THE IMPACT OF ROLE ASSIGNMENT ON KNOWLEDGE CONSTRUCTION IN ASYNCHRONOUS DISCUSSION GROUPS
A Multilevel Analysis

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The present research studied the effect of learning in asynchronous discussion groups on students' levels of knowledge construction. Multilevel analyses were applied to uncover the influence of student, group, and task variables on the one hand and the specific effect of the assignment of roles to group members on the other hand. Results indicate that students' attitudes toward the learning environment and their engagement in the discussion group are significant predictors. As to the effect of role assignment, no significant overall difference in students' mean levels of knowledge construction between the role and no role condition was observed. However additional analyses revealed that (a) the distribution patterns of the levels of knowledge construction differed as students in the role condition more often reached the highest level, and (b) assigning students the role of summarizer resulted in significantly higher levels of knowledge construction.

Keywords: *computer-supported collaborative learning; scripting; higher education; asynchronous discussion group; role assignment*

Computer-supported collaborative learning (CSCL) environments have been argued to foster collaborative knowledge construction (Clark, Weinberger, Jucks, Spitulnik, & Wallace, 2003). Collaboration as such, however, does not systematically produce learning (Dillenbourg, 2002). Research evidence shows that the efficacy of collaborative learning depends on various conditions such as group composition (e.g., size, gender), task features (e.g.,

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task complexity), and individual student characteristics (e.g., learning styles, attitude toward the learning environment; Schellens & Valcke, 2005; Schellens, Van Keer, & Valcke, 2004). These conditions interact with one another in a complex way. Moreover, despite their effect, it must be taken into account that not all of these variables can be manipulated directly while designing CSCL environments. Instead of changing the conditions that indirectly determine the group interactions (e.g., group size, heterogeneity of group members), we especially focus in the present study on variables that can be manipulated to influence students' interactions in a direct way. More specifically, we try to script students' discourse in CSCL environments. This aim corresponds to the suggestion of Dillenbourg (2002), who claims that the application of scripts for collaborative learning can be a technique to affect collaborative learning directly. Collaboration scripts can specify, sequence, and assign collaborative learning activities in online learning environments (Kollar, Fischer, & Hesse, 2003; Weinberger, Reiserer, Ertl, Fischer, Mandl, 2003). More specifically, a script can be defined as a detailed and more explicit didactic contract between the teacher and the group of students regarding their mode of collaboration (Dillenbourg, 2002). In CSCL environments, collaboration scripts are considered to be powerful means to improve processes and outcomes of collaborative learning (Kollar et al., 2003). The concept of script, however, encompasses a very broad range of methods, techniques, and approaches. In this respect, it is difficult to speak about the overall efficacy of CSCL scripts. Each author has his or her own understanding of a CSCL script (Dillenbourg, 2002). The aim of the present study is to analyze the effect of a specific type of collaboration script, namely the assignment of roles to group members in asynchronous discussion groups.

CONTEXT OF THE PRESENT STUDY

The present study was conducted in a naturalistic research setting. The asynchronous discussion groups were a formal compo-

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nent of a seven credit, first year university course, titled Instructional Sciences, that is part of the academic bachelor's curriculum of Pedagogical Sciences at Ghent University. This freshman course introduces students to a large variety of complex theories and conceptual frameworks related to learning and instruction. The innovative redesign of the course has been studied and monitored since the 1999-2000 academic year and focuses on the implementation of social-constructivist principles such as active learning, self-reflection, authentic learning, and collaborative learning (Schellens & Valcke, 2000).

All students taking the course ($N = 286$) participated in the study. The discussion groups were set up in parallel to 12 weekly face-to-face sessions. Participation in the discussion groups was obligatory and evaluated. A total of 25% of the final score for the course was based on the quality of individual student participation in the electronic discussion groups.

THEORETICAL EXPLORATION OF THE VARIABLES INVOLVED

Learning in a CSCL environment can be considered to be a specific type of collaborative learning. It can be argued that research on collaborative learning has moved beyond the question of whether collaborative learning is effective in accelerating knowledge construction to focus on the conditions under which these types of learning environments are optimally effective.

To understand the entire story, we need to consider variables at different levels. Based on the results of previous research where multilevel modeling was used to study the influence of student, group, and task characteristics (Schellens et al., 2004) and on the results of others studies (e.g., Dillenbourg, 2002; Hakkarainen & Palonen, 2003; Weinberger, 2003), the variables to be taken into account in the present study were determined.

Regarding the importance of characteristics of individual students, there is little research evidence about their specific effect in the CSCL field. Variables such as gender, age, and appreciation

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toward the learning environment are rather considered to be background variables. Hakkarainen and Palonen (2003), for example, report about the effect of gender on students' interest in CSCL and how this influences learning outcomes. Other research indicates that learners who are motivated and engaged tend to learn more than those who are not (Bereiter, 1990; Reio & Wiswell, 2000; Sternberg, 1980). Engagement and contributing to the discussion appear to be mutually interrelated: Motivated students are likely to participate more in CSCL environments, which leads to higher levels of knowledge construction (Schellens et al., 2004). Learners generally are more engaged and motivated when the learning mode is compatible with the ways in which they cognitively process information (Sternberg, 1997). Various studies revealed that CSCL could be more effective when learners' personal characteristics and the design of the technology are compatible (e.g., Abramson, 1989; Brown, 1985; Friend & Cole, 1990; Kozma, 1991; Lynch, 1991). Workman (2004) more specifically suggests that design researchers should consider the learning styles of the students and provide fitting learning environments when possible. Schellens and Valcke (2000) also observed that consistency between the requirements of the online learning environment and learning styles is important. They refer to this as the congruency problem in online learning. In the same study, they also pointed to the importance of student satisfaction, which interacts with the effect on knowledge construction. These findings are in line with the results of their subsequent research, where attitudes toward the learning environment appeared to be a strong predictor for the levels of knowledge construction reached through the asynchronous discussion groups (Schellens et al., 2004).

Taking into account the empirical grounds of the aforementioned student characteristics, we will consider the following variables in the theoretical base of the present study: gender, learning styles, attitudes toward the CSCL environment, and engagement in the discussion, which will be operationalized as the individual amount of messages contributed to the discussion group.

In relation to group characteristics, prior research has stressed the importance of fostering intensive group interaction

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(Dillenbourg, Baker, Blaye, & O'Malley, 1995; Schellens et al., 2004; Schellens & Valcke, 2005). Studies more specifically report that an increase of the amount of discourse promotes learning (e.g., Cohen, 1994; Jeong & Chi, 1997; Mäkitalo, Weinberger, Häkkinen, & Fischer, 2004; Roschelle, 1992). Some of these authors also point at the relationship between interaction levels and group size. Group size should not be too large because larger groups do not provide the opportunity for all members to participate in full. On the other hand, when groups are too small, there is not enough interaction to provide a critical amount of exchange of ideas or information to come to higher levels of knowledge construction (Cooper et al., 1990; Johnson, Johnson, & Holubec, 1998; Nurrenbern, 1995; Slavin, 1995). In their meta-analysis of group size effects in electronic brainstorming (EBS), Dennis and Williams (2005) came to the conclusion that group size is indeed a critical factor in determining the effectiveness. As group size increases, the relative benefit of EBS increases. According to them, EBS groups outperform nominal groups when group size reaches 10 people.

In this respect, it is also logical to assume that the number of students depends on the requirements of the collaborative learning task. In the case of asynchronous discussion groups, larger groups with more than 10 students seem more appropriate. In the case of collaborating on a project such as a paper or a Web presentation, smaller group sizes seem more suitable (Kumar, 1996). In addition to level of interaction and group size, the literature also goes into the issue of group composition as a critical characteristic. Research results, however, are less conclusive and come to contradicting results. Some studies emphasize heterogeneous groups (Cooper et al., 1990; Johnson et al., 1998; Nurrenbern, 1995; Slavin, 1995), whereas other studies contradict these research results (Felder, Felder, Mauney, Hamrin, & Dietz, 1995; Rosser, 1997; Sandler, Silverberg, & Hall, 1996).

In the context of the present study, group size will be kept constant (10-12 students per discussion group), and group composition will be randomized, to obtain heterogeneous groups. Intensity

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of the group interaction will be measured and used as an interaction variable.

With regard to task characteristics, recent CSCL research suggests that a clear task structure is needed to foster cognitive processing and academic performance (Dillenbourg, 2002; Roschelle & Pea, 1999; Weinberger, 2003). Dennis, Aronson, Heninger, and Walker (1999) reported the results of an experiment that manipulated both task and time structure. Groups electronically brainstormed on intact tasks or on partitioned tasks. Groups in the partitioned task treatment generated 40% more ideas, but there were no time effects. In the research about transactive memory, the influence of the nature of the task is also put forward as an important variable. Transactive memory research focuses on the shared division of cognitive labor with respect to the encoding, storage, retrieval, and communication of information from different knowledge domains. This shared division is hypothesized to lead to greater efficiency and effectiveness (Wegner, 1987). Building on this hypothesis, Brandon and Hollingshead (2004) introduced the variables of task representation and the task-expertise-person unit as basic constructs in their studies. In related research, Ren (2001) put different kinds of groups in different task environments. His findings indicate that the effect on group performance is dependent on both organizational features and the nature of the task environment. Transactive memory systems seem to be more beneficial for larger groups than for smaller groups, more beneficial for teams than for hierarchical groups, and more beneficial when presented with changing tasks. Other research points to the need to state directions, guidelines, and specific types of expected cognitive processing explicitly to foster high-quality discussions and intended learning outcomes (Cifuentes, Murphy, Segur, & Kodali, 1997; Harasim, Hiltz, Teles, & Turoff, 1998; Palloff & Pratt, 1999; Schellens & Valcke, 2005). Hakkarainen, Lipponen, and Järvelä (2002) also indicate the need to prompt students to articulate their conceptual understanding to promote learning and knowledge building. These prompts are also called collaboration scripts.

As stated above, there is a broad range of approaches that fit the description of collaboration scripts. One of the potential ways of

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imposing structure on learners' collaboration is the use of roles. Roles can be defined as more or less stated functions, duties, or responsibilities that guide individual behavior and regulate intragroup interaction (Hare, 1994). Several approaches developed for cooperative learning adopt roles to support coordination and intragroup interaction (Johnson, Johnson, & Johnson-Holubec, 1992; Kagan, 1994). These roles are either based on differences in individual expertise, the so-called content-based roles, or on individual responsibilities regarding group coordination, the so-called process-based roles.

Roles appear to stimulate group members' awareness of the overall group performance and members' contributions (Strijbos, Martens, Jochems, & Broers, 2004). In addition, according to Aviv (2000), certain roles are required to bridge periods of silence or too-silent participants. Advocates of a more structured learning approach generally assert that assigning roles to group members results in more rapid and more consistent levels of interaction, whereas others contend that less structure stimulates more elaborate and critical dialogue. According to Rose (2002), assigning roles and providing close monitoring of group interaction creates learning advantages in the short term. However small groups may approach similar levels of productive interaction in the long term without the added instructional expense.

In addition to scripting students' interaction by assigning roles, another important task characteristic brought up in the literature is the extent to which the assignments link up with students' zones of proximal development. Illera (2001) states that motivation to work collaboratively on a task and the zone of proximal development are intertwined. Motivation implies that the students are capable of grasping that they can accomplish the activity that is within their zone of proximal development and that it is not something unattainable. He observed that when the task exceeded the abilities of the students, their interest and involvement reduced. Other researchers (e.g., Wynder, 2005) referred to intrinsic motivation and extrinsic motivation as bases for the student task approach and task completion. Intrinsic motivation arises when the task itself is a source of interest, enjoyment, self-expression, and personal challenge

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(Amabile, 1997). Individuals will be intrinsically motivated if the task increases their feelings of competency and self-determination (Deci, Cascio, & Krusell, 1975). These feelings of competence and self-determination will in turn be influenced by task characteristics such as implied skill variety, challenge level, degree of autonomy, and feedback (Hackman & Oldham, 1976). Furthermore individuals are more likely to be motivated when they can identify with their work. Therefore it is important that realistic problems to which students can relate are used. According to Amabile (1988), complex and challenging jobs that enable workers to decide how to carry out tasks are more likely to encourage intrinsic motivation and in turn to increase creativity. This brings us to a second task characteristic: task complexity. This issue has hardly been studied in the context of CSCL. Harper, Squires, and McDougall (2000) indicate that task complexity is necessary to provide authentic learning environments. But they also stress that too much complexity can make learners feel insecure and cause them to lose track of learning objectives. Research has stressed the need to present tasks or assignments that are within zones that match the learners' abilities (Quinn, 1997; Schellens et al., 2004). In the case of the too complex task, students did not engage in the discussion, whereas in the case of the rather simple tasks, students were not interested in discussing the matter.

More research is, however, needed to get a better understanding of the effect of these task characteristics. Therefore the use of roles and task complexity will be considered to be key research variables in the present study.

In the following section, the student, group, and task variables discussed above will be integrated in the theoretical framework of the study. In the report of the research design and the analysis of the results, these three clusters of variables will also form the basis of the discussion.

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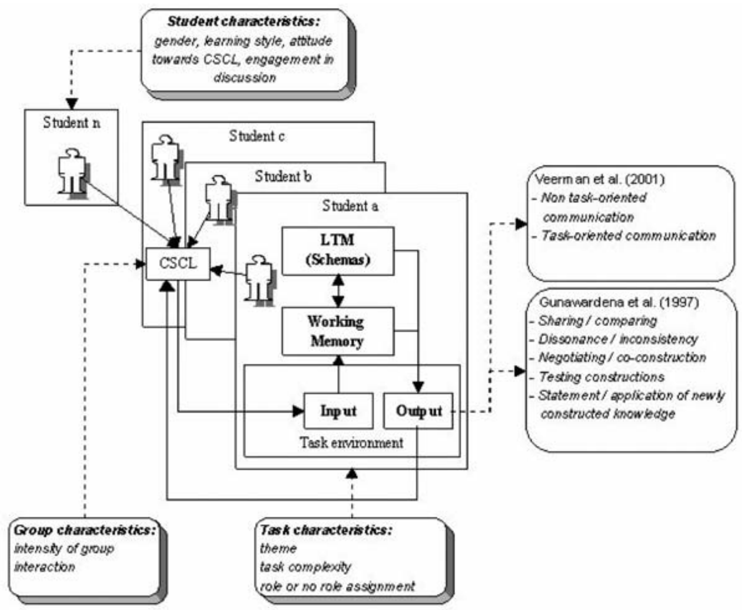

Figure 1: Graphical Representation of the Theoretical Framework

THEORETICAL FRAMEWORK OF THE PRESENT STUDY

Figure 1 presents a graphical representation of the theoretical base for the present study. This is an extension of the approach adopted in previous research (Schellens & Valcke, 2002, in press). It integrates social constructivist principles and concepts derived from the information processing approach to learning (see comparable approaches of Baker, 1996; Doise & Mugny, 1984; Erkens, 1997; Kreijns & Bitter-Rijkema, 2002; Petraglia, 1997; Savery & Duffy, 1996).

The key dependent variable in the theoretical base is students' levels of knowledge construction as reflected in the group discussion contributions. Independent variables are described in the following paragraphs.

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The figure depicts three key substructures: (a) the individual learning process of a student, (b) the task put forward in the CSCL environment, and (c) the collaborative dimension in the CSCL setting. The learning process of an individual student (*student a*) is presented at the center of the figure. Learning is considered to be an information processing activity, building on the assumption that learners engage actively in cognitive processing to construct mental models. In this way, new information is integrated into existing cognitive structures. The active processing assumption invokes three types of processes in and among working and long-term memory: selecting, organizing, and integrating information (Mayer, 2001). The mental models are stored in and retrieved from long-term memory. Because of the importance of individual experiences and existing cognitive structures, characteristics of the individual learner, such as attitude toward the CSCL learning environment, gender, and learning styles are considered to be of importance. Moreover it can be hypothesized that the more students who express their line of thought, the more the construction of mental models is facilitated. Therefore student engagement in the discussion (i.e., the amount of individual contributions) is regarded as relevant.

A second substructure points to the effect of the task put forward in the learning environment and discussed in the CSCL setting. The student assignments in the discussion groups are assumed to trigger the cognitive processes of the individual students. The amount of imposed structure in the discussion, that is discussing with or without roles assigned to the students, and the complexity of the task are considered to influence the nature of the cognitive activities. This results in varying levels of knowledge construction.

Finally, a third substructure refers to the importance of the group in the CSCL setting. An important characteristic in this respect is the intensity of the group interaction. The task is put forward in a collaboration environment. This invokes collaborative learning that builds on the necessity of the learner to organize output that is relevant input for the other learners (*student a* to *student n*). The exchange at input and output level is considered to reflect a richer base for the further cognitive processing at the individual level.

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This assumption is central to the cognitive flexibility theory of Spiro, Feltovich, Jacobson, and Coulson (1988). The more exchange at the input and output levels, the more knowledge construction can be realized. The output is a central element in the theoretical base of the present study. The asynchronous nature of the discussion environment forces the learner to communicate the output in an explicit way. All the written communication in the CSCL environment is therefore considered relevant. The student output mirrors the cognitive processing activities. Individual processing is slowed down by the complex nature of the tasks because learners have to cope with selection, organization, and integration processes. As a consequence, learners experience the limited capacity of their working memory (Mayer, 2001), also referred to as cognitive load (Sweller, 1988, 1994). However learners in a collaborative setting can profit from the processing effort of other group members. The output of each individual student is organized because it is derived from his or her own mental models. Therefore it is assumed that this output is more easily accessible to other learners in the collaborative setting. Because the output of other learners is organized, students are expected to experience lower levels of cognitive load when using this output as input for their own individual cognitive processing. This subsequent output is expected to be of better quality, thus reflecting a higher level of knowledge construction. In the present study, we build on the work of Gunawardena, Lowe, and Anderson (1997) to identify students' levels of knowledge construction. This analysis and coding system will be used to analyze the transcripts of the written communication and to determine students' individual levels of knowledge construction. At a more basic level, the coding will also identify whether the discussion input is task oriented or not task oriented. This distinction is derived from the work of Veerman and Veldhuis-Diermanse (2001). Task-oriented communication input can be coded further following the levels of knowledge construction as distinguished by Gunawardena and her colleagues (1997). Non-task-oriented communication can be focused on (a) planning: "Is it OK to discuss the arguments first?"; (b) technical aspects: "How can we get rid of the

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delete button on the screen?"; (c) social interaction: "Good job!"; and (d) nonsense: "Who joins in to go to the movies?"

According to the theoretical framework, learners construct knowledge by active participation in discussing and sharing knowledge with their peers when working in small groups. Students actively engage in learning processes when working jointly on a learning task by mutually explaining the learning contents, giving feedback to other group members, asking and answering questions, and so on (Weinberger, 2003). However some groups encounter difficulties when engaging in activities of collaborative knowledge construction. Numerous studies indicate that the desired effects often fail to emerge. Research for instance indicates that not all group members are actively engaged in the discussions (Salomon & Globerson, 1989) or that the content of the group discussions remains superficial (Coleman, 1995; Linn & Burbules, 1993). Reasons for these deficits can result from characteristics of the individual students or from characteristics of the group but can also be because of the unique character of the task. The focus in the present research will be especially on the task characteristics and more specifically on the effect of task complexity and the use of roles. Considering the theoretical framework, student and group characteristics will also be taken into account in the analyses because we suppose they interact with one another and influence the dependent variable, level of knowledge construction.

METHOD

RESEARCH DESIGN AND PARTICIPANTS

All students ($N = 286$) enrolled for the course Instructional Sciences were randomly assigned to a discussion group ($n = 23$). Each group consisted of about 12 students. Approximately 7% of the freshmen were male students. The largest part of the students (82.90%) just finished secondary education; only 17.10% already had preliminary training.

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An experimental design was adopted, with the entire first year student population being randomly assigned to the discussion groups. More specifically, two research conditions can be distinguished: Students in the discussion groups did or did not receive role assignments. Informed consent was obtained from all students.

PROCEDURE

After a trial discussion session of 3 weeks, students participated in four consecutive discussion themes. The entire treatment lasted 4 months. Within the 3-week time frame, students were flexible as to the time and place to work on the discussion assignments. After 3 weeks, student no longer had access to the particular theme, and a new discussion theme was presented.

During the first face-to-face session of the semester, the objectives of participation in the discussion were communicated to the students: active processing of the new domain knowledge, presented during the weekly face-to-face working sessions, and application of this knowledge while solving an authentic case in the asynchronous discussion groups. At the same time, a demonstration of the CSCL environment was given. A number of strict rules that defined the nature of expected student participation in the discussion groups were stated. First, participation in the discussion groups was a formal part of the curriculum. Participation was scored and represented 25% of the final score. Second, successful participation implied that each student posted at least one primary reaction to solve the case, making active use of the resources in the course reader. Each student was expected to reply several times to the work of another student, again with arguments and based on the available resources. Third, the instructor followed the ongoing discussions and limited his or her interventions to giving structural feedback (scaffolding).

At the start and the end of the course, a number of instruments were presented to the students. In this way, data with regard to the students' ages, genders, and education levels were gathered. During the first administration, a special section was added to measure students' attitudes toward the task-based learning environment and

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their attitudes toward participation in the discussion groups. Furthermore the Approaches and Study Skills Inventory for Students (ASSIST) was presented to gather information about students' learning styles (Entwistle, Tait, & McCune, 2000). Reported reliability for the ASSIST is high, with Cronbach's α between .80 and .87.

The information about the group characteristic, intensity of interaction, was derived from the analysis of the contributions to the discussion groups. The task characteristic, task complexity, will be explained when describing the discussion themes.

TASK ENVIRONMENT: THE DISCUSSION THEMES AND TASKS

Students worked together in the discussion groups by applying the theoretical concepts of the course to solve problems that were presented in the online environment. These problems were in line with the constructivist principles and based on real-life, authentic situations. For a more detailed description of the kinds of discussion assignments, see the research of Schellens and colleagues (2004).

Task complexity was determined for each task in the discussion groups. The degree of complexity of the tasks showed a strong upward trend in the second and third assignment, whereas the fourth assignment was again less complex. In the initial discussion tasks, students only had to deal with a limited number of questions. Moreover the assignments were supported with all the necessary information (clustered on the same Web page), documented with the conceptual base, and a solution procedure was suggested in the learning environment. The third and fourth tasks were more complex: The conceptual base was not completely available or clear, additional information had to be looked up using different sources, and the solution procedure was not completely made available. A lot of information was given in English (a foreign language for these students), and supplementary questions had to be answered. The fourth assignment, with regard to the theme of evaluation, was less abstract because students were asked to evaluate their learning

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processes in the discussion groups while applying the theoretical framework that was discussed in the face-to-face working sessions.

The nature of the discussion assignments was the same for all 23 discussion groups in the research regardless of the research condition the groups were in: The same learning goals, contexts, inquiry expectations, time requirements, and deliverables were put forward. The experimental treatment was based on whether roles had been assigned or not. Students in 15 of the 23 discussion groups were assigned specific roles. Four different roles were distinguished: moderator, theoretician, summarizer, and source searcher. These roles were randomly assigned to four students in each group. At the start of every new discussion assignment, the roles were assigned to four other students within the same group. This is in line with a collaboration script proposed and tested by O'Donnell and Dansereau (1992).

The moderator closely monitored the discussions in the online environment (every 2 or 3 days) and interjected praise, offered advice, answered questions, and posed critical questions. This student stimulated active group participation. The theoretician had to make sure that all appropriate theories were considered when tackling the task and had to indicate which aspects, relevant theoretical knowledge, or information was lacking. The summarizer summarized the contributions and initial solutions of the students in the discussion groups. This student had to indicate the different points of view and had to try to make some provisional conclusions. The source searcher looked for additional sources and further information so that students were prompted to look further than the content of the available course reader.

HYPOTHESES

The present research aims to observe the differential effects of assigning discussion roles to students on their levels of knowledge construction. In addition, the effects of variables at the student, group, and task levels are studied. Building on the theoretical and empirical base presented above, the following hypotheses are put forward in relation to the research questions.

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Effect of Student Characteristics

- More intensive and active participation in the discussion groups will be positively related to students' levels of knowledge construction.
- Students with positive attitudes toward the online learning environment will reach significantly higher levels of knowledge construction.
- Students with deep or strategic learning styles will obtain significantly higher levels of knowledge construction.

Effect of Group Characteristics

- Being part of a group with intensive discussion activity will lead to significantly higher individual levels of knowledge construction.

Effect of Task Characteristics

- The complexity of the task will have a significant effect on the level of knowledge construction.
- Working in the role condition will have a significantly positive effect on students' levels of knowledge construction.

ANALYSIS OF THE TRANSCRIPTS OF THE DISCUSSION GROUPS

The transcripts of the output of 286 students for four different themes represent a very large amount of research data. Therefore the transcripts of eight groups were randomly selected from the larger data set. For each of the eight groups, the complete communication submitted in relation to the four discussion themes was used for analysis purposes.

CHOICE OF CODING SCHEME

In prior research (Schellens & Valcke, 2002), a cross-validation of previously developed coding schemes by Gunawardena and colleagues (1997) and Veerman and Veldhuis-Diermanse (2001) was conducted. The interrelations between both typologies were clear.

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We presently opted for the coding scheme of Gunawardena and colleagues (1997) because this scheme goes beyond the coding scheme of Veerman and Veldhuis-Diermanse (2001) and is better suited to discriminate among the more advanced levels of knowledge construction. As already stated in the theoretical framework, we retain from the model of Veerman and Veldhuis-Diermanse (2001) the distinction between task-oriented and non-task-oriented communication.

The content analysis scheme of Gunawardena and colleagues (1997) was developed following a grounded theory approach. It proposes a typology to evaluate knowledge construction through social negotiation. The authors developed an interaction analysis model that discriminates among five phases in the negotiation process during a learning process. Every phase corresponds to a typical level of knowledge construction. In the long run, every learner is expected to reach the highest phases in the negotiation process, thus reaching the highest level of knowledge construction:

Phase 1—Sharing or Comparing Information

In this phase, typical cognitive processes are observation, agreement, corroboration, clarification, and definition.

Phase 2—Dissonance or Inconsistency

In this phase, cognitive processes focus on identifying and stating, asking and clarifying, and restating and supporting information.

Phase 3—Negotiating What is to be Agreed (and Where Conflicts Exists) or Co-Construction

This type of message is about proposing new co-constructions that encompass the negotiated resolution of the differences.

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Phase 4—Testing Tentative Constructions

The newly constructed statements or ideas may then be tested and matched again to personal understandings and other resources (such as the literature).

Phase 5—Statement or Application of Newly Constructed Knowledge

This is about final revision and sharing again the new ideas that have been constructed by the group.

THE UNIT OF ANALYSIS

The input of students to a discussion can be short or long, elaborate, or multidimensional or focused on a single issue. As a consequence, content analysis presents researchers with a very critical issue related to the question about the unit of analysis (De Wever, Schellens, Valcke, & Van Keer, in press). The identification of a unit has to be done reliably and must exhaustively and exclusively encompass the sought-after construct (Rourke, Anderson, Garrison, & Archer, 2001). The most commonly used units of analysis are the sentence unit, the paragraph unit, the message unit, the thematic unit, and the illocutionary unit. All of these have benefits but also disadvantages.

In the present research, the complete message was used as the unit of analysis. According to Rourke and colleagues (2001), this choice presents some advantages. First, it is objectively identifiable: Multiple coders can agree consistently on the total number of units. Second, it produces a manageable, controllable set of cases. In the case of the present study, for example, we recorded a total of 1,933 messages, a total that would have been much larger if the messages had been split up into smaller units. The third advantage is the fact that we are dealing with a unit whose parameters were determined by the author of the message.

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CODING OF THE MESSAGES IN THE TRANSCRIPTS

Three coders coded each unit of analysis independently. Quality control of the coding implied the calculation of the level of reliability in the coding. A common method to determine interrater reliability is to calculate the percent agreement statistic (Holsti, 1969). Some methodologists find this method inadequate because it does not account for change agreement among raters (Capozzoli, McSweeney, & Sinha, 1999; Krippendorff, 1980). Other statistics used are chance-corrected measures of interrater reliability such as Cohen's kappa. However these statistics are been criticized as too conservative and too restraining to the researcher.

In the present research, we tried to establish interrater reliability using the following method. Three independent researchers carried out the coding task. Atlas-Ti was used as the coding tool. The researchers received training in the use of the package and had plenty of time to exercise with the tool. Training was provided to all coders and included (a) full explanations of the conceptual framework and coding process, (b) copies of coding rules and guidelines, (c) examples and nonexamples, and (d) practice with sample data. Group discussion helped researchers to get acquainted with the particularities of the coding scheme and to reach mutual agreement about the coding category to be selected.

After the coding of each complete transcript of a discussion by the individual coders, the quality of the coding was assessed by determining percent agreement measures. A value of .70 was put forward as a criterion for interrater reliability. The initial value was .85. After negotiations, percent agreement was .91. To check whether it was not always the same researcher changing the coding category, percent agreement was also calculated for each individual researcher. The latter represents the agreement between the first and second coding of a unit of analysis. Intrarater reliability always exceeded .70.

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RESULTS

TESTING THE HYPOTHESES

To test the hypotheses regarding the effect on students' levels of knowledge construction, students' mean level of knowledge construction per discussion theme was used as the dependent variable.

Considering that in the present research individual students are nested within a smaller number of discussion groups, the focus of our study, that is students' intragroup collaboration, displays a clear hierarchical structure. Observations of individual students within a group are not completely independent because of the shared group history and the experiences students share during the discussions (Hox, 1994). As a consequence, the assumption of independency for using the traditional ordinary least squares regression analysis or analysis of variance is violated. For this reason, multilevel modeling was used to test the hypotheses because this technique takes the interdependency in groups explicitly in account (Bryk & Raudenbush, 1992; Hox & Kreft, 1994). More specifically, the software MlwiN (Rasbash et al., 1999) for multilevel analysis was used to analyze the data.

As multilevel models are very useful for analyzing repeated measures (Snijders & Bosker, 1999), a special kind of hierarchical modeling was defined with regard to the levels of knowledge construction data collected during the four consecutive discussion themes: measurement occasion (discussion theme 1-4) nested within students. In this way, a three-level structure arose: measurement occasions (level 1) are clustered within students (level 2), that are nested within discussion groups (level 3).

To test the hypotheses, a two-step procedure was followed. The first step in the analysis consisted of the estimation of three-level unconditional null models that partitioned the variance of the dependent variables into between groups, between students, and between discussion theme components. The second step involved entering potential explanatory variables at the group and student levels based on the theoretical framework and the hypotheses put forward. Continuous independent variables were grand mean cen-

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tered to facilitate the interpretation of the intercept. More particularly, student characteristics such as gender, learning style, attitude toward the learning environment, and the amount of messages contributed to the discussions were added to the model. With respect to group-level characteristics, the intensity of interaction, which is the amount of original contributions and reactions to the discussion per group, was included. As to the task characteristics, task complexity and the specific experimental treatment of the discussion group (role vs. no role assignment) were added. In the case of the role condition, the type of role was also specified and included in the model. Initially, all predictors were included in the models as fixed effects. Afterward, the assumption of a fixed linear trend was verified by allowing the coefficients to vary at random. Table 1 presents the results of the best fitting and some intermediate models using the iterative generalized least squares (IGLS) estimation procedure.

MEAN LEVEL OF KNOWLEDGE CONSTRUCTION PER DISCUSSION THEME

The first step in the analysis was to examine the results of a fully unconditional, three-level null model (Model 0). The intercept of 1.95 in this model simply represents the overall mean of the level of knowledge construction according to the five-level coding scheme of Gunawardena and colleagues (1997). This initial analysis involves the estimation of the total variance of the dependent variable, namely 0.55, which is the sum of the level 1, level 2, and level 3 variance components. As can be inferred from Model 0, the overall variability in the mean level of knowledge construction per discussion theme can be attributed for the most part (96.20%) to discussion theme-level factors (differences among the four assignments) and to differences among students within the groups (3.26%) and group-level factors (differences among the groups; 0.54%). This is already an important result, implying that the differences among the diverse groups and students are much smaller than the differences in individual students' levels of knowledge construction among the different assignments. This entails that the

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TABLE 1: Summary of the Model Estimates for the Three-Level Analyses of Students' Levels of Knowledge Construction

	Model									
	Model 0		*Model 1*		*Model 2*		*Model 3*		*Model 4*	
Parameter	M	SE	M	SE	M	SE	M	SE	M	SE
Fixed										
Intercept	1.95	0.05	2.21	0.08	2.18	0.07	2.17	0.01	2.19	0.08
Theme 2			–0.34	0.10	–0.36	0.09	–0.36	0.09	–0.41	0.08
Theme 3			–0.38	0.10	–0.41	0.09	–0.41	0.09	–0.40	0.08
Theme 4			–0.31	0.10	–0.21	0.09	–0.21	0.09	–0.25	0.08
Amount of messages					0.06	0.02	0.06	0.02	0.05	0.01
Attitude toward learning environment					0.03	0.01	0.03	0.01	0.02	0.01
Role condition							0.02	0.08		
No role assignment in role condition									–0.02	0.07
Moderator									–0.25	0.12
Theoreticus									–0.16	0.13
Source searcher									–0.67	0.14
Summarizer									1.08	0.13
Random										
Level 3										
$\sigma^2_{\nu}0$	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.01
Level 2										
$\sigma^2_{\mu}0$	0.02	0.03	0.02	0.03	0.04	0.02	0.04	0.02	0.02	0.02
Level 1										
$\sigma^2_{\varepsilon}0$	0.53	0.05	0.50	0.04	0.35	0.04	0.35	0.04	0.25	0.03
$\sigma_{\varepsilon}0\varepsilon$appr.					0.04	0.01	0.04	0.01	0.02	0.00
σ^2_{ε}appr.					0.01	0.00	0.01	0.00	0.00	0.00
Deviance	838.52		821.98		591.25		591.21		487.08	

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features of the assignment will be of central importance in the further analysis.

To gain a clear insight into the development of students' levels of knowledge construction from discussion theme 1 to theme 4, the measurement occasions were added to the fixed part of the model (Model 1). Therefore three dummies were created with themes 2, 3, and 4 contrasted against the first discussion assignment. As can be seen in Table 1, a significant change in levels of knowledge construction could be determined for the second ($\chi^2 = 11.06$, $df = 1$, $p = .000$), the third ($\chi^2 = 13.26$, $df = 1$, $p = .000$), and the fourth ($\chi^2 = 8.78$, $df = 1$, $p = .003$) themes. For these discussion assignments, a significant decrease in students' mean levels of knowledge construction is observed, compared to the first assignment.

As a next step in the analyses, explanatory variables were included in the model. In Model 2, it can be seen that with regard to student characteristics, the number of contributions ($\chi^2 = 14.61$, $df = 1$, $p = .000$) and students' attitudes toward the learning environment ($\chi^2 = 5.39$, $df = 1$, $p = .000$) have a significant positive effect on students' mean level of knowledge construction per discussion theme. By allowing the coefficient of the mean level of attitude toward the learning environment to vary randomly, significant complex variance at theme level was noticed. More specifically, the quadratic variance function indicates that the variance among themes within students in level of knowledge construction increases when students' mean level of attitude toward the learning environment increases. Learning styles do not seem to be a significant predictor. Having a deep ($\chi^2 = 2.67$, $df = 1$, $p = .102$) or strategic ($\chi^2 = 0.11$, $df = 1$, $p = .745$) learning style does not result in a significant difference in level of knowledge construction. At the level of group characteristics, no significant effect was found for group interaction intensity. Compared to groups with low discussion activity, there was no significant effect for both groups with high ($\chi^2 = 0.59$, $df = 1$, $p = .442$) and average ($\chi^2 = 1.17$, $df = 1$, $p = .280$) discussion activity. Taking into account that only 0.54% of the overall variance could be attributed to group differences, this is not a surprising result.

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As for the variables regarding to task characteristics, task complexity was included in the model. We already referred to the importance of this variable when we observed significant differences among individual students' mean level of knowledge construction per theme. By including the task complexity variable, we examined whether the significant differences in students' levels of knowledge construction over the four discussion themes were still observed. After including the variable task complexity in the model, significant differences among the themes were no longer observed. Based on this finding, we can state that the increasing degree of complexity of the theme assignments was at the base of the significant decrease in students' levels of knowledge construction as compared to the first assignment. This corroborates the fact that characteristics of the assignment are of key importance to foster knowledge construction.

Next to task complexity, the key research variable in the present study, role assignment, was added to the fixed part of the model, represented by one dummy (with roles) contrasted against the reference category (without roles; Model 3). As can be seen in Table 1, assignment of roles had no overall significant effect on individual students' levels of knowledge construction ($\chi^2 = 0.02$, $df = 1$, $p = .899$). Students working in a group without roles acquired a comparable level of knowledge construction as did students working in groups with role assignments.

In a following step, role type was included in the model, taking into account that different roles were assigned: moderator, theoretician, source searcher, and summarizer. Five dummies were created with the four roles, and having no roles in a group with roles contrasted against the reference group (student in a group without role assignment; Model 4). This analysis reveals that there was no significant effect of not having to perform a role in a group with roles ($\chi^2 = 0.05$, $df = 1$, $p = .821$) and no effect for having taken up the role of theoretician ($\chi^2 = 1.37$, $df = 1$, $p = .242$). These students did not differ in their levels of knowledge construction as compared to students in a group without role assignment. However there was a significant negative effect for students being assigned the role of source searcher ($\chi^2 = 24.90$, $df = 1$, $p = .000$) and moderator ($\chi^2 =$

4.14, *df* = 1, *p* = .042). Those students obtained a significant lower level of knowledge construction. As compared to students in the groups without role structuring, only students who performed the role of summarizer reached a significantly higher mean level of knowledge construction (χ^2 = 73.98, *df* = 1, *p* = .000), with a large effect size of 1.46 standard deviation.

In summary, it can be concluded that both student and task characteristics significantly influence students' mean level of knowledge construction. At the student level, higher individual numbers of postings and a positive attitude toward the learning environment result in higher mean levels of knowledge construction. At the task level, especially the complexity of the assignments affects students' mean level of knowledge construction per theme. In particular, it appears that the reported significant decrease in mean levels of knowledge construction from the first to the subsequent themes disappears when correcting for task complexity. Structuring the task by assigning roles to students does not have an overall significant effect on the mean level of knowledge construction. Students who were asked to take up the role of theoretician or moderator did not score differently as compared to students who worked in groups without role structuring. Students who were assigned the role of source searcher or moderator scored significantly lower. However students who had to summarize the discussion at various moments obtained significantly higher mean levels of knowledge construction. Finally, as to the effect of group level variables, the research findings revealed no significant effect of the intensity of the group's interaction on students' mean level of knowledge construction.

ELABORATION OF THE AFOREMENTIONED RESULTS WITH REGARD TO THE EFFECT OF A PRESCRIBED FUNCTIONAL ROLE INSTRUCTION, AS COMPARED TO NO ROLES, ON STUDENTS' LEVELS OF KNOWLEDGE CONSTRUCTION

To unravel the discourse taking place in the different research conditions, additional analyses were carried out to take a closer look at the differences in the discourse between the discussion groups with and without roles assignment. More specifically, we focused on the following questions:

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- Is there a difference in the proportion of task-oriented versus non-task-oriented communication under the two research conditions?
- Is there a difference in the distribution of the different levels of knowledge construction under the two conditions?
- Are there differences with regard to the changes in students' levels of knowledge construction over time for the different conditions?

Chi-square analyses were used to explore potential differences in the distributions within the research conditions. Mann-Whitney *U* tests were used to test for differences between the role and no role conditions.

Is There a Difference in the Proportion of Task-Oriented Versus Non-Task-Oriented Communication Under the Two Conditions?

As can be derived from Table 2, it is clear that the amount of task-oriented messages far outweigh the amount of non-task-oriented messages in both the role ($\chi^2 = 992.88$, $df = 1$, $p = .000$) and no role ($\chi^2 = 341.88$, $df = 1$, $p = .000$) conditions. By comparing both conditions using Mann-Whitney *U* tests, we noticed no significant difference ($Z = -1.45$, $df = 1$, $p = .148$).

TABLE 2 ABOUT HERE

Is There a Difference in the Distribution of the Different Levels of Knowledge Construction Under the Two Conditions?

To explore the differences between the two research conditions, we first analyzed whether the amount of messages in the five levels of communication are equally distributed in both conditions. Analysis of the descriptive data in Table 2 already suggests that no equal distributions are observed for both conditions. This is confirmed by the chi-square analysis for both the role ($\chi^2 = 1397.24$, $df = 4$, $p = .000$) and no role ($\chi^2 = 470.29$, $df = 4$, $p = .000$) conditions. More specifically, in both conditions, level 1 and level 3 communication types were observed to a significantly higher extent, whereas levels 4 and 5 have hardly been observed.

If we compare both research conditions using the Mann-Whitney *U* test, no significant differences can be noticed for the mean

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TABLE 2: Percentages of Students' Task-Oriented and Non-Task-Oriented Communication and Levels of Knowledge Construction

	Theme 1 %	*Theme 2* %	*Theme 3* %	*Theme 4* %	*All Themes* %
Veerman and Veldhuis-Diermanse (2001)					
Role condition					
Task oriented	79.6	74.6	70.8	58.7	71.2
Task oriented and non-task oriented	16.9	15.5	24.0	33.1	22.0
Non-task oriented	3.5	9.9	5.3	8.2	6.8
No role condition					
Task oriented	71.0	75.4	73.3	69.6	72.4
Task oriented and non-task oriented	26.0	22.1	16.5	29.6	23.5
Non-task oriented	3.0	2.5	10.3	0.8	4.1
Gunawardena, Lowe, and Anderson (1997)					
Role condition					
Level 1	40.8	59.0	58.8	56.9	52.9
Level 2	10.1	6.6	4.5	3.2	6.1
Level 3	35.3	27.0	29.5	29.8	29.8
Level 4	6.6	2.3	0.6	2.1	2.8
Level 5	7.1	5.1	6.7	8.0	6.5
No role condition					
Level 1	38.0	55.4	58.6	48.8	50.6
Level 2	15.0	8.3	6.0	0.8	7.1
Level 3	35.0	30.6	34.5	48.8	37.4
Level 4	9.0	5.8	0.9	1.6	4.1
Level 5	3.0	0.8	0.0	0.0	0.6

levels of knowledge construction reached under both conditions ($Z = -0.23$, $df = 4$, $p = .82$), although it appears that the distribution of proportions over the five levels is not quite similar ($\chi^2 = 572.64$, $df = 4$, $p = .000$). Correspondence analysis revealed that the differences are mainly found in the three higher levels and more especially in the highest level of knowledge construction. In the role condition, students more often reached the highest level of knowledge construction, which was, however, at the expense of messages in levels 3 and 4. No significant differences were found with regard to the percentage of messages situated in levels 1 and 2. In summary, the findings indicate that, regardless of the research condition, numerous contributions were situated at the lower levels of knowledge construction.

Are There Differences in the Changes Over Time for Both Conditions?

This component questions whether significant differences can be observed between the first and last discussion as to the proportions of communication reflecting higher levels of knowledge construction. The results in Table 2 suggest a change over time. Findings more specifically reflect a certain decrease in communication reflecting higher levels of knowledge construction for both conditions.

In the role condition, there is an increase of level 1 knowledge construction that was at the expense of a decrease in messages situated at levels 2 to 4. However there is an increase in level 5 knowledge construction. This change in proportions is significant (χ^2 = 51.18, *df* = 4, *p* = .000). Correspondence analysis indicated that the changes in proportions of levels 3 and 5 were not significant. However there are significant proportion changes for levels 1, 2, and 4.

In the no role condition, a different picture arose. There were shifts in the distribution of proportions, but these were not similar to the changes in the role condition. Level 1 communication increased over the discussion themes, whereas there was a decrease in the amount of messages situated at level 2. Clearly different as compared to the role condition was the fact that the communication situated at level 3 increased, whereas there was a complete drop of messages in level 4 and level 5. This overall change in proportions is significant (χ^2 = 36.52, *df* = 4, *p* = .000). Correspondence analysis showed that the most significant distribution changes were situated at levels 2 to 4.

In conclusion, it can be argued that there is a change in students' levels of knowledge construction over time. However the changes are different in both research conditions.

DISCUSSION

In this section, we put the aforementioned results in a broader perspective to explain particularities and compare the present results with the findings of other studies.

With regard to freshmen students' levels of knowledge construction, the present study analyzed the effects of student, group, and task characteristics. The results indicate that a large part of the overall variance in students' levels of knowledge construction is mainly to be attributed to differences among the various discussion themes and tasks.

As to the effect of student characteristics, the amount of individual contributions and students' attitudes toward the online learning environment are significant predictors of students' mean level of knowledge construction. Accordingly it can be concluded that the first two hypotheses concerning the effect of student characteristics are confirmed. More intensive and active individual engagement in the discussion groups is positively related to students' achieved levels of knowledge construction. In addition, a comparable positive relationship is found with regard to students adopting a positive attitude toward the online learning environment. However the third hypothesis concerning the effect of students' learning styles on their levels of knowledge construction in the discussion groups has to be rejected. Students with deep or strategic learning styles did not obtain significantly higher levels of knowledge construction as compared to students with surface approaches. These findings are completely in line with the findings of previous research (Schellens et al., 2004).

Contrary to the results with regard to the influence of student characteristics, the hypothesis regarding the effect of group characteristics could not be corroborated. Students in groups with a lively discussion did not discuss or perform at a qualitatively higher level. This is conflicting with the results of previous research, where we pointed at the importance of stimulating interaction in the discussion groups (Schellens et al., 2004). Possibly the present results can

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be explained by the fact that, compared to the prior study, far less divergence in interaction activity among the discussion groups could be observed. This probably relates to the fact that, based on these previous results, a few rules were changed concerning the minimum requirements with regard to participating in the discussion groups. Students now were expected to contribute more messages to the discussion groups to get a higher score. As a consequence, no significant differences among the groups could be detected as to their interaction activity. The combination of the findings with regard to the effects of both student and group characteristics makes us aware of the fact that just forcing students to contribute more to discussion groups to reach a higher effect is not the same as stimulating students to thoroughly discuss and inviting them to contribute frequently. The fact that a positive attitude toward the learning environment did have a positive effect illustrates that students can be good learners if they want to learn (Westrom, 2001). In line with other researchers (Jones, 1998; Quinn, 1997), this author stresses that learning should be an enjoyable activity. Instead of using a reward system, he suggests to foster engagement in students' learning activities. There are a number of recognized strategies, including achievable goals, authentic learning, and tasks set at the appropriate complexity level, to be considered in future research that are consistent with constructivist approaches to learning and instruction to foster engagement in an online learning environment.

As to the effect of task characteristics, significant differences among the consecutive themes were found. The importance of task instruction is recognized as an important issue in earlier research on collaborative learning (Barab & Duffy, 2000; Choi & Hannifin, 1995). The present results showed a significant decrease in mean levels of knowledge construction. Further analysis, however, illustrated that this significant decrease disappeared when correcting for task complexity. This finding points at the importance of the task design and task solution support. When the tasks were too complex, the levels of knowledge construction were significantly lower. On the other hand, when the tasks are too straightforward, we might expect that students hardly experience a challenge, and as a consequence the number and the quality of the contributions might also drop. Harper et al. (2000) mention in this respect that although complexity may be necessary to provide authentic learning environments, too much complexity can make learners feel insecure and lose track of learning objectives. In previous research, we already emphasized the relevance of presenting an assignment within a zone that matches the learner's ability (Quinn, 1997; Schellens et al., 2004). Illera (2001) associates this to motivation and states that motivation also implies that the students are capable of seeing that they can realize the activity that is within their zone of proximal development and that it is not something unattainable. Intrinsic motivation is defined as

> the motivation to engage in an activity primarily for its own sake, because the individual perceives the activity as interesting, involving, satisfying, or personally challenging; it is marked by a focus on the challenge and the enjoyment of the work itself. (Collins & Amabile, 1999, p. 298)

It appears that challenge is an important concept in this context. The learning challenge should be balanced to keep it within a zone that matches the learner's ability (Quinn, 1997). Czikszentmihalyi (1990) refers in this respect to the flow state, expanding on the challenge concept. The challenge level needs to be matched to the available knowledge and skills of students. In all cases, Beatty and Nunan (2004) state that it is the perception of the learner that defines the challenge, its difficulty, and the balance of motivation necessary to address it. Individual learners' perceptions of challenges to learning or doing a task influence their degree of collaboration. According to James, Lederman Gerard, and Vagt-Traore (2004), a challenge tests one's abilities to resolve a problem and in it's very nature is interesting and motivating. Next to a challenging and motivating task, it is also important to design tasks that leave enough scope for discussion. More specifically, Amabile (1998) argues that "freedom about process also allows people to approach problems in ways that make the most of their expertise and creative-thinking skills" (p. 82). The freedom for students to define their own problems to be solved, rather than a teacher presenting

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the students with rigidly designed problems, is maybe the most creative phase in the work.

To keep the learning in the zone of proximal development, we point to the importance of structuring the assignments in CSCL environments. Other research also emphasizes the relevance of task structuring (De Wever, Valcke, Van Winckel, & Kerkhof, 2002; Lockhorst, Admiraal, Pilot, & Veen, 2002; Strijbos et al., 2004) and more specifically points at the significance of assigning roles (e.g., Weinberger, 2003). However in the present study, structuring the task by assigning roles to students did not reveal an overall positive effect on students' mean levels of knowledge construction. These results are not in line with the results of other research. Weinberger (2003) observed that cooperation scripts proved to substantially affect positive learning outcomes. Mäkitalo and colleagues (2004) pointed at the possibility of decreasing the uncertainty level by using roles and therefore stimulating more discourse because low uncertainty levels increase the amount of discourse, which also might promote learning (e.g., Cohen, 1994; Jeong & Chi, 1997; Roschelle, 1992), and observed that the scripted uncertainty reducing condition indeed lead to better learning outcomes. Strijbos and colleagues (2004) mentioned that functional roles appear to increase students' awareness of group interaction and collaboration. However we should take into account that these abovementioned types of scripting are not directly comparable with the role assignment that was applied in the present study. Moreover the dependent variable studied in these studies was different, which makes comparison of research outcomes difficult.

Despite the fact that in the present research students' mean level of knowledge construction in discussion groups in the role and no role conditions did not differ, additional analyses revealed some potentially interesting results. As to the differences in the proportion of task versus non-task-oriented messages, no significant differences were observed between the role and no role condition. This is not in line with other research (Strijbos et al., 2004), where students in the role condition contributed more task content focused statements. However we have to put the present findings in perspective by mentioning that important parts of these messages

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were inherent to the specific role description (e.g., encouraging, planning, etc.).

As stated above regarding the levels of knowledge construction, the overall picture does not reflect significant differences. At the end of the experimental treatment period, the mean levels reached did not differ in both conditions. We noticed, however, that the distribution pattern of the levels was no longer similar. In the role condition, students more often reached the highest level of knowledge construction, although this was at the expense of messages on level 3 and level 4. There were no significant differences for the proportion of messages that could be situated in levels 1 and 2. In this respect, the question arises whether students need a certain foundation of level 1 messages (exchanging information) before they can move forward to the higher levels of knowledge construction. Based on the findings, it can be concluded that even though students' mean level of knowledge construction in both conditions did not differ, the application of roles does seem to have an effect on the interaction in the discussion groups. The findings reveal that students in the role condition more often reach the highest levels but apparently still need a certain amount of low level postings as a starting point to ground the rest of the discussion.

Apart from the fact that being part of a role-based group did not have an effect on students' mean levels of knowledge construction, we investigated whether having a specific role assignment had an effect on the levels of knowledge construction for individual students. We found that students who had to perform the role of theoretician did not reach significantly different levels of knowledge construction as compared to students who worked in groups without role structuring. Students who were assigned the roles of source searcher and moderator, however, scored significantly lower than did the reference students in the no roles condition. Only students who had to summarize the discussion at various moments obtained significantly higher levels of knowledge construction. This is an important finding and points to the importance of clearly defining and explaining the roles to the students. We noticed, for example, that source seekers most of the time only mentioned interesting Web sites or books but failed to explain the link with the ongoing

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discussion. Moreover the other group members hardly used the extra alternative sources. The fact that the summarizers achieved higher levels of knowledge construction as compared to other students corroborates this assumption: The role description for the summarizer was very clear, and the summarizers knew that they had to indicate the different standpoints, describe which of the contributions held similar points of view, and indicate contradictions. These students actively processed the input of the other students. Providing clear and active role descriptions is certainly a point of interest that should be taking into account in follow-up research. On the other hand, we have to be aware of the danger of too rigid scripting because we noticed that students who were assigned roles did stick too close to these roles and no longer participated in the ongoing discussion in a way that went beyond their specific roles.

LIMITATIONS, IMPLICATIONS, AND DIRECTIONS FOR FUTURE RESEARCH

The results of the present study must be considered in the light of a number of limitations. The study was conducted in an ecologically valid learning environment. The asynchronous discussion groups were part of the standard curriculum and were introduced next to the weekly face-to-face sessions. The negative side of the naturalistic setting is its specificity in terms of the context and research population. In this study, the research sample consisted of a specific—but entire—group of first-year educational science students. Further research is needed to study whether the present research results can be confirmed when involving other types of students and when set up in different educational contexts.

The present research is also limited because only quantitative approaches have been adopted. In this study, content analysis has been used to assess students' levels of knowledge construction. To replicate or elaborate these findings, qualitative analyses may be particularly useful. Students, for example, might be interviewed to better comprehend what can be observed in discourse through content analysis.

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A third comment can be made about the fact that we have explored the effect of a very specific type of scripting. Further studies are needed to explore knowledge construction in view of different kinds of script conditions, for example the use of prompts, social scripts, epistemic scripts, and so on. On the other hand, using the same way of scripting in a cross-age, peer tutoring condition could be illuminating as well. A final comment is related to the fact that not all messages from all students submitted during the 12 weeks have been incorporated in the study. Coding the complete communication input of all students would be a labor-intensive task. But analysis of a larger data set might have helped to study a number of more complex interactions. Future research can build on, for example, automated coding strategies to reach this objective.

Next to the recommendations for future research that result from the limitations of the present study, some additional research ideas might help to support the present findings and present more substantial empirical evidence. First, it can be argued that similar studies with larger sample sizes and wider ranges of higher education students will lead to a better understanding of the effect of group, student, and task characteristics. Next, not only levels of knowledge construction could be taken as a dependent variable but also exam scores that mirror the evaluation results of knowledge acquisition in the specific knowledge domain of the course.

A number of practical implications can be derived from this study. The critical importance of task design has been underlined. Task complexity has to be carefully considered. Next, although the overall positive effect of role assignment could not be detected, the present study revealed that certain roles promote or hinder levels of knowledge construction, and some roles do not make a difference. The results show that, for example, being in the role of summarizer promotes knowledge construction. Students actively review the contributions of others and incorporate them in their construction of mental models. But, as also stated by Lockhorst and colleagues (2002), subsequent research is needed with regard to these task variables.

CONCLUSION

The present study focused on the differential effect of assigning roles to students in asynchronous discussion groups. This key variable was studied in relation to the potential effect of other student, group, and task characteristics. The multilevel analysis approach adopted in this study helped to unravel the complex interactions of the variables on knowledge construction. The research results could confirm the effect of a variety of these variables, but because of the multilevel analysis, the key effect of the task characteristic task complexity could be underlined. As to the task characteristic that was central in the main research question, the study could not indicate in a conclusive way that role assignment does in general result in a positive effect on the dependent variable. However some interesting differences in the effect of different roles could be revealed.

In general, further research is needed to ground the specific and interrelated effect of the variables in the theoretical framework put forward in this study. Notwithstanding the reported restrictions and the fact that further research is called for, we have been able to disclose a complex interactive process within an ecologically valid context. Overall the strength of this study lies in the fact that the full complexity of the interaction in online discussion groups in two conditions (role vs. no role condition), taking into account student, group, and task variables, was considered.

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