’, which is considered important for lifelong learning in a digital age.

A comprehensive survey conducted by Plomp and Voogt (2009) indicates a gap between teachers’ perceptions and principals of pedagogy toward a more learner-centred pedagogical approach with the aim of making students more active in and responsible for their own learning. Although this concept of learner-centred learning has already received an enormous amount of attention in the internet industry and beyond, its implications in the context of learning technologies have, thus far, not been properly explored (Plomp and Voogt 2009).

Cuban (2001) indicated that we are facing a dilemma of technology being oversold and underused. With a further review of the root of the problem, it is found that learning in the Web 2.0 tends to focus on technical issues of design and ignores pedagogical aspects that are necessary for the effectiveness of learning. Most applications lacked pedagogical underpinnings in the use of new technology and failed to understand learning behaviour that takes place in the social context (Tynjälä and Häkkinen 2005). The lack of pedagogical guidance about integrating tools for collaboration and communication into one’s classroom or training setting leaves instructors across educational settings with mounting dilemmas and confusion (Bonk and Cunningham 1998).

Though we do know that new technology offers enormous potentials and affordances to facilitate teaching and learning, it is less effective than expected in applying various social tools in education (Wang 2011). In other words, technologies have not been systematically utilized to improve educational practices based on approaches and findings of educational psychology (Gräsel et al. 2000). Consequently, there is great concern as to how educationalists can appropriately deploy these technologies to enhance learning.

1.2 A Glance Back: Underlying Constructivism Theories

The promise of technology must be built on sound learning principles and educational values. Keep this in mind, it is time to take a look backwards at the beliefs, assumptions, and theories that underlie the emerging needs of learning in the digital age, so that the relative disassociation between the new technology and educational practice (Solomon and Schrum 2007) can be fixed. Recently, many instructional models have been designed and implemented to resemble the constructivist view of learning and teaching (Gräsel et al. 2000). Constructivism has been considered to have a pervasive influence to reframe learning (Donnell and King 1999). However, ‘constructivism’ was taken only as slogans by most researches so that neither the basic assumptions of these theories nor the relationship between theory and practice is systematically theorised.

As the name of constructivism suggests, the theory draws a picture that learning takes place in contexts and that learners form or construct much of what they learn and understand as a function of their experiences in situation (Schunk 2000). Rather than talk about how knowledge is acquired, constructivism views learning as a process of knowledge construction. The emphasis that these theories place on the role of knowledge construction is central to constructivism (Schunk 2000).

Collaborative learning is not new when we consider its theoretical roots. Many of the concepts underlying the constructivist reform of educational practice today have a long and distinguished history (Harris and Graham 1994). Constructivism, as an outgrowth of cognitive science, was promoted by all of the theoreticians of intellectual development, from Piaget (1970), Vygotsky (1978) to contemporary cognitive scientists. Ernest (1995, p. 459) stressed that “there are as many varieties of constructivism as there are researchers”. Moshman (1982) carried out extensive works to characterize this diversity as three major trends that are often grouped together: Exogenous Constructivism, Endogenous Constructivism and Dialectical Constructivism. At this point, it is important to take into account such various perspectives and key concepts which each perspective consists of and ultimately to get a deeper understanding from an integrated perspective.

1.2.1 Exogenous Constructivism

Exogenous Constructivism posits a strong influence of the external world on knowledge construction. Contemporary information processing theories reflect this notion (Schunk 2000). The basic assumption of information processing is that the human system functions similar to a computer it receives information from the environment, stores it in memory and retrieves it when necessary (Schunk 2000). Thus the extreme perspective refers to the idea that the acquisition of knowledge represents a reconstruction of structures that exist in the external world (Applefield et al. 2000).

1.2.2 Endogenous Constructivism

In contrast, Endogenous Constructivism, or cognitive constructivism (Cobb 1994), represents another extreme form of constructivism, which is exemplified by the Piagetian theory (Moshman 1982). Piaget’s work led to the expansion of understanding of child development and learning as a process of construction that has underpinned much of the theory relating to constructivism (Sawyer 2006).

The main goal of Piaget is to explain how knowledge develops (Piaget 1977). A key assumption of his theory is that mental structures are created from earlier structures, not directly from environmental information (Schunk 2000). From this perspective then knowledge is not passively transmitted from the environment to the individual, but rather is the result of active cognizing from the cumulative experiences of the individual (Bruning et al. 2004; Piaget 1973; von Glasersfeld 1984). In contrast to socio-cultural theorists’ frequent references to the works of

Vygotsky (which will discussed later on), learning is characterized as a process of self-organization in which the subject reorganizes his or her activity to eliminate perturbations (von Glasersfeld 1987).

Although von Glasersfeld defines learning as self-organization, this is not to say that social interaction is useless. von Glasersfeld (1995) acknowledges that this constructive activity occurs as the cognizing individual interacts with other members of a community. In this way, people can be and must be considered active learners who try to make sense of the world around them based on experience as they live and grow (Duffy and Cunningham 1996; Pritchard and Woollard 2010). The focus is on the individual within the group, and cognition occurs in the mind of the individual. Indeed, other humans are simply additional environmental entities, which may provide the impetus for an individual to rethink his or her ideas. As a consequence, it is this rethinking, not the social interaction, that is responsible for the construction of knowledge (von Glasersfeld 1984).

To further illustrate the internal and individual constructions of knowledge, Piaget defined three essential processes, namely equilibration, assimilation and accommodation, to describe the 'genesis' (growth) of 'epistemology' (Piaget 1970). In Piagetian terms, Equilibration is the central factor and the motivating force behind cognitive development (Schunk 2000), which refers to the optimal state of having no contradictions between the cognitive structures and the environment. Equilibration coordinates the actions of the other two processes and makes internal mental structures and external environmental reality consistent with each other. However, learning occurs when children experience Cognitive Conflict (Schunk 2000), which is seen as a driver for developmental change (Buchs et al. 2004). Cognitive conflict arises when the learner realizes that there is a contradiction between his/her existing understanding and what he/she is experiencing. Assimilation and Accommodation are complementary processes to deal with the conflict. Assimilation refers to fitting external reality to the existing cognitive structure, while Accommodation refers to changing internal structures to provide consistency with external reality. In this way, the linked processes are the means by which the state of equilibrium (or adaptation) is sought.

Cognitive constructivism rooting in the information processing has led to a multitude of significant empirical findings and conceptual frameworks, including schema theory (Anderson 1977; Schank and Abelson 1977; Spiro et al. 1980), working memory models (Atkinson and Shiffrin 1968), and structural learning theory (Scandura 2001).

1.2.3 Dialectical Constructivism

Probably the most influential theoretical approaches towards the mechanisms of collaborative knowledge construction can be derived from *dialectical constructivism* which represents a moderate form between the extreme exogenous and endogenous perspectives (Moshman 1982). Rather than focusing on individual constructions, dialectical constructivism emphasizes social interaction as the source of knowledge construction (Tudge and Scrimsher 2003). As a direct reflection of Vygotsky's socio-cultural theory of learning (1978), the view of placing great emphasis on the social context of the learning process has been increasingly popular in today's learning and teaching environments.

A summary of major points appears below with details. First of all, Vygotsky's theory stresses that social interactions are critical and knowledge is constructed between two or more people (Meece 2002). Through a highly interactive process, which involves sharing, comparing and debating among peers and mentors, learners refine their own meanings and help others find meanings. In this way, knowledge is mutually built (Rogoff 1990).

According to Meece (2002), what learners can do on their own and what they can do with assistance from others is associated with the *Zone of Proximal Development* (ZPD), which might be the best known concept of the socio-cultural theory. In Vygotsky's own words, the ZPD is "the distance between the actual developmental level of a child as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky 1978, p. 86). Appropriate and timely intervention within an individual's ZPD has become an essential strategy for teachers working with the social constructivist approach (Pritchard and Woollard 2010).

Working in the ZPD requires learners a good deal of guided participation (Rogoff 1990). Vygotsky stressed that learners need to be guided by more competent partner(s) to solve the problem they could not handle alone. In other words, learners need to be 'scaffolded' in a given situation to make progress across their ZPD (Pritchard and Woollard 2010). Over the past two decades, an increasing number of educators and researchers have used the synonymous concept of *scaffolding* to illustrate the nature of learning progress. Generally, Scaffolding can be characterized as an appropriate intervention which has the purpose of enabling a learner to move forward (Pritchard and Woollard 2010). Typically, learners receive scaffolding through the help of peers, teachers, virtual community sources, or other social software. Reviewed by Printchard and Woollard (2010), there is a wide range of variety of scaffolds can be employed in practice, such as support, prompt, critical listener, feedback, simplifier, motivator, highlighter and so on. Through scaffolding, learners solve problem, generate solutions, and gain insights that would ordinarily rest beyond their independent abilities (Bonk and Cunningham 1998).

To be of benefit, scaffolding must be temporary (Pritchard and Woollard 2010). When the learner shows signs of handling the task in question, the scaffolding can be removed gradually until it is no longer needed (DCSF 2009). Through the dynamic scaffolding process, learners may internalize the knowledge that they do not yet possess at the beginning of their learning. Internalization, as one of the central notions in Vygotsky's account of development describes the process in which the knowledge becomes part of the individual cognitive structures. In other words, internalization occurs when the learning processes first performed with others on a social and interactive plane are successfully executed by a learner in an independent learning activity (Bonk and Cunningham 1998). It must be noted that internalization of new learning is not the copy of eternally presented input, but rather as involving adaptation of external input while coming to understand it in terms of what one already knows (Harris and Graham 1994).

1.2.4 Integrated Principles to Guide Learning 2.0

To sum up, endogenous constructivism and dialectical constructivism, worked in parallel with similar but occasionally diverging ideas (Pritchard and Woollard 2010). Endogenous constructivists highlight the contributions of individuals to what is learned. By contrast, the dialectical constructivists claim that learning is social in origin. They further give priority to social interaction in the acquisition of skills and knowledge. Against the background of the contrasts between these two perspectives, each of them can never be proved unequivocally true or false. Schunk (2000) acknowledged that each of these perspectives has merits and is potentially useful for learning and teaching. In this view, neither active individual construction nor the social interaction can be adequately accounted for without considering the other.

It is not our purpose to detail all these differences across the many perspectives of what constructivism means. Thus despite the differences sketched above, there is important congruence among most constructivists with regard to the general views:

(i) Collaborative learning is an active process of knowledge construction rather than knowledge transmission. The traditional teacher-centred model is often considered to be transforming knowledge from the 'chalk and talk' teacher to the listening students. Nowadays, such a teaching model is rapidly being replaced by alternative prototypes of constructive instructions in which learners should be allowed to construct knowledge rather than being given knowledge (Brown 2001; Cobb 1994; Duffy and Cunningham 1996). Constructivism decried passive learning with an epistemological view of knowledge construction rather than knowledge transmission (Applefield et al. 2000). In other words, knowledge is not received from the outside or from someone else; rather, it is actively built up by the individual learner (von Glasersfeld 1989).

(ii) Learner plays a critical role to construct his/her own learning. In a traditional classroom, the learner plays a relatively passive role, while in all constructive teaching-learning settings the traditional telling-listening relationship between teacher and student has been redefined. A great contribution of Piaget to the theory and practice of education was his view of taking learners as the active constructers and independent explorers of their own knowledge (Schunk 2000). Vygotskian' social-cultural theory (Vygotsky 1978) was built upon the Piagetian idea of the child as an active learner, whereas with the emphasis on the role of social interaction in learning and development. Temporary constructivists tend to see learners as the center of a learning environment (Mohamed 2004). They regard the teacher-dominated classroom and curriculum as obsolete (McLoughlin and

Lee 2007). The notion of learner-centred learning holds increasing appeal for teachers, educators and researchers, for example, Prawat (1992) claimed that it should involve a dramatic change in the focus of teaching by putting the students' own efforts to understand at the center of the educational enterprise. Similarly, the trend is getting widely accepted that teaching should include a focus on student variables to positively affect student outcomes (American Psychological Association 1993).

And (iii) scaffolding is needed to adapt the dynamic process of knowledge construction. Scaffolding has been traditionally defined as the process by which a teacher or more knowledgeable peer provides assistance that enables learners to succeed in problems that would otherwise be too difficult (Wood et al. 1976) and hence develop understandings beyond their immediate grasp (Reiser 2002, 2004). Thus, it is obvious that the conception is associated with Vygotsky's (1978) notion of the ZPD, which characterizes the region of tasks between what the learner could accomplish alone and what he or she could accomplish with assistance (Rogoff 1990). In recent research on the learning sciences, scaffolding has become increasingly prominent. Fox and Helford (1999) listed several more suggestions specific to effective teaching online, including scaffolding principle which stress the educational value of creating material that is slightly too difficult for the student to encourage cognitive 'stretch'. Similarly, scaffolding is a critical component in facilitating students' learning (Chi et al. 1994) and a key strategy in cognitive apprenticeship (Collins et al. 1989), in which students can learn by taking increasing responsibility and ownership for their roles in complex problem solving with the structure and guidance of more knowledgeable mentors or teachers. Central to the notion of scaffolding is the gradual appropriation of full control of the thinking, managing, and enacting the task at a pace that is appropriate for the individual learner.

The three integrated principles give rise to an integrated and promising perspective on coordinating cognitive constructivist and socio-cultural perspectives to apply new technologies in education which further give us a good starting point to understand the theoretical rationale for the ideas presented in this book.

1.3 A Look Forward: Computer-Supported Collaborative Learning

Dramatic changes in digital technology following the so-called 'Web 2.0 revolution' in computer science, forward new insights into providing multiple forms of instruction approaches and creating new learning environments (Dillenbourg and Schneider 1995) where learners can take control of their own content (Wagner and McCombs 1995), connect, interact and share ideas in a fluid way (Pritchard and Woollard 2010), structure learning activities that address student misconceptions, seek student elaboration of their answers, and pose questions (Bonk and Cunningham 1998) and generate new knowledge for rapid distribution and cooperation (Rollett et al. 2007).

Besides the enormous excitement inspired by the interactive technologies, the 'ruminated' understanding of learning triggers us to rethink of learning science research in a different manner (Ferdig et al. 2007). The unique features of the Web 2.0 application in particular are seen to mirror much of what we know to be good models of learning (Maloney 2007), in that they are collaborative and encourage active roles for learners. In many countries the use of educational technology is part of school improvement or reform shifting toward constructive approaches of teaching and learning (Pelgrum and Plomp 2002). The reminiscence approach presented in this book builds further on the works of Vygotsky and Piaget that encourage students to collaborate, solve meaningful problems and reflect on their own thinking processes (Bonk and Cunningham 1998).

Many studies emphasize the advantages of using computer and Internet technologies, however, a fundamental issue facing educators is how to incorporate the paradigm-altering technology to truly change and impact teaching in real learning settings (O'Donnell 1996). The aspects of interactive technologies make it easier to create online learning environments, however, the technology itself do not guarantee effective learning (Bransford et al. 2000). In addition, constructivism, as Kirschner et al. (2004) argued, is neither an approach to nor a model for instructional design. It is therefore challenging for teachers to understand and further operationalize the 'philosophy of learning' in the classroom. To some extent, our teaching and learning in the classroom has been backward in emerging technologies and even lags behind the existing pedagogical theories. Synthetically speaking, the theme of this book is to investigate how the insights of constructivism could be incorporated into our Web 2.0-based support environment to suit the social needs and unique requirements of individual learners.

Koschmann (1996) identified Computer-Supported Collaborative Learning (CSCL) as a promising field in educational research that combines the instructional trends of collaborative learning and the potential of information and communication technology (ICT) to offer major promises for learning. Briefly, CSCL is focused on "how collaborative learning supported by technology can enhance peer interaction and work in groups, and how collaboration and technology facilitate the sharing and distribution of knowledge and expertise among community members" (Lipponen 2002, p. 72).

To some extent, cognitive and social constructivism can be regarded as a set of theoretical assumptions that have deep historical roots. Its gaining of popularity is in line with the emergence of computer-supported collaborative learning (Lipponen 2002). Influenced by the theoretical assumptions, a vast amount of resources has been invested to develop and establish CSCL in all kinds of learning settings (Strijbos et al. 2004), covering many, even very different instructional approaches and research topics (Lipponen 2002).

While a majority of studies have shown that collaborative learning is often efficient (Webb 1991), the empirical literature brought contradictory evidence that sometimes computer-supported collaborative learning does not work as expected due to students being rarely accustomed to constructing knowledge collaboratively (Weinberger 2003).

Socially, learners often do not collaborate well if left to their own devices (Cohen 1994) and thus miss the opportunity to benefit from their collaboration (Dillenbourg et al. 1995). Negative social processes occur when learners have problems in effectively coordinating their joint efforts (Gräsel et al. 2000), do not participate equally (Cohen and Lotan 1995), do not sufficiently reference each others' contributions (Hewitt 2005), do not interact in positive ways(Lou et al. 2001), engage in quick and superficial consensus building (Weinberger 2003), or generally fail to engage in productive learning interactions when left without teachers' consistent support and scaffolding (Hewitt 2005).

Cognitively, the cognitive processing which explain the effectiveness of collaboration might not occur routinely (King 2007). For instance, learners often engage in low-level argumentation (Stegmann et al. 2007, 2012), rarely explain and justify their opinions, articulate their reasoning, or elaborate and reflect upon their knowledge (Kobb et al. 2007) and hence seldom converge on a comparable level of knowledge acquisition (Fischer et al. 2002).

It has been clear that free collaboration does not systematically produce learning. Gillies (2003) emphasized that it is the structured forms of cooperative learning in particular that lead to better learning outcomes than traditional teaching methods. Therefore, to be successful, collaborative learning needs to be supported by appropriate instructional support that guarantees a higher quality of both collaborative learning processes and individual learning outcomes (Fischer et al. 2007; Kollar et al. 2006).

Chapter 2
Introduction to Collaboration Scripts

The recognition that not all learners are willing to execute the social and cognitive activities that lead to successful learning has long been recognized (McLoughlin 2002). Thus, supports are needed to assist the learners to develop competencies in self-regulated learning and social interaction. Based on constructivist models of learning, the term of *Scaffolding* is becoming increasingly popular in educational researches and practices. The term is mainly used by learning scientists to describe the help given to learners that assumed to promote deeper learning (Sawyer 2006). The term was first employed by Wood and colleagues to "adult controlling those elements of the task that are essentially beyond the learner's capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence" (Wood et al. 1976, p. 9). Consequently, a learner develops the skills necessary for completing such tasks independently (Bonk and Cunningham 1998; Rogoff 1990). Originating in the socio-cultural perspective of Vygotskyan theory (1978), it is clear that the conception was derived from the notion of the Zone of Proximal Development, which characterizes the region of tasks within which learners would not be able to accomplish on their own but can successfully complete it with the assistance of a person competent in the task (Duffy and Cunningham 1996). In short, scaffolding enables the learner to bridge this gap between the actual and the potential depends on the resources or the kinds of support provided (Puntambekar and Hübscher 2005).

A number of scaffolding approaches have been developed based on empirical findings and socio-cognitive theories to directly facilitate specific processes of collaborative knowledge construction. Such instructional supports have been described and analyzed more systematically as *Collaboration Scripts* (Fischer et al. 2007). Collaboration scripts illustrate the convergence between instructional engineering and socio-constructivism (Dillenbourg and Jermann 2007). From this standpoint, collaboration scripts have been regarded as scaffolds that aim to improve collaboration through structuring the interactive processes between two or more learning partners (Kollar et al. 2006). In order to get an idea of why and how collaboration scripts are likely to be effective, let us first consider some of the

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crucial features of what these scripts may look like. As with many such concepts that are felt to have useful power in theoretical and practical realms, it will be worthwhile to do some historical excavation by circumscribing the early uses and roots of the concept and then craft a conceptual map relating the term collaboration scripts.

2.1 Previous Works on Conceptualize Collaboration Scripts

As a 'boundary concept', the term scripting has be associated with various theoretical sources (Fischer et al. 2007) and it was introduced long before the development of computer technologies as ubiquitous educational tools (King 2007). Fischer and other pioneers (2007) in the multidisciplinary context of CSCL presented an extensive overview on recent researches with a special focus on collaboration scripts. Although the term 'script' refers to the notions originally used in computer science (Ayala 2007; Miao et al. 2007) and cognitive psychology (Schank and Abelson 1977), it has also begun to be used more often in educational settings, where the meaning it has taken on is somewhat different (King 2007). In educational settings, a script is designed externally (by a teacher or other learning facilitator) as a guiding structure to specify, sequence, and assign activities to collaborative learners (Weinberger 2003).

The first use of the term scripting in an educational context is the well-known MURDER script to facilitate text comprehension (O'Donnell and Dansereau 1992). The script includes detailed instructions on how to proceed in a text processing task, in which structured dyads take turns in the role of 'recaller' who recalls all the remembered information and 'listener-detector' who listens and then detect errors, identify omissions and ask for clarifications in the recall.

Led by the initial work of O'Donnell and Dansereau (1992), several other instructional approaches have been subsumed as script approaches (Derry et al. 1998). King (1998, 1999, 2007) developed a peer-tutoring model for classrooms to support knowledge construction in dyads or in larger groups of learners. The guided ASK to THINK—TEL WHY model distributes structured reciprocal tutoring roles (questioner vs. explainer) among the learners and structures the activities on a rather detailed level by requiring learners to complete question prompts. Question sequencing from review questions through thinking and meta-cognitive questioning and responding serves to both control the progression of learning and monitor its extensiveness (King 2007).

Even more recently, collaboration scripts have become a major topic in research on computer-supported collaborative learning (Dillenbourg 2002; Kollar et al. 2007), where collaboration is partly or totally mediated by computer as opposed to consisting of face-to-face interaction (Dillenbourg and Jermann 2003; Ertl et al. 2007; Lauer and Trahasch 2007). The Argue Graph script (Dillenbourg and

Jermann 2003) was developed to trigger argumentation among pairs: First, each student is required to fill out an online questionnaire, that is related to the studied content domain (e.g., how to react to students' erroneous answers within educational software). The multiple-choice questions have no correct or incorrect answer. Questions measure opinions and students provide a short written argument for each of their choices. The system produces a graph in which students are positioned according to the collected answers. The system or the tutor forms student pairs by selecting students with the largest distance on the graph (i.e., with the most different opinions). And then pairs answer the same questionnaire together and provide arguments again. The system therefore aggregates the collected answers and the arguments that were given individually and collaboratively. The role of the tutor is to organize the students' arguments into theories, or, in other words, into the structured knowledge. Finally, each student individually writes a structured synthesis of the arguments collected for a specific question.

Another example is provided by the social and epistemic scripts (Weinberger et al. 2005) which consist of the following phases and interactions between the members of groups of three students: First, each student gets information about an (educational) case A and is required to write a report about the case. After that, each student gets the case B and the report of the student to his left and writes a comment about the report. Then, each student gets a case C and the report and the comment the student to his left produced, and write a second comment about the report. Finally, each student gets back his own report to case A together with the comments of the two other students and rewrites it taking the comments into account.

As shown in the preceding quick review, although the specific combination of procedures often varies from one collaboration script to the next, most researchers in the field have posited models that to some degree consist of shared conceptual components that are assumed to be important to ensure successful collaboration scripts. Despite a substantial number of empirical studies on the effects of collaboration scripts on processes and outcomes of learning, a 'coherent theoretical account' is still missing (Fischer et al. 2013). A few pioneering works (Dillenbourg and Jermann 2007; Kollar et al. 2007) made the first attempt to formalize some of the ideas of distinguishing internal/external and macro/micro collaboration scripts.

2.1.1 Internal Versus External Scripts

Schank and Abelson (1977) introduced the term (internal) scripts to describe the abstract mental structures that organize the processing of sequences of events. In short, they used scripts as personal knowledge and memory structures of a "sequence of actions that define a well-known situation" (Schank and Abelson 1977, p. 41) which determines how people act in specific every-day situations, such as in a restaurant. In a typical restaurant, for instance, individuals know that they first need to order a menu, subsequently wait to be served, and finally pay the bill after eating. Following Schank and Abelson's idea, Kollar et al. (2007) distinguished internal scripts as cognitive structures from external scripts as instructional approaches. In contrast to the Schank and Abelson (1977) view of scripts as a fairly static internal memory structure with a narrowly constrained set of actions and roles, researchers in educational psychology talk about scripting the interaction of learning groups (O'Donnell and Dansereau 1992). From this perspective, collaboration scripts are normally represented in the learners' minds (internal representation) as a memory structure and on the other hand, scripts can be represented somewhere in the learning environment (external representation), with complex interplay between these two levels of representation (Carmien et al. 2007).

In this context, scripting is used more broadly to describe how collaborative learning can be externally structured or scaffolded for the purpose of prompting group interaction that promotes learning. Scripting of the interaction during collaboration is designed so that the roles of participants, the actions engaged in and the sequence of events, prompt specific cognitive, socio-cognitive, and meta-cognitive processes, thus ensuring that the intended learning takes place (King 2007). In short, as a working definition, external collaboration scripts provide a structure to collaborative knowledge construction by specifying, sequencing, and assigning roles or activities to learners (Kollar et al. 2006).

2.1.2 Macro Versus Micro Scripts

In a pioneering attempt to analyze collaboration scripts, Dillenbourg and Jermann (2007) made a distinction between macro- and micro-scripts. According to the distinction, micro-script scaffolds tend to directly influence the interactions of group members by giving more specific instructions, such as sentence starters or question prompts. Most examples described here are on the 'micro' side: in the work reported by O'Donnell and Dansereau (1992), King (2007), and Weinberger et al. (2005) that tends to provide more scaffoldings to students such as sentence starters, question prompts or descriptions (Kollar et al. 2007). Compared to micro-scripts, macro-scripting indirectly promotes productive interaction by arranging basic conditions like the group size, the group task or the communication media rather than specific support. Typically, macro-scripts describe longer time segments and are spread over more social planes compared to micro-scripts. The example presented by Dillenbourg and Jermann (2003) describe environments that articulate micro-scripts within phases of a macro-script.

Generally speaking, micro scripts reflect a psychological perspective, whereas macro-scripts are based on a pedagogical perspective that influences the process more indirectly (Häkkinen and Mäkitalo-Siegl 2007). For all apparent differences, micro and macro-scripts do not constitute clear-cut categories but only differentiate in the level of granularity (Kobbe et al. 2007). They share the same compositional structure and can therefore be described with the same set of components and mechanisms.

2.2 Script Theory of Guidance

Recently, Fischer et al. (2013) outlined a *Script Theory of Guidance* that is more systematic than works of other predecessors and takes a more analytic view of a few central components that are shared among different scaffolding approaches and several leading principles to explain a broad range of findings from the CSCL literature. Two main theoretical perspectives underpin the unified theory on collaboration scripts, namely, the schema theory (Schank 1999; Schank and Abelson 1977) and socio-cultural constructivism (Vygotsky 1978). We present a brief overview of our understanding of these perspectives and then describe the integration of these perspectives in the research motivation for the present study.

What is of great interest and expressed by constructivists is the dynamic process of knowledge construction that bridges the outside world and mind. As we have summarized earlier in the first chapter (i) collaborative learning is an active process of knowledge construction rather than knowledge transmission; (ii) learner plays a critical role to construct his/her own learning; and (iii) scaffolding is needed to adapt the dynamic process of knowledge construction. More like a 'philosophy of learning' (Kirschner et al. 2004), constructivism is thus criticized for the lack of guidelines to specify the critical role of learner, the dynamic feature of scaffolding and more important, the active process of knowledge construction triggered by the interplay between the internal side of learner and external side of scaffolds. As a solution to overcome the major problem, the *Script Theory of Guidance* bridges the gap between the philosophical constructivist thoughts on the one side and the research practice on computer-supported collaborative learning on the other.

2.2.1 *Central Components*

The *Script Theory of Guidance* started with the elaborated distinction between internal and external collaboration scripts. According to Fischer et al. (2013) an internal collaboration script is a configuration of knowledge components about a collaborative practice and its parts at different levels of complexity, while an external collaboration script is a configuration of representations to guide the collaborative practice.

First, four conceptual components were identified to constitute the internal configuration of knowledge (internal scripts): The *play* component is at the top level and includes knowledge of the sequence of *scenes* and of the *roles* involved in it. The *scene* components include knowledge about situations in a play and the *scriptlet* component refers to knowledge of sequences of single activities within particular scenes. Finally, the *role* components typically extend across several scenes and activities, which thereby constitute knowledge of taking part in several scenes and organizing specific scriptlets.

Since the purpose of external collaboration scripts is to guide CSCL practice by facilitating or inhibiting the internal collaboration script components (Fischer et al. 2013), the external collaboration scripts have a one-to-one correspondence between the structure of internal collaboration scripts and its four types of components: *Play scaffolds* guide the topmost level by presenting the main goal of the collaboration but no elaborating how to reach the goal. *Scene scaffolds* specify and sequence a set of scenes, which constitutes a comprehensive play. *Role scaffolds* assign specific roles to the participating learners. Assigning roles is meant to assure that learners are equally involved in establishing and maintaining shared conceptions and they can approach a problem from multiple perspectives. Typically, the equal participation and the diversity of perspectives can be achieved with role scaffolds that require learners to change roles transgressing the boundaries of scenes. Finally, *Scriptlet scaffolds* target the specific activities that constitute a scene.

This is an important advancement towards the direct comparison of various scaffolding approaches since the availability of the systematic framework provides the common language, basic structure, and general levels to be applied to interpret the differences. The comparison results of a few exemplifying collaboration scripts are summarized in Table 2.1.

2.2.2 Guiding Principles

Built on a recent version of schema theory and integrated constructivist perspectives, seven guiding principles were outlined in the *Script Theory of Guidance*.

2.2.2.1 Internal Script Guidance and Configuration Principle

The internal script is different form the notion proposed by Schank and Abelson (1977) in their early works in which script is an invariant structure that describes an appropriate sequence of events in a particular context. It seems clear that this initial version of the script is not subject to change, nor do they provide the apparatus for handling novel situations. Any structure proposed for memory must be capable of self-modification (Schank 1999). The notion of cognitive psychology was elaborated progressively by emphasizing the internal dynamism of scripts to explain the highly flexible configuration and reconfiguration of knowledge components according to a changing situation (Fischer et al. 2013).

According to the *Script Theory of Guidance*, prior experience and knowledge, connotated as internal collaboration scripts about collaborative practices play a crucial role for guiding the person's understanding of and actions in the collaboration (***Internal Script Guidance Principle***). The dynamic configuration and/or re-configuration of internal collaboration scripts are influenced by the learner's goal and the perceived situational characteristics (***Internal Script Configuration Principle***).

Table 2.1 Comparison external collaboration scripts

External scripts	Components			
	Play	Scene	Scriptlet	Role
MURDER	Text comprehension in pairs	• Reading a set of text passages • Switching roles after completing one passage	Within each pair and for each passage of text: • Both students set the **M**ood for studying • Both students read the text material for **U**nderstanding • The recaller **R**ecalls the material • The listener **D**etects errors/omissions and gives feedback • Both students **E**laborate on the learning material • Both students **R**eview the learning material and what they have learned	Recaller Listener
ASK to THINK-TEL WHY	Peer tutoring	• Learning sessions • During any learning sessions, partners exchange roles	**ASK to THINK**: Questioner ask question in certain sequence • Review questions • Thought-provoking questions • Hint questions • Probing questions • Metacognitive questions **TEL WHY**: Explainer answer those questions	Questioner Explainer
ArgueGraph	Argumentative dialogue	• Individual question and argumentation • Group formation according to **Argue Graph** • Pair question and argumentation • Teacher organized debriefing • Synthesis		Individual/pairs

(continued)

Table 2.1 (continued)

External scripts	Components			
	Play	Scene	Scriptlet	Role
Social cooperation script (SCOS)	Case-based problems solving	The SCOS-learners were guided through all three cases and were asked to alternately play the role of the analyst and that of the critic • First analysis • First constructive critique • Second constructive critique • Reply to first critique • Reply to second critique • Third constructive critique • Fourth constructive critique • New analysis of the case	**Prompts for the constructive critic** • These aspects are not clear to me yet • We have not reached consensus concerning these aspects • My proposal for an adjustment of the analysis is **Prompts for the case analyst** • Regarding the desire for clarity • Regarding our difference of opinions • Regarding the modification proposals	Analyst Critic

2.2.2.2 Internal Script Induction, Re-configuration and Transactivity Principle

Learning is a process of internalizing external reality (Iran-Nejad 1990). Many of the classical script approaches that were developed to facilitate collaborative learning are built on the assumption that through extended practice with the external script, portions of the external script become more and more internalized by individuals in their internal scripts (Palinscar and Brown 1984). In this way, internal collaboration scripts can be consequently induced and continually modified.

As I have pointed out above, the grounding assumption that external scripted collaboration should lead to an internalization of relevant aspects of the script is not new: "Every function in the child's development appears twice: first, on the social level, and later on the individual level; First, between people (inter-psychological) and then inside the child (intra-psychological)" (Vygotsky 1978, p. 57). Therefore, individual development could be referred to as a process from the internalisation through social interactions, restructuring conceptual system to new understanding (Liu and Robert 2005).

Before addressing the principles, a few essential assumptions need to be back-tracked. In Piagetian terms, individual knowledge construction stimulated by internal cognitive conflict as learners strive to resolve mental *Disequilibrium* via assimilation or accommodation to construct or alter internal structures (Piaget 1970). A more careful reading of Piaget indicates that he actually also emphasized the critical role of internalizing knowledge by making changes in the mental structure. According to cognitive constructivism, when new information is processed, it is considered by the extent to which it fits into an existing internal collaboration scripts. And most of the learning that occurs is either incorporated within internal scripts (*assimilation*) or modifies internal scripts (*accommodation*) if the discrepancies become too great. In this case, the learner has to either build new configuration to an existing internal scripts or alter the internal scripts to allow for what has been newly experienced in order to maintain a state of equilibrium (as we already know from the principles mentioned above).

Of key importance to the *Script Theory of Guidance* (Fischer et al. 2013) is the specification of the dynamic internalization process which refers to the generic link between the external and internal collaboration scripts. In order to address the essential issue of how to produce greater internalization and deeper understanding, three further principles were developed. That is, if a learner participates in an initially unfamiliar CSCL practice, then he or she builds a new configuration of already available internal script components and, through repeated application of this configuration of internal script components, develops new higher-level components (play, scene, or role) that organize the subordinate components (scenes, roles and scriptlets) for this CSCL practice (***Internal Script Induction Principle***). If a learner's employed internal collaboration script does not lead to understanding or successful actions in a CSCL practice, the internal collaboration script configuration is likely to be modified (***Internal Script Re-configuration Principle***).

On the other hand, it is assumed that a cognitive conflict arises more often in a social situation and can cause active and reflective ways of solving the conflict which then can lead to deeper understanding and better learning (Hesse 2007). In Vygotskyan terms, cognitive conflicts may arise through the dynamics of social exchange when the difference in the state of knowledge of an individual learner to that of a more advanced other person exists in collaborative learning (Dillenbourg and Schneider 1995). The difficulty of gaining consensus in the midst of conflict between perceptions and opinions can also contribute to learning and knowledge building cooperation through discussion and the nurturing of thought processes (Stahl et al. 2006). While Vygotsky never used the scaffolding metaphor (Stone 1998), it is widely accepted that the Zone of Proximal Development underpins the theoretical conceptualisation of scaffolding as the heart of that notion. From this perspective, the ZPD indicates the distance between a learner with and without scaffolding. In computer-supported collaborative learning, ZPD can be created by means of the entire learning environment, including learning partners as well as external collaboration scripts.

One major goal of collaborative learning is to support social interaction and hence encourage the learner's cognitive processes (Ertl et al. 2007). Socio-constructivist stated that the knowledge can be only built through discourse with others, that is, through social interaction (Pritchard and Woollard 2010). According to Vygotsky's idea, the learner develops as a result of active participation in social interaction with other individuals (Lave and Wenger 1991; Vygotsky 1978). Thus, development cannot be separated from its social and cultural context. Although Piaget's theory contends that development can proceed without social interaction, the social environment is nonetheless a key source for cognitive development (Schunk 2000). While the impetus for developmental change is internal, extrinsic environmental factor can still influence development (even not directly)—through activities that provide social interactions with the environments (Piaget 1977). Therefore, one more ***Transactivity Principle*** states that the more a given CSCL practice requires the transactive application of knowledge, the better this knowledge is learned through participation in this CSCL practice.

2.2.2.3 External Script Guidance and Optimal External Scripting Level Principle

Collaborative knowledge construction may be always more or less guided by external scripts, either as facilitators to select functional internal scripts, or as inhibitors to 'preclude' dysfunctional internal scripts (Fischer et al. 2013), but the effect of the facilitator or inhibitor is not guaranteed. The *Script Theory of Guidance* proposed the last set of principles to address the problem.

The *Scripts Theory of Guidance* acknowledges that effective external collaboration scripts enable learners to engage in collaborative practice at a level beyond what they can do without external collaboration scripts (***External Script Guidance Principle***). The most effective external collaboration scripts are at the highest possible hierarchical level of available internal collaboration scripts (***Optimal External Scripting Level Principle***). The principles are capable of explaining the undesired effects of external collaboration scripts, either 'Under-scripting' or 'Over-scripting'.

2.2.2.4 Under Scripting

Minimally guided instruction is likely to be ineffective (Kirschner et al. 2006). According to the *Script Theory of Guidance*, the prime purpose of external collaboration scripts is to prevent under-scripting effect. Specifically, it is more likely that an external script addresses scenes (e.g., 'Please provide a counterargument!') without sufficient information on the activity or addresses scripts that are not known (e.g., 'Please engage in knowledge building by integrating pros and cons!'). As shown in Fig. 2.1, the level of external collaboration scripts far beyond the ZPD of learners is insufficient to support learning. This kind of interference between internal and external scripts might be called '*under-scripting*'.

2.2.2.5 Over Scripting

Although collaboration scripts show some potential for facilitating collaborative learning, this potential is not guaranteed. Recently, over-scripting is a widely cited

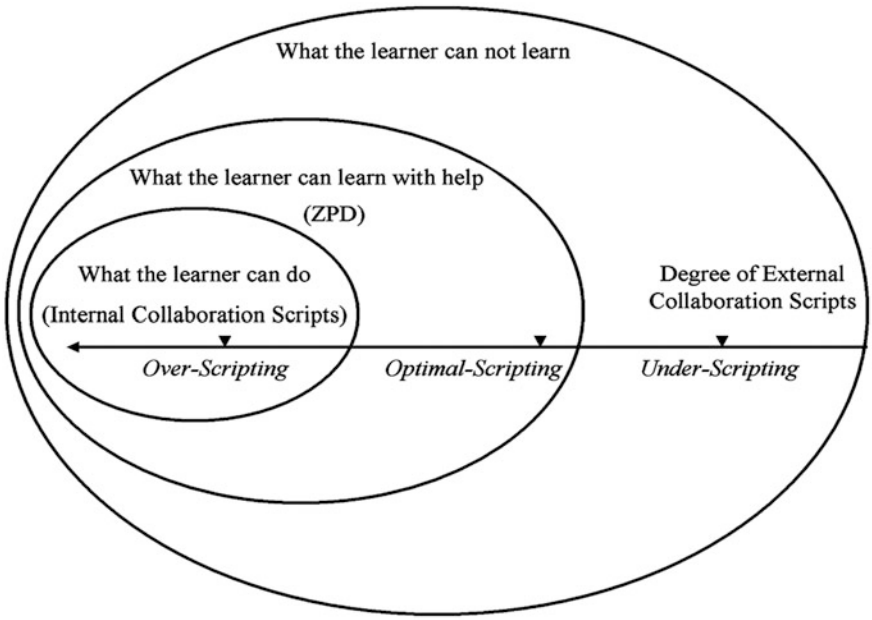

Fig. 2.1 The effects of external collaboration scripts

term, which is often connotated with negative and unexpected learning outcomes. This occurs when the collaboration is supported by ‘too much script’ (Dillenbourg 2002). Specifically, ‘*Over-scripting*’ occurs once external script provides scaffolds that guide procedures for which the corresponding internal scripts are already represented by the learner or even a learner might hold more effective or efficient internal script, the performance of the learner will decrease (Kollar et al. 2007). Therefore, an external collaboration script that includes unnecessary scaffolds at lower level (e.g., Scriptlets) is likely to impede learners to control the learning for them and hence hinder higher-order thinking (Cohen 1994; Fischer et al. 2013). In this case, learners just go through the motions rather than being reflective about what is required (Reiser 2004).

2.2.2.6 Optimal Scripting

Finding the balance between giving and withholding information or assistance is a fundamental challenge in designing effective instruction (Koedinger and Aleven 2007). To avoid the pitfalls of over- or under-scripting, the ***optimal external scripting level principle*** implies that it is essential for learner to get their chance to apply the newly developed script components—beyond available internal scripts but within the ZDP.

It is important to clear up the misunderstanding of recognizing that internal collaboration scripts are fixed and stable. In contrast, the *Script Theory of Guidance* proposed a new dynamic opinion inspired by cognitive and social constructivism. From this point of view, internal collaboration scripts can continually be induced and modified. Thus, the degree of scripting might be dynamic during the learning process to match the best balance between internal and external scripts. Against this background, the suboptimal fit between internal and external scripts may have negative effects on cognitive processes during collaboration. For instance, if collaboration lasts a certain amount of time, the originally perfect fit of internal and external script may become over-scripting, owing to an ongoing internalization of the external collaboration scripts (Wecker and Fischer 2010).

The *Script Theory of Guidance* yields substantial improvement in reframing the relationship between internal and external collaboration scripts, which allows the methodical differentiation between under-scripting, over-scripting, and optimal scripting when compared with preceding works.

Chapter 3
How to Realize Flexible Scripting in CSCL

In CSCL, scripts are designed to structure collaborative processes by distributing activities and roles to group learners and by constraining the mode of interaction among peers or between groups (Fischer et. al. 2013). Designing and implementing scripts, however, requires striking the balance between too little script to be helpful and too much control to allow for natural group interactions (Koedinger and Aleven 2007).

Despite the emphasis on the existence of the risks of over-scripting (Beers et al. 2005; Cohen 1994; Dillenbourg 2002; Karakostas and Demetriadis 2009; Kollar et al. 2007), little attention has been given to defining clearly what accounts for over-scripting. Against this background, the question arises here is how to further conceptualize over-scripting and how to realize flexible scripting in CSCL to avoid the risk of over-scripting.

3.1 Over-Scripting

In scripted CSCL, there is the concern of "over-scripting". Dillenbourg (2002) pointed out that the purpose of scripting is to induce constrains that will shape productive collaborative interactions while avoiding the risk of over-scripting. Some empirical studies provided post hoc evidence for the over-scripting assertion: when negative effects (compared to unscripted collaboration) of scripts on learning outcomes were found, they were explained as 'over-scripting' (Beers et al. 2005; Stegmann et al. 2011). For example, a study by Beers et al. (2005) compared a less coercive scripted version of online discussions to a more coercive one when college students tried to solve the high school drop-out problem using a NegotiationTool. The less coercive version presented students on-screen information about every contribution, and asked students whether it needed to be verified or decided upon (agreeing or disagreeing). The more coercive version presented the same information but divided the problem-solving process into two distinct phases:

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negotiation of meaning, and negotiation of opinion. Compared to the less coercive script, the coercive one was found to have negative effects on students' contribution and negotiation of common ground. The negative effect was explained as the coercive script caused disruption of collaboration (over-scripting). This is apparently a post hoc explanation of over-scripting. In order to avoid over-scripting in advance, however, we need to know why over-scripting occurs.

3.1.1 Quantitative Over-Scripting

Over-scripting has often been explained cognitively (Dillenbourg 2002). For experienced students in collaborative learning, for instance, their knowledge on collaboration might be chunked and well-structured, if a script segments collaboration into too many sub-processes, it will increase cognitive load and therefore, hinder learning (Dillenbourg 2002). In addition, segmenting collaboration in too many pieces or distributing the resource to too many group members may make it difficult for group members to adopt shared goals, which have often referred to as an important criterion to define good collaboration (Dillenbourg 1999).

Dillenbourg and Tchounikine (2007) revised their definition of over-scripting by the degree of coercion. Degree of coercion describes how many constraints a script imposes on collaborative learning processes. For example, if a script constraints collaboration in a way that makes it sterile by inhibiting the natural interaction mechanisms, over-scripting occurs. In order to operationalize degree of coercion, Dillenbourg and Tchounikine (2007) made a distinction between intrinsic and extrinsic constraints of scripts.

Intrinsic constraints refer to the script design rationale, which is the core mechanism of how a collaboration script would shape peer interaction. For instance, in the Argue Graph script (Jermann and Dillenbourg 2003) which aims at triggering argumentation among pair members, conflict resolution is the core mechanism.

Extrinsic constraints describe different issues such as technological choices, contextual factors or arbitrary decisions. For instance, in the Concept Grid script (Dillenbourg 2002) which distributes partial knowledge to group learners and aims at triggering mutual explanation, researchers' arbitrary fix of group size is extrinsic constraint.

According to Dillenbourg and Tchounikine (2007), intrinsic constraints set up the limits of flexibility. That means, if intrinsic constraints are removed, the script is off the way of its underlying learning principle. For example, the ArgueGraph script requires students with the most different opinions on a given problems to be paired to trigger argumentation. If this constraint is violated and students are freely paired, the design rationale of the script is destroyed.

Extrinsic constraints describe the spaces for flexibility. That is, when there are too many extrinsic constraints imposed by a script, the script runs the risk of over-scripting because extrinsic constraints increase learners' unnecessary load.

3.1.2 Qualitative Over-Scripting

Fischer et. al. (2013) argued that over-scripting occurs not only because of the quantity of constraints, but also because of the quality. In their Script Theory of Guidance, internal collaboration scripts are learners' configuration of knowledge about how to act appropriately in collaborative learning while external collaboration scripts are instructional approaches that provide external constraints to collaboration. Both internal and external scripts have four components arranging from a high to a low level. They are *play*, *scene*, *role* and *scriptlet* component. Their theory emphasizes the importance of an external script to be 'optimal' in regards to the script components it provides.

According to the optimal external scripting level principle in the Script Theory of Guidance, over-scripting occurs when the external script targets at a wrong hierarchical level. For example, when a learner poses already a high level component in his/her internal script such as *scene* or *role* component, an external script targeting at a low level such as *scriptlet* would be less efficient because the learner has to process unnecessary information. In contrast, an external script providing supports at a high level would help the learner's dynamic configuration of his/her subordinate internal script components at a low level.

A study by Mäkitalo and colleagues (2005) provides evidence for the optimal scripting principle. In their study, college students participated in CSCL discussions in triads. An external collaboration scripts providing scaffolds at scriptlet level was found to impede learners' knowledge acquisition. Authors argued that these teacher students from educational science have had adequate scriptlet and thus receiving a low level external script caused extra load.

3.1.3 Motivational Over-Scripting

Beyond these two explanations aforementioned, there may also be a motivational explanation of why over-scripting occurs. Following Self-Determination Theory (Ryan and Deci 2000), when a CSCL script is too coercive, it may cause motivational problems since it reduces the necessary feeling of autonomy. Negative effects of collaboration scripts on intrinsic motivation are, therefore, to be expected, particularly in the long term and with adult learners (Bruhn 2000; Hron et al. 1997).

A study by Stegmann et al. (2011) supports this assumption. 81 students of Educational Science participated in online argumentative knowledge construction in their study. Degree of an argumentative script was manipulated (low vs. medium vs. high) and negative effects of the medium and the high degree of scripting on students' intrinsic motivation was found.

3.2 Script with Fading

If over-scripting occurs when an external script imposes too many constraints or when it provides scaffolds at a wrong hierarchical level, a straightforward way to avoid over-scripting is by fading out unnecessary external script components. The philosophy behind the instructional design principle of fading is that once students have acquired the desired competencies the external support becomes redundant and should be faded out (Puntambekar and Huebscher 2005). There are studies investigating different algorithms of fading in various learning contexts (Wecker and Fischer 2007; Renkl et al. 2004).

3.2.1 Forward & Backward Fading

Forward fading is a fading procedure from a starting point with little external collaboration scripts. The degree of external collaboration scripts can be increased by prompts, hints or explanations when learners have no sufficient internal scripts to complete the required tasks appropriately or effectively. However, forward fading is seldom used in practice, which leads to a deficiency of empirical evidence if forward fading outperforms a full and continuous script from a starting point.

Backward fading refers to fading from a starting point with full external collaboration scripts, and then scaffolds are removed gradually. From the constructivist perspective, the backward pattern is much more correspondent to the theoretical definition of fading, which emphasize the process of reducing the amount of external instructions.

Forward and backward fading presented here are distinct from the notions when they were first employed by the studies on worked examples. In a series of studies, Renkl and colleagues (Atkinson et al. 2003; Renkl et al. 2002, 2004) consistently demonstrated that detailed worked examples i.e., all solution steps are shown to the learner, were most appropriate when presented to novices, but they should be gradually faded out with increased levels of learner knowledge. Therefore, two different approaches to fading were investigated in the problem-solving studies, namely, backward fading, in which the last solution steps are faded first and forward fading, in which the first solution steps are faded first. It is clear that the forward/backward fading applied in the worked example study was only different in sequence but not in the degree of providing instructional supports.

3.2.2 Horizontal & Vertical Fading

As stated in the Script Theory of Guidance (Fischer et. al. 2013), collaboration scripts indeed embody four important elements based on a hierarchical model:

namely Scriptlet, Role, Scene and Play. One of the basic principles in this theory is that the effective external collaboration script is to direct learners at the highest possible hierarchical level of internal collaboration script components for which subordinate components are already available to the learner. From this point of view, collaboration scripts not only need to be faded horizontally within bottom layer of Scriptlet, but also crossing the layers to be faded vertically and hence enables learner to reach beyond the current competencies, handle the entire task in question and explore new understandings from a broader and generalizes layer (e.g., Scene & Play).

So far, only a couple of studies on the fading effects have been conducted from the hierarchical perspective of collaboration scripts. Wecker and Fischer (2010, 2011) proposed a systematic schedule to operationalize the fading process, in which three types of scaffolds (external script components) that differ in their cognitive target levels including exemplifying and explanatory application supports, the sequential information prompts and the structural argument schemata were gradually faded out (in a backward fashion) to foster the internalization of the required argumentation skills. The fading occurred after the accomplishment of certain required learning tasks. Results of these pioneering work, however, indicated that in some cases at least, merely reducing the support does not seem to be enough.

3.2.3 Fading Effects

It's expected that fading the external collaboration script forces students to practice their knowledge and develop the necessary skills to apply it in similar situations. This argument is theoretically in line with the 'internalization' idea stated by Vygotsky (1978). In practice, however, research results on the effects of fading are sparse and inconclusive.

A study by McNeill et al. (2006) found students who received fading of the written scaffolds gave stronger explanation in terms of their reasoning compared to those with continuous support. Wecker and Fischer (2010, 2011) found that fading fosters learning only in combination with additional support such as distributed monitoring among learners. Another study (Bouyias and Demetriadis 2012) also demonstrated that enriching argumentation scripts with the peer-monitoring technique can substantially improve learning outcomes, while simply fading out the script did not seem to improve student learning in any aspect. There seems an interaction between peer monitoring and faded collaboration scripts.

Peer monitoring is often cited together with peer feedback and peer assessment (Topping 1998; Topping and Ehly 1998), in which specific components of control may be distributed among collaborating learners. Hence, one of the appealing features of the notion is that peer-monitoring provides an opportunity for students to take over more control of their own learning (King 1998). Researchers argued, therefore, fading should not be based on a fixed procedure, but on ongoing diagnosis of learners' performance; fading algorithm should not be designer controlled but learner controlled. That is an adaptive or adaptable fading, a topic we will turn into in the next two sections.

Another important limitation of the previous studies is that effects of fading were measured only by means of declarative test (target at subject matter knowledge), but not in a separate performance in transferable situations in which learners' collaborative learning was guided by their internalized script components (Wecker and Fischer 2011).

From an instructional point of view, the central point of CSCL is not only to facilitate domain-specific knowledge acquisition, but also to foster learners' mastery of desirable collaboration skills through the internalization mechanism. These skills are to some extent domain-general and might be applied in similar situations in further learning practices (Kolodner 2007). In scripted CSCL, the fading effect on learners' internalization of external scripts is still a topic not yet well investigated.

To summarize, the research on fading is still at an early stage. In order to address the effects of the 'optimal' scripts to scaffold collaborative learning, researchers and pioneers in the field should be more careful with building a best-fit procedure of fading by drawing on precise theoretical models and practical evidence. Particularly, attention should be paid to the manipulation of fading pattern (forward/backward; horizontal/vertical), fading procedure (based on ongoing diagnosis) and learner control (instead of designer control) of fading. Additionally, educators need to pay careful attention to the effects of fading collaboration scripts on script internalization.

3.3 Adaptive Scripting

3.3.1 Adaptivity

In recent years, there has been a new trend in research concerned primarily with the adaptive use of instructional supports or scaffolds (Deiglmayr and Spada 2010; Fischer et al. 2013; Walker et al. 2009). In contrast to the classic approaches to support learning with static, one-size-fits-all instructions, the promising direction of research on implementing collaboration scripts is to provide students with instructional supports "adaptively tailored to the particular needs of particular learners in a particular moment of the learning process" (Rummel and Krämer 2010, p. 3). Thus scaffolding is a flexible process in which instructional supports must be adjusted based on ongoing diagnosis of learners' performance rather than remaining constant.

The highlighted adaptive nature of scaffolding (Wood et al. 1976) is based on the intrinsic component of the scaffolding system called 'internalization', as introduced by Vygotsky (1978). In the context of scripted CSCL, this implies that once learners have internalized the collaboration script for performing a particular learning task, they will be able to perform this task independently. The specificity of the external script therefore, needs to "gradually be reduced to ensure that learners are not given instruction they actually do not need" (Collins et al. 1989, p. 456). The process of reducing the amount of external instruction (Pea 2004) is known as fading, which was introduced in the previous section. It is important to note that adaptive instruction requires dynamic fading in and fading out of instrumental support, rather than fading based on a fixed procedure designed by the researcher. Adaptive instruction, in this sense, is a temporary entity that is used to reach one's potential and then is removed when learners demonstrate their learning.

3.3.2 Intelligent Tutoring Systems

Adaptive educational systems have received some attentions in the context of Intelligent Tutoring Systems (ITS), which are computer-based instructional systems that specify what to teach and how to teach (Wenger 1987). Specifically, the intelligent tutoring system uses the intelligent tutor to assess what a student knows and needs to know and fades in/out scaffolds accordingly (Lajoie 2005); carefully monitor the problem-solving process to ensure that it stays on track and to help direct students back toward a productive solution path when needed (Merrill et al. 1995); and allow the intelligent tutor to more closely approach the benefits of individualized instructions (Murray 1999).

Synthetically, intelligent tutors typically accomplish two of the principal task characteristics: (i) monitoring the student's performance and providing context-specific instruction just when the individual student needs it, and (ii) monitoring the student's learning and selecting problem-solving activities involving knowledge goals just within the individual student's reach (Koedinger and Corbett 2006).

A number of adaptive support systems have been evaluated with beneficial effects compared to fixed support (Diziol et al. 2010; Kumar et al. 2007) in a variety of domains. Diziol and colleagues (Diziol et al. 2010; Walker et al. 2008) worked with the CTA (Cognitive Tutor Algebra), which is a tutoring system providing just-in-time feedback once an incorrect problem solving action was automatically detected. In addition, students can actively request help from the CTA, receive hints tailored to their current focus of attention.

COLER (Collaborative Learning environment for Entity-Relationship modeling) is another intelligent collaborative learning system which aims to promote group interactions and maintain balanced participation (Constantino-Gonzalez et al. 2003).When relevant opportunities for learning are found by monitoring students' participation and recognizing differences between students' individual and group solutions, the coach tries to guide students to practice collaborative skills, providing advice such as encouraging students to participate and to discuss their differences in real time.

Baghaei and colleagues (2007) developed a constraint-based intelligent tutoring system COLLECT-UML to support the acquisition of both problem-solving skills and collaboration skills, by providing feedback at different levels of detail if a difference between the group solution and individual solutions is detected. The initial level of feedback is deliberately low, which indicates whether or not a problem solution is correct, a feedback without too much detailed information is given. And the level of feedback can be increased incrementally by providing hints which provide a more detailed message.

3.3.3 Adaptive Collaboration Scripts

It must be emphasized that Intelligent Tutoring Systems (typically single user, with system feedback) on the one hand, and Computer-Supported Collaborative Learning systems (typically multiple users, usually with no system feedback) on the other hand were two more-or-less separated research fields (Scheuer et al. 2010). But the trend toward the promising integration of the advanced educational systems ITS and CSCL grows stronger because of the emerging demand for providing adaptive instructional support for learners in computer-based learning settings.

Thus far, the Intelligent Tutoring Systems being shortly reviewed above often apply Artificial Intelligence (AI) techniques to provide 'intelligent' supports for learners. In the field of CSCL, however, researchers prefer the broader term 'adaptive scripting' rather than 'intelligent tutor' because the former is in line with other pedagogical terms widely used in this field such as collaboration scripts. Additionally, by using efficient but very simple techniques, some adaptive collaboration scripts are not intelligent, even though both of these notions are certainly of interest to providing 'optimal' scaffolds to meet the personalized needs of learners.

A script is adaptive when a computer system within which collaboration takes place is able to reliably assess learners' internal scripts on the fly and adjust the external script based on the level at which the group is currently collaborating. This is achieved by building a model of optimal collaboration and comparing it to a constantly updated user model based on collaboration quality (Diziol et. al. 2010). First studies of adaptive scripting provide evidence for its effectiveness. For instance, Walker et. al. (2011) found that learners who collaborated in a peer-tutoring scenario with the support of Adaptive Peer Tutoring Assistant (APTA), an adaptive script designed to improve help-giving, showed higher levels of collaboration during the experiment than those whose collaboration was supported by a fixed peer-tutoring script; however, no effect on individual learning outcomes (measured by domain-specific subject knowledge) was found.

Despite this promising evidence, building adaptive systems (e.g., computing a user model) is quite demanding. An model of optimal collaboration needs to be defined (if possible), the on-the-fly assessment of learners' current collaboration needs to be reliable and valid, and the fit between the measured performance level and the automatically adapted instance of the external collaboration script needs to be calibrated. To achieve this, extensive intelligent tutoring technology (Walker et. al. 2011) or automated language analysis (Mu et. al. 2012) has to be developed, tested and constantly refined. Furthermore, from a theoretical perspective, adaptive scripting is not unproblematic; because adaptive scripts do not require students to make conscious decisions about the amount of support they need, which may hinder learners from regulating their collaboration unaided. The effect of adaptive scripting on collaboration processes and learning outcomes measured by domain-specific knowledge as well as domain-general skills is therefore still inconclusive and needs to be investigated in the future.

3.4 Adaptable Scripting

3.4.1 Adaptability

Apart from adaptivity, adaptability is another way to realize customized instructional support. A learning environment is called 'adaptable' when users (i.e., teachers or students) can adjust external support to meet their perceived needs (Leutner 2009). When learning with an adaptable system, it is the learners who have control over the learning processes rather than the system or the designers. By adapting the environment to suit individual needs, learners get the opportunity to self-regulate their learning, which has been regarded as an influential factor in academic achievement, especially in domain-general skill acquisition (Anderson 1987; Zimmerman and Kitsantas 1997). Skills that get acquired or practiced through adaptation experiences can further be transferred to other similar situations in further learning (Scheiter and Gerjets 2007).

Although both adaptive scripting and adaptable scripting aim to realize flexibility of CSCL scripts, they vary in the degree of 'learner control' (Merrill 1975; Scheiter and Gerjets 2007). Proponents of learner control argued that in order to improve the fit between learners and learning environments, it should not be the system or the instructor who decides what treatment is best for a single learner, it should be the learners who make decisions on how to adapt the environment to themselves (Merrill 1975; Scheiter and Gerjets 2007). Following the learner control perspectives, learning with an adaptive system which always has the optimal tactic provided makes students depend on a perfect system and unable to cope with the real world which is not so accommodating. Adaptable system, on the contrary, might enable students to select the particular tactic that is optimal for their unique configurations of aptitudes and expertises at a specific moment in time (Merrill 1975; Scheiter and Gerjets 2007).

By making decisions on how to adapt the system and to select tactics learners are expected to be self-regulated in learning, such as to monitor the process or to evaluate their performance. Self-regulated learning and the feeling of control over their own learning are also expected to help cultivate intrinsically motivated learners, according to Self-Determination Theory (Ryan and Deci 2000).

3.4.2 Learner Control with Hypermedia

As the adaptability idea originates in learner control perspectives, the accumulating research on leaner control in web-based instruction and learning with hypermedia (e.g., control over the navigation) will be taken to discuss the operationalization of adaptable scripting. When learning with web-based instructions, three factors are often subject to learner control, namely the control of learning activities and contents, control of sequence, and control of pacing (McLoughlin et al. 2006; Scheiter and Gerjets 2007).

The form of control over learning activities provides learners with the opportunity to choose the content they wish to explore. Within a specific content, learners are given the option to access different activities, such as viewing examples, practicing problems, and taking tests. Control of sequence refers to a learner's opportunity to control the order in which he/she would like to receive instruction. The learner may also skip and revisit topics. For example the forward or backward button offers users the opportunity to return to previously visited content. Leaner control of pacing allows learners to adapt instructional pace to their comfort level. Control of pacing allows learners to cover the learning content slower or faster, and allows them to take a break from instruction.

3.4.3 Adaptable Scripting

Although originated in the field of learning with hypermedia, the three forms of learner control cannot be directly translated to adaptable scripting as scripts are interaction-related guidance other than web-based instruction provided to individual learners. Nevertheless, like the control of learning activities and content in learning with hypermedia, the basic components of an external collaboration script (task specification, sequencing, and role distribution) could be subject to learner control to realize adaptability. For example, learners could be provided with the opportunity to have control over the component of role distribution in a way that learners decide rather than being assigned the roles that they would like to play in a CSCL practice.

Furthermore, other components of an external collaboration script, such as the use of prompts in the aforementioned peer-review script by Weinberger et al. (2005) could also be subject to learner control. Learners could make decision on whether they would like to use the prompts or not (by switching them off).

It is noteworthy that an external collaboration script provides both intrinsic and extrinsic constraints to collaborative learning processes, as proposed by Dillenbourg and Tchounikine (2007; see Sect. 3.1). According to the authors, extrinsic constraints of a script should be adaptable to teachers and/or students, while intrinsic constraints should be fixed and constant, because intrinsic constraints ensure the core mechanism of how a collaboration script would shape peer interaction.

By adapting an externally provided collaboration script to suit individual needs, learners are expected to benefit on learning as an adaptable script has the potential to provide the optimal external scripting level. ‘Optimal’ means the degree of external scripting should be based on learners internal collaboration scripts (Fischer et al. 2013). Learners vary from each other on their internal collaboration scripts (Kollar et al. 2007) within a specific CSCL environment. An external collaboration script is likely to hinder rather than foster knowledge acquisition when it provides narrow structuring that inhibits learners’ application of appropriate internal collaboration script components (Fischer et al. 2013). An adaptable script, on the other hand, allows learners to turn off the unnecessary parts of the external script and to apply their appropriate internal collaboration script components to guide learning.

Furthermore, external collaboration scripts should provide the optimal scripting level on the basis of learners’ domain-specific prior knowledge (Dillenbourg 2002; Reisslein et al. 2006). Learners differ in their domain-specific prior knowledge. Low-knowledge learners need in principle very much support to achieve the learning goal, whereas high-knowledge learners need little or no support at all to achieve the same goal (Kalyuga et al. 2003). For high-knowledge learners, too many scaffolds may contrariwise impede learning as they cause unnecessary workload (“redundancy effect” or “expertise reversal effect”; Kalyuga 2007). Although it was content scaffolds that have been argued to be redundant for high-knowledge learners to acquire domain-specific knowledge, scaffolds that aim at structuring interactive processes (e.g., external collaboration scripts) might also be redundant for high-knowledge learners as their processing of external collaboration scripts or even the interactive processes might be unnecessary for them to gain domain-specific knowledge (Johnson and Johnson 1999). An adaptable script might compensate the redundancy effect for high-knowledge learners to acquire domain-specific knowledge as they can switch off the redundant scaffolds to avoid over-scripting (Leutner 2009).

Thirdly, it has been argued that scaffolding should be a dynamic process based on learners’ performance at any moment in time, so is fading. Therefore, fading on the fly, that is adaptive or adaptable fading, has been regarded as promising approaches, as the former provides feedbacks or supports based on dynamic assessed level of performance (Diziol et al. 2010) while the latter gives learner opportunities to fade in/out external support based on self-perceived needs (Leutner 2009). As there is a lack of empirical studies on adaptable scripting in CSCL, it is still an open question whether adaptable scripting is an encouraging approach to realizing flexibility.

Evidence from outside CSCL supports the argument that adaptable scaffolding enhanced learning compared to the inflexible counterpart. However, adaptable scripting may also be problematic as it requires learners to use high-level metacognitive skills, such as monitoring and reflection on learning; research from learning with hypermedia has shown that by no means all learners are competent in this respect (Azevedo 2005; Scheiter and Gerjets 2007). Against this background, we will report a study on adaptable scripting in Chap. 5 to provide some empirical evidence in the field of CSCL.

Chapter 4
An Empirical Study on Adaptive Scripting

The empirical study which I am going to describe here aims at investigating the effects of computer-supported epistemic and argumentative collaboration scripts on the processes and outcomes of argumentative knowledge construction. While the studies relative to the theme have been published (Weinberger et al. 2005, 2007), the current study is more concerned with a comprehensive investigation which compiled some classic constructive thoughts to understand the underlying principles associated with successful collaboration scripts in the setting of computer-supported collaborative learning. Based on the preceding efforts in the dissertation to identify the key elements and principles that determine the effectiveness of collaboration scripts, mainly outlined by the *Script Theory of Guidance* (Fischer et al. 2013), it is clear that a more rigorous and carefully conducted research is required to be complementary with theoretical insights what we have explored.

4.1 Designing Adaptive Collaboration Scripts—An Example

Despite the fact that the theoretical review revealed the attractiveness and effectiveness of collaboration scripts (as can be seen above), more knowledge is desperately needed when we attempt to apply the novel scaffolding approach to real learning settings, which often pose, in turn, substantial barriers for teachers, educators and researchers alike. General speaking, the CSCL community often faces two methodological challenges with respect to research on collaboration scripts.

This enriched view of learning from constructivist perspective makes the task of designing instructional supports in terms of collaboration scripts more challenging than ever before. While the increasingly large literature on the specifics of collaboration scripts in varying experimental conditions, there still remains little systematic research which explicitly considers how to design effective collaboration

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scripts in a systematic structure and format that is compatible with both cognitive and social sciences (Strijbos et al. 2004). One way to approach these challenges is to take a somewhat in-depth look at the theoretical mechanisms which underpin the effective collaborative learning, and to check whether these underlying mechanisms can be reproduced in computer-supported collaborative learning (Dillenbourg and Schneider 1995). In particular, a deeper understanding of the theoretical underpinning of the collaboration scripts is important to explaining why a scaffolding tool reflecting these guidelines would benefit learners (Reiser 2004) and further provide important clues to designing more effective computer-supported collaborative learning environments (Cohen 1994). The book is beginning to address both of the critical remarks about designing the collaboration scripts. Before the empirical study which might be mainly concerned here can be further discussed, a detailed approach to a systematic framework for designing collaboration scripts is proposed here.

In light of this problem, the *Script Theory of Guidance* (Fischer et al. 2013) presented a conceptual framework of collaboration scripts which also offers the possibility of guiding users through a certain series of components to design the collaboration scripts: in external collaboration scripts the *play* is reached by engaging in a set of *scenes* distributed among the learners in the form of *roles*. These scenes are further constituted by specific *scriptlets*. It is argued that these basic thoughts and underlying principles are also some common mechanisms about how to design external collaboration scripts more productive for learners. I am aiming at enriching the understanding about the chosen framework by specifying the collaboration scripts implemented in the present research to foster argumentative knowledge construction.

4.1.1 Play: Argumentative Dialogue

Collaborative learning can be so broad and vague in topics that it is difficult to sustain a common focus among learner partners (Koschmann 2003). Thus, the first critical element that needs to be considered for developing collaboration scripts is to provide a general task definition detailing the main goal of the collaboration. In the current context, I strived to investigate a theme that is now of increasing importance in the field of CSCL: *Argumentation Dialogue*. Through argumentation, students learned to think critically, articulate their own views, and negotiate their own thoughts with others' different perspectives (Andriessen et al. 2003).

Although one primary purpose of argumentation is to convince someone else of one's own position or belief, engaging in such constructive argumentation usually promotes learning (Kuhn et al. 1997). Principal requirements for successful computer-supported collaborative learning are to enhance the cognitive conflict and resolved it collaboratively (Dillenbourg and Schneider 1995). Active engagement in collaborative argumentation seems to fit this principle. The field of computer-supported collaborative learning has, in particular, been interested in argumentation and how students can benefit from it (Baker 2009; de Vries et al. 2002; Muller et al. 2009; Schwarz and De Groot 2007; Stegmann et al. 2007).

From the cognitive perspectives, the production of high-quality argumentation is frequently thought to promote deeper understanding about the topic or issue being argued (Nussbaum 2008), increase students' understanding of challenging concepts (Andriessen et al. 2003), promote self-explanations (Baker 2009), foster deep cognitive elaboration (Stegmann et al. 2012), and hence contribute to the individual knowledge acquisition (Leitão 2000; Wright 1995).

From the point of view of social interactivity, argumentation fundamentally involves an interaction carried out among two or more individuals, in which a dialog emerges as a response to doubts or divergences of positions (Osborne et al. 2004). Such a conflicting situations are of particular interest with respect to collaborative interaction because they induce socio-cognitive conflict (Andriessen et al. 2003; Doise and Mugny 1984). As Von Glaserfeld (1989) has noted, other people are the greatest source of alternative views to challenge our current views and hence to serve as the source of cognitive conflict that stimulates learning.

To sum up, the ubiquity of argumentation makes it an appealing subject within the field of education. The basic assumption is that learners need to construct arguments appropriately in order to benefit from collaborative learning environments (Weinberger et al. 2007). And the ability to appreciate and engage in sound argument is among the most widely valued educational objectives for students of middle-school age and beyond (Kuhn and Udell 2007).

4.1.2 Scene and Scriptlet: Argumentation and Counter-Argumentation

As I clarified earlier, *Scriptlet* scaffolds prompt the learner to apply available knowledge of the sequence of activities within particular scenes, and the activities in sequence constitute a situation which can be further guided by *Scene* scaffolds. Therefore, the second critical step with respect to the conceptual framework is to decide which specific discourse activities and activity sets in certain sequence can be implemented and further facilitate the construction of argumentative knowledge.

Weinberger and Fischer (2006) have developed a framework to demonstrate the critical dimensions (namely, participation, epistemic, argumentative, social mode) of the argumentative activity which has been shown to foster argumentative knowledge construction in online discussions (Stegmann et al. 2007; Weinberger et al. 2007). Drawing on this conceptual framework, the approach to scaffold argumentative knowledge construction in the current study focused on two dimensions, (i) the epistemic dimension which structures *what* learners discussed to handle the group task and (ii) the argumentation dimension which aims to facilitate *how* learners argue and interacted with each other. I did not additionally support the collaborative learning on the dimension socio model, since the structured of interaction has been illustrated by the argumentation activities and the role distributions. Research has suggested that argumentation can be nurtured if both the epistemological and social discourse structures are taken into account (Clark et al. 2003). The detailed descriptions with respect to the dimensions will be given in the following paragraphs.

4.1.2.1 Epistemic Activities

The epistemic dimension refers to the question of how learners work on the tasks they are confronted with the goal to (re-)construct knowledge (Fischer et al. 2002). As epistemic activities aim to guide the attention of the learners towards the task, learners may more frequently engage in specific task-oriented activities, which in turn have been reported to foster knowledge acquisition (Cohen 1994). In this respect, the epistemic dimension of arguments is an important indicator for the extent to which learners are able to adequately apply knowledge (Weinberger et al. 2005). More recent studies have distinguished several epistemic activities with a differentiated effect on the learning outcome. Fischer et al. (2002) differentiated three types of epistemic activities in collaborative knowledge construction, which include the construction of problem space, the construction of conceptual space, and the construction of relations between conceptual and problem space.

The importance of **the construction of the problem space** has been outlined (Fischer et al. 2002). The construction of the problem space is a prerequisite for successfully solving a complex problem, which includes selecting, evaluating and relating individual components of problem case information. However, a focus on the concrete level of problem case information may hint at an engagement of learners in the learning task on a low level (Salomon and Perkins 1998). In this way, learners may retell rather than interpret a problem. Accordingly, it has been shown that discourse beyond a concrete level of the problem space may reflect better strategies in learning scenarios based on complex problems (Fischer et al. 2002; Hogan et al. 1999).

Within collaborative knowledge construction environments, **the construction of conceptual space** has been argued to be essential for successful problem-solving (Grave et al. 1996). In order to solve problems on the grounds of theoretical concepts, learners need to share the understanding of a theory. During this process, theoretical terms or principles are being defined and categorized by the learners (Pontecorvo and Girardet 1993). The construction of conceptual space also implies to distinguish concepts from each other.

The construction of relations between conceptual and problem space can be regarded as the main task in problem-oriented learning environments (Grave et al. 1996), which indicate how learners approach a problem in detail, as well as to what extent learners are able to apply knowledge adequately.

The collaborative application of theoretical concepts to a problem space may also indicate the internalization of these relations between conceptual and problem space (Palincsar et al. 1993). In other words, learners who apply theoretical concepts to problems collaboratively may be able to transfer this knowledge to future problem cases and apply theoretical concepts individually (Vygotsky 1978). Therefore, the frequency of the construction of relations between conceptual and problem space may thus indicate knowledge acquisition. To sum up, epistemic scripts can assist the structuring of subject matter knowledge, which can be more or less specific to the domain that is to be discussed (Stegmann et al. 2007).

4.1.2.2 Argumentation Activities

The activity of argumentation can be described by at least two sub-dimensions, i.e. the construction of single arguments and the construction of argumentation sequences (Weinberger and Fischer 2006). Argumentative script components aim to help learners construct formally adequate arguments and thus better elaborate the argumentative knowledge construction (Andriessen et al. 2003).

Typically, **conducting a single argument** includes the processes such as identifying alternative perspectives, developing solutions and supporting a solution with adequate and convincing evidence or reasoning to support one's claims, statements and other assertions (Kuhn et al. 1997; Voss 1988). Toulmin's Model (1958) has been widely used in recent literature (Bell 2000; Osborne et al. 2004), which puts forth a single-argument structure consisting of multiple components: C*laim* is a conclusion that is being presented and justified in the argument. The component of the claim is based on a *ground*, which is a fact that is supposed to support the claim. Additionally, a *warrant* specifies the underlying theoretical presumptions of how the ground supports the claim. This is reasonable for distinguishing between ground and warrants: ground is appealed to in order to be explicit, while warrant is more implicit. Sometimes arguments may optionally also provide a *qualifier*, which indicates the extent to which the datum warrants the claim or may limit the validity of a claim. *Backing* refers to the theoretical assumptions on which the warrants rest, and *rebuttal* serves to anticipate parts of a counterargument that attack the data or the warrant.

The attraction of Toulmin's model is to pose an alternative to formal logic, which is closer to reasoning in real-world situations (Yeh 1998). Besides, from a pedagogical perspective, the model is the explicit procedural representation of the basic layout of arguments (van Eemeren et al. 1996). However, Toulmin's model has been criticized for difficulties in distinguishing between the single components of the model in everyday argumentation. For example, it is challenging for the learner to differentiate between a qualifier and a rebuttal (Voss and Van Dyke 2001). I decided to simplify the Toulmin's model instead of using it completely in order to make it more closely accessible to target participants. Thus, the single argument dimension comprises how learners construct arguments with regard to defining formal connection among the three basic and core components: Claim, Ground and Warrant.

Construction of argumentation sequences captures the dynamic of argumentative dialogue consisting of arguments, counterarguments, and integrations (Leitão 2000; Weinberger and Fischer 2006). In this argumentation sequence, learning partners first try to justify their (initial) position by constructing arguments. Then, counterarguments challenge this position and may lead to a reconsideration of the initial argument. The counterargument is not necessarily the opposite of the initial argument, but calls it into question (Stegmann et al. 2007). As a minimum, a counterargument makes the acceptability of the initial position less certain. To some extend, conducting a counter-argument is integrated with the peer monitoring process which served as 'a starting point' to justify the initial position which is unanimous or conflicting with other peer partners. Finally, learners construct replies and may possibly synthesize their initial positions in integration or decide which alternatives fit the best (Stegmann et al. 2007).

4.1.3 Role: Analyst, Critic and Replier

The learners take different roles in formulating an initial argument and criticizing it with a counter-argument. Crossing different case-based problem solving tasks, the roles can be switched. The script provided guidance on the roles (namely, analyst, critics and replier) that the students had to follow during the activity. The analyst is responsible for constructing arguments. The critic constitutes a counter-argument that goes against the argument produced by the analyst. The replier combines the initial argument and the counterargument to the integrated argument.

4.1.4 Overview of the Designed External Collaboration Scripts

It is essential to accumulate what has been presented about argumentative knowledge construction as a systematic configuration before designing the external collaboration scripts to facilitate the targeted collaborative practice. The theoretical framework upon which the design is based was developed by Fischer and colleagues (Fischer et al. 2013) which highlighted a few essential elements accounting for effectiveness of collaboration scripts. Figure 4.1 displays the general architecture for representing the entire desired collaboration scripts to foster argumentative knowledge construction.

The architecture illustrates three layers of collaboration scripts that aim at promoting argumentative knowledge construction, which differs in the levels of scripting components. As the target collaborative practice, the *Play* for learners is to take part in an argumentative dialog with the purpose of resolving three case-based problems by applying a psychological theory (see in Chap. 5 for more details). The second layer is to specify the *Scene* in which learners work together to construct arguments, counter-arguments and integrate their statements. To conduct a single argument, a set of *scriptlets* are identified to scaffold the process of constituting claim, ground and warrant according to Tulmin's model (1958). I further argue that the hierarchical and dynamic architecture of the collaboration scripts can further

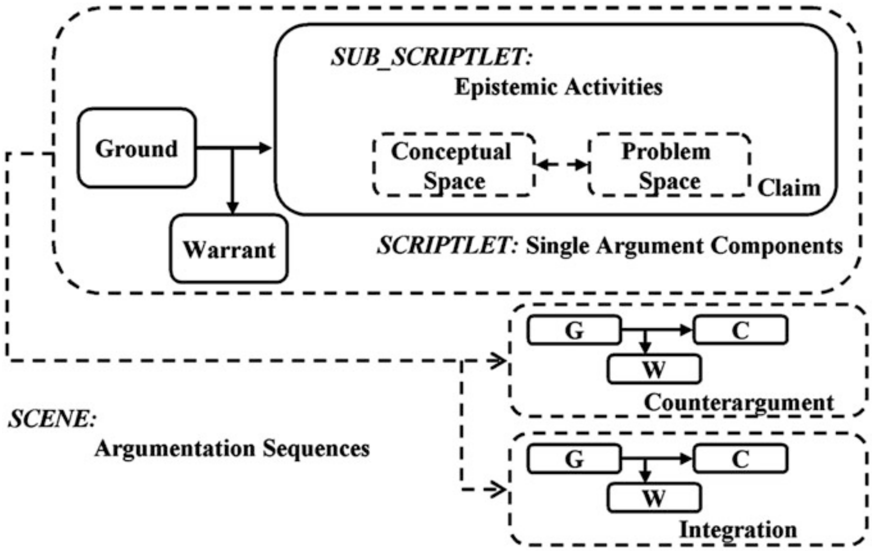

Fig. 4.1 Overall conceptual framework for the argumentative and epistemic activities

specify 'tiny' unit of activities, which is presented on the sub-layer of scriptlets (*Sub-scriptlet*). In this case, a claim is composing the construction and consequently the connection conceptual and problem spaces.

In order to scaffold the desired argumentative activities at the 'bottom' levels of the *scriptlet* and *sub-scriptlet*, a rather detailed framework of external collaboration scripts was developed in the present CSCL research. The collaboration scripts identify detailed steps to guide learners in contrasting single argument, counter argument and integrated argument. Learners are expected to respond to specific questions about the respective scripts which assumed to contribute to individual learners constructing single arguments (e.g. What is your claim regarding the subject and concept? What is your ground to support the claim, and what is the warrant to connect the claim with the ground?) In addition, counterarguments can be contrived through a defined sequence of interaction phases (e.g. Do you agree with the claim of your partner? If yes, have you any other ground to support the claim?).

The entire collaborative practice can be divided into ten phases, so that a set of specific activities for each phase can be undertaken by learners either individually or collaboratively. The computer program presented the participants at first with one case requiring independent problem solving. Each learner was responsible for the analysis of one of the three cases in the first phase to compose the first analysis consisting of single argument(s). By following the external collaboration scripts (as shown in Fig. 4.2), each learner was required to combine epistemic subject (from problem space) and concept (from conceptual space) to state a claim, provide ground to support the claim, and then a warrant is required to connect the ground to claim. Consequently, five steps are used to formulate one single and complete argument.

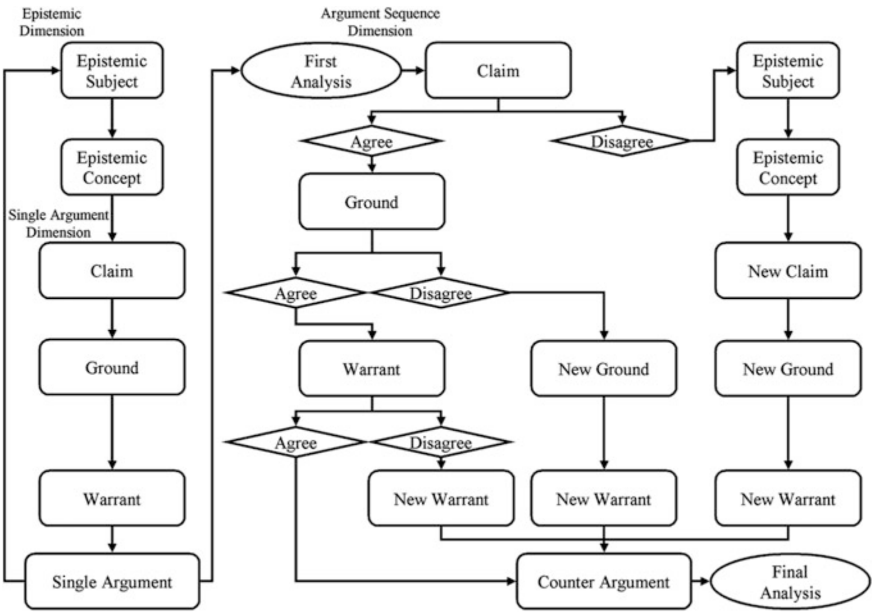

Fig. 4.2 Flowchart to outline the designed collaboration scripts

In the next two phases, each learner switched to other cases to provide counterarguments for the analysis constituted by other partners. Drawing on Walton's analysis (1989), two goals of argumentation have been identified: one is to secure commitments from the opponent that can be used to support one's own argument; the other is to undermine the opponent's position by identifying and challenging weaknesses in his or her argument. In this manner, both of these goals require attention to the opponent's positions. Due to the unique feature of argumentation, the scriptlets on the argument sequence dimension to some extent function as peer monitoring to justify the reasonableness of the claim, ground and warrant produced by partner learners. Besides the judging steps, learners are required to build new argument components, if conflicting opinions exist among peers.

In the following, the learner shifted back to the initial case to integrate the counterarguments given by learning partners into the initial analysis. Phases from two to four were repeated twice for the purpose of promoting more collaborative practices. In addition, each step of the script includes an explanation and example to further clarify the task in details. At the tenth phase of the discussion, each group had to find a consensus and outline a final analysis for each of the three cases.

Strijbos et al. (2004) have pointed out that one of the major problems of current research in the field of computer-supported collaborative learning is the lack of design principles for the learning settings. For practitioners, the components and mechanisms elaborated here may serve as a checklist for the design of the scripted CSCL environments. I also expect the detailed examples to be useful as models of good practice. More empirical testing is clearly required, and numerous other issues with respect to implementing the collaboration scripts in a real online learning environment remain to be discussed in the following chapter.

4.2 Dependent Variable: What Can We Learn from Argumentation

Knowledge plays a vital role as the learning objectives in the literature on learning and instruction. Generally, it comprises collecting facts about the world and procedures for how to solve problems (Sawyer 2006). Recently, there has been a shift in the views of what education is for, with an appealing emphasis on the need to enable and support not only the acquisition of concepts and facts, but also to develop the skills necessary to engage with the emerging social and technological changes, and to continue learning throughout life. Therefore, knowledge can be thought of having two dimensions: domain-specific and domain-general knowledge (Penner and Klahr 1996). The domain-specific knowledge lives in books and in our brains as concepts and facts and deals with the '*know-what*', while the domain-general knowledge deals with the '*know-how*' that is best manifested in practices and skills (Carud 1997).

Indeed, knowledge is characterized by strong links between elements, a high degree of abstraction, and a hierarchical nature (de Jong and Ferguson-Hessler 1996). However, it is rare to find a CSCL research on collaboration scripts which has well-articulated learning objectives. It is much more common to encounter a final and singular goal such as 'learning outcome' or 'achievement'. Not much thought has been given to the multiple aspects of knowledge or to the entire knowledge construction. In the present study, it is noteworthy to explore the properties of different knowledge components and the interrelationship among them.

As I began addressing the general question, I quickly realized that it was well beyond my reach to clarify all the issues pertaining to knowledge. For this reason, I concentrate on an in-depth discussion of Argumentative Knowledge Construction (AKC) in which learners construct arguments in interaction with their learning partners in order to acquire knowledge about argumentation as well as knowledge of the content under consideration (Andriessen et al. 2003) (Fig. 4.3).

Andriessen et al. (2003) further identified the difference between '*Learning to Argue*' and '*Arguing to Learn*' knowledge. The first kind of knowledge involves the acquisition of general skills such as justifying, challenging, counterchallenging, or conceding. In contrast '*Arguing to Learn*' often fits a specific goal fulfilled through argumentation, and in an educational framework, the (implicit) goal is to understand or to construct domain-specific knowledge. By scaffolding good argumentation practices, the scripts employed in this study attempt to not only support students in '*Learning to Argue*' but also help students learn about specific domain

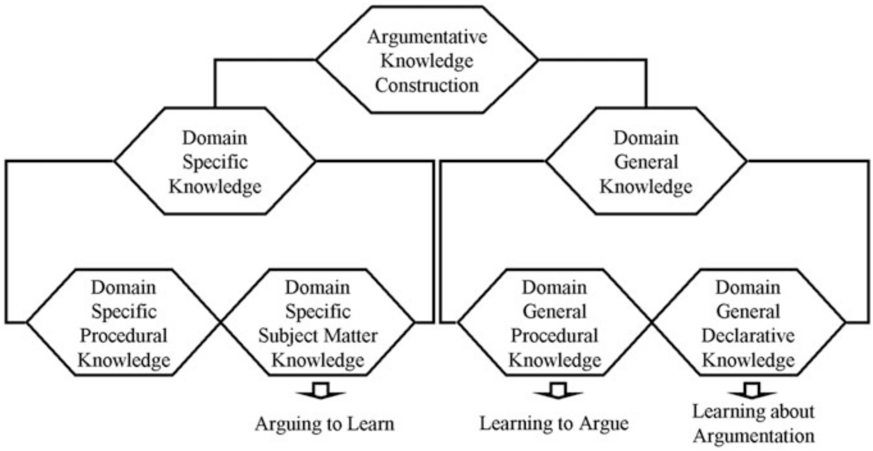

Fig. 4.3 Argumentative knowledge construction

topics through argumentation ('*Arguing to Learn*'). In addition, I further differentiate the knowledge of '*Learning about Argumentation*', which refers to the conceptual knowledge on argumentation, and thus is different from the procedural knowledge of '*Learning to Argue*'. When we tend to identify the learning outcomes of argumentative knowledge construction in the studies undertaken, indeed, the three categories of knowledge are often mutually dependent (Koschmann 2003) since both declarative (subject matter) and procedural (skill or procedure) knowledge are essential to solving problems (Larkin and Reif 1979).

To exemplify the hierarchical knowledge structure, the learning objectives of the current study are presented in details. Specifically, the designed scripts aim at three kinds of learning outcomes, namely: (i) the acquisition of '*Arguing to Learn*' knowledge about the domain-specific topic at hand (e.g. Attribution theory, specifically used in the current study) which refers to specific subject matter knowledge that can be attained by the learner as the predefined goals (e.g. Attribution theory) (ii) the acquisition of '*Learning about Argumentation*' knowledge which basically means becoming better acquainted with the argumentation (e.g. A single argument may consist of claim, ground and warrant). This kind of learning outcome can be seen as the declarative knowledge (factual information) on argumentation (Alexander and Judy 1988) (iii) the acquisition '*Learning to Argue*' knowledge, which is closely associated the general procedural skills of argumentation (compilation of declarative knowledge into functional unites). This kind of procedural knowledge is not described as a definitive object, but rather as an activity state of cognitive structures when individuals or groups perform tasks (de Jong and Ferguson-Hessler 1996). Corresponding with what I had emphasized in the *Script Theory of Guidance*, it makes the distinction more clear that the knowledge of '*Learning to Argue*' can be regarded as internalized collaboration scripts.

4.3 Independent Variable: Degrees of Scripting

Dillenbourg's comments (2002) are echoed in the contemporary concerning the degree of scripting. He argued that different scripts vary regarding their degrees of coercion, that is, the extent to which they force users into specific actions. This introduces a serious problem in collaboration scripts because of a dilemma between maximum flexibility on the one hand and minimal freedom on the other. Too much external collaboration scripts may result in 'forced' artificial interaction, but no structure may result in 'fragmented' interaction.

With respect to the '*degree of scripting*', external scripts can differ substantially. An unresolved issue is to what degree is 'optimal' for a learner (free or coerced) to follow a structure given by external collaboration scripts. Instead of investigating the polarized degrees of with or without collaboration scripts, three degrees of scripting from high to low are distinguished (as shown in Fig. 4.2) in the current study to examine their impacts on learning processes and outcomes.

4.3.1 Low Degree of Scripting

With an interest in the thinking that occurs in daily lives, Kuhn (1991) pursued the notion of thinking as argumentative reasoning. While argumentation is a discursive practice which forms part of everyday experience, it is rarely spontaneous in professional life (Muller et al. 2009). As a result of the complexity of the argumentation activities, unfortunately, even adults rarely engage in constructing adequate arguments and interacting productively without specific prompting and scaffolding (Kuhn 1991). Specifically, a review of recent literature on argumentation pointed out that adult discussants have difficulty articulating and justifying their claims (Sadler 2004), rarely ground or warrant their claims and thus rarely construct complete arguments with logical reasoning (Kuhn et al. 1997); and often fails to embrace the dual objectives of argumentative discourse —to identify weaknesses in the opponent's arguments and to secure commitments from the opponent that can be used to support one's own claims (Walton 1989). Because of these challenges, it has become clear that simply asking learners to collaborate is not sufficient for fostering argumentative knowledge construction (Stegmann et al. 2007). Learners therefore need to be explicitly scaffolded in order to be successful in this social practice.

As a control condition, the low degree of scripting was manipulated by providing only general *Play* scaffold to ask learner to attend the argumentative dialog in the present study, which is assumed to cause the negative effects of *under-scripting*.

4.3.2 High Degree of Scripting

The other side of the coin in designing well-defined instructions is the risk of *over-scripting*. Designing and implementing collaboration scripts requires addressing a pedagogical dilemma that is very classical but particularly salient in CSCL: if the scaffolding is too weak, it will not produce the expected interactions; if it is too strong, it will increase the cognitive load of the learner (Dillenbourg 2002), spoil the natural richness of free collaboration (Dillenbourg and Tchounikine 2007), cause stronger negative motivational reactions as compared to the traditional script approaches (Rummel and Spada 2007), inhibits the learner's self-regulated application of appropriate higher-level internal collaboration script components (Fischer et al. 2013) and actually impede knowledge construction (Larson and Dansereau 1986).

However, these assumed obviously negative effects must be thought through carefully. In contrast to the above statements, Stegmann et al. (2011) claimed that negative effects of scripts on collaborative learning should not any longer simply be classified as over-scripting. Rather, the problems of 'too much script' exist only if learners have sufficient access to internal collaboration scripts that can be disturbed. There is not much of a worry about over-scripting for novices in particular.

In order to address the complex problem of '*over-scripting*', the high degree of scripting was designed, which includes the scaffolds on the levels of play, scene, scriptlet and even sub-scriptlet (as present in Chap. 3). And for each specific component of external collaboration scripts, external explanation and example were additionally provided to further scaffold learners in the collaborative practices.

4.3.3 Medium Degree of Scripting

Many of the classical script approaches that were developed to facilitate collaborative learning are built on the assumption that through extended practice with the external collaboration script, a learner would, little by little, internalize relevant elements of the script so that the external scaffolding provided by the script could be faded out over time (Palincsar and Brown 1984).

One especially acute issue that needs to be clarified here is how to implement the adaptive collaboration scripts. In the current study, the components of external collaboration scripts were removed gradually overtime, and on average, the degree of scripting stay at the medium level. I call this 'limited adaptive collaboration scripts' and it differs from 'really adaptive collaboration scripts' because it was not responsive to what was happening in the collaboration, but faded with fixed time interval and therefore limited to be really adaptive to the individual learners. Particularly, the collaboration scripts were faded from highest degree of scripting (backward fading), and crossing various layers (vertical fading) (Fig. 4.4).

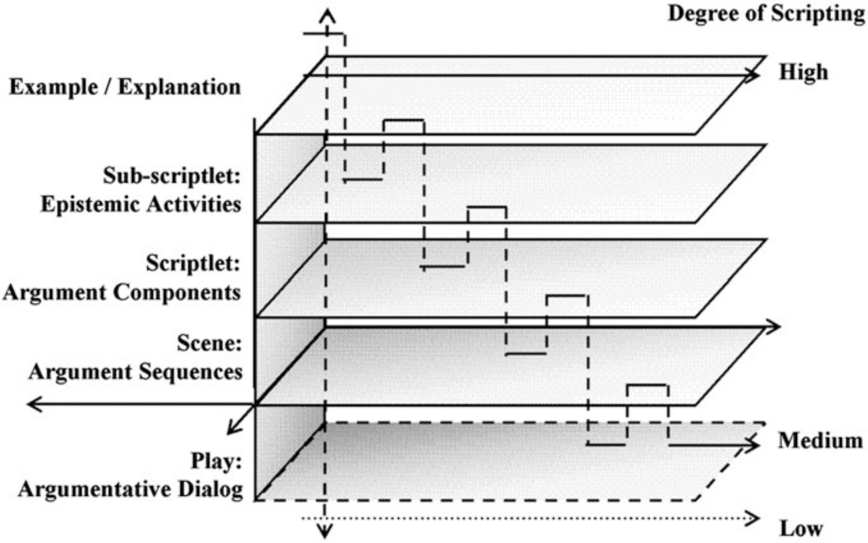

Fig. 4.4 Framework to outline the three degrees of scripting

Therefore, the empirical research aims to build in-depth knowledge of how the expected argumentative knowledge acquisition is related to degrees of scripting. The learning effects of adaptive collaboration scripts (fading condition with medium degree of scripting) are compared to other two conditions: a condition in which the collaboration scripts maintain at the high lever (*over-scripting*) and a condition without additional scaffolding supports as the control condition (*under-scripting*).

4.4 Research Questions

The *Script Theory of Guidance* for computer-supported collaborative learning provides a systematic way of describing and interpreting the internal collaboration scripts, external collaboration scripts provided and the dynamic interaction between them (Fischer et al. 2013). By studying this theoretical framework, the present work goes beyond the previous studies to explore the underlying socio-cognitive mechanism account for effectiveness of collaborative learning, a set of research questions can be formulated to implement the underlying mechanism of the interactive and intricate relationship among those decisive components, e.g. internal collaboration scripts retained by individual learner, external scripts manipulated with various degrees, learning processes and outcomes covering multiple perspectives of the target cognitive-social activities, and last but not least, the influence from motivational variables.

4.4.1 RQ 1: To What Extent Does the Degree of Scripting Affect Students' Participation?

The original social-constructivist assumption of collaboration scripts is to design a set of instructions which directly impact the learning processes of how the group members should interact and collaborate. As a consequence the enhanced learning outcomes are expected.

Students' engagement in computer-based learning environments often has problems. A learner often does not engage enough (Cohen and Lotan 1995). Without some form of explicit instruction, it is rare for learners to spontaneously use effective interaction procedures and match them to the task at hand (King 2007). Indeed, even when given instructions to work collaboratively on a task, learners generally tend to interact with each other at a very basic level (Webb et al. 1986). For this reason, numerous attempts have been made to promote learning by structuring and regulating the interaction with collaboration scripts.

The first research question mainly serves as a treatment check of whether the designed collaboration scripts can foster the expected activities during the collaborative practices. Participation becomes the key concept (as contrasted with acquisition and conceptual change), serving as both the process and the goal of learning (Sfard 1998). Even though student engagement is not the best measure of educational value (Dewey 1963), constructivists stressed that active participation in a task leads to deeper and richer understanding and use of knowledge (Moallem 2003); students need to actively participate to construct their own learning (Anderson 2008) and active participation and interaction is critical to the success of online collaborative learning (Lave and Wenger 1991; Vygotsky 1978).

However, the active participation should not only be determined by the number of messages sent by group members (Harasim 1993) but also by a deeper (contrast to the surface level characteristics of the communication) content analysis to figure out the amount of off-task activities. Drawing on the analytical framework of Henri (1992), participation can be considered at the two levels: (i) *Overall Participation*, which is the total number of messages and contributions to the online discussion made by learners, while (ii) the *Active Participation* in the learning process is the number of statements directly related to learning (non-off-task activities). External collaboration scripts have proven to be powerful strategies for supporting collaboration in learning and problem-solving contexts (Kollar et al. 2007; Rummel and Spada 2007; Weinberger et al. 2002). Schwarz and Glassner (2003) took one more step and acknowledged that appropriate interface and interaction designs caused students to use more relevant claims and arguments and less off-task expressions.

Therefore, I expect (H1a) that the collaboration scripts manipulated in the current study can help to ensure the participation by instructing the collaboration and cognitive activities, and learners supported by collaboration scripts will contribute more to the collaboration and conduct less off-task activities (H1b).

4.4.2 RQ 2: How Does the Degree of Scripting Affect Learning Outcomes of Argumentative Knowledge Construction?

There is a growing body of evidence that shows that collaborative learning is only beneficial with respect to the acquisition of knowledge and skills when appropriate instructional support is provided (Cohen 1994). Fading is promising for removing some of the explicit instructions or restrictions of scripts in the course of the learning process, as learners internalize the script more and more. Therefore, I expect that the medium degree of scripting, which provides limited adaptive collaboration scripts is expected to be able to most effectively foster the acquisitions of knowledge. Qualitative content analysis was conducted in the post/transfer case to estimate the knowledge acquisition of '*Learning to Argue*' as the one of the indicators of learning outcomes. In the post case, the procedural knowledge can be regarded as internalized scripts on how to argue and collaborate. This study aims to provide more empirical evidence on this issue by manipulating three degrees of scripting to figure out the 'optimal' collaboration scripts to foster collaborative learning.

4.5 Methods

4.5.1 Participants

Ninety-six (96) students of educational science at the University of Munich participated in this study during the summer term 2010. The experimental sample consisted of 19 males and 74 females. The age of the participants ranged from 18 to 44 years old, and the average age of the participants was $M = 23.48$ years (standard deviation $SD = 3.87$). The participants were volunteers who are varied in majors, and were randomly assigned to groups of three.

4.5.2 Study Design

A one-factorial quasi-experimental design with three experimental conditions differing in the 'degree of scripting' was implemented. During the entire learning process, groups were randomly assigned to one of the three experimental conditions. As shown in Table 4.1, there were 11 triads in the experimental conditions

Table 4.1 Experimental conditions and participants

Participants	Degree of scripting		
	Low	Medium	High
Number	30	33	33
(*Group*)	(*10*)	(*11*)	(*11*)

(with medium and high degree of scripting) and 10 triads in the control condition with low degree of scripting.

4.5.3 Learning Materials

The subject of the learning environment was Weiner's attribution theory (1985) and its application in education. The students read the text of this theory and the text of introducing argumentation individually before the experimental session.

The task of the participants was to apply the attribution theory of Weiner (1985) to five problem cases (see Table 4.2 as an example case) and reach agreement on a final analysis for each case. In this empirical study the problem-based cases are designed to be varying similar to the problems the participants encountered within real-life studying contexts. The case 'Math' describes the attributions of a student with respect to his poor performance in mathematics. In the case 'Class reunion' a math tutor talks about how he tries to help female students deal with success and failure in assignments. The case 'Between-culture variance' describes differences in school performance between Asian and American/European students that were explained by attribution theory. Another two cases were used in the pre and post test, which mainly concern the factors that affect a student's choice of a major at the university and student's explanation for failure in the exam of 'Text analysis'.

4.5.4 Learning Environment

A computer-based learning environment served as an asynchronous, text-based discussion board for the delivery of the learning materials, instructional contents and the exchange of text messages that resembled emails. The online learning environment was developed using a tool called S-COL (Scripting for Collaborative Online Learning), which allows the sustainable development of scripts and scaffolds that can be used with a broad variety of content and platforms (Wecker et al. 2010). Learners accessed the learning environment directly via the Internet. While three students in each group were together in a laboratory room (but not sitting next to each other), all communication in the study was computer-mediated.

Supervision was kept standard and was represented in the form of videos which contained basic and concise instructions. In general, video A is a generic instruction that was given to all participant. It was presented before all the learning phases to introduce (i) the fundamental goal of the research, (ii) features of the interface, such as how to type into the input box and how to submit the text message, (iii) required steps for proceed with the learning phases, and (iv) other details with timing and scaffolding information. Video B presented before the collaborative learning phase is specified with various conditions, which differentiated mainly in their introductions of the different degrees of scripting.

Table 4.2 One of the three problem cases, namely the 'math case', learners needed to analyze and discuss

As a student teacher in a high school, you participate in a school counselling session with Michael Peters, a pupil in the 10th grade
'Recently I've started to realize that math is just not my thing. Last year I almost failed math. Ms. Weber, my math teacher, told me that I would really have to make an effort if I wanted to pass 10th grade. Actually, my parents stayed pretty calm when I told them this. First mom said that nobody in our family is a math whiz. My father just kept smiling and told the story about how he cheated on his final math exams by copying from other students and using cheat sheets. 'The Peters family,' he said, 'has always been a math teacher's nightmare'. Once when I was slightly tipsy at a school party, I told this story to Ms. Weber. She said that it was not a bad excuse, but not a good one either. She said it was just one of a number of excuses you could come up with to justify being lazy. Last year I barely made it through mathematics, so I am really nervous about the upcoming school year!'

Collaboration scripts were dynamically integrated into the computer environment. Three conditions of implementing the various degrees of collaboration scripts are described below in detail.

4.5.4.1 Low Degree of Scripting

Participants in this condition received no additional support in solving the three problem cases. However, they were advised to argue well according to the text on argumentation they had to read before the experimental session.

Figure 4.5 presents the screenshot of treatment condition with low degree of scripting. The main screen is divided into three areas: The scripting bar in the left-hand panel was to define the script elements, the reading area in the top part of the right-hand panel served to present the on-working case, and the typing area just below the case material used to crate a discourse text.

While in the control condition the left-hand fields of the collaboration scripts were blank and hidden, the web-based discussion boards provided selection bars with an overview of all message headers as well as the timing information. The program allowed the participants to select and work on the cases freely by clicking the case buttons only in the control condition. The descriptions of the problem cases were embedded into the web-based learning environment, so that the participants could study the problem case while composing new messages on the web-based discussion board. The interface allowed the exchange of text messages that resemble emails. Each typing area consisted of two parts: text and title. These areas have the look and function of most e-mail systems. If no title was entered, the system default title was 'No Title'.

All submitted messages were recorded on a central database and typically represented in discussion threads (Fig. 4.6). These threads started with one particular

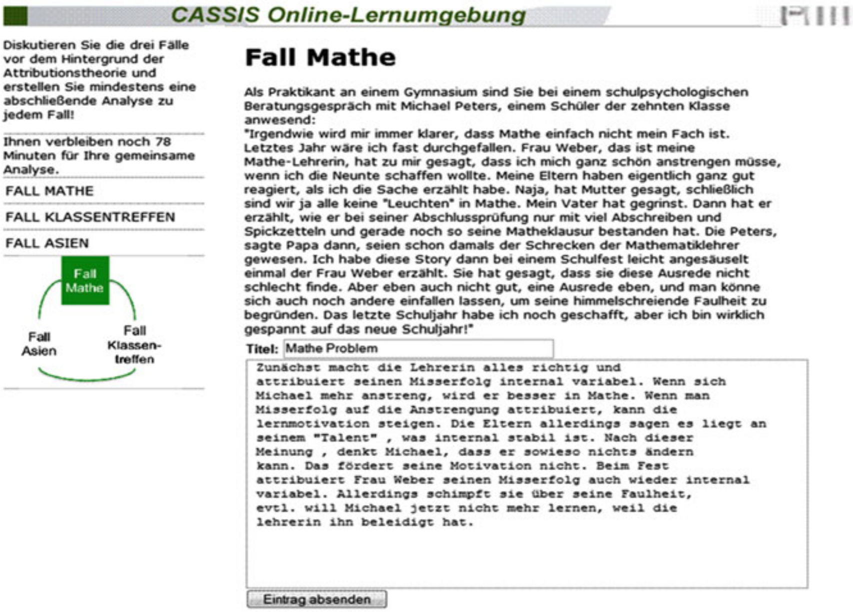

Fig. 4.5 Interface example—low degree of scripting

message that was indicated in a message overview by its title, the author, and the time of entry. In this overview, answers to original messages appeared in an outline form. The learners could read the full text of all messages, reply to the messages, compose and post new messages. In the replies, the original messages were quoted out with > as in standard newsreaders programs. Any response to a message is graphically connected to a message that initiates a discussion by a ‘thread’. Thus, an increasingly indented discussion thread is built in which the discussants are supposed to continue the specific subject which was initialized with the very first message.

4.5.4.2 High Degree of Scripting

In the high degree of scripting condition, a set of written prompts were presented in the left-hand part of the text field. As already illustrated in Chap. 3, the collaborative learning session was divided into ten phases. For each phase, written prompts were delivered to guild the constructions of claim, ground, warrant, counter-argument and the integrated statements by providing highly detailed information (as shown in Fig. 4.6). The prompt were further accompanied by an illustrating example and explanation.

The progression from phase to phase was designed in advance, i.e. after a certain time, learners were automatically forwarded to the next phase. The participant was

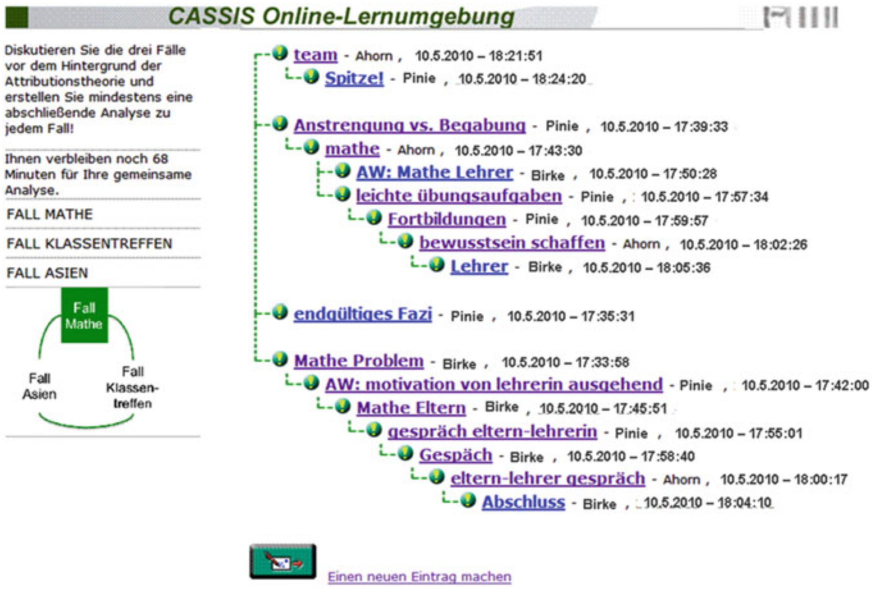

Fig. 4.6 Discussion tree structure example

not allowed to switch cases as he/she will. While the activities and activity sequences were scripted in a fixed way, it is worthy of note that learner may choose freely whether or not to follow the steps to argue and collaborate. In other words, they always had the chance to write statements in the message box 'supported with low degree of scripting'.

4.5.4.3 Medium Degree of Scripting

The medium degree of scripting was implemented through continuous fading-out of the prompts of the external script with fixed time interval (as shown in Fig. 4.7). The environment handles the fading levels according to a designed sequence specified by the researchers in advance. Specifically, the written prompts in first phase were identical to the condition with high degree of scripting. After each turn point, which is also the point of switching phases and cases for learner in the groups with high degree of scripting, the degree of the provided collaboration scripts were gradually reduced by slightly fading out as well as fading in. For example, in the end of the tenth phase, learners received only one textboxes for creating a whole argumentation neither specifying the argument components, nor providing explanation and example.

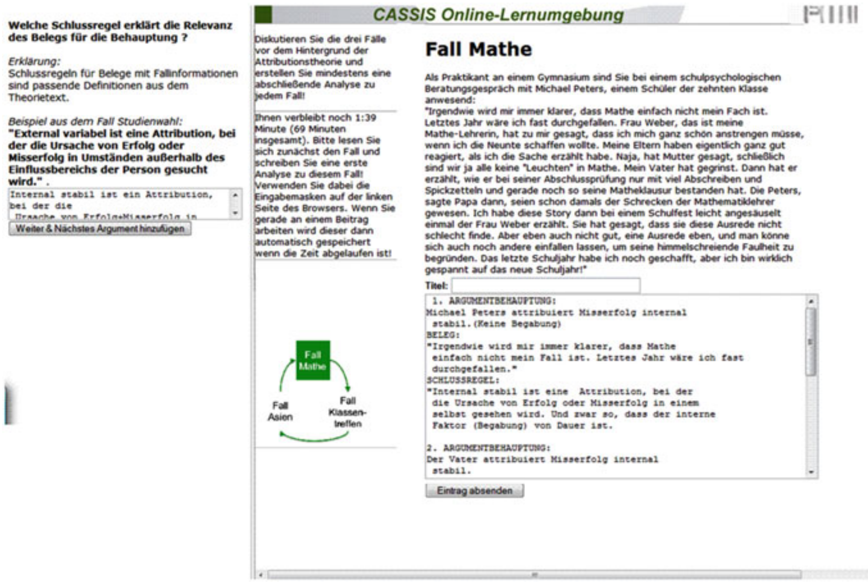

Fig. 4.7 Interface example—high degree of scripting

Table 4.3 Illustration of dummy variable coding schema

	A: code variables			B: code variables	
Degree of scripting	*SCRIPT*	*FADE*	**Degree of scripting**	*CONTROL*	*FIX*
Low (**R**)	0	0	Low	1	0
Medium	0	1	Medium (**R**)	0	0
High	1	0	High	0	1

Note Group marked with R was taken as the reference group

4.5.5 Procedure

The study was comprised of four main learning stages. Table 4.3 provides an overview of the procedure of the experimental study. Prior to the lab experiment, the randomization of participants was successfully controlled using individual questionnaires and tests, for example, on motivation, computer literacy, and other personal information. After the introductory section with the video A, the participants proceeded to practice the learning environment task with one pre-case. During this learning phase, learners' individual domain-specific prior knowledge and the internal collaboration scripts were assessed by the automatic approach of content analysis. Before the real treatment, the students received a standard introduction via video B, which differed with respect to the computer-supported script components that were implemented in the interface of the online learning environment. The collaborative learning phase, in which learners communicated with each other via the text and

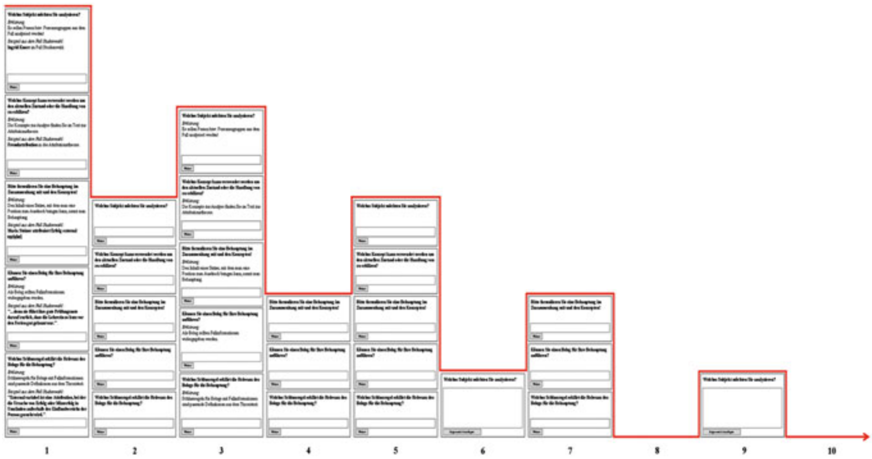

Fig. 4.8 Fading procedure

web-based discussion board, was 80 min for all experimental groups. During the 80 min learners in triads were required to solve each of the three cases. All discourse data within the web-based discussion board were recorded and served as the sources for analyzing the processes of argumentative knowledge construction (Fig. 4.8).

4.5.6 Variable Measurements

Both quantitative questionnaire data as well as qualitative content analysis of discourse data were collected. In order to put the pieces together, it is essential to have an overview of the data obtained from the multiple sources.

4.5.6.1 Variables Measured by Questionnaires

Several individual learning prerequisites have been discussed as important factors for collaborative knowledge construction. These individual learning prerequisites may be categorized as cognitive (Computer Literacy, and Learning Strategies) and motivational (Intrinsic and Extrinsic Motivation). All of these variables measured with individual instruments will be described in the following sections.

4.5.6.2 Computer Literacy

Computer literacy was measured by four items to rate the perceived computer skill and experiences, with 1 representing very much below average and 5 representing very much above average.

4.5.6.3 Learning Strategy

The learning strategies were measured with the German language scale (Inventars zur Erfassung von Lernstrategien im Studium) developed by Wild and Schiefele (1994). Learning strategies, which describe how learners deal intentionally with learning material, may influence how well learners understand theoretical texts (Wild and Schiefele 1994). Learners who read through learning texts critically, for instance, may have advantages over learners with inadequate learning strategies when applying theoretical concepts to a problem. The 6-item-scales was sufficiently reliable to be used in the current study (Cronbach's alpha = 0.76).

4.5.6.4 Academic Motivation (Pre Test)

Motivation after the intervention was measured using the Academic Motivation Scale (Vallerand et al. 1993), which further consists of two subscales, which separately address Intrinsic Motivation (IM) and Extrinsic Motivation (EM). Three types of IM can be identified as intrinsic motivation to know, to accomplish things and to experience stimulation. Specifically, IM to know can be defined as the fact of performing an activity for the pleasure and the satisfaction that one experiences while learning, exploring, or trying to understand something new (e.g. Because I experience pleasure and satisfaction while learning new things), while IM to accomplish focuses on engaging in an activity for the pleasure and satisfaction experienced when one attempts to accomplish or create something (e.g. For the pleasure that I experience while I am surpassing myself in one of my personal accomplishments). Finally, IM to experience stimulation is present when someone engages in an activity in order to experience stimulating sensations derived from one's engagement in the activity (e.g. For the intense feelings I experience when I am communicating my own ideas to others).

According to the self-determination theory (Deci and Ryan 1985, 1991), three types of EM can be ordered along a self-determination continuum. From lower to higher levels of self-determination, they are: external regulation is to regulate behaviour through external rewards and constrains (e.g. Because with only a high-school degree I would not find a high-paying job later on); with introjected regulation, the individual begins to internalize the external reasons for his or her action (e.g. To show myself that I am an intelligent person); and the internalization of extrinsic motive become regulated through identification (e.g. Because eventually it will enable me to enter the job market in a field that I like).

Each of the subscales lists 12 items that may represent reasons why students go to college. These reasons are scored on a seven point scale from 'not at all' to 'Exactly' with a midpoint at 4 ('Moderately'). Cronbach's alpha was 0.92 for the Intrinsic Motivation Subscale and 0.91 for the Extrinsic Motivation Subscale. An average score for each subscale can be derived by summing the subscale items and dividing by the number of items that make up the dimensions. The higher the score, the more motivated the learner is.

4.5.6.5 Variables Measured by Content Analysis

Participation

Initial studies attempted to analyze the effectiveness of collaboration scripts by counting a few superficial features of discourse data, such as the student participation rates (e.g. raw number of messages sentences or words). While the drawbacks of using such superficial features to indicate the complex learning processes is obvious, the content analysis on the participation dimension provides basic information. Since the general idea of collaborative learning is to encourage student participation and promote peer interaction, it is imperative to establish a pattern of participation in the online discussion.

Quantitative data on participation, in terms of the *Overall Participation* and *Off-task Activities*, were collected as part of a preliminary analysis. The *Overall Participation* in the learning setting can be easily measured by counting the number of segments the discussants actually produced during the collaborative learning phase. *Off-Task Activity* can be identified by the automatic approach to content analysis, which has been presented in detail in Chap. 3. Such an analysis on the participation provided first-hand evidence of the success of the collaboration scripts for facilitating argumentative knowledge construction.

4.6 Statistics

It is argued that the assumption of independence between the scores of members in the same group is violated in the small group research –which makes the use of ANOVA and OLS regression inappropriate. In this manner multilevel analysis appeared to be the best suited technique to analyze the cluster data collected in the present study. A set of HLM models with two levels was performed to detect the potential affects of scripts on the small group collaboration. In addition, a few statistics issues are addressed in the section before I can proceed to the results of the experimental study.

Coding systems typically use two different dummy-coding variables to represent the three levels of experimental treatments. Through the use of dummy codes, the categorical information can be rendered into quantitative forms. Table 4.3 presents alternative dummy-variable coding schemes that could be used for the current study.

In section A, three treatment conditions are represented by two dummy codes with the control group as the reference group. Having chosen a low degree of scripting as the reference group, each of the other group is given a value of 1 on the dummy-coded variable that will contrast it with the reference group in the regression analysis and a value of 0 on the other dummy-coded variables. As is illustrated in Table 4.3, *SCRIPT* contrasts a high with a low degree of scripting, *FADE* contrasts a medium with a low degree of scripting. However, I am also interested in a comparison between high and medium degree of scripting but neither of them is the reference group. The easiest way to accomplish this comparison between two non-reference-groups is to rerun the analysis after the data have been recoded by using another dummy coding system in which one of the comparison conditions is taken as the reference group (Cohen and Cohen 1983). Section B in the table shows the alternative dummy codes in which a medium degree of scripting is taken as the reference group. In this way, the full comparisons among all three treatment conditions are available now.

4.7 Results

4.7.1 Preliminary Analyses

To control for differences prior to the treatments within the various conditions, I compared the three different conditions using a ONEWAY ANOVA. No significant effects of the degree of script in the online discussion on the pre-test case were found regarding the concerned control variables. Table 4.4 includes a more detailed description of the variables used in the analysis. More specifically, some descriptive statistics, such as the means, standard deviations as well as the ANOVA results of each variable are presented.

However, the students disposed of extremely little applicable prior knowledge on argumentation. In total, 6881 segments (syntactically meaningful sentences) were analyzed with the automatic content analysis model presented in this chapter. Table 4.5 presents an overview of the descriptive results. During the online discussion, students included many cognitive activities to constitute claims and grounds, but fewer warrants.

Table 4.4 Mean and standard deviations of control variables by experimental conditions

Control variables		Degree of scripting				
		Low	Medium	High	F	η
Computer literacy	*M*	3.06	3.07	3.11	0.09	<0.01
	(*SD*)	(0.58)	(0.42)	(0.68)		
Learning strategy	*M*	2.68	2.75	2.63	0.49	0.01
	(*SD*)	(0.46)	(0.47)	(0.52)		
Academic motivation						
Intrinsic motivation	*M*	3.98	4.31	4.27	0.73	0.02
	(*SD*)	(1.20)	(0.98)	(1.27)		
Extrinsic motivation	*M*	3.97	4.49	4.23	1.42	0.03
	(*SD*)	(1.06)	(1.11)	(1.45)		

Note N = 96. *$p < 0.05$, **$p < 0.01$. Standard deviations appear in parentheses below means

Table 4.5 Mean and standard deviations of participation by experimental conditions

Control variables		Degree of scripting		
		Low	Medium	High
Overall participation	*M*	54.07	52.57	42.24
	(*SD*)	(20.31)	(21.29)	(22.76)
Off task activities	*M*	10.70	6.37	3.70
	(*SD*)	(7.01)	(3.98)	(3.80)

Note Standard deviations appear in parentheses below means

4.7.2 *RQ 1: To What Extent Does the Degree of Scripting Affect Students' Participation?*

The process variables I present here are the *Overall Participation* and *Off Task Activities*, a measure of student's active participation in the online discussion. For each process variable, the HLM analyses were performed in three stages. In the first stage, a null model was tested in which no independent variables were included in the analysis. In the second stage, the group-level independent variables were added to the model, while in the third stage the group-level independent variables were re-runed with alternative dummy codes. All results present in this section are meant to answer the first research question.

4.7.2.1 The Effects of Degree of Scripting on Overall Participation

Table 4.6 presents the parameter estimate and standard errors for three models. In this table, the intercept-only model estimates the intercept as 49.49, which is simply

Table 4.6 Fixed effects and variance estimates for models of the degree of scripting affecting learning processes in terms of overall participation

Parameter	Model 1	Model 2	Model 3
Fixed effects			
Intercept	49.49** (2.34)	54.07** (4.21)	52.57** (2.34)
Level 2 (group)			
Script		−11.83 (6.06)	
Fade		−1.51 (4.82)	
Control			1.51 (4.82)
Fix			−10.32* (4.95)
Random parameters			
σ^2_{u0}	25.83 (5.08)	3.29 (1.81)	3.29 (1.81)
σ^2_{e0}	450.33 (21.22)	445.15 (21.10)	445.15 (21.10)
−2*log likelihood	864.08	858.57	858.57

Note Values in parentheses are standard errors. $*p < 0.05$; $**p < 0.01$

the average value of *Overall Participation* across all groups and individual learners. The variance of the group level residual errors, symbolized by σ^2_{u0}, is estimated as 25.83, which is not significantly different from zero ($\chi^2 = 37.51$, df = 31, $p = 0.20$). The variance of the individual learner level residual errors, symbolized by σ^2_{e0}, is estimated as 450.33. The intra-class correlation (ICC), calculated by the equation of $\rho = \sigma^2_{u0}/(\sigma^2_{u0} + \sigma^2_{e0})$, is 0.054. Thus 5.40% of the variances of the *Overall Participation* are at the group level, which is not so high. Since the intercept-only model contains no explanatory variables, the residual variances represent unexplained error variance. The deviance reported here as −2*log likelihood function value, is a measure of model misfit. In general, the larger the deviance, the poorer the fit to the data (Raudenbush and Bryk 2002). Therefore, when more explanatory variables are added, a lower level of deviance is expected.

The second model includes two dummy variables (*SCRIPT* and *FADE*) as explanatory variables. The intercept of 54.07 in this model represents the estimated average amount of segments contributed by learners only in control groups. The regression coefficient for SCRIPT is −11.83, which marginally significant ($p = 0.06$). Since the dummy variables are coded as 1 = High Degree of Scripting, and 0 = Low Degree of Scripting, this means that on average students receiving scripts with high degree contribute 11.83 unit of analysis (segments) fewer than students in the control condition ($\text{Mean}_{\text{High}} = 54.07 - 11.83 = 42.24$).

Rerunning the analysis with the alternative dummy coding system, in which medium degree of scripting is taken as the reference group, will yield that the estimated coefficient is negative and significant ($\beta = -10.32$, $p < 0.05$), indicating that the mean of *Overall Participation* in the groups with high degree of scripting is significantly lower than the groups with medium degree of scripts ($\text{Mean}_{\text{Medium}} = 52.57$).

The group-level variance is still not significantly different from zero ($\chi^2 = 31.93$, df = 29, $p = 0.32$) in the model. However, note that the level 2 variances are dramatically reduced, reflecting the importance of the *Degree of Scripting* as the predictor. It isn't possible to obtain a true R-squared value in HLM; however, there are statistics that provide a value of the total variance that can be explained by the model at the different level, and they are often referred to as R-squared values (Kreft and De Leeuw 1998). The results of this analysis suggested that 87% of the variance in *Overall Participation* across groups could be explained by the predictors of *Degree of Scripting* at the group level. And only 1% of variances within groups are explained in the model.

In addition, it is generally preferable to carry out a likelihood ratio test by estimating the 'deviance' for the full model and the null model omitting the level 2 variables (Raudenbush and Bryk 2002). The deviances are 864.08 and 858.57 respectively, with a difference of 5.51 which is referred to the chi-square distribution with the difference in number of parameters as degrees of freedom (here, df = 2) and is marginally significant ($p = 0.06$). According to the likelihood ratio test, I can conclude that a better model-fit can be achieved by adding the explanatory variable at the group level.

Table 4.7 Fixed effects and variance estimates for models of the degree of scripting affecting learning processes in terms of off task activity

Parameter	Model 1	Model 2	Model 3
Fixed effects			
Intercept	6.80** (0.90)	10.70** (1.91)	6.37** (0.91)
Level 2 (group)			
Script		−7.01** (2.13)	
Fade		−4.34* (2.11)	
Control			4.34* (2.34)
Fix			−2.67* (1.32)
Random parameters			
σ^2_{u0}	22.62** (4.76)	14.49** (3.81)	14.49** (3.81)
σ^2_{e0}	10.45 (3.23)	10.45 (3.23)	10.45 (3.23)
−2*log likelihood	562.14	550.20	550.20

Note Values in parentheses are standard errors. *$p < 0.05$; **$p < 0.01$

4.7.2.2 The Effects of Degree of Scripting on Off-task Activity

Table 4.7 presents the results of a series of models for *Off-task Activities*. Model 1 is a null model that contains only an intercept term. The intercept of 6.80 in this model, which is the average frequency for off task behaviour, occurred during the collaborative learning phases. The null model estimates the group-level variances as 22.62, which is significantly different from zero ($\chi^2 = 239.85$, df = 31, $p = 0.00$). Hence, the proportion variance at the group level is estimated as 0.684, which is very high, and means that only one thirds of variances are situated within groups.

In model 2, two dummy variables (*SCRIPT* and *FADE*) are added to explain the large variances at the group level. The model predicts a mean value of 10.70 for the control group, which reduces to 7.01 ($p < 0.01$), and 4.34 ($p < 0.05$) respectively for the learner in the groups with a high and medium degree of scripting. By rerunning the dummy coding variable, it can be estimated that the mean value of *Off-task Activities* in groups with high degree of scripts ($\text{Mean}_{\text{High}} = 10.70 - 7.01 = 3.69$) is even slightly lower ($p = 0.05$) than groups with fading-out scripts ($\text{Mean}_{\text{Medium}} = 10.70 - 4.34 = 6.36$).

By comparing the variance components of model 1 with model 2, it is clear that entering the dummy variables representing various degrees of scripting decreases the group-level variances considerably, while it is still significantly different from zero ($\chi^2 = 165.10$, df = 29, $p = 0.00$). The effect of the *Degree of Scripting* is clearly significant, which suggests that 36% of the variances could be explained by the treatments. In addition, the model 2 (same with model 3) achieves a better fit than the null model for the difference in deviance of both models is highly significant ($\chi^2 = 11.95$, df = 2, $p = 0.00$).

4.7.3 RQ 2: How Does the Degree of Scripting Affect Learning Outcomes of Argumentative Knowledge Construction?

The quantitative findings show that collaboration scripts can influence the participation. More detailed analysis has been conducted to examine how does the degree of Scripting affect learning outcomes of Argumentative Knowledge Construction with respect to the knowledge acquisition of '*Learning to Argue*'.

The following three excerpts provide examples illustrating various patterns of discussion threads in experimental conditions. Specifically, Fig. 4.9 shows the flow charts that derives communication threads out of the structure of relating messages. Messages with a reference to themselves initiate new threads, each of which is assigned a unique thread number. The index number shows the exact position in the thread tree. Messages referencing other messages inherit their thread number.

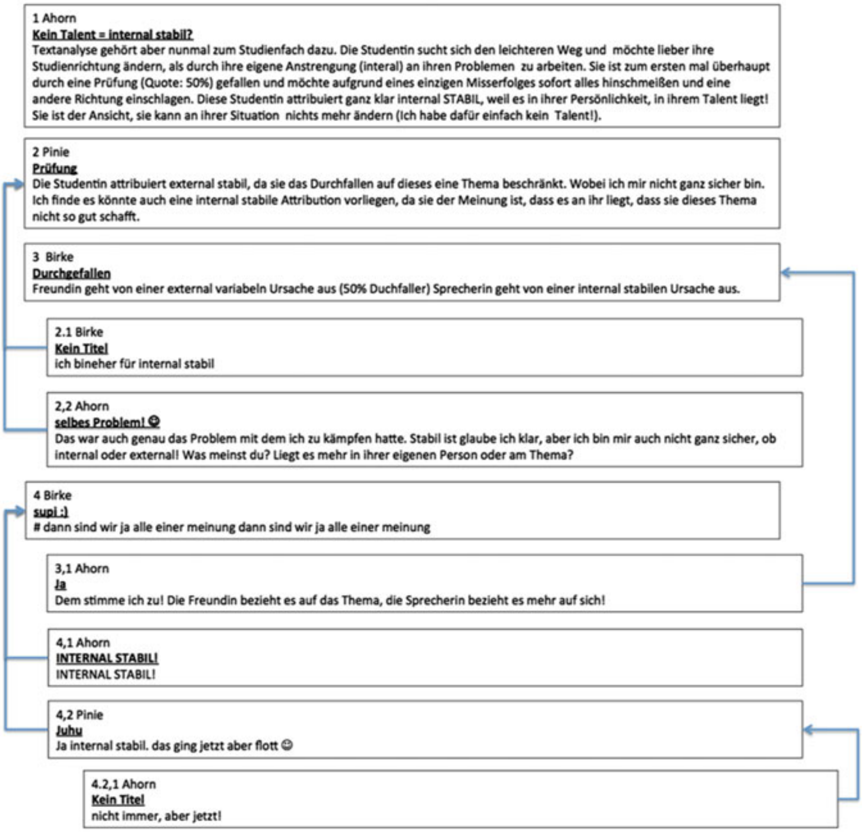

Fig. 4.9 Discussion threads with low degree of scripting

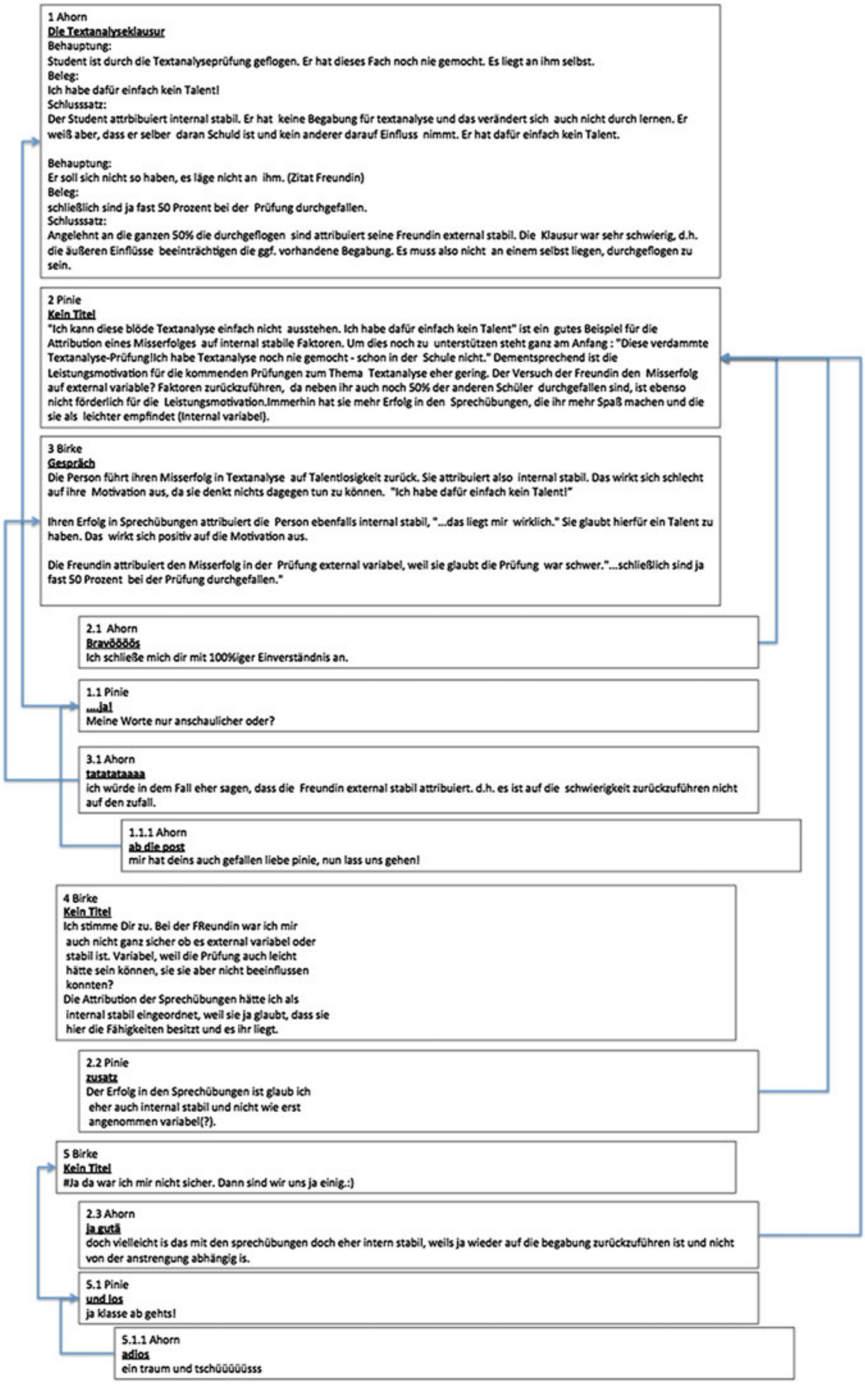

Fig. 4.10 Discussion threads with medium degree of scripting

The thread number is part of the index number, based on the position in the resulting thread tree. Threads can contain branched trees as well as chains, or they can be single entries (Figs. 4.10 and 4.11).

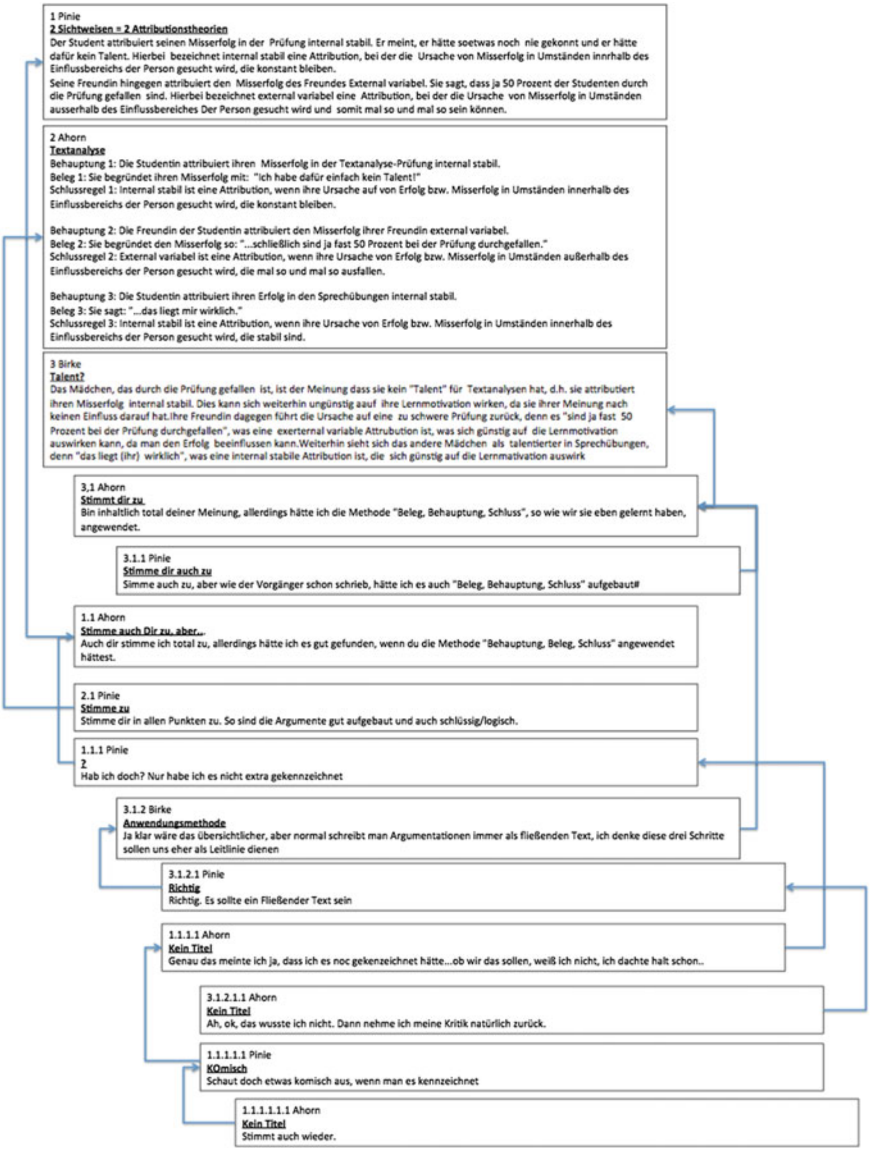

Fig. 4.11 Discussion threads with high degree of scripting

4.8 Summary of Results and Discussion

As has already been stated above, the study dealt with the questions of to what extend the degree of scripting affects the learning processes and outcomes of Argumentative Knowledge Construction. In short, a number of notable findings have been produced and summarised under the following headings in which the compound arguments are evidenced empirically and further warranted by drawing on the interpretative *Script Theory of Guidance* (Fischer et al. 2013) and other theoretical principles.

4.8.1 RQ 1: To What Extent Does the Degree of Scripting Affect Learning Processes of Argumentative Knowledge Construction?

The first research question is to examine the effects of the designed collaboration scripts on various aspects of learning processes.

4.8.1.1 Without Scripts, Learners Do Participate but Engage in Off-task Activities

The empirical study revealed that collaboration scripts can influence the participation. However, it yielded mixed results with respect to *Overall Participation* and *Off-Task Activities* on task. Apparently, without scripting stimulated free coordination, and as a result, learners in control groups tended to simply express but frequently ignore or fail to concentrate on the target tasks, indicating a need for support. Conversely, while learners supported by either high or medium degree of scripting contributed less text, the number of unit of analysis relevant to arguments produced in the intervention conditions was significantly higher than in the control groups with low degree of scripting. In sum, the results confirmed the hypotheses, that is, scripting students' activities positively contributed to active participation (favourable behaviour relevant to arguments) and suppressed unexpected behaviour (off-task activities).

The surface methods of counting messages to determine students' participation can provide a useful initial orientation, but more detailed analysis is needed to understand the underlying mechanisms of group interaction (Strijbos and Stahl 2007). Taken together, the results with respect to the first research question partially supported the hypotheses that the external collaboration scripts employed in the present study are effective to guide learners to actively engage in argumentative and collaborative activities.

4.8.2 RQ 2: To What Extent Does the Degree of Scripting Affect Learning Outcomes of Argumentative Knowledge Construction?

4.8.2.1 Medium Degree of Scripting Did Not Promote the Internalization of Scripts in Terms of 'Learning to Argue' Knowledge as Expected

First of all, the results proved the effects of collaboration scripts in the intended direction by offering evidence in favour of the medium degree of scripting. The superiority of adaptively scripted collaboration over under-scripted and over-scripted collaboration, however, was observed only on certain learning outcomes.

Specifically, the results did not prove the assumed effects of adaptive scripts with respect to '*Learning to Argue*' knowledge (Internalized Collaboration Scripts). The empirical finding was against this initial assumption in which fading was expected to foster the internalization of collaboration scripts.

4.8.2.2 High Degree of Scripting Fostered the Internalization of Collaboration Scripts—'Learning to Argue' Knowledge

The negative effect of '*over-scripting*' on the knowledge acquisition of '*Learning to Argue*' did not occur. The empirical study showed that high degree of scripting indeed increased the internalization of '*Learning to Argue*' knowledge. Specifically, learners with detailed external collaboration scripts produced more formally complete arguments in the transferable post-case than learners in other two conditions.

In order to explain the complex results, it appears to be necessary to utilize the ***optimal external scripting level principle*** outlined in the *Script Theory of Guidance*: "an external collaboration script is most effective for knowledge acquisition if it is directed at the highest possible hierarchical level of internal collaboration script components for which subordinate components are already available to the learner" (Fischer et al. 2013). From this point of view, there have appeared to have not only one optimal scripting for all kinds of knowledge acquisitions, since even single individual learners might have different prior knowledge or 'already available' script components for each kind of knowledge acquisition.

Different categories of knowledge are hardly compared or contrasted with one another. However, learners often lack procedural knowledge of how to construct and interpret arguments (Kollar et al. 2007). Compared with the conceptual knowledge acquisition goals, therefore, it might be more challenging for learners to construct a formally complete argument/argument sequence due to little 'available' script components (smaller Zone of Proximal Development, ZPD), and thus the failure of fading on knowledge acquisition of '*Learning to Argue*' might be due to the un-individualized scripting fading out too quickly, which led to the scaffolding residing outside of learner's ZPD and hence the unexpected effects of under-scripting.

4.9 Overall Discussions

This experimental study has unique value in that it outlines a systematic investigation by involving multi variables and their interactions, which extends our understanding of the role of internal/external collaboration scripts in the computer-supported collaborative learning.

First, this study contributes to the growing empirical literature on the effectiveness of adaptive collaboration scripts by providing a direct comparison between low, high and medium (limited adaptive) degree of scripting in a one-factorial quasi-experiment.

In doing so, this study directly addresses the call for a more rigorous investigation of the various degree of scripting, rather than the polarized with/without distinction. The empirical evidence from the present study gave clear supports for the hypothesis that the groups supported by collaboration scripts achieved performances superior to those learner in control groups on their own. The findings suggested that even though the adaptive collaboration scripts manipulated with fixed fading do not offer the real-individualized scripts, the limited adaptive fading provided learners with the opportunity to achieve a deeper understanding of the problem domain. Learner also benefited from the self-regulation and knew more 'about' the skilled collaboration.

Second, previous studies have shown that scaffolding improves student learning outcomes (Kollar et al. 2007; Rummel and Spada 2005; Schellens et al. 2007; Stegmann et al. 2007). However, few of these studies are accompanied by empirical evidence whether *over-scripting* exist and why and how the unexpected effects of collaboration scripts occurs. The current study indicates that an absolute threshold (above which the scripting degree will be 'too much' for learners) indeed does not exist. Rather, whether an external collaboration script being 'too much' or not, is relative to and depending on the available resource stored in human mind as prior knowledge/internal collaboration scripts. Therefore, a certain degree of scripting might be 'over' the optimal level for an experienced learner but still 'under' the required scaffolds for other learner with less competence. Furthermore, due to the dynamic feature of knowledge construction, the delicate balance between internal and external collaboration scripts is temporal, which means that the pervious 'optimal' scripting might impede following learning after internalizing practices. In this manner, adaptive collaboration scripts are not simply dichotomous alternatives to full collaboration scripts, and the key distinction between them is not seen in the specific degree provided at a given time, but in how the degree changes as the learner changes.

Generally, the purpose of the empirical study is to emphasize the need for a systematic conceptual framework underlying the effects of adaptive collaboration scripts, rather than focusing on the intelligent part of particular technologies or special pedagogical methods. This finding can help us investigate different types of adaptive collaboration support in more detail in order to increase our knowledge of when and why adaptive collaboration support is effective. The issue addressed in the current study is not to demonstrate the inherent superiority of one degree of scripting over another, but to emphasize the recognition of the scaffolding approaches toward providing appropriate supports to specific learner and particular learning goals (facets of knowledge) at a given point in time.

The recent emphasis on exploring effective scaffolding approaches to foster collaborative learning has revitalized the research interest in the most closely-studied differences between the adaptable and adaptive collaboration scripts. In a typical setting which provides adaptive collaboration scripts, the instructional variations are controlled by the teacher, program or other kind of authority, while the control is based on the needs of learners. An obvious alternative is to place the same instructional options under the control of learners (Hannafin and Land 1997). In particular, the factor of control refers to the tendency of learners to control what happens to them and direct his/her own learning process (Lawless and Brown 1997; Shyu and Brown 1992), by giving learners control they gain the opportunity to determine many aspects of their learning such as depth of study, range of content, and time spent on learning (Hadjileontiadou et al. 2012; Kirschner et al. 2004).

Learner control is appearing in recent instructional strategies because learner's control is assumed to help learners to feel capable of engaging in an educational experience (Reeve 2006; Shroff and Vogel 2009), to use the provided choices toward his/her self-selected goals (Ryan and Deci 2000), to increase the learner's motivation to learn (Schnackenberg and Sullivan 2000; Steinberg 1989), and ultimately to lead to improved academic performance (Kinzie et al. 1988). However, inconsistent research findings with respect to the effects of learner control have incurred benefits as well as raised problems (Lin and Hsieh 2001). For instance, it has been found that not all students are capable of monitoring and regulating their learning, Many don't seek help when they need it (Hadwin and Winne 2001). Learner, especially novice, may not be capable of judging when they need help (Aleven and Koedinger 2000). In earlier days, Hannafin (1984) concluded that compared with program control learner control is likely to be most successful when the following conditions are met: (i) the learners are older and more skilled; (ii) the educational objective is to impart a higher order of skills rather than factual information; (iii) the content is familiar; and (iv) advice is provided to assist learners in making decisions. Similarly, Tennyson and Rothen (1979) suggested that learner control seems to work best for tasks that require minimal prerequisite knowledge and that have a simple content structure.

Given the various findings regarding the effects of learner control, one conclusion is that in order to have beneficial learner control, learners need to have at least some minimal knowledge to make authentic choices (Jones and Issroff 2005), a well established conceptual understanding of the content domain (Gay 1986), high meta-cognitive skills or high prior domain-specific knowledge (Clark and Mayer 2003) and they need to be capable of acting appropriately on that knowledge (Ross and Morrison 1989).

Recently, Wang et al. (2011) found that compared to the unscripted collaboration and non-adaptable script, an adaptable script improved individual knowledge and skill acquisition by providing learners with control over whether they would like to use the interaction-oriented prompts and the time they would like to spend on each learning task. However, it is worthy of note that the positive effects of adaptable collaboration scripts were observed after a 44-minute training phase, which helped learner "get a first experience on how to handle the learning environment and how the collaboration script worked on" (Wang et al. 2011, p. 384). From this perspective, the participants were already experienced and with the assumed sufficient prior knowledge to make appropriate use of learner control options. Therefore, they benefited from learner-controlled collaborative learning. In other words, before providing the 'freedom' and delivering the 'control' to learners, they might need to be 'forced' to accumulate their knowledge and skill in the relevant domain. Strictly speaking, the adaptable script employed in the study is a mixed learning approach rather than a pure controlling by learners.

Swaak and de Jong (2001) explore the issue of how much control the system should provide versus how much control the student should have. However, they do not provide a conclusive answer on what is the ideal delicate balance between student control and system control. Learner control must be approached more cautiously, since one level of control does not fit all learners. While some experienced students may perform best when learner control options are available and gain educational benefit from this freedom, other novices may "suffer as a consequence of being handed such control over their learning" (Large 1996, p. 104).

In this respect, it is important to emphasize that in designing collaboration scripts to support learner either with adaptive or adaptable script, the educator must keep in mind that the ultimate goal is to remove the script components in order to move toward appropriating self-regulated learning. The combination of the both the scaffolding approaches (adaptive and adaptable collaboration scripts), which can be further elaborated in the future work, is potentially practical and effective.

With respect to the practical implementation, I present a promising approach which identifies the core elements in designing collaboration scripts and argue that the educational program must be integrally linked with constructivist thoughts as the basis in order for significant progress in learning and instruction to occur in computer-supported learning settings. Specifically, the work also has direct implications for designing an exemplar of computer scripts that can inspire future research on argumentative knowledge construction.

Effective instruction design should be based on proven and sound learning theories (Inaba et al. 2001) for allowing effective collaborative learning to occur. Therefore, systematic instruction design with a theory-based analysis are needed to achieve actual facilitation of collaborative knowledge construction (Strijbos et al. 2004). A number of theorists have discussed the ways in which constructivist values influence instructional design and have proposed several principles of the 'constructivist instructional design model' (Jonassen 1994; Lebow 1993; Willis 1995). Compared to traditional instructional systems approaches to designing instruction, constructivism makes a different set of assumptions about learning and suggests new instructional principles. The challenge instructional designers face is caused by the difficulty of translating the philosophy of constructivism into actual practice (Karagiorgi and Symeou 2005) due to the lack of common and solid background concepts for collaborative learning.

In the Script Theory of Guidance, the hierarchical approach to represent internal/external collaboration scripts provides some critical advantages over the traditional method of decomposing scripts, the first of which is that the hierarchical decomposition method gives the researcher a much richer view on how collaboration scripts (internal/external) are structured across levels. The four components representing different levels can be used to decompose nearly any scaffolding approach applied in the earlier days into a hierarchical model. In this way, the outlined components can be regarded as a shared language to explicitly interpret and compare the variety of collaboration scripts at different levels of detail.

The second advantage of the hierarchical approach lies in the underlying models of Script Theory of Guidance. The scripts theory does not just place all collaboration scripts into the polarized categories of macro and micro collaboration scripts (Dillenbourg and Tchounikine 2007), but argues that there is a continuum of scripting levels, from coarse-grained play, moderate-grained scene to finer-grained scriptlets. The script architecture is actually quite divers and flexible, which provides the possibility for abstracting from a set of low-level components to build a higher-level component. From this perspective, a learner's level of expertise is a critical factor in determining the size of component on each layer of the script architecture.

Central to the Script Theory of Guidance is not just a demonstration of the differences between a set of separate components but also the gradual transformation in learners' knowledge, skill, and strategic processing that bring about those differences. In fact, the trajectories plotted in the Scripts Theory of Guidance offer an internalization process versus product look at collaboration scripts. Dillenbourg and Schneider found that the process of internalization is rather vague and somewhat mysterious (Dillenbourg and Schneider 1995). The hierarchical structure of collaboration scripts makes the process (typically via fading) explicit and potentially efficient.

When confronted with a specific configuration of collaborative practice (e.g. counter-argumentation), experts are able to abstract or mentally represent the pattern as a familiar internal script and act on the whole configuration as a single unit at higher level (play or scene). These might be processes that don't require much effort but which map the collaborative practice(s) onto the most appropriate schemata more effectively (Alexander and Judy 1988). Therefore, those experienced learners may not need any additional instructional guidance because their internal scripts provide the full guidance. In contrast, novices lack sophisticated internal collaboration scripts associated with a practice or situation at hand.

As a consequence, external collaboration scripts that serve as instructional guidance that maybe essential for novices may have negative consequences for more experienced learners (over-scripting). Besides the horizontal differences among different learners, it is also vertically different, particularly when internal collaboration scripts of the same learner may be 'sublimated' to a higher level after further intense interactions take place. For more experienced learners, rather than risking the counterproductive redundancy of external collaboration scripts, it may be preferable to eliminate the scripts (fading). Thus, the most important instructional implication of this flexible collaboration script is that to be efficient, instructional design should be dynamically tailored to the level of experience of the individual learners, not only horizontally but also vertically. By understanding the developing process of collaboration scripts, educators can better conceptualize and carry out their roles as guides for learners at different points in this journey.

Chapter 5
An Empirical Study on Adaptable Scripting

5.1 Learning Environment

Computer-supported collaborative learning (CSCL) describes a variety of educational practices in which technologies are used primarily to create conditions under which effective group interactions, which constitute the most important factor in collaborative learning, are expected to occur (Dillenbourg et al. 2009). CSCL occurs at various social levels (e.g., small group, class, knowledge community), across different contexts (e.g., laboratory, classroom, field trips) and media (e.g., video, audio, text-based). In the reported work asynchronous online discussions forum, which has been regarded as a typical CSCL scenario (De Wever et al. 2006), will be introduced as a prototypical CSCL-environment. More specifically, the learning scenario that is going to be studied in this work includes learning with complex problem cases in asynchronous online discussions. In this section three main issues will be illustrated. First, how would asynchronous online discussions influence collaborative learning? Second, how would learning with problem cases facilitate favorable interactions? Third, what are the desirable cognitive and social processes in asynchronous online discussions that would yield individual gain in learning outcomes?

5.1.1 Asynchronous Online Discussions

An asynchronous online discussion is defined as "a text-based computer-mediated communication environment that allows individuals to interact with one another without the constraint of time and place" (Hew et al. 2010, p. 572). Asynchronous online discussions provide the means for discussions to occur. Discussions have been identified as a key component of CSCL by educators and researchers (Ertmer et al. 2007) on the one hand. On the other hand, students also regarded online discussions as one of the most beneficial activities to their learning (Richadson and

X. Wang and J. Mu, *Flexible Scripting to Facilitate Knowledge Construction in Computer-supported Collaborative Learning*, Perspectives on Rethinking and Reforming Education, DOI 10.1007/978-981-10-4020-7_5

Swan 2003). There are different ways how asynchronous online discussions would afford certain benefits from collaborative learning.

Firstly, asynchronous online discussions encourage active and equal participation in expressing one's own ideas. Discussants in asynchronous online discussion often express their opinions in writing. This form of communication facilitates participation of those who hesitate to participate in spoken discussions (Vonderwell 2003). In addition, messages in asynchronous online discussions are often posted anonymously or with code names, which further encourages participation (Fabos and Young 1999). The written messages anonymously posted in asynchronous online discussions reduce social cues, such as dialect, gender, skin colour etc. "Because of the lack of social cues, it is more likely that people will pay more attention to the content of the messages, thus creating an environment of equal opportunity and reciprocity in roles" (Sugar and Bonk 1998, p. 3).

Secondly, asynchronous online discussions afford deep-level thinking. Communication in writing is believed to promote higher levels of thinking than in face-to-face discussion where the interactions happen spontaneously and quickly, leaving little time for in-depth thinking (Marttunen and Laurinen 2001; Newman et al. 1997). The very process of writing in itself allows time and also helps students carefully construct their ideas. Furthermore, the reviewability and revisability of messages in asynchronous online discussions would also support in-depth feedback and reflective contribution (Suthers et al. 2008). For example, a study by Marttunen and Laurinen (1999) found students in written discussions provided more structured opinions than students in face-to-face discussions. Another study by Hawkes (2001) found that asynchronous online discussion encouraged discussants' critical reflection on content.

Thirdly, threaded discussions in asynchronous online discussions assist learning from a socio-cultural perspective. Socio-cultural perspectives suggest that individuals learn by exchanging opinions or viewpoints with one another (Palincsar 1999). For the exchange of opinions to take place, sustained online discussions, typically characterized by long discussion threads, should ideally be the pattern since in long threads there are many exchanges of postings or notes for individuals to share ideas, explore different perspectives, negotiate issues and create mutual understandings (Hewitt 2005).

5.1.2 Learning with Complex Problem Cases

Learning with complex problem cases in asynchronous online discussions further assists learning, as the problem/case-based method has been identified as an effective practice in collaborative learning (Flynn and Klein 2001; Hmelo-Silver 2004). In case-based asynchronous online discussions, carefully constructed problem cases are presented to discussion groups. These cases often consist of a description of observable phenomena that are to be understood in terms of their underlying theories central to a particular domain of study.

Proponents of the case-based method argue that "case[s] make[s] learning relevant and meaningful to the student through active participation in analyzing, discussing, and solving real problems in a specific field of inquiry" (Flynn and Klein 2001, p. 71). For example, in one of her statements for case-based reasoning, Kolodner (1997) argued that a case-based reasoner learns by acquiring cases and indexing them. The experience of solving cases or problems is an important resource for students as they learn how to identify issues to pay attention to, how to move forward, and how to project the effects of solutions they have come up with. Initial analyses of the cases help students activate whatever knowledge, formal or informal, they may have about the cases, which in turn, will facilitate the comprehension of subsequently processed information. When a group of students comes together to discuss their different perspectives (if any), the critical reflection upon their understanding of the cases help students deepen and elaborate their knowledge (Schmidt et al. 2007). Furthermore, solving real problems shift the focus of learning away from memorization of information to the application of theories, principles, and techniques to practical situations. It helps prepare students to be lifelong learners and adaptive experts (Hmelo-Silver et al. 2007).

5.1.3 Desirable Collaborative Knowledge Construction Processes

Although there is evidence for positive effects of cased-based discussion groups on learning attitude and performance (Flynn and Klein 2001), it has been argued that the effectiveness of group discussions depends very much upon the extent to which group members actually engage in productive interactions (e.g., exchanging and negotiating opinions; Hmelo-Silver and Barrows 2008). From cognitive and socio-cultural perspectives, the underlying cognitive and social processes of overt activities during collaborative learning are the mechanisms for the advantage (or disadvantage, when the processes are dysfunctional) of collaborative learning over individual learning (van Blankenstein et al. 2011).

Cognitive processes of learning take place within the individual when learners modify their own thinking and restructure their own knowledge. Social processes are induced by joint activity where learners jointly construct and negotiate meanings with each other. In the following, desirable collaborative knowledge construction processes for learning in case-based asynchronous online discussions will be introduced in more details.

5.1.3.1 Cognitive Processes

Cognitive processes describe how learners process learning materials and construct knowledge individually. For example, to solve the collaborative task, learners may activate their prior knowledge to interpret and process the learning materials. They might also refer to specific new concepts that they ought to learn. Although cognitive processes take place within individuals, opinions or output from peers could be taken as input for individually cognitive processing, for example to re-structure their own knowledge, when learning in a collaborative setting (Fischer et al. 2002; Webb et al. 1995).

According to Chi's taxonomy, cognitive processes could either be active, constructive, or interactive (Chi 2009). Being active means doing something while learning, for example, posting messages during asynchronous online discussions. Doing something is necessary, but not sufficient in online learning to acquire knowledge. Constructive processes are characterized by learners' production of additional outputs. Learners are engaging in constructive processes only if they undertake activities where the outputs contains ideas that go beyond and are not explicitly presented in the learning materials. For example, if a self-explanation is either nonsensical, or a verbatim utterance, then the underlying process is merely being active. But if the generated self-explanation is a meaningful elaboration that goes beyond the learning materials, then the underlying process is constructive. Being interactive describes the social aspect of cognitive processes and will be introduced later on. As Chi (2009) stated, constructive processes are more likely to encourage modification and restructuring of one's own knowledge and therefore, represent high-level cognitive processing.

Similarly, Weinberger and Fischer (2006) differentiated in learning with complex cases to what extent learners relate to case information, to what extent they relate to theoretical concepts, and to what extent they construct relations between theoretical concepts and case information. In their framework, constructing relations between theoretical concepts and case information describes high-level cognitive processing, since it requires learners' application of theory to solve problem cases. This framework was taken in the current work to guide analysis, as the same learning scenario, which is learning with complex problem cases in asynchronous online discussions, was used in the current study as in their previous work (Weinberger et al. 2002, 2005). The cognitive processes identified in the framework are construction of problem space, construction of conceptual space, and construction of relations between conceptual space and problem space. More details concerning cognitive processes in this framework will be provided in the following.

The construction of problem space is required for learners to gain an understanding of the problem, which is a prerequisite to successfully solve a complex problem. In order to understand the problem, learners select, evaluate, and relate single components of problem case information. To construct problem space is necessary, it has been shown however, to go beyond a concrete level of the problem space may foster knowledge construction in learning scenarios based on complex problems (Fischer et al. 2002).

In order to solve problems on the ground of theoretical concepts, learners need to acquire an understanding of the theory. "The construction of conceptual space comprises summarizing, rephrasing, and discussing theoretical concepts and principles" (Weinberger and Fischer 2006, p. 75). Learners construct relations between individual theoretical terms or principles or they make distinction between concepts. Constructing the conceptual space is essential to understand the theory to be learned.

In order to apply a theory adequately and to solve a problem efficiently, the main task in knowledge construction when learning with complex problems is to construct relations between problem and conceptual space. Relations between conceptual and problem space that learners construct can indicate to what extent learners are able to apply knowledge adequately, as well as to what extent learners approach a problem in detail. The construction of relations between conceptual space and problem space indicates which concepts or principles learners resort to in order to solve the problem. This type of cognitive activity represents a higher level of knowledge construction, the constructive processes (Chi 2009), in problem-oriented collaborative learning and has been found to be predictive for individual knowledge acquisition (Weinberger and Fischer 2006).

5.1.3.2 Social Processes

From socio-cultural perspectives, discourse activities between an individual learner and another person, who can be a peer, a teacher, a tutor, constitute the most important factor in collaborative learning (Vygotsky 1978). In the field of CSCL, interactions among peers have been given particular emphasis although without excluding other interactions (Dillenbourg et al. 2009). It has been argued that peer interactions make it more likely for learners to engage in negotiation of multiple perspectives (Hogan et al. 2000), as peer interactions are more equal and horizontal than the hierarchical or vertical interactions with teachers. A reconstruction of cognitive structure can be initiated more easily in peer interactions than in interactions with teachers (Webb and Mastergeorge 2003). Social processes describe group learners' co-construction of knowledge which means when learning in small group learners construct knowledge together by applying individually hold knowledge and negotiating the solutions to complex problems (Weinberger and Fischer 2006).

But of course not all discourse activities are the same, concerning their contribution to knowledge co-construction. As classified in Chi's taxonomy, being interactive is the highest level of knowledge co-construction processes underlying collaborative learning (Chi 2009). There, being interactive means more than just interacting in dialogues, as some dialogue patterns are in fact not interactive at all. For example, it is often the case that one learner dominates and makes most of the contributions and the other learning partners merely agree with a response like "ok" or "great". Interactive processes take place only if "both peers make substantive contributions to the topic or concept under discussion, such as by building on each other's contribution, defending and arguing a position, challenging and criticizing each other on the same concept or point" (Chi 2009, p. 83).

The social processes described in Weinberger and Fischer's framework likewise depict how learners interact with each other, and how they relate their contributions to contributions from their learning partners in solving the task (Fischer 2001; Weinberger and Fischer 2006). Specific social activities vary in the degree of transactivity, which is defined as reasoning that operates on the reasoning of another (Teasley 1997). In the following paragraphs five social activities with increasing degree of transactivity, which were identified in the framework from Weinberger and Fischer (2006), will be introduced. They are namely externalization, elicitation, quick consensus building, integration-oriented consensus building, and conflict-oriented consensus building.

Externalization (of knowledge) means that learners explicate their knowledge without reference to other contributions. Learners externalize what they know; this may make (mis-)conceptions accessible to learning partners and bring about discussions. To externalize opinions to each other makes co-construction of knowledge possible. Externalization may indicate prior differences between learners but cannot be made responsible for variance resulting from collaborative learning.

"Elicitation has been described as using learning partners as a resource by asking questions" (Weinberger and Fischer 2006, p. 78). Elicitation aims at initiating a reaction and receiving information from the learning partners. Elicitation may foster externalization and inspire further exploration when learners find gaps of understanding (Fischer 2001). Past research showed, however, that elicitation appeared to facilitate knowledge construction only if learners asked task-related questions, received help, and applied the help in the situation themselves (King 1994; Webb 1989).

Learners need to build consensus regarding the learning task in the process of social negotiation, in order to reach a common goal, for instance, to solve a complex problem. There are different styles in reaching consensus. Quick consensus building has been described as learners simply pretending to accept the contributions of their learning partners in order to continue discourses (Weinberger and Fischer 2006). In this way, quick consensus building may not represent an actual change of perspectives, but is rather a coordinating discourse type. Quick consensus building may be detrimental to knowledge construction when learners disregard other forms of consensus building in favour of quick consensus building.

In contrast to quick consensus building, integration-oriented consensus building has been regarded as taking over and operating the perspectives of learning partners. Integration-oriented consensus building indicates that learners "show a willingness to actively revise or change their own views in response to persuasive arguments" (Keefer et al. 2000, p. 77). Learners may come to better understanding by adopting and integrating each other's perspectives. Thus, integration-oriented consensus building has been regarded as favourable social activity with high-level underlying social processes. By building integration-oriented consensus, learners may eventually establish and maintain shared conceptions of a subject matter. Previous studies found, however, integration-oriented consensus building appeared to take place rarely in collaborative knowledge construction (Weinberger et al. 2003).

Conflict-oriented consensus building has been considered as an influential component in collaborative knowledge construction (Teasley 1997). Conflict-oriented consensus building has been described as disagreeing and modifying the perspectives of learning partners (Weinberger and Fischer 2006). By facing critique, learners may be pushed to test multiple perspectives to solve the conflicts in the process of social negotiation. This leads to more closely operation on the reasoning of their learning peers and more elaborated arguments for their positions. This reflective and constructive resolution of conflicts has been related to learning (Chan et al. 1997).

These five types of social activities in the processes of collaborative knowledge construction differ in the degree to which learners refer to the contributions of their learning partners. Integration-oriented and conflict-oriented consensus building are regarded as the most favourable types of social activities that relate to knowledge construction. These two types of consensus building are in compliance with what Chi (2009) identified as being interactive in collaborative learning. Prior findings suggested, however, without instructional support, learners often engaged in quick and superficial consensus building (Weinberger et al. 2003).

Summary

Asynchronous online discussions, as often used technology for CSCL, encourage active participation and afford individual information processing as well as social exchange. Learning in a CSCL environment, such as asynchronous online discussions, involves discourse activities with multiple underlying processes, including cognitive and social processes (King 2007).

5.2 Research Questions and Hypotheses

In the empirical study presented in this chapter, triads of learners collaborated in a case-based online discussion environment in which they had to solve psychological problem cases by aid of previously selected theories. The learning experience consisted of two parts.

In the first phase (training phase), all triads were supported by aid of a collaboration script similar to the script provided by Weinberger et al. (2005) (see Chap. 2). In a second phase (treatment phase), the same triads had to solve other cases (based on a different theory than in the training phase). During this phase, we implemented three collaboration conditions: (a) a condition in which learners received no script (NS); (b) a condition in which learners continued to receive the script from the training phase, without having the opportunity to adapt it (non-adaptable script condition; NAS); and (c) a condition in which learners were allowed to repeatedly adjust the script based on their self-perceived needs (adaptable script condition; AS). This study aimed to answer two main research questions:

RQ1: To what extent does the adaptable collaboration script have effects on cognitive processes of collaborative knowledge construction, compared to a non-adaptable collaboration script or learning without script?
RQ2: To what extent does the adaptable collaboration script have effects on social processes of collaborative knowledge construction, compared to a non-adaptable collaboration script or learning without script?

As indicated in Chap. 3, we expect that an adaptable collaboration script will facilitate cognitive and social processes of collaborative knowledge construction, relative to learning with a non-adaptable script or learning without script.

In addition, we are interested in a third research question:

RQ3: Which pattern of discussion threads can be identified when learning without script, with a non-adaptable script or with an adaptable script in a CSCL environment?

A case study aims to explore how the pattern of discussion threads are changed or shaped regarding collaborative knowledge construction processes by inducing a collaboration script (a non-adaptable or an adaptable one) to a collaborative online discussion is conducted. No hypotheses are established for the case study due to its explorative character.

5.3 Methods

This section serves to illustrate the methodology of the empirical study, including sample and design, learning environment, experimental phases, and measurement of all the variables.

5.3.1 Design and Sample

To answer the research questions listed above, a one-factorial experimental design with three conditions was used. The factor 'adaptability' (CSCL with a non-adaptable script vs. CSCL with an adaptable script) was experimentally varied (see Table 5.1). There was also a reference condition in which learners received no collaboration script.

87 students from Ludwig Maximilians University (LMU) of Munich participated in this study. The sample can be described as follows (see Table 5.2).

Most of the participating students (54) were from educational science and their participation was required and counted as part of an assignment in a lecture. The

Table 5.1 Design of the experimental study

CSCL without script (NS)	CSCL with a non-adaptable script (NAS)	CSCL with an adaptable script (AS)
N = 27 students (9 triads[a])	N = 30 students (10 triads)	N = 30 students (10 triads)

[a]System logs were not saved for the 10th triad in this trial due to technical problems

Table 5.2 Demographic data of the participants

	NS	NAS	AS
Gender			
Female	22	23	23
Male	5	7	7
Age	24.00 (3.70)	26.07 (6.72)	23.53 (4.50)

Values in parentheses are standard deviations

rest were from psychology, sociology or communication sciences. They got either a certificate or hourly pay for their voluntary participation. The non-educational participants were equally distributed across the three experimental conditions. All participants were randomly assigned to small groups of three.

5.3.2 *Learning Material and CSCL Environment*

The students' task was to analyze three authentic educational problem cases on the basis of Weiner's (1985) Attribution Theory in asynchronous online discussion boards. This section will introduce the theoretical texts learners had to read as a preparation, the problem cases that were used during collaboration as well as the individual components of the online learning environment.

5.3.2.1 Theoretical Texts and Problem Cases

The learning subject was Weiner's Attribution Theory (1985) and its application in education. Students got a short description of the theory beforehand, which they were asked to learn on their own. The theory mainly addresses the question how students seek for causes for their academic success or failure. The theory allocates causes for attribution to two dimensions, namely locality and stability. Locality means that students attribute their success or failure internally (e.g., effort) or externally (e.g., difficulty). Stability describes whether attributed causes are temporally stable (e.g., talent) or variable (e.g., luck).

This classification system explains functional or dysfunctional attributions with respect to learning motivation. Weiner (1985) assumes that in order to sustain learning motivation, failures should be attributed to variable causes such as chance, while success should be attributed to internal, stable factors such as talent. Besides the attribution of the concerned student him- or herself, attribution of other persons, such as parents or teachers, may have equivalent effects on learning motivation. The short theoretical text introduces also re-attribution trainings, which from the practical point of view may change the inappropriate attribution pattern and thereby foster learning motivation. The theoretical text is from a previous study (Weinberger et al. 2005). It is about one thousand words in length.

In the collaborative learning phase, students were asked to analyze three problem cases from practical contexts that can be considered to be familiar to students. These problem cases are complex and ambiguous, which require students to apply Attribution Theory and to negotiate upon. These cases are from the previous study from Weinberger et al. (2005) as well, each of which is about 150 words in length. The description of problem cases was embedded into the online learning environment, so that they were available to students while they posted their messages and exchanged their opinions in small groups.

Since there was a training phase before students were about to learn the Attribution Theory, atheoretical text that was about the Cognitive Theory of Multimedia Learning (Mayer 2001), which was irrelevant to the learning subject, was handed out to students as well. During the training phase, the task of the students was to analyze three other problem cases with the help of the Cognitive Theory of Multimedia Learning.

5.3.2.2 CSCL Environment: CASSIS

Group discussions were led in a web-based CSCL environment, which was a revised version of the CASSIS environment (Stegmann et al. 2007; see Fig. 5.1). CASSIS is an asynchronous discussion board in which three participants can post messages that, apart from the experimenters, only the members of the learning group could read. The participants were logged in with code names in an effort to warrant anonymity, i.e. students from the same triad were unlikely to personally know their peer members.

Upper left is the description of the task, which is to analyze the problem case with the help of the according theory and discuss with peers. Middle left is a timer that tells the students how much time left for the current task. Lower left is an orientation map depicting which case the students is currently working on. Upper right is case information and lower right is the discussion board where students can post their messages.

5.3.3 Procedure

The experiment spanned over three hours and included four phases. (1) Individual learning: participants read two four-page theory sheets and filled out questionnaires

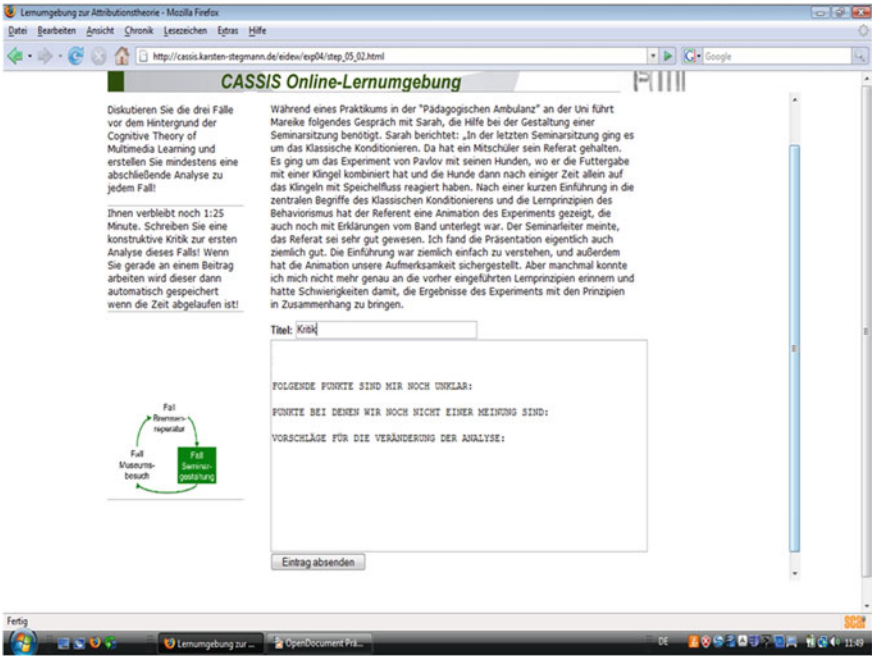

Fig. 5.1 Screenshot of the learning environment CASSIS

concerning demographic information and control variables. (2) Training: by applying the Cognitive Theory of Multimedia Learning students learned how to handle the learning environment and how the collaboration script works. (3) Chat: before the collaborative learning phase, students chatted online to plan for the coming phase. (4) Collaborative learning: students learned Attribution Theory and its application in education either with the help of a non-adaptable script (the same one they got during training), an adaptable script, or without script.

5.3.3.1 Individual Learning

First of all, students were introduced to the learning goals, which were to experience forms of virtual learning with new media and to learn a prominent theory of Educational Science together with two learning partners. After that, they were invited to an online questionnaire of demographic and control variables. At this phase, participants were randomly assigned to small groups of three, and each group was randomly assigned to one of the two experimental conditions. One week before the experiment, students received the theoretical texts and information about the general procedure and task of the online learning session. They were asked to learn the theory before hand, individually. However, it was impossible to control the time and effort students put into individual learning. Thus, domain-specific knowledge was therefore measured at the very beginning of the collaborative learning phase, (see Sect. 5.3.3.4) to avoid bias caused by individual learning.

5.3.3.2 Training

To start the online learning session, each student was equipped with a standard MacBook with web-browser (Firefox). With the help of this, students could communicate with each other within small groups via CASSIS. Students in triads were given socio-emotionally neutral code names (Ahorn, Birke, and Pinie). Immediately after students logged in CASSIS with code names, they were informed about the individual components of the learning environment (task description, timer, orientation map, etc.) by a standard video instruction. After that, they were asked to read cases and write messages against the Cognitive Theory of Multimedia Learning, which is unrelated to the learning subject (Attribution Theory). Their discussion was supported by a peer-review script. The training phase aimed to help students get familiar with the online learning environment and get to know how the collaboration script works, which was important especially for the realization of adaptability, since students could not be expected to adapt the collaboration script appropriately without having made experiences on how the script worked. Students' discussions during the training phase were not assessed.

5.3.3.3 Online Chat

After a short break, students were guided to the collaborative learning phase in the same environment. Before their group work, there was a 4-min online Chat, within which students were asked to make strategic planning for the coming collaborative learning phase. In addition, students in the adaptable scripted condition were provided with opportunities in the Chat to adapt parts of the peer-review script (see Sect. 5.3.4.3), which was the role distribution.

5.3.3.4 Collaborative Learning

In this 70-min collaborative learning phase, the task of the students was to discuss three problem cases on grounds of the Attribution Theory. Here students got another standard video instruction by which they were introduced to the specifics of the individual experimental conditions. From the moment that all three participants in the same group finished watching the video instruction, the learning environment worked automatically, depending on the experimental condition. During this collaborative learning phase, a copy of the theory text was available to each student to support them in analyzing the cases. The whole discourse was recorded by means of the discussion boards within which the participants communicated.

5.3.4 *Experimental Conditions*

The implementation of CSCL without script, collaboration with a non-adaptable script and collaboration with the aid of an adaptable script will be illustrated below.

5.3.4.1 CSCL Without Script

Students in the NS condition worked on the case analyses without support of a collaboration script. They were allowed to switch between the three discussion boards and freely work on any of the three problem cases through navigation (see Fig. 5.2).

Within each discussion board new contributions (initial messages) that start a discussion thread could be posted or existing messages could be answered in order to continue a discussion thread.

5.3.4.2 CSCL with a Non-adaptable Script

Students in the non-adaptable script condition worked on the case analyses with the help of a peer-review script (Weinberger 2005; see Table 5.3), which assigned two

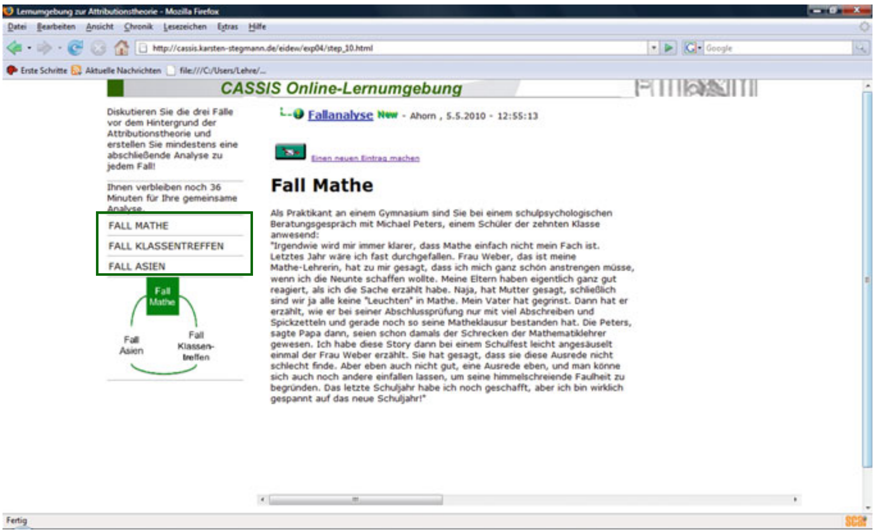

Fig. 5.2 Screenshot of the Learning Environment CASSIS in the NS condition. *Middle left* is a navigation through which students can switch between different problem cases

Table 5.3 Peer-review script for one of the three cases with respective time limits

Student A (analyst)	Student B (critic)	Student C (critic)
Initial analysis (12 min)		
	Constructive critique[a] (8 min)	Constructive critique[a] (8 min)
Responses to both critics[a] (10 min)		
	Constructive critique[a] (6 min)	Constructive critique[a] (6 min)
Responses to both critics[a] (8 min)		
	Constructive critique[a] (4 min)	Constructive critique[a] (4 min)
Concluding analysis (10 min)		

[a]These activities were facilitated by prompts (see Table 5.4)

Table 5.4 Prompts to support the roles of critic and analyst

Prompts for the role of critic
These aspects are not clear to me yet
We have not reached consensus concerning these aspects
My proposal for an adjustment of the analysis is
Prompts for the role of analyst
Regarding the desire for clarity
Regarding our difference of opinions
Regarding the modification proposals

different roles (role A: analyst for one of the three cases and role B: constructive critic for the other two cases) to individual learners in a small group.

Role A (analyst) took over the responsibility for the preliminary and concluding analysis on one case and responding to critiques from his or her learning partners on the same case. In the role of critic (role B) students were required to constructively criticize their partners' analyses of the two other cases. Each student took the analyst role for one of the three problem cases and the critic role for the other two cases. The execution of the two roles was supported by interaction-oriented prompts (see Table 5.4), which were automatically inserted into the message field in order to help students play their roles successfully. In addition, there was a time limit for each sub-activity.

5.3.4.3 CSCL with an Adaptable Script

In the adaptable script condition the peer-review script introduced above was adaptable. "Adaptability" in the current study was operationalized by (1) providing students self-control over role distribution, which means, distribution of

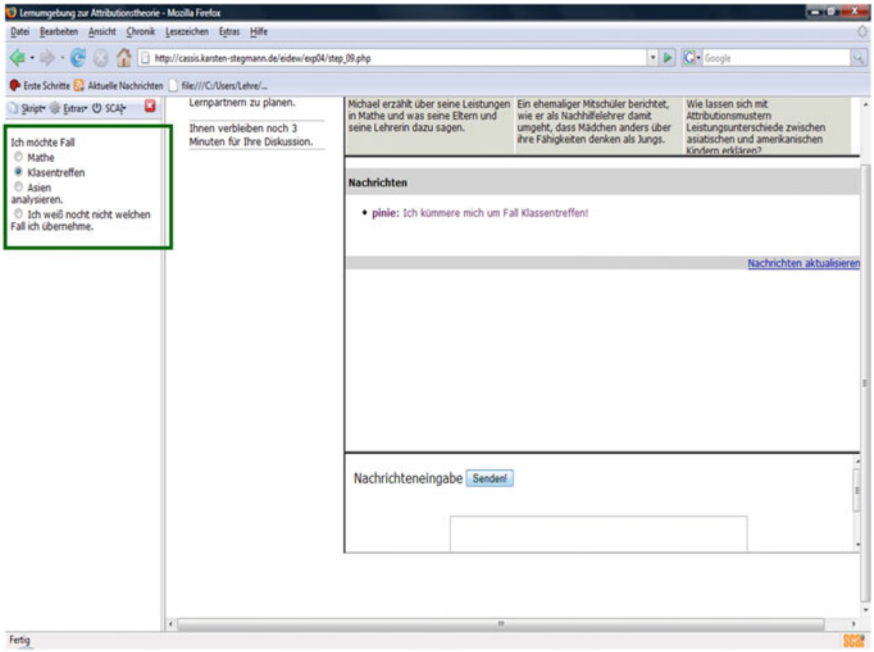

Fig. 5.3 Screenshot of the Chat in the Adaptable Script Condition (*Upper left* learners can choose for which of the three cases they would like to play the role of analyst)

responsibilities for case analyses was not determined by the collaboration script, but was based on students' group decision during Chat (see Fig. 5.2) and (2) providing students self-control over their use of interaction-oriented prompts, which means, students were allowed to switch on/off the prompts according to their own perceived needs (see Fig. 5.3). It is students' individual decision whether they would like to use the prompts or not (Fig. 5.4).

5.3.5 Operationalization of Dependent Variables

Discourse data, which was recorded by means of the discussion boards within which the participants communicated during the collaborative learning phase, was assessed from different dimensions. Cognitive and social processes of collaborative knowledge construction were coded with the help of the coding system developed by Weinberger and Fischer (2006).

First of all, two independent coders segmented 10% of all discourse data into units of analysis (Chi 1997), which were meaningful pieces of stated or declared messages in the current study (most often is a sentence with a punctuation mark or a question mark, but it could be also a single word or a group of sentences). Accuracy

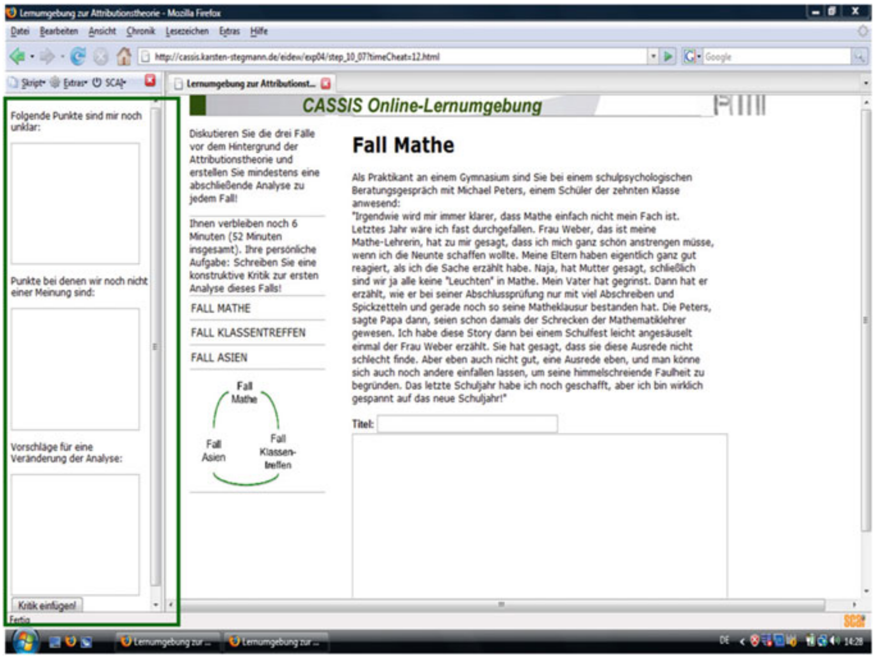

Fig. 5.4 Screenshot of the learning environment CASSIS in the adaptable script condition. On the *left side* learners can choose which prompt they would like to use by posting messages in the text field down there and clicking on the button 'Kritik einfügen'; or they can switch off all the prompts by clicking on the 'Schließen' button

on segmentation was 93%, reaching to a Cohen's Kappa of $\kappa = 0.85$. The remaining 90% of the material were then segmented by the trained coders individually.

Secondly, each of the resulting segments was rated as either on-task or off-task. On-task means the learners attempt to solve the task at hand (e.g., "Should we start now to apply what we learned from the attribution theory?") while off-task means learners talk something unrelated (e.g., "What bad weather it is!"). Accuracy of rating was 96%, $\kappa = 0.83$ (based on 10% of all segments; henceforth the same criterion for calculating inter-rater agreement was applied).

In a last step, each on-task utterance was coded from both a cognitive and a social dimension based on the framework from Weinberger and Fischer (2006). Both coding schemes are introduced in more detail below.

5.3.5.1 Measure of Cognitive Processes

According to Weinberger and Fischer (2006), when learning with complex cases, cognitive processes describe how learners construct the problem space, the conceptual space, and the relation between problem and conceptual space. An utterance is coded as *construction of problem space* when learners try to gain an understanding of the case by selecting, evaluating, and relating individual components of case information (e.g., "The student in the case thought that he failed in an exam because of inability"). *Construction of conceptual space* is defined as when learners try to gain understanding of the theory by constructing relations between individual theoretical terms or principles (e.g., "Internal stable attribution of failure has negative effects on learning motivation."). *Construction of relations between problem space and conceptual space* describes discourse activities when learners resort to theoretical concepts in order to solve problems (e.g., "The student is attributing internally stable when he took ability as the reason of his failure.").

The category "*construction of relations between problem space and conceptual space*" is considered as representing the highest quality of knowledge construction, since by applying theoretical concepts to a problem, students undertake activities that as an output produce ideas that go beyond the presented learning materials. As individuals vary in the amount of overall contributions, the percentage of utterances coded as construction between problem space and conceptual space in all cognitive utterances was taken as the indicator of the quality of cognitive processes of collaborative knowledge construction for each individual learner in order to avoid biases caused by more or less individual contributions in general (Weinberger 2003). Accuracy of coding on cognitive processes was 94%, Cohen's $\kappa = 0.73$.

5.3.5.2 Measure of Social Processes

Social processes of collaborative knowledge construction describe to what extent learners refer to contributions of their learning partners (Fischer et al. 2002). *Externalization* (of knowledge) means that learners explicate their knowledge without reference to other contributions. Most often the initiating message to start a discussion thread is coded as externalization (e.g., "The attribution theory says…"). *Elicitation* has been described as taking peers as a resource by asking questions. Elicitation aims at provoking reactions from the learning partners (e.g., "What kind of attribution is 'luck and chance', would you like to give an example?").

Quick consensus building is described as learners simply make agreement in the form of a short sign of approvals or affirmatively repeat utterances (e.g., "I agree with you in every respect"). *Integration-oriented consensus building* indicates that learners adopt and integrate each other's perspectives to gain a better understanding of the learning material (e.g., "And of course not only the teacher, but also the parents' attitude matters, I agree with this point"). *Conflict-oriented consensus building* describes how learners disagree and modify the perspectives of learning partners (e.g., "but I think it's not the right thing to do when you try to persuade Michael that his failure results from the environment").

Integration-oriented and conflict-oriented consensus building are regarded as the most favourable types of social activities that relate to collaborative knowledge construction (Weinberger and Fischer 2006). Percentages of utterances coded as integration-oriented and conflict-oriented consensus building in all utterances coded as social processes were taken as indicators of the quality of social processes. Accuracy of coding on social processes was 94%, Cohen's $\kappa = 0.91$.

5.3.6 Control Variables

Although not being manipulated, the control variables are regarded as moderators that might explain the variance in collaborative knowledge construction processes and individual learning outcomes when learning with collaboration script in a CSCL environment.

5.3.6.1 Domain-Specific Prior Knowledge

Students' domain-specific prior knowledge was assessed by the initial individual analysis of one of the three problem cases before their group discussion during collaborative learning phase. The initial unsupported case analysis by an individual student was coded against a check list from a previous study (Stegmann et al. 2007), which employed the same cases in a CSCL environment. The check list itemizes possible correct relations between the case and the attribution theory (e.g., "Her friend is attributing externally when she took difficulty of the task as the reason of her failure."). By checking the individual analysis the number of correct relations an individual learner pointed out was calculated as the indicator of individual's domain-specific prior knowledge. Inter-rater agreement was 91%, amounting to a Cohen's Kappa of $\kappa = 0.78$.

To avoid biases caused by discrepancy in difficulty among the three problem cases, z-values within each case were calculated to make students' prior knowledge comparable across different cases.

5.3.6.2 Internal Collaboration Scripts

Students' internal collaboration scripts were assessed by an open ended question at the very beginning of the training phase, after the video instruction. The question asked learners to describe how they would like to organize their group work, more specifically what steps they would like to take and why.

More specifically, students' answers to this open question were differentiated whether a contribution represented "task specification" (e.g., "I suggest that we read and summarize our analyses in the discussion thread."), "role distribution" (e.g., "each of us takes one case") or "sequencing" (e.g., "We should firstly work on our own analyses."). The inter-rater agreement regarding coding on internal collaboration scripts was 87%, and the inter-rater reliability was Cohen's $\kappa = 0.71$. The occurrence of these codes was counted and the resulting sum scores were used as an indicator of internal collaboration scripts.

5.3.6.3 Initial Intrinsic Motivation

Students' initial intrinsic motivation before they undertook this experiment was assessed by the "Academic Motivation Scale" (AMS) from Vallerand, Blais, Brière, and Pelletier (1989) during the pre-test phase (see Appendix 5), which measures a relatively stable construct of motivation towards education amongst college and university students. The intrinsic motivation sub-scale of AMS included twelve items (e.g., "I go to college for the pleasure I experience while surpassing myself in my studies."), with Cronbach's $\alpha = 0.92$ in the reported study.

5.3.7 Statistical Analyses

The data in the present study had a hierarchical structure. The individual students and the randomly formed small groups could be defined at separate levels of a hierarchical system (Hox 2010). In this respect, the assumption of independency for using unilevel statistic techniques was violated. This meant that in the present study, the data from individual students within a group could not be treated as completely independent because of their shared group experiences (Hox 2010). Therefore, hierarchical linear modelling was applied.

To investigate the research questions aforementioned, two-level models were built. A random intercept null model was calculated as the very first step, which only estimates the intercept for the specific dependent variable, without involving any explanatory variables. Random intercept models other than random slope models were taken for the reason that it was not the random variance between groups but the systematic variance between experimental conditions which was of interest in the current work. Therefore, random intercept models were taken to control the random variance between groups rather than to estimate it, as done by random slope models. In the null model, the total variance of the according dependent variable was decomposed into between-group, and between-student variance. As a next step, predictive variables were added to the null model to test the hypotheses.

The descriptive results were calculated with PASW statistic 18. HLM 6.08 (Raudenbush et al. 2004) was used to perform the multilevel modeling. Model estimation was based on the Restricted Maximum Likelihood (RML) solution. At individual level ground centering was used. At group level no centering was used. All analyses assume a 95% confidence interval.

5.3.8 Qualitative Approach

The quantitative approach to analysis of collaborative knowledge construction processes quantified the cognitive and social processes with the aid of respective coding scheme. Qualitative analyses might further reveal the differences that a non-adaptable script and an adaptable script brought about to learning processes in collaboration in a CSCL environment, which was asynchronous online discussion in the current study.

One group from each of the two experimental conditions was randomly selected for case studies. In general, case analysis means a search for patterns in data (Neuman 1997). According to Yin (2003) there are three general analytic strategies for analyzing cases: relying on theoretical propositions, thinking about rival explanations, and developing a case description. Here the third strategy, developing a case description, was used to provide further information about the collaboration processes in addition to the quantitative analysis.

Within the selected group, one of the three problem cases, which was case ‘Math’, was analyzed qualitatively. Discourse activities on case ‘Math’ were described with respect to all available information, including the number of messages, the author of each message, the length of each message, character of each message (prompted or not), original text of each message, number of discussion threads, and the length of each discussion thread. To keep the originality of the messages, texts were not translated.

The information from the detailed described group was used to explore the pattern of discussion threads in a specific experimental condition. Once the pattern was identified or uncovered, two other groups from the same experimental condition were randomly selected aiming at providing evidence for reliability (Yin 2009). The original messages of the other two groups in each condition were spared from presentation but the structure of discussion threads, which helped validate the pattern of discussion threads identified in the detailed presented group in the same condition.

5.4 Results

Quantitative results of the study will be reported on grounds of all 60 participants. The results will be reported following the sequence of research questions in Sect. 5.2. After reporting results from quantitative analyses, results from the case studies on grounds of three groups in each experimental condition will illustrate the pattern of discussion threads when learning with or without script. At the end of this section, there will be a short summary of all empirical findings.

5.4.1 Preliminary Analyses

Before performing statistical analyses related to the research questions, it was checked whether learners in the three experimental conditions were comparable with respect to their learning prerequisites, including domain-specific prior knowledge, internal collaboration scripts and initial intrinsic motivation (see Table 5.5).

On initial intrinsic motivation there was a significant difference across the three experimental conditions ($F_{(2.84)} = 3.85$, $p < 0.05$). Students in the AS condition had higher initial intrinsic motivation than those in the NAS condition *(*$p < 0.05$; with Bonferroni Post Hoc test). On none of the other measures significant difference across the three conditions was found ($F_{(2.84)} = 0.05$, *n.s.*, for domain-specific prior knowledge; $F_{(2.84)} = 0.97$, *n.s.*, for internal collaboration scripts). To avoid biases of effects of the treatment on the post-test measures, however, all aforementioned individual learning prerequisites were taken as control variables in all of the following analyses.

5.4.2 Effects of Adaptable Script on Cognitive Processes (RQ1)

First, results from descriptive analyses concerning the cognitive processes of collaborative knowledge construction in each experimental condition are reported in Table 5.6. As can be seen from the descriptives, cognitive processes are clearly unevenly distributed. The main cognitive process of students across all three experimental conditions was the construction of relations between conceptual space and problem space. Students engaged least in cognitive processes to construct the conceptual space (5% and below).

Descriptive statistics suggest differences among experimental conditions. The adaptable script reduced the frequency of overall cognitive processes, compared to the fixed script. The percentage of high level cognitive processes (construction of relations between conceptual space and problem space), however was higher when learning by aid of an adaptable script (76%), when contrasted to learning without script (57%).

Table 5.5 Descriptive analyses of control variables

	NS	NAS	AS
Domain-specific prior knowledge[a]	0.22 (1.23)	0.14 (0.88)	0.20 (0.71)
Internal collaboration scripts	2.38 (0.71)	2.10 (0.83)	2.22 (0.77)
Initial intrinsic motivation	4.05 (1.72)	3.39 (1.68)	4.45 (1.00)

[a]Standardized score (see Sect. 5.3.6.1)

Table 5.6 Frequencies and percentages of the three cognitive processes

	NS		NAS		AS	
	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%
Construction of problem space	2.81 (2.99)	38	2.67 (2.54)	27	1.77 (2.42)	21
Construction of conceptual space	0.48 (0.98)	5	0.33 (0.80)	4	0.20 (0.55)	3
Construction of relations between conceptual and problem space	5.15 (4.25)	57	7.10 (4.54)	69	5.00 (3.93)	76

To test RQ1 about the effect of the adaptable script on cognitive processes, results from multilevel modelling are presented in Table 5.7.

The null model showed that the between group variance was significantly different from zero ($\chi^2 = 68.41$, $df = 28$, $p < 0.001$), and explained 33% of the total variance on the dependent variable (*Intra class correlation (ICC)* = 0.33). ICC indicates that the between group variance should be taken into account, multilevel modeling is hence an appropriate method for hypotheses testing.

In model 1, the independent variable (adaptability of collaboration script) was computed with possible explanatory variables at individual level serving as covariates. Shown in model 1, the quality of cognitive processes was significantly higher when learning with an adaptable script, in comparison to that when learning without script ($\beta = 0.21$, $p < 0.05$). There was no significant difference between the NAS condition and the NS condition with respect to the quality of cognitive processes.

Model 4 was basically the same as model 1, with the NAS condition as reference. Results in model 4 revealed that learning with an adaptable script led to no higher quality of cognitive processes when compared to a non-adaptable script.

Results reported in model 2 and model 5 showed that there was no interaction between domain-specific prior knowledge and adaptable script with respect to the quality of cognitive processes.

It was shown in model 3 and model 6 that there was an interaction between internal collaboration scripts and external collaboration script. Compared to the NS condition, a non-adaptable script or an adaptable script inhibited students' internal collaboration scripts from playing a positive role in their performance on cognitive processes of collaborative knowledge construction.

5.4.3 *Effects of Adaptable Script on Social Processes (RQ2)*

With respect to social processes of collaborative knowledge construction, firstly, results from descriptive analyses in each experimental condition are reported in Table 5.8. The most often occurring social processes across all three experimental

Table 5.7 Multilevel regression for the effects of adaptable script on cognitive processes

Parameter	Null Model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Fixed- Level 1							
Intercept	0.67*** (0.04)	0.55*** (0.08)	0.67*** (0.04)	0.66*** (0.04)	0.68*** (0.06)	0.67*** (0.04)	0.66*** (0.04)
PreKn		0.09** (0.03)	0.11* (0.05)	0.07* (0.03)	0.09** (0.03)	0.07 (0.04)	0.07* (0.03)
ICS		−0.02 (0.03)	−0.02 (0.03)	0.08 (0.05)	−0.02 (0.03)	−0.02 (0.03)	−0.06 (0.03)
IMot		−0.01 (0.04)	−0.002 (0.04)	−0.01 (0.04)	−0.01 (0.04)	−0.002 (0.04)	−0.01 (0.04)
Level 2-NS as reference							
NAS		0.13 (0.10)					
AS		0.21* (0.09)					
NAS*PreKn			−0.04 (0.07)				
AS*PreKn			−0.02 (0.08)				
NAS*ICS				−0.14* (0.06)			
AS*ICS				−0.14* (0.06)			
Level 2-NAS as reference							
AS					0.08 (0.08)		
AS*PreKn						0.02 (0.07)	
AS*ICS							0.001 (0.04)
Random							
Level 2—Between group	0.03*** (0.17)	0.03*** (0.16)	0.03*** (0.17)	0.03*** (0.17)	0.03*** (0.16)	0.03*** (0.17)	0.03*** (0.17)
Level 1—Between student	0.06 (0.25)	0.05 (0.23)	0.06 (0.23)	0.05 (0.23)	0.05 (0.23)	0.06 (0.23)	0.05 (0.23)

PreKn domain-specific prior knowledge, *ICS* internal collaboration script, *IMot* initial intrinsic motivation, *NAS* CSCL with a non-adaptable script, *AS* CSCL with an adaptable scripted; henceforth the same abbreviations will be used

Values in parentheses are standard errors $^*p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 5.8 Frequencies and percentages of social processes

	NS		NAS		AS	
	M (SD)	%	M (SD)	%	M (SD)	%
Externalization	2.81 (3.76)	25	2.70 (2.69)	21	2.47 (3.53)	21
Elicitation	0.30 (0.72)	3	0.67 (0.96)	6	0.40 (0.67)	3
Quick consensus building	0.78 (1.15)	8	0.57 (0.94)	6	0.53 (0.86)	6
Integration-oriented consensus building	5.67 (4.55)	54	6.23 (4.67)	58	4.63 (3.56)	61
Conflict-oriented consensus building	0.81 (1.33)	9	1.13 (1.48)	9	0.63 (1.16)	9

conditions were the integration-oriented consensus building and externalization. Students engaged least in social processes of elicitation.

Descriptive results suggest differences among experimental conditions. The adaptable script reduced overall social processes relative to NS and NAS condition. The percentage of higher level social process (integration-oriented consensus building) was, however, higher when learning by aid of a collaboration script, especially by an adaptable script (61%), when contrasted with learning without script (54%). Regarding conflict-oriented consensus building, which also represents a high level social activity of collaborative knowledge construction, there was descriptively no difference across the three experimental conditions (9% in all three conditions).

To test RQ2 about the effect of adaptable script on the quality of social processes of collaborative knowledge construction (percentage of integration-oriented consensus building as well as conflict-oriented consensus building), multilevel modeling was performed and results are reported in Tables 5.9 and 5.10.

The null model shows that the between group variance was not significantly different from zero (χ^2 = 34.28, *df* = 28, *n.s.*). Between group variance explained 11% of the total variance on the dependent variable (*ICC* = 0.11).

Results presented in model 1 and model 3 showed that an adaptable script had neither positive nor negative effects on social processes of integration-oriented consensus building, compared to a non-adaptable script. When contrasted to NS condition, learning with the aid of a collaboration script, either a fixed one or an adaptable one, did not give rise to a higher quality of social processes with respect to integration-oriented consensus building.

Tested in model 2 and model 4, there was no interaction between internal and external collaboration scripts on social processes of integration-oriented consensus building. Internal collaboration scripts had no significant effect on social processes of integration-oriented consensus building in any of the three experimental conditions.

As for integration-oriented consensus building, both the non-adaptable script and the adaptable one had no effect on social processes of conflict-oriented consensus building (shown in model 1 and model 3 in Table 5.10).

Table 5.9 Multilevel regression for the effects of adaptable script on social processes of integration-oriented consensus building

Parameter	Null model	Model 1	Model 2	Model 3	Model 4
Fixed—Level 1					
Intercept	0.57*** (0.03)	0.52*** (0.06)	0.57*** (0.04)	0.58*** (0.04)	0.57*** (0.04)
PreKn		0.002 (0.04)	−0.01 (0.04)	0.002 (0.04)	−0.01 (0.04)
ICS		0.002 (0.03)	0.07 (0.06)	0.002 (0.03)	−0.03 (0.05)
IMot		0.02 (0.03)	0.01 (0.03)	0.02 (0.03)	0.01 (0.03)
Level 2-NS as reference					
NAS		0.06 (0.07)			
AS		0.09 (0.09)			
NAS*ICS			−0.10 (0.07)		
AS*ICS			−0.09 (0.07)		
Level 2-NAS as reference					
AS				0.03 (0.08)	
NS*ICS					0.10 (0.07)
AS*ICS					0.02 (0.07)
Random					
Level 2—Between group	0.01 (0.08)	0.01 (0.10)	0.01 (0.09)	0.01 (0.10)	0.01 (0.09)
Level 1—Between student	0.08 (0.28)	0.08 (0.29)	0.08 (0.29)	0.08 (0.29)	0.08 (0.29)

Values in parentheses are standard errors. $^{***}p < .001$

Table 5.10 Multilevel regression for the effects of adaptable script on social processes of conflict-oriented consensus building

Parameter	Null model	Model 1	Model 2	Model 3	Model 4
Fixed- Level 1					
Intercept	0.09*** (0.02)	0.09*** (0.01)	0.09*** (0.02)	0.58*** (0.04)	0.10*** (0.02)
PreKn		0.004 (0.02)	0.01 (0.01)	0.004 (0.02)	0.01 (0.01)
ICS		0.01 (0.01)	−0.04* (0.02)	0.01 (0.01)	0.02 (0.02)
IMot		−0.02 (0.02)	−0.01 (0.01)	−0.02 (0.02)	−0.01 (0.01)
Level 2-NS as reference					
NAS		0.003 (0.03)			
AS		0.01 (0.05)			
FS*ICS			0.06 (0.02)		
AS*ICS			0.09* (0.04)		
Level 2-NAS as reference					
AS				0.01 (0.05)	
NS*ICS					−0.06 (0.02)
AS*ICS					0.03 (0.04)
Random					
Level 2—Between group	0.002 (0.05)	0.003 (0.05)	0.003 (0.06)	0.003 (0.05)	0.003 (0.06)
Level 1—Between student	0.02 (0.15)	0.02 (0.15)	0.02 (0.15)	0.02 (0.15)	0.02 (0.15)

Values in parentheses are standard errors. $^{*}p < .05$; $^{***}p < .001$

Shown in model 2 and model 4, there was interaction between internal and external collaboration scripts on social processes of conflict-oriented consensus building ($\beta = 0.09$, $p < 0.05$). Internal collaboration scripts had negative effects on conflict-oriented consensus building when learning without script. When learning with an adaptable script, internal collaboration scripts had a positive effect on social processes of conflict-oriented consensus building.

Seeing from the results reported above in Tables 5.9 and 5.10, collaboration scripts, neither a non-adaptable nor an adaptable script, had any effect on social processes, relative to learning without script. Internal collaboration scripts interacted with adaptable script on social processes of conflict-oriented consensus building.

5.4.4 Effects of Collaboration Script on the Pattern of Discussion Threads (RQ3)

In this section, three groups from each experimental condition were randomly selected and presented in the following. Within each group, discourse on one of the three problem cases (case 'Math') was analyzed qualitatively. One of the three groups in each experimental condition will be presented with all the available information, including the number of messages, the author of each message, the length of each message, character of each message (prompted or not), number of discussion threads, length of each discussion thread, structure of discussion threads, and content of each message (original text). The original text of the other two groups from the same condition will be saved from presentation. This detailed presented group in each condition is for exploration, while the other two groups in the same condition provide evidence of reliability.

5.4.4.1 Discussion Threads in the NS Condition

In the following, discourses (on case Math) of a learning group without support of a collaboration script (NS) will be analyzed. The problem case the students were required to analyze and discuss was about a fictional student who is subject to a variety of attributions regarding his in-class-failure in mathematics. Ahorn (nickname) in this NS group was a 29 year old female; Birke was a 23 year old male; and Pinie was a 29 year old female. The three participants were 2nd- semester students at the University of Munich from educational science, when they undertook this experiment.

As Fig. 5.5 shows, there were seven messages posted on case 'Math'. Four out of the seven messages were from Pinie, one from Ahorn, two from Birke (Fig. 5.6).

Pinie started discussions by providing a first analysis of the problem case. There were 187 words in this message (Fig. 5.7).

Fig. 5.5 Discussion Threads in the first NS group

Ahorn developed a discussion thread by responding to the first message. There were 136 words in this message (Fig. 5.8).

Pinie further developed this discussion thread by feeding Ahorn's suggestion back. There were 24 words in this message (Fig. 5.9).

The second discussion thread was developed by Birke, also by answering Pinie's first analysis. There were 42 words in this message (Fig. 5.10).

The fourth message was the response from Pinie to Birke. There were 18 words in the message (Fig. 5.11).

The sixth message was Birke's feedback to Pinie. There were 21 words in this message (Fig. 5.12).

The seventh message was the last message on case ‚Math', posted by Pinie. It was the final analysis of the problem case based on the first analysis and her discussions with Ahorn and Birke. There were 256 words in this message.

On average there were 48 words in each message during discussion. The first analysis was not counted as a message during discussion as it was posted before discussion started. The final analysis was not counted as discussion as well, because it was rather an individual product after discussion. Although there was no support from the peer-review script during their group work, students in this group organized their discussion the way the peer-review script required. As there was a

1st message titled „ Mathe-Analyse "

posted by Pinie at 17:34 ,10.6.2010

1. abschnitt:

die lehrerin attributiert internal variabel, was grundsätzlich günstig ist für die leistungsmotivation, es handelt sich hierbei um eine sog. fremdattributation, die möglicherweise zu einer reattributation beim schüler führen könnte.

2. abschnitt:

Die Mutter attributiert zwar znächst internal stabil (begabung), was sich zunächst ungünstig auf die leistungsmotivation auswirkt, in bezug auf Misserfolge.

3. Abschnitt:

Der Vater attributiert external variabel (Glück, Zufall), was sich zwar günstig für die Leistungsmotivation bei Misserfolgen auswirkt , aber unünstig für die Leistungsmotivation bei Erfolgserlebnissen.

4. Abschnitt:

die Peters seien schon immer schlecht in mathe gewesen...ist eine internal satbile Attrib, die sich bei Misserfolgserlebnissen ungünstig auf die Leistungsmotivation auswirkt.

5. Abschnitt:

Die Lehrerin attr. wieder internal- variable (anstrengung). auch wieder eine Fremdattribut die sich günstig auf die lernmotivation auswirken soll.

6. Abschnitt:

nächstes schuljahr: schüler hat ein kleineres Selbstkonzept (sagt man das so???) und attribtiert wieder external-variable, also interprtiert seine leitsungen als zufällig oder glücksfall, und nicht aufgrund seiner anstrengung!

external-stabile Attrb. taucht hier meiner meinung nach nicht auf!? höchstens in dem sinne, dass sich die schwierigkeit der Aufgaben im nächsten Schuljahr erhöhen werden, und der schüler dadurch wieder misserfolge haben wird...

Fig. 5.6 First message in the first NS group

training phase before their collaborative learning (see Sect. 5.3.3.2), students in this NS group obviously internalized the script quite well and were able to apply the internalized script implicitly to guide their collaboration. Pinie in this unscripted group implicitly played the role of analyst, who was responsible for the first and final analysis and response to critic. Ahorn and Birke implicitly played the role of critic, whose task was mainly to provide constructive critique to the first analysis and negotiate with the analyst on different opinions. This group can be regarded as the 'trained scripted' group.

To provide evidence for reliability of the discourse structure when learning without script, two other NS groups were randomly selected and the discourse structures in these two groups will be presented below. Figure 5.13 showed how discussions proceed in the second NS group.

3rd message titled „ Kritik zu MATHE "

posted by Ahorn at 17:49 ,10.6.2010

Hallo. ich stimme mit dir überein, was die Arten der Attribution angeht. Ich würde aber unbedingt noch einleitend die Theorie dahinter erklären, also die 2 Dimensionen und die 4 Kombinationen, die sich daraus ergeben. Außerdem fände ich es leichter verständlich, wenn die Positionen einfach zusammengefasst würden. Lehrerin sieht es so, Mutter so, Vater so und was der Junge am Ende für sich da rauszieht. Der abschnittsweise Ablauf ist zwar richtig, aber man springt immer so hin und her. Als 'Pädagoge' würde ich zu dem Fall generell sagen, die Eltern machen hier echt Mist, was Fremdattribution angeht. Dadurch, dass sie dem Jungen indrekt bestätigen, dass er nix dafür kann, verstärken sie seine internal-stabile Attrbution. Die Lehrerin versucht ihn zu motivieren, aber hat nicht genug Einfluss, um gegen die Eltern anzukommen. Verdeutlicht die Zusammenarbeit von Eltern und Schule.

Fig. 5.7 Second message of the first discussion thread (the third message in all seven messages) in the first NS group

5th message titled „ Kritik 2 "

posted by Pinie at 17:53 ,10.6.2010

da wir ja alles wissen worum es geht, habe ich mir die schreibarbeit gespart und die theorie nicht eingangs erläutert! ansonsten gehen wir konform!

Fig. 5.8 Third message of the first discussion thread (the fifth message in all seven messages) in the first NS group

2nd message titled „ external Stabil "

posted by Birke at 17:40 ,10.6.2010

Finde es insgesammt sehr gut, vorallem die aufschlüsselung nach den einzelnen Aussagen.Glaube aber nicht das man bei den höheren Anforderungen im nächsten Jahr von stabiler attribution reden kann, da sich die Schwierigkeit ja verändert aber bin mir da auch nicht sicher.

Fig. 5.9 s Message of the second discussion thread (the second message in all seven messages) in the first NS group

4th message titled „ KritikKritik "

posted by Pinie at 17:50 ,10.6.2010

bezieht sich die stabilität nicht darauf, dass man eh nichts daran ändern kann? oder bin ich jetzt blöd??

Fig. 5.10 Third message of the second discussion thread (the fourth message in all seven messages) in the first NS group

6th message titled „ KritikKritikKritik "

posted by Birke at 17:55 ,10.6.2010

ja bin mir eben auch nicht sicher aber im text steht halt:...variieren Attribution im Hinblick darauf, ob Ursachen zeitlich gleichbleibend...betrachtet werden.

Fig. 5.11 Fourth message of the second discussion thread (the sixth message in all seven messages) in the first NS group

In the second NS group, five messages were posted altogether. There were two discussion threads, one with two messages, and the other with three. On average there were 62 words in each message during discussion. In this NS group, discussions were not that interactive as Ahorn's first analysis got only one response from each learning partner. In addition, only one response (from Birke) got a further answer from Ahorn. This group was characterized as a "quick-consensus building" group.

Figure 5.14 showed the discourse structure in the third NS group.

In the third NS group, nine messages were posted altogether, four from Ahorn, two from Birke and three from Pinie. There were three discussion threads, with three messages within each thread. The first discussion thread was so developed that Ahorn posted the first analysis, Pinie provided feedback and Ahorn agreed with Pinie. The second discussion thread started with a first analysis from Pinie, and ended up with responses from both Birke and Ahorn. The third thread started with a summary message from Pinie, and followed by the agreement from both Ahorn and Birke. On average there were 20 words in each message during discussion. In this NS group there was no clear role distribution, as both Ahorn and Pinie contributed a first analysis to group discussion. Seeing from the discourse structure, this group was characterized as an "equally distributed" group.

As reported above, there was no consistent structure of discussion threads across different unscripted groups. Group learners could either follow a trained script, play the roles implicitly, they could quickly reach consensus without too many interactions, or they could distribute tasks relatively equally among peers. There could be two discussion threads with mediate length (three to four messages), two threads either short (two messages) or mediate (three messages), or three discussion threads with the same length (three messages).

5.4.4.2 Discussion Threads in the NAS Condition

Discourse of a learning group facilitated by the non-adaptable script will be analyzed in the following. Ahorn in this NAS group was a 25 year old female; Birke was a 26 year old male; while Pinie was a 23 year old female. They were all 2nd-semester students from educational science.

7th message titled „ Endanalyse "

posted by Pinie at 18:21 ,10.6.2010

Attributationsmuster für Leistungsmotivation bei Erfolg:

günstig: internal- stabil (Begabung)

ungünstig: external- variabel (Zufall)

Attributationsmuster für Leistungsmotivation bei Mißerfolg:

günstig: intrnal/external variabel

ungünstig: internal stabil

Abschnitt 1

die lehrerin attributiert internal variabel, was grundsätzlich günstig ist für die

leistungsmotivation, es handelt sich hierbei um eine sog. fremdattributation, die möglicherweise zu einer reattributation beim schüler führen könnte.

Abschnitt 2

Die Mutter attributiert zwar znächst internal stabil (begabung), was sich zunächst ungünstig auf die leistungsmotivation auswirkt, in bezug auf Misserfolge.

Abschnitt 3

Der Vater attributiert external variabel (Glück, Zufall), was sich zwar günstig für die Leistungsmotivation bei Misserfolgen auswirkt , aber unünstig für die Leistungsmotivation bei Erfolgserlebnissen.

Abschnitt 4

die Peters seien schon immer schlecht in mathe gewesen...ist eine internal satbile Attrib, die sich bei Misserfolgserlebnissen ungünstig auf die Leistungsmotivation auswirkt.

Abschnitt 5

Die Lehrerin attr. wieder internal- variable (anstrengung). auch wieder eine Fremdattribut die sich günstig auf die lernmotivation auswirken soll.

Abschnitt 6

nächstes schuljahr: schüler hat ein kleineres Selbstkonzept (sagt man das so???) und attribtiert wieder external-variable, also interprtiert seine leitsungen als zufällig oder glücksfall, und nicht aufgrund seiner anstrengung!

external-stabile Attrb. taucht hier meiner meinung nach nicht auf!? höchstens in dem sinne, dass sich die schwierigkeit der Aufgaben im nächsten Schuljahr erhöhen werden, und der schüler dadurch wieder misserfolge haben wird...

Die Eltern agieren in diesem fall besonders ungünstig, indem sie dem jungen vermitteln, dass er ja für seine begabung nix kann und somit wird seine internal-stabile A. bestätigt und verstärkt! Die Lehrerin hat zu wenig Enfluss und kann durch ihre Fremdattr. kaum eine verbesserung erwirken!

Fig. 5.12 Last message in the first NS group

Fig. 5.13 Discussion threads in the second NS group

Fig. 5.14 Discussion threads in the third NS group

As Fig. 5.15 showed, there were eight messages posted on case ‘Math’. Four out of the eight messages were from Ahorn, two from Birke, two from Pinie.

Within these eight messages, two discussion threads were developed, with four messages in each (Fig. 5.16).

Discussions started with the first analysis of the problem case posted by Ahorn. There were 145 words in this message (Fig. 5.17).

Fig. 5.15 Discussion threads in the first NAS group

1st message titled „ analyse mathe "

posted by Ahorn at 17:40 ,17.6.2010

michael hat von seinen eltern die attribution schlecht in mathe zu sein übernommen. michael glaubt aufgrund von mangelnder begabung, die bereits in seiner familie herrscht, schlecht in mathe zu sein. er hat die internal stabile attribution keine begabung, welche sich ungünstig auf seine leistungsmotivation auswirkt. dies könnte sich aber dadurch ändern, indem eine reattribuierung stattfindet. die ungünstigen fremdattribtionen sollten geändert werden. zum beispiel sollte man michael erklären, dass er nicht wegen seinen internalen stabilen attributionen versagt, sondern sollte seinen misserfolg auf variable ursachen zurückführen, wie zum beispiel auf den zufall. seine lehrerin versucht dies schon indem sie seinen misserfolg auf die variable attribution anstrengung zurückführt, womit sie vielleicht auch recht hat. es gelingt ihr aber nicht sein verhalten zu ändern. vielleicht auch, weil seine eltern seine internale stabile attribution unterstützen. diese ist vielleicht zu stark um etwas zu ändern, also sollte hier eine reattribuierung stattfinden.

Fig. 5.16 First message in the first NAS group

3rd message titled „ andere Begründung finden "

posted by Birke at 17:55 ,17.6.2010

FOLGENDE PUNKTE SIND MIR NOCH UNKLAR:

PUNKTE BEI DENEN WIR NOCH NICHT EINER MEINUNG SIND:

VORSCHLÄGE FÜR DIE VERÄNDERUNG DER ANALYSE:

Insgesamt stimme ich überein, aber das mit dem Zufall würde ich ändern. Denn dieser Schüler ist ja schon seit knapp 2 Schuljahren schlecht in Mathe, das mit dem Zufall wird er Dir nicht glauben ;)Besser ist das mit der Faulheit, zusätzlich sollte man die Eltern einladen und ihnen erklären, dass sie ihren Sohn nicht in dem Glauben festigen sollten, in Mathe von Natur aus eine Niete zu sein.

Fig. 5.17 Second message of the first discussion thread (the third message in all eight messages) in the first NAS group

Birke developed a discussion thread by responding to the first message. There were 69 words in this message. One of the three interaction-oriented prompts (My proposal for an adjustment of the analysis is:) was used by Birke (Fig. 5.18).

Ahorn further developed this discussion thread by answering Birke's critique. There were 60 words in this message. Also one prompt (Regarding the modification proposals:) was applied (Fig. 5.19).

The first discussion thread ended up with Birke's second response to Ahorn. There were 22 words in this message. One prompt (We have not reached consensus concerning these aspects:) was used (Fig. 5.20).

The second message on case 'Math', which developed the second discussion thread, was posted by Pinie. It was a response to Ahorn's first message, the case analysis. There were 23 words in the message. One prompt was used (Fig. 5.21).

4th message titled „ antwort zur Kritik "

posted by Ahorn at 18:00 ,17.6.2010

ZU DEN UNKLARHEITEN:

ZU DEN MEINUNGSVERSCHIEDENHEITEN:

ZU DEN ÄNDERUNGSVORSCHLÄGEN:

mir ist da nix anderes eingefallen....wollte ne externale variable attribution finden und im skript steht zufall :) aber du hast recht.....vielleicht hat er auch immer mathe in der ersten stunde und geht zu spät ins bett....das wäre auch eine externale attribution, die man ändern könnte......oder so.....keine ahnung....gut mit dem vorschlag die eltern mit einzubeziehn, danke.

Fig. 5.18 Third message of the first discussion thread (the fourth message in all eight messages) in the first NAS group

7nd message titled „ Die gute alte Faulheit "

posted by Birke at 18:19 ,17.6.2010

FOLGENDE PUNKTE SIND MIR NOCH UNKLAR:

PUNKTE BEI DENEN WIR NOCH NICHT EINER MEINUNG SIND:

Ich würd das zu Faulheit ändern, das ist meist auch die zutreffendste Begründung (zumindest wenn ich mich an meine Schulzeit erinnere ;))

VORSCHLÄGE FÜR DIE VERÄNDERUNG DER ANALYSE:

Fig. 5.19 Fourth message of the first discussion thread (the seventh message in all eight messages) in the first NAS group

The fifth message was Ahorn's response to Pinie. There were 75 words in this message. It was a prompted message (Fig. 5.22).

The sixth message was the second critique from Pinie to Ahorn. There were 58 words in this message. One prompt was used (Fig. 5.23).

The seventh message was the last one on this case. It was the final case analysis posted by Ahorn. There were 121 words in this message.

On average there were 51 words in each message during discussion. Ahorn in this FS group played the role of analyst (as predefined by the script), who was responsible for the first, final analysis and response to critic or suggestions from Birke and Pinie. Birke and Pinie played the role of critic, whose task was mainly to provide constructive critique to Ahorn's analyses of the case. All of the messages

2nd message with an automatically generated title „ Kein Titel "

posted by Pinie at 17:48 ,17.6.2010

FOLGENDE PUNKTE SIND MIR NOCH UNKLAR:

PUNKTE BEI DENEN WIR NOCH NICHT EINER MEINUNG SIND:

VORSCHLÄGE FÜR DIE VERÄNDERUNG DER ANALYSE:

mehr beispiele zu änderung bringen, nicht nur sagen, dass de stabilen attributionen in variable attributionen umgewandelt werden soll. was genau ist damit gemeint?

Fig. 5.20 Second message of the second discussion thread (the second message in all eight messages) in the first NAS group

5th message titled „ antwort auf Kritik2 "

posted by Ahorn at 18:05 ,17.6.2010

ZU DEN UNKLARHEITEN:

ZU DEN MEINUNGSVERSCHIEDENHEITEN:

ZU DEN ÄNDERUNGSVORSCHLÄGEN:

man sollte herausfinden welche externalen variablen attributionen eine mögliche ursache für den misserfolg sein könnten. zum beispiel ist vielleicht diemathestunde immer in der ersten stunde und michael geht vielleicht zu spät ins bett und kann sich am morgen noch

nicht konzentrieren. oder er hat halt zufällig immer einen schlechten tag gehabt..... aber er ist ja schonlange schlecht in mathe...also wird das schwierig.....oder er sitzt im matheunterricht neben einer person, die ihn ablenkt.

Fig. 5.21 Third message of the second discussion thread (the fifth message in all eight messages) in the first NAS group

during discussion were prompted. Altogether there were six (out of 18) prompts being used by students. This group adhered to the script quite well. The structure of their discussion threads was exactly the same as what the script required.

Figure 5.24 showed how discussions proceed in the second NAS group.

In the second NAS group, eight messages were posted altogether. There were two discussion threads, with four messages in each. The structure of discussion thread was similar to that in the first NAS group. The difference was that each discussion thread included messages contributed by all three learners in this group

6th message with an automatically generated title „ Kein Titel "

posted by Pinie at 18:17 ,17.6.2010

FOLGENDE PUNKTE SIND MIR NOCH UNKLAR:

PUNKTE BEI DENEN WIR NOCH NICHT EINER MEINUNG SIND: aber zu versuchen, dem michael einzureden seine schlechten noten lägen an der umgebung ist nicht wirklich

das richtige. Man sollte auf jedenfall mit seinen Eltern reden und sich vielelicht die NOten in der Grundschule anschauen. Wenn die gut bzw. normal waren könnte schon ein nachhilfe lehrer helfen, damit michael fleipig übt und man seine schlechten noten dann wi

VORSCHLÄGE FÜR DIE VERÄNDERUNG DER ANALYSE:

Fig. 5.22 Fourth message of the second discussion thread (the sixth message in all eight messages) in the first NAS group

7th message titled „ abschlussanalyse "

posted by Ahorn at 18:28 ,17.6.2010

michael hat von seinen eltern die attribution schlecht in mathe zu sein übernommen. michael glaubt aufgrund von mangelnder begabung, die bereits in seiner familie herrscht, schlecht in mathe zu sein. er hat die internal stabile attribution keine begabung, welche sich ungünstig auf seine leistungsmotivation auswirkt. dies könnte sich aber dadurch ändern, indem eine reattribuirung stattfindet. die ungünstigen fremdattribtionen sollten geändert werden. zum beispiel sollte man michael erklären, dass er nicht wegen seinen internalen stabilen attributionen versagt, sondern sollte seinen misserfolg auf variable ursachen zurückführen, wie zum beispiel auf die mangelnde anstrengung. seine lehrerin versucht dies schon indem sie seinen misserfolg auf die variable attribution anstrengung zurückführt, womit sie vielleicht auch recht hat. es gelingt ihr aber nicht sein verhalten zu ändern. vielleicht auch, weil seine eltern seine internale stabile attribution unterstützen. diese ist vielleicht zu stark um etwas zu ändern, also sollte hier eine reattribuierung stattfinden. man könnte auch einen nachhilfelehrer einsetzen, der es vielleicht schafft die anstrengung zu steigern. auf jeden fall sollte mit den eltern gesprochen werden, dass es keinem sinn macht den misserfolg auf die mangelnde begabung der familie zu schieben.

Fig. 5.23 Last message in the first NAS group

Fig. 5.24 Discussion threads in the second NAS group

Fig. 5.25 Discussion threads in the third NAS group

instead of two (in the first NAS group). But it should be mentioned that the two end-up messages (the message titled 'Rückantwort' from Pinie and the message titled 'Rückantwort ahorn' from Birke) were no more than short yes-messages ('genau lass deine analyse, war gut!' and' ich finde du sollst auch deine analyse so lasen'). Therefore, the interactive discourses actually took place between two peers within each discussion thread. On average there were 34 words in each message during discussion. Two out of the six messages during discussion were prompted.

Figure 5.25 showed how discussions proceed in the third NAS group.

In the third NAS group, eight messages were posted altogether, four from Ahorn, two from Birke and two from Pinie. There were two discussion threads; three messages within the first while five within the second. The structure of discussion threads was also similar to the first two NAS groups. The difference was that Birke contributed his second message to the second thread instead of the first one, which was the case in the first NAS group. It made the second thread more interactive in a way that all three learners engaged in it. All messages during discussion were prompted. On average there were 60 words in each message during discussion.

Discourses in these three NAS groups suggested that the non-adaptable script introduced a consistent structure to online discussions. One of the three learners played the role of analyst while the other two acted as critics. Interactions took place mainly between analyst and critic, but rarely between critics. There were two discussion threads in each NAS group, with four messages each, or one with three the other with five. Most of the messages were prompted (78%).

5.4.4.3 Discussion Threads in the AS Condition

In the following, discourses of a learning group facilitated by an adaptable script will be analyzed and presented. Ahorn, Birke, and Pinie were all 20 year old females in this group. Ahorn and Pinie were from educational science and at their 2nd semester. Birke was from special education, at her 2nd semester as well. Figure 5.26 showed there were one main discussion thread and a following final analysis.

Fig. 5.26 Discussion threads in the first AS group

As Fig. 5.26 showed, there were seven messages posted on case ‘Math’. Three out of the seven messages were from Ahorn, two from Birke, two from Pinie.

Within these seven messages, there was one main discussion thread with six messages (Fig. 5.27).

Discussions started with the first analysis of the problem case posted by Ahorn. There were 78 words in this message (Fig. 5.28).

Pinie developed this discussion thread by responding to the first message. There were 80 words in Pinie’s message. Pinie did not use any of the interaction-oriented prompt (Fig. 5.29).

Birke further developed this discussion thread by answering Pinie’s critique. There were 119 words in this message. This message was not prompted (Fig. 5.30).

Ahorn extended the discussion thread by answering the two comments from Pinie and Birke together. There were 117 words in this answer-message. It was not prompted (Fig. 5.31).

Pinie’s second message in this discussion thread was a quick-consensus building. There were thirteen words in the message (Fig. 5.32).

The sixth message was Birke’s response to Pinie. There were one word and a smiling face in this message (Fig. 5.33).

The seventh message was the last one on this case. It was the final case analysis posted by Ahorn. There were 121 words in this message.

1st message titled „ Analyse Mathe “

posted by Ahorn at 13:25 ,25.6.2010

Die Attributionstheorie besagt, dass die Ursachen, auf welche man seine Erfolg oder Misserfolg zurückführt, eine wichtige Rolle für die Lernmotivation spielen.

Michael attribuiert hier seine mangelnde Mathematikfähigkeit auf die mangelnde Begabung, die sowieso wie sein Vater ihm bestätigt in der Familie liegt. Somit kann man vo neiner internal stabilen Attribution sprechen: Internal, weil die mangelnde Begabung in Michael selbst lokalisiert werden kann und stabil, weil man nicht annehmen kann, dass Michael bei der nächsten Mathematikklausur begabter sein wird.

Fig. 5.27 First message in the first AS group

2nd message titled „ Kommentar "

posted by Pinie at 13:42 ,25.6.2010

Ich finde deine Analyse sehr gelungen, da du genau auf seine Aussagen eingegangen bist. Ich würde vielleicht noch hinzufügen, dass es natürlcih auch sein kann, dass Michael die Begabung nur als Ausrede benutzt, wie die andere Lehrerin sagt. In wie weit seine Aussage richtig ist, oder ob er nur nichts lernt, lässt sich aber natürlch aus diesem text nicht

erschließen.

Die Aufgabe der Lehrer ist es in diesem Fall in wieder zu motivieren,wie dass funktioniert ist ach in der Thero

Fig. 5.28 Second message of the discussion thread in the first AS group

On average there were 66 words in each message during discussion. Ahorn in this AS group played the role of analyst while Birke and Pinie played the role of critic. But the activities attached to these roles were adapted or flexible in a sense that for example Birke (the critic) answered to Pinie's (the other critic) response and Ahorn's (analyst) initial analysis at the same time (the message titled 'kritik'), rather than answered only to Ahorn's first analysis, as prescribed in the script. So did Ahorn and Pinie. It made the discussion thread so condense that it engaged all three learners in one main discussion thread instead of two, as in NAS groups. None of the posted message was prompted.

Figure 5.34 showed how discussions proceed in the second AS group.

In the second AS group, eight messages were posted altogether. There was one main discussion thread with seven messages. This discussion thread was started by Ahorn. Birke and Pinie commented, and then Ahorn responded. This cycle repeated one more time. In addition, there was a response message (which was a quick agreement) from Birke (the message titled 'bin durch') got no further response. On average there were 34 words in each message during discussion. None of these messages was prompted.

Figure 5.35 showed how discussions proceed in the third AS group.

In the third AS group, nine messages were posted altogether. There were two discussion threads, one with six messages and the other with three. The first discussion thread was so developed that Ahorn posted the first analysis, Birke provided feedback and Ahorn responded and clarified the unclear points. Response from Ahorn was followed by comments from both Pinie and Birke. The second discussion thread started also with the first analysis from Ahorn. Due to technical problem the response from Pinie was not saved (the message titled 'Kein Titel' posted by Pinie at 14:38 was an empty message). This thread ended up with a question from Ahorn which was about the technique failure (the message titled 'Kritik???'). On average there were 43 words in each message during discussion (with the empty message excluded). Five messages were prompted.

3rd message titled „Kritik “

posted by Birke at 13:49 ,25.6.2010

ich stimmte der analyse aufgrund der internal stabilen attribution vollkommen zu.

man könnten ergänzend jedoch noch auf die fremdattribution durch den vater und die lehrerin eingehen.

die aussage der lehrerin, dass michael sich anstrengen muss, lässt schließen, dass er in ihren augen nicht sonderlich begabt ist. diese fremdattribution könnte michael übernehmen und denken, lernen hätte sowieso keinen wert.

die fremdattribution des vaters, der den misserfolg auf mangelnde begabung zurückführt, könnte dieselbe reaktion wie eben angesprochen auslösen. es könnte bestimmt hilfreich sein, wenn der vater nicht die "ausrede" der begabung verteidigt, sondern seinem sohn vor augen führt, dass es auch an mangelnder anstrengung liegen könnte. somit würde michael vielleiht internal variabel attribuieren und versuchen, den erfolg mit größerem lernaufwand erbeizuführen.

Fig. 5.29 Third message of the discussion thread in the first AS group

4th message titled „ Antwort "

posted by Ahorn at 13:59 ,25.6.2010

Die Fremdattributinstheorie muss auf jeden Fall noch mit in die Analyse rein, da habt ihr recht.

Die Lehrerin lässt erkennen, dass Michael aufgrund mangelnder Begabung sich mehr anstregen müsste und unterstützt ihn wie du schon gesagt hast in der Annahme, dass er sowieso nix mehr daran ändern kann, was natürlich negativ ist.

Genauso attribuiert der Vater ungünstig, in dem er sagt, dass die schlechten Mathematikkentnisse in der Familie liegen und Michael somit ebenfalls das Gefühl gibt, dass er nichts an dem Zustand ändern kann.

Deinem Verbesserungsvorschlag, dass der Vater internal variable Attributionen verwenden sollte, stimme ich voll und ganz zu, weil Michael somit durch ein größeres Engagement im Fach Mathematik auch etwas an seiner Note ändern könnte.

Fig. 5.30 Fourth message of the discussion thread in the first AS group

5th message with an automatically generated title „ Kein Titel "

posted by Pinie at 14:09 ,25.6.2010

Ich kann "leider" ;) nichts mehr hinzufügen, ich stimme dem Gesagten vollkommen zu.

Fig. 5.31 Fifth message of the discussion thread in the first AS group

6th message titled „ . "

posted by Birke at 14:11 ,25.6.2010

"Punkt" :)

Fig. 5.32 Sixth message of the discussion thread in the first AS group

When online discussion was supported by an adaptable script, there was also a consistent structure across groups, which was, however, obviously different from that when learning with a non-adaptable script. In adaptable script groups, one main discussion thread developed, which was long (with six to seven messages) and with contributions and interactions from all three learners within the group. In one of the three selected groups most messages were prompted (the third AS group) while in the other two groups (the first and the second), no prompt was used at all. On average, 28% messages were prompted when learning with an adaptable script.

7th message titled „ Abschleißende Analyse "

posted by Ahorn at 14:22 ,25.6.2010

Die Attributionstheorie besagt, dass die Ursachen, auf welche man seine Erfolge oder Misserfolge zurückführt, eine wichtige Rolle für die Lernmotivation spielen.

Michael attribuiert hier seine mangelnde Mathematikfähigkeit auf die mangelnde Begabung, die sowieso wie sein Vater ihm bestätigt in der Familie liegt. Somit kann man von neiner internal stabilen Attribution sprechen:Internal, weil die mangelnde Begabung in Michael selbst lokalisiert werden kann und stabil, weil man nicht annehmen kann, dass Michael bei der nächsten Mathematikklausur begabter sein wird.

Zudem spielt die Fremdattribution in diesem Fallbeispiel auch eine bedeutende Rolle. Michaels Lehrerin gibt ihm mit der Aussage, dass er sich viel anstregen müsste zu verstehen, dass er eine mangelnde Begabung für das Fach Matematik aufweist. Somit könnte

Michael annehmen, dass es sowieso nichts hilft, wenn er lernen würde, weil dies nichts an seiner Leistung verändern würde.

Ebenso spielt die Attribution des Vaters eine entscheidende Rolle. Dieser führt die schlechten Leistungen seines Sohnes auf die mangelnde Mathebegabung die in der

Familie Peters liegt und die sein Sohn wohl geerbt hat, zurück. Besser wäre es, wenn er external variable auf den Misserfolg seines Sohnes attribuieren würde um

ihm somit verstehen zu geben, dass er durch ein größeres Engagement durchaus in der Lage wäre eine bessere Leistung erzielen zu können.

Fig. 5.33 Last message in the first AS group

Fig. 5.34 Discussion threads in the second AS group

Fig. 5.35 Discussion threads in the third AS group

Summary of Results

- The adaptable script enhanced the quality of cognitive processes relative to NS condition;
- Compared to learning without script, both a non-adaptable and an adaptable script inhibited learners' application of internal collaboration scripts to support cognitive processes;
- Internal collaboration scripts contributed positively to social processes of conflict—oriented consensus building only when learning with an adaptable script;
- Case studies showed that collaboration scripts had effects on the pattern of discussion threads.

5.5 Discussion and Conclusions

How to implement flexible scripting to maximize the effectiveness of CSCL has recently drawn more and more attention in related research (Dillenbourg and Tchounikine 2007; Diziol et al. 2010; Gweon et al. 2006). In this study, the question whether adding adaptability to the scripting approach is an effective way to reduce the coercion of collaboration scripts without losing the benefit from the process structuring was explored.

In this section, results presented in Sect. 5.4 will be interpreted on grounds of the theoretical background and previous findings. Some limitations will be discussed to avoid overgeneralization. Implications, both theoretical and practical, will be discussed as well. At the end of this section, conclusions will be drawn.

5.5.1 *Effects of Adaptable Script on Cognitive Processes*

It was found in the reported study that a non-adaptable collaboration script had no effect on cognitive processes of collaborative knowledge construction relative to unscripted collaboration. As the peer-review script applied in the reported study was by nature a communication-oriented script (Schellens et al. 2007) which targeted at stimulating productive collaboration rather than provoking content elaboration, it was not surprising that this script had no effect on cognitive processes (Weinberger and Fischer 2006).

According to Dillenbourg (1999), a collaboration script of a high degree of coercion might hinder cognitive processes when it segments collaboration into too many sub-processes, especially for learners with high prior knowledge, for the reason that a fine-grained script may conflict with the well chunked prior knowledge and therefore, cause unnecessary work load.

The cognitive over-scripting explanation was supported by the evidence that when the script was adaptable, quality of cognitive processes was enhanced. When learning by aid of an adaptable script the restriction on cognitive processes caused by the relatively high degree of coercion provided by a fixed script was avoided (Fischer et al., in press). When learning with an adaptable script, the opportunity was provided to learners to get rid of parts of the script that were subjectively regarded as unnecessary, for example, by switching off the prompts.

Furthermore, to adapt the external script, students were required to reflect on their individual and collaborative performance and to monitor the learning processes accordingly (Scheiter and Gerjets 2007). These regulatory processes might to some extent influence the effectiveness of collaborative learning in CSCL environments (Zimmerman and Tsikalas 2005), for the reason that learning about complex and challenging topics in a computer-based environment requires students to make necessary adjustments regarding their background and the learning context (Azevedo 2007).

In addition to the main effect, adaptable script interacted with learners' internal collaboration scripts on cognitive processes. The interaction effect could be explained by the internal script configuration principle and the external script guidance principle (see Chap. 2; Fischer et al., in press), which state that learners' dynamic configuration of internal collaboration scripts might be influenced by an externally induced collaboration script. In the current work, both a non-adaptable script and an adaptable script inhibited learners' employment of their internal collaboration scripts to support cognitive processes of collaborative knowledge construction, compared to unscripted collaboration. However, as learners' internal collaboration scripts could be dysfunctional or functional, it is not necessary that the suppression of an external collaboration script on the employment of internal collaboration scripts would bring about negative effects on learning processes and outcomes (Fischer et al., in press). As discussed above, despite its constraints on learners' application of internal collaboration scripts, the adaptable script enhanced the overall quality of cognitive processes, compared to unscripted collaboration.

5.5.2 Effects of Adaptable Script on Social Processes

Although the evidence for a positive effect of the scripting approach on social processes is ample (Stegmann et al. 2007; Vogel et al., accepted), it was found that the non-adaptable script applied in the reported study had no significant effect on social processes of collaborative knowledge construction relative to unscripted collaboration, neither did the adaptable script.

As the same script was found to have positive effects on social processes of collaborative knowledge construction in a previous study (Weinberger et al. 2005), we had in the current study a so-called missing effect. A possible explanation of the missing effect is due to the training phase, which did not occur in the previous study. The training phase might lead to some extent internalization of the script so that learners in the unscripted condition would still implicitly use parts of the script during their collaborative learning. Evidence for the internalization assumption is supported by findings from qualitative analyses reported in Sect. 5.4.4, where the 'trained scripted' group structured their online discussion exactly the way introduced by the external collaboration script, although the external script was not available to them during their collaborative learning. But of course there was reason to include such a training phase in the current work. As we argued, the training phase was necessary for realizing adaptability, since without knowing about the mechanism of the collaboration script, adequately adapting it would be impossible.

The optimal external scripting level principle claims that an external script should provide a high or low scripting level based on learners' internal collaboration scripts (Fischer et al., in press). Learners' high structured internal collaboration scripts might be inhibited from being applied when learning with a coercive script (over-scripting; Fischer et al., in press). External scripts provided at an optimal level would contra wise induce or trigger students' employment of appropriate internal script components (Fischer et al., in press).

The interaction between adaptable script and students' internal collaboration scripts supports the optimal scripting argument. When learning with an adaptable script, internal collaboration script components that were functional for social processes were triggered rather than inhibited (which was the case in the non-adaptable script condition) and therefore, high structured internal collaboration scripts (with appropriate components accessible) contributed positively to social processes of conflict-oriented consensus building. When learning without script, internal collaboration scripts had no effect on social processes probably because there was no affordance from the social context to induce students to apply the appropriate internal script components. In other words, no script was not of an optimal scripting level as there was a lack of affordance (Fischer et al., in press).

Results of the interactions between internal and external collaboration scripts on social and cognitive processes revealed that the adaptable script triggered learners' employment of internal collaboration scripts components that are helpful for interactive processes but impeded their application of internal collaboration scripts components that are dysfunctional for cognitive elaboration (Fischer et al., in press). Through the requirement for adaptation, the adaptable script shifted learners' efforts and their use of internal collaboration scripts away from cognitive aspects toward social aspects. However, the support provided by the adaptable script itself compensated this side-effect, as the adaptable script enhanced the overall quality of cognitive processes for all learners, regardless of their internal collaboration scripts.

5.5.3 *Effects of Collaboration Script on the Pattern of Discussion Threads*

As reported in Sect. 5.4.4 findings from case studies suggested that collaboration scripts not only influenced the quantity of discourses, but also had effect on the pattern of discussions threads.

When learning without script, there was no consistent pattern of discussion threads across groups. Students in the unscripted condition could be seen as guided by their high or low structured internal collaboration scripts (Fischer et al., in press). For example, the 'trained script' group was guided by the internalized collaboration script through their collaborative learning phase.

The non-adaptable script, on the other hand, introduced a consistent structure to online discussions across groups. The structure that the non-adaptable script posed to online discussions is exactly the one predefined by the script. Students in the fixed script condition were guided by the external script provided to them. Although the structure shaped by the external script was to some extent artificial in a way that interactions took place only between analyst and critic, rarely between critics, students did adhere to it.

The adaptable script introduced an obviously different structure to online discussions. When learning with an adaptable script, learners developed a long discussion thread rather than two small ones as did students in the non-adaptable script condition. Moreover, interactions in adaptable script condition took place among all learning partners other than between analyst and critic only, as did students in the non-adaptable script condition. Long discussion threads, in which there are many exchanges of ideas, often characterize sustained online discussions for productive collaboration to occur (Hewitt 2005; Palincsar 1999). It suggested that the adaptable script allowed to a certain extent learners' employment of internal collaboration scripts (Fischer et al., in press) which made their discussions more interactive and more effective.

Fewer messages (28%) were prompted when learning with the adaptable script compared to the non-adaptable script condition (78%), but the quality of collaborative knowledge construction remains the same, if not better (seeing from the quantitative analyses). It indicated firstly that the adaptable script was all and all more effective than was the non-adaptable script to structure collaborative learning and secondly, learners were capable of purposely fade out unnecessary parts of the scripts without losing the benefit from process structuring.

However, due to the exploratory nature of the case studies and the lack of statistic analysis, findings from qualitative analysis only provided information additional to the quantitative process analysis. Explanation of the pattern of discussion threads identified when learning with a specific type of collaboration script requires further systematic and theory-based investigation.

5.5.4 Limitations and Implications

This section discusses the limitations of the reported study before discussing the theoretical and practical implications of the reported findings.

5.5.4.1 Limitations

The present work had some limitations. Firstly, the peer-review script was implemented in a short term directing toward immediate effects on collaborative knowledge construction processes. A more long-term intervention and a delayed post-test would be helpful in understanding the long-term effects of collaboration scripts on collaborative knowledge construction and the transferability of the 'adaptation' skills.

Secondly, the measurement of internal collaboration scripts, which was an open question measuring declarative knowledge rather than a performance test that measures the applicable internal collaboration scripts, might not be optimal, since declarative knowledge may not be the best predictor of the internal collaboration scripts that learners actually applied during collaborative learning.

Thirdly, the current work is by some means an exploratory one on adaptable scripting in CSCL. Although the effects of an adaptable script on collaborative knowledge construction processes were compared to a non-adaptable script and unscripted collaboration, degree of adaptability has not been manipulated. Further studies that vary the degree of adaptability systematically would contribute to answer the question how to design CSCL scripts to provide the optimal scripting level based on individualized needs (Fischer et al., in press).

Furthermore, operationalization of the non-adaptable script and the adaptable script left the possibility that the difference between these two conditions was ignorable. Learners were not forced to use the interaction-oriented prompts when learning with the non-adaptable script (see Sect. 5.4.4, 78% messages were prompted), so that it was also possible for them to 'switch off' the prompts as was it for learners in the adaptable script condition. The difference could have been enlarged by forcing learners to use every single prompt when learning with the non-adaptable script. But our goal was to investigate whether adding adaptability to a script that has been used in practice and proved to be effective would bring about further benefits for scripted collaboration other than to purposely vary the degree of coercion. Future studies that compare adaptable script with a more coercive non-adaptable script than the peer-review script used in the current study would help generalize the effect of adaptability to a more coercive setting or limit it to a setting with a medium degree of coercion, such as the peer-review script in our study.

A further limitation was that the sample size of the reported study was not large (87 students in 29 triads). Although it was acceptable in CSCL research, for example, the study from Demetriadis et al. (2011) had a sample size of 63 (nine dyads and 15 triads), it was not large to perform multilevel modeling, which requires a large sample at both individual (e.g., 10 individuals in each group) and at group level (e.g., 50 groups), statistically (Hox 2010). Moreover, case-based asynchronous online discussion was selected as the learning scenario in our study; it was still unclear whether adding adaptability to scripted collaboration would have the same effects in other CSCL environments, such as synchronous discussion. Therefore, the interpretation of the reported findings should not be over-generalized.

5.5.4.2 Implications

Despite of the aforementioned limitations, the findings of the current study indicated that an adaptable script is a promising approach to realizing flexibility in order to maximize the effectiveness of collaboration scripts in CSCL.

Efforts have been put into realizing flexible scripting in CSCL through adaptivity, for example the use of intelligent tutoring (Diziol et al. 2010) and natural language processing technology (Mu et al., in press). Although the concept 'adaptability' (Leutner 2009) or 'learner control' (Scheiter and Gerjets 2007) has drawn some attention recently in the field of learning with hypermedia, adaptable scripting is quite new a topic in the field of CSCL research. The reported study was rather an exploratory one on adaptable scripting in CSCL. Theories and empirical evidences for the possible advantages of an adaptable script over a non-adaptable one and unscripted collaboration were mainly from other research areas, such as learning with hypermedia (Scheiter and Gerjets 2007). However, results of the reported study were encouraging. The study yielded that it was possible to facilitate collaborative knowledge construction processes in CSCL with an adaptable script. An adaptable script could immediately support students to construct relations between conceptual and problem space (cognitive processes).

The study also showed that an adaptable script influenced students' configuration of internal collaboration scripts. The internal script configuration principle claims that learners' dynamic configuration of internal collaboration script components is influenced by their perceived situational characteristics (Fischer et al., in press). The external script guidance principle states that external collaboration scripts guide learners in collaborative learning situations by inhibiting their automated use or by inducing their application of internal script components (Fischer et al., in press). Following these two principles in the Script Theory of Guidance (Fischer et al., in press), the adaptable script applied in the reported study influenced students' configuration of internal collaboration script components in a way that it inhibited students' employment of internal script components dysfunctional for cognitive processes but induced their application of internal script components beneficial for social processes. A non-adaptable script, on the other hand, inhibited students' application of internal collaboration script components for both cognitive and social processes. The results suggested that adaptable scripts should be carefully designed in order to induce students' application of different internal collaboration script components to fulfil specific instructional goals.

Given that the adaptable script was more effective than the non-adaptable script and unscripted collaboration on collaborative learning processes, the adaptable scripting approach is a practical example of realizing flexibility in scripted CSCL, at least for fostering cognitive processes and students' application of internal scripts for social processes of collaborative knowledge construction. Design of adaptable learning environments or adaptable instructional supports would be of success in other educational practices outside CSCL, for example, formal classrooms, since a learning environment or an instructional approach can be adaptable not only to students but also to teachers (Leutner 2009).

5.5.5 Conclusions

How to make the scripting approach more flexible is an increasingly interesting topic in CSCL (Dillenbourg and Tchounikine 2007; Diziol et al. 2010; Fischer et al., in press).

In the present study, an adaptable script, which means students can adjust the external script based on their perceived needs (Leutner 2009), was implemented to realize flexible scripting in CSCL. Results of the study revealed that an adaptable script was overall advantageous over a non-adaptable script and unscripted collaboration with respect to collaborative knowledge construction processes in case-based asynchronous online discussions. However, to fulfil specific instructional goals, adaptable scripts should be carefully designed because that different internal collaboration script components might be inhibited or induced by an adaptable script (Fischer et al. 2013).

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