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Effects on participation of an experimental CSCL-programme to support elaboration: Do all students benefit?

F.R. Prinsen *, M.L.L. Volman, J. Terwel, P. van den Eeden

Department of Curriculum and Education, Vrije Universiteit, Van der Boechorststraat 1, 1081 BT Amsterdam, The Netherlands

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ABSTRACT

Computer-supported collaborative learning (CSCL) is aimed at enhancing and supporting the active participation of all students in knowledge sharing and knowledge co-construction. In this study, an experimental programme was designed to support students in elaborating and justifying their positions in CSCL discussions. The effects of this experimental programme on the participation of students as compared to their counterparts in a control programme were determined. It was hypothesised that special attention to elaboration improves the degree and quality of student's participation. The subjects in the study were 190 students from nine different primary school classes. The results both show a main effect on the degree of participation of students in the experimental programme and the expected effects of the programme in terms of better quality participation. Although the programme aimed at enhancing the degree and quality of the participation of all students, participation appeared to depend on certain learner characteristics. Students from minority backgrounds benefited less than majority students from the programme in terms of degree of participation. Boys benefited less than girls from the programme in terms of the quality of their participation.

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1. Introduction

Computer-supported collaborative learning (CSCL) aims at supporting the active participation of *all* students in knowledge sharing and knowledge co-construction. In CSCL arrangements the computer is used as a medium for supporting communication, but the support embedded in the computer software varies, ranging from very complex scripts which have to be followed step-by-step, to the simple facilitation of sending each other messages (e.g. Weinberger, Fischer, & Mandl, 2002). If one wishes to involve students in productive dialogue, simply providing a medium is not sufficient. Learner involvement is facilitated by the instructional design principles that are embedded in the larger CSCL environment.

It is widely acknowledged that the success of CSCL is determined by the degree and quality of the interaction process (Van der Linden, Erkens, Schmidt, & Renshaw, 2000). However, not all students are activated and the quality of CSCL discussions is often disappointing (Kirschner, Buckingham Shum, & Carr, 2003; Stahl, 2002; Veldhuis-Diermanse, 2002). More research is needed to reveal conditions of CSCL that may lead to participation and learning for all students.

In this study, the effects of an experimental CSCL-programme on the degree and quality of participation of students in the fifth grade of Dutch primary education were investigated. The subjects were 190 primary school students from nine different classes. The topic of the programme was 'nutrition and health', one of the possible themes in the domain of 'World orientation'. Building on to theoretical and empirical evidence regarding the conditions under which collaboration works, a learning environment was designed from a socio-cultural perspective (see Section 3.3 of this text). Two programmes – experimental and control – were designed. The two programme versions were identical with respect to content and general conditions for collaboration in a CSCL environment. In the experimental programme, following recent trends in CSCL (Dillenbourg, 2002), the interactions between students were structured and regulated directly. Alongside the setting of the general pre-conditions, the interactions were influenced directly by providing specific feedback on students' interactions and by stimulating students to use this feedback to reflect on their contributions (see also Farivar & Webb, 1991). This feedback and the reflection thereon by the students were focused on improving the interaction processes of the students, especially on stimulating elaborative con-

* Corresponding author. Tel.: +31 20 5988917; fax: +31 20 5988745.

E-mail address: fr.prinsen@psy.vu.nl (F.R. Prinsen).

tributions in the group. The programmes will be referred to as respectively the 'Elaboration programme' and the 'Collaboration programme'.

The second aim of the study was to explore whether our programme benefits all students. Differential effects of the programme for different categories of students (e.g. girls versus boys, students from different socio-cultural backgrounds) were examined, in order to find an answer to the question whether all participants profit equally from working in these two CSCL environments, in terms of degree and quality of participation. By including several student characteristics in the analyses an attempt was made to identify those student characteristics that may be related to degree and quality of participation.

The investigation was based on the following research questions: a. What are the general effects of an experimental CSCL programme aimed at stimulating elaborated contributions on the participation of students as compared to their counterparts in a control programme? b. What are the differential effects of the programme on the participation of various categories of students e.g. gender and socio-cultural background?

The general hypothesis is that the special attention to providing explanations, asking (high-level) questions and elaborating on the acceptance or rejection of other students' contributions improves both the degree and quality of all students in the experimental programme as compared to their counterparts in the control programme. Since an examination of the degree of participation is only superficially informative about students' opportunity for learning, the quality of the interaction in which students engage (for example whether they provide explanations and ask each other questions) is also reported. These categories of interaction come closer to being determinants of the actual learning gain. In addition to these expected general (main) effects, we will, in an exploratory way, search for differential (interaction) effects concerning specific categories of students. The exploration is driven by the general idea that all students should benefit from CSCL.

This article is structured as follows: first, the theoretical and empirical background of the study will be described; secondly, a section will be devoted to the research design and methods, reporting on the instruments that were used, the procedure that was followed and how the programme was implemented. The results section describes and analyses the effects of the programme on the participation of different categories of students. The chapter closes with conclusions, discussions, and some suggestions for further research.

2. Theoretical and empirical background

Collaboration necessitates the mutual engagement of participants in efforts towards joint problem solving. To ensure that all students are actually engaged, students' participation could be monitored. Monitoring requires some notion about what categories of students require special attention when it comes to participating. Secondly, to support students in their participation, conditions for collaboration can be created and/or direct influence on the interactions can be exerted.

2.1. Cognitive elaboration perspective

Learning is an activity that is situated in a broader socio-cultural environment. [Vygotsky \(1978\)](#) proposed that learning is the sharing of meaning in a social context. With proper guidance, students working together in small collaborative groups can profit from cultural resources offered by the others and by materials used in the activity. This study is based on the premise that learning requires an exact specification of the settings and processes of collaboration and elaboration that are implicated. For this purpose some of the literature will be explored in which the 'cognitive elaboration perspective' plays an important role.

[Palincsar and Brown \(1989\)](#) noted that learning is not simply an outcome of solving problems in collaborative groups but the result of the activities (i.e. elaboration and justification of positions in the discussion) elicited in certain social settings. In line with this point of view, they argue that more attention should be paid towards realising these settings and structuring student interactions to promote elaboration. This approach of structuring interactions is gaining in interest. In recent years, CSCL studies have started to focus on student interactions in order to improve them ([Constantino-González & Suthers, 2001](#); [Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2001](#); [Saab, 2005](#); [Scardamalia & Bereiter, 1996](#); [Soller & Lesgold, 2000](#); [Strijbos, 2004](#); [Weinberger & Fischer, 2006](#)).

A peer collaboration setting has three benefits ([Crook, 1994](#)): articulation, conflict and co-construction. Through peer collaboration, students are challenged to make their ideas explicit and they need to clearly articulate them. When students disagree in their interpretations, conflict may arise and the students must mutually justify and defend their positions, reflecting on their own (mis)conceptions. Socio-cognitive conflict can be a catalyst for change when students start explaining and elaborating on their understanding. Students build upon each others' ideas and thus co-construct (local) knowledge and a shared understanding collaboratively. In order to achieve deeper understanding students should provide each other with elaborate responses, either restructuring the existing knowledge structures or adding new information to the existing structures. Although conflict may be an essential trigger, it appears that change is more likely the outcome of co-elaboration and co-construction ([Brown & Palincsar, 1989, p. 403, 407](#); [O'Donnell and O'Kelly, 1994](#); [Reder, 1980](#); [Weinstein & Mayer, 1986](#)).

Webb stresses the importance of providing high-level elaboration, such as giving and receiving explanations in learning interactions (e.g. [Webb & Farivar, 1999](#)). It is likely that, in providing elaborated responses to each other, students rehearse and reorganise their understanding, thus actively processing the information ([Dansereau, 1988](#); [O'Donnell and Dansereau, 1992](#)).

Although the theoretical benefits of collaboration and elaboration are uncontested, the practical question remains as to whether these classroom processes can be improved by structuring, training and guidance. Here we can also learn from other sources than the CSCL literature. Classrooms, groups and individual students can learn to collaborate and to elaborate. In general, students in classes trained to collaborate are more cooperative and give more elaborated responses than their peers in untrained classes ([Cohen, 1994](#); [Terwel, Gillies, Van den Eeden, & Hoek, 2001](#); [Webb & Farivar, 1999](#)). A study on guiding knowledge construction by [King \(1994\)](#) clearly shows the positive effects of teaching children how to elaborate.

By focusing students' attention on those activities (e.g. elaborating) that are theoretically linked to achievement, students can improve the quality of their participation and thus improve the benefits that can be gained from collaboration for all members of the group. If achievement is, in fact, linked to elaborated responses, it is important that all students in a group have the opportunity to participate in elaboration processes.

It is against this theoretical background that our hypothesis was formulated. From a cognitive elaboration perspective, and against the empirical background on collaborative learning in various settings, it is expected that (in a CSCL learning environment) collaboration and elaboration of students can be fostered.

2.2. Differences in participation between student categories

Although we strongly support the idea that all students should benefit from CSCL there is no guarantee that all students will profit. As in other educational settings, patterns of participation in CSCL may be related to socio-cultural background, gender, ability and pre-knowledge, (Berger, Rosenholz, & Zelditch, 1980; Cohen, 1994; O'Donnell and O'Kelly, 1994; Webb & Palincsar, 1996).

A review of the literature on participatory differences in computer-supported environments showed that mainly gender differences were well documented. Differences in participation of different ability students and of students from different social and ethnic backgrounds have hardly been a subject of study in research on CSCL. There are however some clues regarding differences in participation of students in these categories in the literature on cooperative and collaborative learning without computer support (Gillies & Ashman, 2003; Terwel et al., 2001).

A review of the literature on gender-related (participatory) differences in computer-supported environments showed gender differences in both the degree and type of participation in computer-supported environments (e.g. Barrett & Lally, 1999; Carr, Cox, Eden, & Hanslo, 2004; Li, 2002; Prinsen, Volman, & Terwel, 2007; Savicki, Kelley, & Oesterreich, 1999; Selfe & Meyer, 1991). In CSCL environments, boys seemed to participate as much as, or more intensely than, girls. In an earlier (descriptive) study, we disconfirmed this finding and showed more active participation by girls in a specific CSCL learning environment (Prinsen, Volman, & Terwel, 2006). In terms of different contribution types, these findings suggest that disagreeing is more in line with male communication styles and that females tend to show more agreement. Males are more authoritative in their statements and females tend to ask more questions and provide fewer explanations.

For findings on the participation of low- versus high- ability students and the participation of students from different social and cultural backgrounds, we have to turn to earlier collaborative learning research. Studies by Webb (1982, 1989) show that high-ability students in heterogeneous groups participate more than others. A study by Hooper and Hannafin (1991), on the other hand shows that low-ability students participated more actively and completed the instruction more efficiently in heterogeneous groups than in homogeneous groups. Cooperation was significantly related to achievement for heterogeneous ability groups, but not for either homogeneous high- or low-ability students. Webb furthermore found differences in type of participation. In groups that are heterogeneous with respect to ability, the high-ability students do most of the explaining and the low-ability students most often ask for assistance (Webb, 1982a). Learners' ability to facilitate group members is variable. Advanced knowledge and skills (like social, meta-cognitive and scaffolding skills) are necessary to provide effective help to group members. This might be why high-ability students do most of the explaining. A study of Terwel et al. (2001) revealed that in the context of collaborative learning, the higher the individual ability levels of students, the more solicited explanations were given. One of our recent studies showed that in CSCL attention needs also be paid to the participants' level of computer skill and their proficiency in comprehensive reading to assure active participation (Prinsen et al., 2006).

As regards the participation of minority students, a number of studies by Cohen (1972), Cohen (1982) show that minority students in groups are often ignored or fail to participate and that special measures need to be taken in order to realize a more balanced participation.

There are theoretical and empirical reasons to expect differences in participation, but the literature suggests that when explicit criteria are set to enhance high-quality participation, including 'broad participation', a more balanced participation emerges (e.g. Lipponen, Rahikainen, Hakkarainen, & Palonen, 2003; Prinsen et al., 2007). The support provided in the collaborative programme should sustain active participation of all students and the additional support in the elaborative programme should stimulate all students to provide more elaborate (types) of contributions. At the same time, we should be careful and realise that, even given our intentions that all students should benefit from the intervention, some may not. That is why we will search, in an exploratory way, for differential effects.

2.3. Instructional design principles

A lesson series on the topic of nutrition and health was developed, in which groups of four students engaged in Knowledge Forum discussion tasks. A set of instructional design principles was implemented in both the control and experimental condition. The difference between the conditions lies in the focus on either collaboration or elaboration. The design principles are presented below.

1. Open problems in real life contexts to enable meaningful learning (e.g. Bruner, 1985; Lave, 1988; Vygotsky, 1978).
2. Heterogeneous groups according to gender, socio-cultural background and ability (e.g. Hooper & Hannafin, 1991; Webb, 1985).
3. Using adapted scaffolds as elements in the CSCL environment (e.g. Scardamalia & Bereiter, 1996).
4. Providing 'Golden rules' for the collaboration/elaboration process.
5. Guided collaboration/elaboration and problem solving in groups.
6. Individual feedback and feedback for the group on the process of collaboration/elaboration and on the use of the participation-supporting features of the programme.
7. Group reflection on the individual and group feedback received (e.g. Dewiyanti, 2005; Ulicsak, 2004; Yager, Johnson, Johnson, & Snider, 1996).

These principles are in line with the theoretical background of socio-cultural and cognitive elaboration perspectives (e.g. Brown & Palincsar, 1989; Webb & Farivar, 1994, 1999; Gillies & Ashman, 2003). Although specific characteristics of the arrangements and models from e.g. Cohen and Lotan (1995), Slavin (1995) and Johnson and Johnson (1994) are not implemented, their main ideas were taken into consideration (inclusiveness, interdependence, individual accountability and group reward).

A more elaborate description of these seven instructional design principles, as well as the content, the lessons and their implementation can be found in the section on research procedures.

3. Method

3.1. Design

The research design is characterized as a quasi-experimental design. The study was of a quantitative nature; most variables were assessed by means of questionnaires and tests (pre- and post-measures). The others were assessed by means of content-coding and counts. In Fig. 1, the basic conceptual model guiding the study is presented.

The figure can be read as follows: the horizontal arrow refers to the main effect of student characteristics such as gender, socio-cultural background, and ability etc., on participation. The slant arrow represents the general (main) effect of the programme on participation. The vertical arrow refers to the differential (interaction) effects of the programme for the various student categories.

3.2. Participants

Students of nine primary school classes (grade 5, average age of students 11 years) participated in the study. The schools were located in the city of Amsterdam (The Netherlands) and its surrounding areas and were selected from a network of schools which all subscribed to a local organisation facilitating the schools computer networks. They were selected to represent schools with a diverse student population and from different socio-economic areas in the city. The teachers agreed to dedicate approximately 70 min a week for a period of 6 weeks of their regular lesson plan to implementing our programme. A total of 190 children participated in the CSCL discussions and completed the questionnaires. Nearly half of the children who participated had two parents born in countries other than the Netherlands. This implies that half of the participants were from minority backgrounds. 103 Students participated in the control group condition (53 girls, 50 boys; 49 immigrant students, 54 non-immigrant students) and 87 in the experimental group condition (45 girls, 42 boys; 40 immigrant students, 47 non-immigrant students).

3.3. Variables and Instruments

The control and independent variables were measured as follows.

For the programme a dummy variable was constructed, with the experimental programme receiving a score of 1 and the control programme receiving a score of 0 on this variable.

Ability: IQ. The Standard Progressive Matrices test (60 items) was administered to determine general intellectual ability. Internal consistency reliability as measured by Cronbach's alpha was 0.83

The socio-cultural background of the children was measured by asking the children in which country their parents were born. If both parents were born abroad, the children were considered to belong to a minority sociocultural background (mostly Moroccan and Turkish). Minority students received a score of 1 on the dummy variable; majority students received a score of 0.

For gender, another dummy variable was constructed, with girls receiving a score of 1 and boys a score of 0 on this variable.

Comprehensive reading was assessed by a Dutch standardised test (CITO) which is routinely administered in Dutch primary schools.

General computer skills were determined before the lessons started by means of a questionnaire, on which the children could cross on a list of computer skill items which skills they thought they possessed (33 items, alpha = 0.90).

The dependent variable, *participation*, was measured in three ways:

1. The number of words per message
2. The type of contributions (for quality of participation)
3. The proportion of elaborated contributions (for quality of participation)

These measures were taken from two out of three Knowledge Forum discussions. It was decided to take the participation measures only from lesson two and three (the last two lessons in the lesson series) because the intervention needed some time to gain effect. The differences in participation between the control and experimental programme were expected to begin to show in these last two lessons.

(ad. 1) To measure students' active participation, the number of words per message was used. The literature proposes different ways of measuring active participation. Usually, in these kinds of studies, the measure for participation is the number of contributions. Another measure which is used in research is the total number of words contributed. The number of words per message is another way to measure students' active participation (see also Li, 2002; McConnell, 1997; Rourke, Anderson, Garrison, & Archer, 2001). In this study, the number of words per message is taken as a surface measure of the elaborateness of the contributions. Work by Hara, Bonk, and Angeli (2000) also supports this measure. They refer to lengthy messages as "one sign of depth to student electronic interaction" (p. 129).

(ad. 2) The type of interactions students engage in provides more information on the quality of students' participation. The type of participation was established by using a coding scheme similar to an instrument first developed by Veldhuis-Diermanse (2002). The original

Fig. 1. Conceptual model guiding the study.

scheme was adapted in order to make it more suitable for our discussion task and the age of the students in our study. The coding scheme distinguishes types of cognitive, affective and regulative contributions to the discussion. In this study the focus is on the cognitive contributions, although we do acknowledge the importance of the affective and regulative contributions. Cognitive contributions include asking questions (questions about facts and questions for explanation or illustration); formulating answers (with and without elaboration); and agreeing or not agreeing (with and without elaboration). Affective contributions concern affective/emotional remarks or responses. Regulative contributions are contributions aimed at monitoring progress in the discussion, evaluating the group process or instructing fellow students. Finally, a rest category included off-topic contributions, chat and social talk.

(ad. 3) To establish the proportion of contributions with an elaboration, types of participation were first established. Subsequently, the scores on the coding categories which represented elaborated contributions, such as disagreeing with elaboration, were added.

A representative sample of 2660 messages was taken from a total of about 7980 contributions which were made to Knowledge Forum by the students. This was done by coding, for each student, one of the two discussion questions taken from lesson two and three (mean of seven contributions per student, times two lessons). The unit of analysis was the contribution. All students were represented in the sample with their contributions in each lesson and all lessons were equally represented in the sample. With two coders a sample of 241 codes was double-coded (6% of the total coded). Not much time was needed to reach agreement. Twice 1 h was spent to compare the scores before the inter-rater scores could be considered reliable. An inter-rater agreement of 0.82 was achieved. The validity can of course only be grounded (generalised) to similar task arrangements.

3.4. Analysis

The data were analysed using analysis of variance and regression analysis. Various models were explored by applying a multi-level analysis. Two levels were first explored (small group, individual) and no variance between the groups was found. It was then decided to apply a multiple regression analysis. There were some missing values for the dependent variables, since some children had been ill during the lessons. These were imputed (6% of the students missed the second KF lesson, 6.8% missed the third KF lesson) by taking the mean over the two other lessons and subsequently looking at the trends from lesson one to lesson two and from lesson two to lesson three. The individual mean scores were adapted according to that trend.

3.5. Procedures

In the control and experimental programme, very similar procedures were followed. The procedures followed in the two programmes will now be described.

The experiment started with a workshop during which the use of the software was explained to the nine primary school teachers who participated in the experiment. The software used was the client version of Web Knowledge Forum. WKF was developed by Scardamalia and Bereiter of the Ontario Institute for Studies in Education at the University of Toronto. Of the facilities that the Knowledge Forum programme offers for enhancing students' knowledge building the 'build-on' facility (linking students reactions to each other) and the scaffolds (sentence openers) were the ones used in this implementation. All teachers joined three 2-h sessions in which they became familiar with the WKF application. The conditions for computer-supported collaborative learning were discussed. We wanted the teachers to know as much as possible about the programme and its background.

The researchers conducted all the lessons. In doing so they combined the researcher's role with that of developer and teacher. There were several reasons for this triple role. For one, the teachers did not have the time to go through a training period. The interventions had to be carried out according to a set of instructional design principles (for the research conditions to be comparable across classes). It would have been too time-consuming to fully prepare the class teacher in implementing the rather complex programme according to those rules. Secondly, the researchers had their own expertise in the theoretical backgrounds of CSCL and the role of cognitive elaboration in this educational setting, and were thus more broadly prepared and familiar with the programme than the class teacher. Thirdly, the researchers wanted to have first-hand experiences in order to understand the implementation processes. These reasons made the researchers decide to fully carry out the interventions themselves. From here on, the participating researcher will be referred to as 'teacher', because that was the researchers' role in implementing the programme.

Before the lessons started for the students, the researchers applied the questionnaires and IQ tested the students. Then the lesson plan was introduced by the researcher to the children in their classes. The students of each class were divided by the teacher into heterogeneous groups of four (according to gender, ability and socio-ethnic background). The teachers tried to make combinations of two by two divisions in the groups, placing, as much as possible, two boys with two girls, two lower achievers with two higher achievers and finally two pairs with different socio-ethnic backgrounds.

The lesson plan consisted of six lessons concerning the topic of 'nutrition and health', a domain within the integrated subject 'World orientation and Science'. In line with socio-cultural theories, the lessons were embedded in a context of meaningful cultural practice. In learning about nutrition and health, the students were given scenarios of problems in which two cooks were arguing how to prepare healthy meals for their guests in the restaurant. Below, an example discussion question is shown.

Example discussion question:

You have read Chapter one of the textbook 'The Smart Chef'. Now you can find the possible answers to the question below. Fill out your answers on this sheet. Make clear sentences and write down everything carefully. Make sure you don't forget anything.

After you have found as many possible answers, you go and sit down behind your computer and tell the people in your group what you've found. Perhaps they found different answers to yours. Might they be right too?

Question: Mind the sugar

Derreck is a new chef in our restaurant. He proposes to put a new recipe on the menu. "Let's make a chocolate pudding!" he says "and then we will add a sugar coating and put a cookie on the top!" Another chef, Mary, says: "Yes, Derreck, that sounds great but it is very unhealthy. There is far too much sugar in it and all sugar is bad for you. Sugar is never good for you." Is Mary right?

The first lesson was a practice lesson, in which students received instructions in the use of the programme, and were required to discuss a sample question in Knowledge Forum with their group. They were also made familiar with the scaffolds (sentence-openers) provided in the Knowledge Forum programme. These scaffolds were simplified for improved matching of the task and the level at which the students collaborate (e.g. 'Opinion' was changed to 'I think...'). We made sure it was always possible to choose a sentence-opener that would fit the sentences they wanted to contribute.

The students in the elaboration programme received some simple practice examples on how they were expected to formulate their reactions to each other. These were excerpts from a student discussion of another school. The students would have to read this excerpt and then answer a question about it, for instance: *In the text John says: "I think: I agree because I think this is true too". Does John really explain clearly why he agrees with Suze? Yes or no?* In the elaboration programme the students also received a small list called the 'golden rules'. These comprise the following six rules:

1. When you agree with someone, write down clearly what you agree on precisely.
2. Provide clear answers (state why you think this or give a clarifying example).
3. Ask each other (clear) questions.
4. Be sure to ask for clarification if you do not understand what is said.
5. When asked, provide an explanation and be sure it is helpful to the other.
6. It is all right to disagree as long as you explain why you disagree.

The sentence-openers in the Knowledge Forum programme mirror the golden rules in their support for providing constructive and elaborated reactions to each other. For instance, the sentence-opener "No, because ..." will remind you that disagreeing is okay as long as you explain why you disagree with the others' contribution. The ways of reacting to each other in a constructive (and elaborated) manner in this research were scaffolded by the following sentence openers: "I think ..."; "My question is ..."; "That's right, because ..."; "Yes, but ..."; "No because ..."; "Remark: ..."; "Explanation: ..." "What do you think?" and "An example: ...". These sentence openers were available for the students in both experimental conditions, but in the elaboration programme their function was better supported by their link to the golden rules.

The 'Golden rules' for the collaboration programme were that everybody should contribute, read each others contributions, ask each other questions, help each other and encourage each other.

After the introduction there was an evaluation lesson in which the students received some feedback on the group process and also some individual feedback. In this feedback care was taken to make sure that all students (in both programmes) received at least some positive comments to keep them motivated. The feedback will now be described more specifically.

All students were required to first post their own answer to the discussion questions in the Knowledge Forum (KF) before they reacted to the postings of the other students in their group. This was required so as to stimulate individual responsibility and to achieve some initial diversity of ideas in the answers. Because they initially tend to come up with different possible answers (taken from the text-book), the disagreements in their interpretations gave rise to some socio-cognitive conflict, which is seen as a starting point for discussion. If a student did not first post their own contribution, this was noted in the feedback. In addition, there was feedback on the use of what we call the 'participation supporting features' of the programme. It was assumed that the use of the KF programme affordances would support participation (and elaboration), so it was important that students used, for instance, the sentence openers and that they provided clear titles to their contributions. Although direct feedback was not provided on the content-quality of the students' postings, the groups did receive a general remark assessing the proportion of time spent on task and off task. The evaluation of all these categories was recorded either as group-feedback, which was read aloud to the class, or as individual feedback, which was recorded and handed out to the students in their groups.

Individual feedback was of a special character in the elaboration programme. It consisted of both positive and critical feedback comments on elaboration. The teacher had marked her comments on the discussion print (of last weeks' discussion) next to the printed contributions, giving every student personal feedback on the way they reacted to the others. With his/her feedback the teacher reinforces appropriate socio-cognitive behaviour and discourages inappropriate or ineffective behaviours (see excerpt 1 for an example).

Excerpt 1. Failure to provide an explanation

Title: answer to the second question

By: Tufan

Remark: I would choose this dessert because it tastes better

Which desert, Tufan?

Title: for the answer to question 2

By: Manaar

... yes but why!!!!???

Good thing you are asking for an explanation, Manaar. Try to ask nicely

Title: also for question 2

By: Tufan

I think: just because

Tufan, you have to give an explanation if somebody asks you to explain

In the collaboration-only programme, the students also received their printed-out discussion from the previous week, but instead of feedback on their elaborations they received some more general remarks on their collaboration.

After the group evaluation was read out loud and the individual evaluations were handed out, the students (in both conditions) received a reflection assignment, asking them to write down and discuss what they, as a group, would like to do differently next time. In this assignment the students got the chance to integrate the group feedback and the individual feedback that they had received. The group evaluation

was expected to create awareness of the importance of their group process. The individual evaluation was expected to make them (also) feel individually accountable. In the assignment, this awareness was transformed by the students into intentions. These intentions were expected to be translated into actions for improving the group process.

Three lessons followed in which students carried out discussion tasks. Each lesson started with the reading of a (context-rich) chapter on nutrition and health (about 1500 words at a time) followed by the introduction of two discussion questions, after which the children were given some time to prepare the discussion questions individually. The children were told to prepare the answers well, since they would have to discuss their answers with their group afterwards. Subsequently, each group of four students spent 30 min discussing the answers to two questions on the chapter in Knowledge Forum. The questions were designed for non-fixed answers. The children were instructed to find collectively as many alternative (right) answers as possible. Group members sat at their own computers and were instructed only to communicate through the computer. In total the children discussed answers to seven complex questions during the course of the lessons (including one practice lesson).

After the first and second discussion lesson there were also evaluation lessons in which the children received feedback regarding their group performance and their individual performance. This was done in the same way as described for the first evaluation lesson. They then received their reflection assignment asking them to formulate what they would like to do differently next time.

At least one researcher was always present at the time the groups were behind their computers, to assist in case of problems with the use of the programme. Since some children were out of the classroom during this time and the regular lessons were to continue, it also seemed wise to keep an eye on the groups, to make sure they only communicated by means of the computer programme.

4. Results

The results section is structured as follows. First, the descriptives of the various dependent and independent variables used in this study will be presented. They will be followed by a discussion of the (general and differential) effects of the programme on students' participation for all three of the dependent variables. The differential effects will be explored with a regression analysis for two of the participation measures (the number of words per message and the proportion of elaborated contributions). The rest of the analyses will be conducted through Analysis of Variance.

4.1. Descriptives and correlations of the main variables

In Table 1, the descriptives of the dependent and the independent variables included in the study are presented. Table 4 presents the correlations between the variables.

Possible differences in the independent measures (gender, socio-cultural background and IQ) between the two experimental conditions were explored to see if the populations were comparable. Although the differences were not significant, all variables were included in a regression analysis by way of accurate control.

Because socio-cultural background and gender are important categories in this study, we also present the descriptives separated for those categories. In Table 2, the descriptives are separated according to socio-cultural background and in Table 3 they are separated according to gender.

Table 4 presents the correlation between the main descriptive variables.

4.2. Differences between the programmes (simple ANOVA's)

In the examination of the relations between variables, the expected relation between the programme and the number of words per message is first explored. Since this showed a significant positive correlation, an ANOVA was conducted to explore the relation in greater depth. The result shows that students in the elaboration programme write significantly more words per message (mean = 17 in lesson two and three) than students in the collaboration-only programme (mean = 14 words per message) (ANOVA, $df\ 1,2 = 1, 188$; $F = 13.98$; $sign = 0.00$). The effect size was medium to large ($d = 0.65$).

Table 1
Descriptive statistics for the dependent and independent variables

	<i>M</i>	<i>SD</i>	<i>Min.</i>	<i>Max.</i>
<i>Control group (n = 103)</i>				
Gender (0 = male, 1 = female)	0.52	0.50	0	1
Socio-cultural background (0 = majority, 1 = minority)	0.47	0.50	0	1
IQ (score on SPM)	42.79	6.37	16	55
Computer skills	26.89	6.15	10	33
Comprehensive reading	43.59	15.02	15	95
Number of words per message	13.95	4.70	6.59	29.71
Elaborated contributions (proportion) ^a	0.41	0.23	0	1
<i>Experimental group (n = 87)</i>				
Gender (0 = male, 1 = female)	0.52	0.50	0	1
Socio-cultural background (0 = majority, 1 = minority) 0.46	0.46	0.50	0	1
IQ (score on SPM)	43.88	6.43	23	55
Computer skills	29.67	4.75	12	33
Comprehensive reading	46.63	15.89	17	83
Number of words per message	17.02	6.58	5.70	35.30
Elaborated contributions (proportion) ^a	0.60	0.20	0.17	1

^a Calculated as the mean of the categories presented in Table 4.

Table 2

Descriptive statistics separated for socio-cultural background

	Mean (SD)		Min.		Max.	
	Min.	Major	Min.	Major	Min.	Major
<i>Control group (n minority students = 49, n majority students = 54)</i>						
IQ (score on SPM)	40.82(6.62)	44.59 (5.60)	16.0	30.0	54.0	55.0
Computer skills	27.61 (11.0)	26.47 (10.0)*	5.27	6.83	33.0	33.0
Comprehensive reading	36.43 (9.28)*	50.09 (16.30)	15.0	23.0	57.0	95.0
Number of words per message	13.62 (4.53)	14.25 (4.87)*	6.59	7.09	27.29	29.71
Elaborated contributions (proportion) ^a	0.41 (0.23)*	0.41 (0.23)*	0.00	0.00	1.0	0.88
<i>Experimental group (n minority students = 40, n majority students = 47)</i>						
IQ (score on SPM)	43.15 (6.97)	44.51 (5.94)	23.0	28.0	55.0	55.0
Computer skills	28.48 (6.05)	30.70 (2.96)*	12.0	22.0	33.0	33.0
Comprehensive reading	42.75 (13.11)*	49.94 (17.38)	20.0	17.0	83.0	83.0
Number of words per message	15.15 (5.92)	18.61 (6.75)*	5.70	7.68	35.28	35.30
Elaborated contributions (proportion) ^a	0.58 (0.21)*	0.61 (0.19)*	0.18	0.17	0.93	1.0

^a Calculated as the mean of the categories presented in Table 5.

* Significant differences (ANOVA) between minority students in the control group as compared to minority students in the experimental group and between majority students in the control group as compared to majority students in the experimental group.

Table 3

Descriptive statistics separated for gender

	Mean (SD)		Min.		Max.	
	Female	Male	Female	Male	Female	Male
<i>Control group (n male students = 50, n female students = 53)</i>						
IQ (score on SPM)	43.40(5.52)	42.16 (7.16)	30.0	16.0	54.0	55.0
Computer skills	25.38 (6.87)*	28.50 (4.85)*	10.0	14.0	33.0	33.0
Comprehensive reading	44.45 (13.61)	42.68 (16.47)	23.0	15.0	88.0	95.0
Number of words per message	14.96 (4.82)*	12.88 (4.37)*	8.2	36.59	29.71	25.15
Elaborated contributions (proportion) ^a	0.40 (24)*	0.41 (0.23)*	0.0	0.0	1.0	1.0
<i>Experimental group (n male students = 42, n female students = 45)</i>						
IQ (score on SPM)	43.64 (5.79)	44.14 (7.12)	27.0	23.0	54.0	55.0
Computer skills	28.60 (5.43)*	30.83 (3.62)*	12.0	16.0	33.0	33.0
Comprehensive reading	47.05 (17.43)	46.19 (14.25)	17.0	22.0	83.0	83.0
Number of words per message	18.49 (6.58)*	15.44 (6.27)*	7.92	5.70	35.30	32.25
Elaborated contributions (proportion) ^a	0.65 (18)*	0.54 (21)*	0.22	0.17	1.0	0.92

^a Calculated as the mean of the categories presented in Table 5.

* Significant differences (ANOVA) between female students in the control group as compared to female students in the experimental group and between male students in the control group as compared to male students in the experimental group.

Table 4

Correlations between the variables (n students = 190; Pearson correlation)

	Socio-cultural background	IQ	Computer skills	Comprehensive reading	Number of words per message	Properties of elaborative contribution	Programme
Gender	−0.04	0.04	−0.24**	0.044	0.22**	0.10	0.00
Socio-cultural background		−0.21**	−0.03	−0.35**	−0.17*	−0.04	−0.02
IQ			0.07	0.52**	0.22**	0.09	0.09
Computer skills				0.08	0.09	0.16*	0.24**
Comprehensive reading					0.28**	0.18**	0.09
Number of words per message						0.54**	0.26**
Proportion of elaborated contributions							0.39**

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

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

4.3. Type of contribution per programme

Secondly, the differences in types of contributions made by students in the two programmes were explored to see if they showed significant differences.

Table 5 shows the significant differences (marked with a star *) between the programmes in the frequencies of contribution types, presented as a percentage of all the contributions explored by Analysis of Variance. A summary of the results shows that the students in the elaboration programme learned to not only show their acceptance of other contributions but also to add an elaboration on what they actually agreed with. The tendency in the collaboration programme to simply agree with each other (19% as compared to 13% in the other pro-

Table 5

Means and standard deviations for different categories of interactions in the control versus experimental programme

	Control		Experimental	
	M	SD	M	SD
1. Cognitive contributions				
a. Answers with elaboration	16%	0.15	19%	0.13
b. Answers only	11%	0.14	8%	0.09
c. Acceptance with further elaboration*	15%	0.15	23%*	0.16
d. Acceptance without further elaboration*	19%	0.15	13%*	0.13
e. Rejection with further elaboration	5%	0.09	6%	0.08
f. Rejection without further elaboration	3%	0.06	1%	0.04
g. Comprehension questions*	5%	0.08	12%*	0.13
h. Factual and verification questions*	5%	0.07	3%*	0.06
2. Affective contributions	1%	0.06	2%	0.04
3. Regulative contributions*	19%	0.17	12%*	0.12
4. Other contributions	1%	0.03	1%	0.05
Proportion of elaborated contributions* (1a+1c+1e+1g)	41%	0.23	60%*	0.20

* Significant differences between the control and experimental programme, explored by Analysis of Variance.

programme) might signal that the students try to quickly reach a consensus without exploring more (possible) answers. There is a lot more questioning going on in the elaboration programme. A major proportion of these questions consists of more complex types of questions (directed more towards comprehension than towards factual or verification answers).

The last difference of interest between the two groups is the fact that in the collaboration-only programme students spend much more time regulating the group discussion than the students in the elaboration programme. This might signify that there is less need for regulation when the rules of constructive inter-reaction are clear to all.

Since, with regard to the quality of messages, coding the type of contributions is more informative than counting the number of words per message, the categories that showed more elaborate type of contributions were added up to assess the proportion of elaborated contributions. The differences between the two programmes for this measure of participation were explored. The results show that students in the elaboration programme did, in fact, provide a higher proportion of elaborated contributions than students in the collaboration-only programme (ANOVA, $df\ 1,2 = 1,188$; $F = 36.25$; $sign = 0.00$).

It's interesting to note that the two measures for participation (number of words per message and proportion of elaborated contributions) also show a strong inter-relationship, with a correlation of 0.523 on the 0.01 level. A significant correlation among the measures suggests the existence of an underlying construct and thus adds support to the measure's construct validity.

4.4. Effects of the programme on degree of participation (words per message)

To explore the effects of the programme on participation, several possible regression models were tested. In our regression analysis, Z-scores were used for all variables and dummies for gender, socio-cultural background and the programme (condition). A model is presented with number of words per message as dependent variable. All independent variables were included (stepwise) into the model to find the best fit. Since both general and differential effects of the programme are to be explored, all predictor variables (gender, socio-cultural background, IQ, comprehensive reading, computer skill and programme) and their possible interactions with the programme variable in the model were included.

After examination of the coefficients it was decided to exclude the predictors with non-significant coefficients one by one in subsequent models (IQ, socio-cultural background, and computer skills). In the final, best fit, model, all betas are significant (see Table 6).

In the best fit model (see Table 6), 20% of the variance in participation (number of words per message) can be explained by four predictors that are included in the study. The outcomes of the regression analysis are presented in Fig. 2.

Gender, comprehensive reading skill, the programme and the interaction between programme and socio-cultural background all contribute significantly to an explanation of the variance in the dependent variable. The interaction effect means that minority students benefit less from the programme with respect to degree of participation as measured by the number of words per message. It should be noted that the proportion of the total variance in participation explained by our model is small. However, within the context of the final model the effect of the programme is considerable. As a general (main) effect, the programme explains almost 6% of the variance over and above the variance already explained by the co-variables. In addition, the programme also shows an interaction effect of 0.025 (with socio-cultural background). The combined main and interaction effect is thus 8%.

Table 6

Regression of the predictors on the dependent variable 'Number of words per message'

Model	R square	Standard error of the estimate	R square change	F change	Sign F change
1	0.05	0.98	0.047	9.32	0.003
2	0.12	0.94	0.074	15.73	0.000
3	0.18	0.91	0.056	12.69	0.000
4	0.20	0.90	0.025	5.89	0.016

1. Predictors: (Constant), Gender.

2. Predictors: (Constant), Gender, Comprehensive reading.

3. Predictors: (Constant), Gender, Comprehensive reading, Programme.

4. Predictors: (Constant), Gender, Comprehensive reading, Programme, Interaction variable Programme and Socio-cultural background.

(* With B-coefficients; standard errors between parentheses)

Fig. 2. Graphical presentation of the outcomes from the regression analysis presented in Tables 6 and 7 (degree of participation)*.

Table 7

Coefficients of the regression of predictors on the dependent variable 'Number of words per message'

Model 4		Unstandardised coefficient		Standardised coefficient		
		B	Standard error	Beta	t	Sign
4	(Constant)	−0.43	0.11		−3.84	0.00
	Gender	0.41	0.13	0.20	3.09	0.00
	Comprehensive reading	0.22	0.07	0.22	3.34	0.00
	Programme	0.70	0.16	0.35	4.35	0.00
	Interaction variable					
	Programme Socio-cultural background	−0.48	0.20	−0.19	−2.43	0.02

Dependent variable: Number of words per message in lessons 2 and 3

To obtain a more concrete sense of the differences in results presented above, ANOVA's were carried out for those student characteristics that are related to differences in participation. The results show that girls generally participate more actively in the CSCL environments. Girls contribute an average of 17 words, boys an average of 14 words per message (this difference is also significant in a simple ANOVA). In the elaboration programme students from a minority background participate less actively; they write a mean of 15 words per message, while Dutch-background students write a mean of 19 words per message (this difference is also significant in a simple ANOVA). The model also shows that students with high ability in comprehensive reading do better in terms of participation (number of words per message) than students with lower comprehensive reading ability (although this relation did not remain significant in a simple ANOVA).

4.5. Differences in type of participation by programme for various student categories

Next to the effects of the programme on students' participation in terms of amount of words per message, the differences in type of participation (by programme) for various student categories were explored.

The differences in type of contributions of the various categories of students in the elaboration programme will be reported on first. In the analysis, gender differences and differences related to the socio-cultural background of the students were found. Girls in the elaboration programme ask more comprehension questions (15%) than boys (9%) (ANOVA, df 1,2 = 1.85; $F = 4.25$; sign = 0.42). Students from Dutch backgrounds show more (elaborated) non-accepting answers (8%) than students from minority backgrounds (4%) (ANOVA, df 1,2 = 1.85; $F = 3.95$; sign = 0.50).

In the collaboration (only) programme the results also show differences related to the socio-cultural background of the students. Minority students in the collaboration-only programme ask more (simple) questions (7%) than students from Dutch backgrounds (4%) (ANOVA, df 1,2 = 1.99; $F = 6.99$; sign = 0.09). They also show less contributions including simple agreement (14% acceptance without an elaboration) than students from Dutch backgrounds (24%). Furthermore there are differences in type of participation related to comprehensive reading skill. Student with lower skill in comprehensive reading in the collaboration programme provide more (non-elaborated) answers than students with a high(er) skill in comprehensive reading (ANOVA, df 1,2 = 33.67; $F = 2.79$; sign = 0.00). This difference was not present in the elaboration programme. Furthermore, the results show that good comprehensive readers contribute more (elaborated) disagreement statements than poor comprehensive readers do in the collaboration programme (ANOVA, df 1,2 = 33.67; $F = 1.68$; sign = 0.36). There are no gender differences in type of participation in the collaboration-only programme.

4.6. Effects of the programme on the quality of participation (proportion of elaborated contributions)

Finally, the effects of the programme on the proportion of elaborated contributions were determined. The aggregated 'type of contribution' scores were used as the dependent variable in the analysis. Again, several possible regression models were explored. In our regression analysis Z-scores were used for all variables and a dummy variable was created for gender, socio-cultural background and the programme variable. A model is presented with proportion of elaborated messages as dependent variable. All independent variables (gender, socio-cultural background, IQ, comprehensive reading, computer skill and programme) were included. Since both general and differential effects of the programme are to be explored, all possible interactions between the co-variables and the programme (stepwise) were included in the model to find the best fit. The final regression model is shown in Table 8.

Table 8

Regression of the predictors on the dependent variable 'Proportion of elaborated contributions'

Model	R square	Standard error of the estimate	R square change	F change	Sign F change
1	0.03	0.99	0.03	6.35	0.013
2	0.18	0.91	0.15	32.44	0.000
3	0.20	0.90	0.02	5.61	0.019

1. Predictors: (Constant), Comprehensive reading skill.

2. Predictors: (Constant), Comprehensive reading skill, Programme.

3. Predictors: (Constant), Comprehensive reading skill, Programme, Interaction variable Programme and Gender.

Table 9

Coefficients of the regression of predictors on the dependent variable 'Proportion of elaborated contributions'

Model 3		Unstandardised coefficients		Standardised coefficients		
		B	Standard error	Beta	t	Sign
3	(Constant)	−0.35	0.09		13.93	0.000
	Comprehensive reading	.14	0.07	0.14	2.11	0.037
	Programme _a	0.53	0.17	0.26	3.18	0.002
	Programme Gender	0.46	0.19	0.19	2.37	0.019

(* With B-coefficients; standard errors between parentheses)

Fig. 3. Graphical presentation of the outcomes from the regression analysis as presented in Tables 8 and 9 (quality of participation)*.

In the final model as represented in Table 8, 20% of the variance in participation (Proportion of elaborated contributions) can be explained by three predictors that are included in the study. In the following Table 9 the relevant coefficients are presented.

From Table 9, it may be concluded that in the final model (model 3), all betas are significant. Below in Fig. 3, the outcomes of the regression analysis are presented in a graph.

Comprehensive reading skill, the programme and interaction between programme and gender all contribute significantly to an explanation of the variance in the dependent variable. The interaction effect means that girls benefit more from being in the elaboration programme than boys. Again, it has to be noted that the proportion of the total variance in Participation explained by our model is small. However, the programme contributes considerably to the explanation of the variance. When included in the model (after control for the co-variables), the programme explains 15% of the variance. In addition, the analysis reveals an interaction effect (0.02) with Gender which yields an explanatory proportion of 17% in respect of the programme.

To obtain a more concrete sense of the differences in the results presented above, it was decided to conduct an analysis of variance on the means for the student categories that show differences in participation in the two programmes. Girls in the elaboration programme write a larger proportion of elaborated contributions (66%) than boys (55%) (ANOVA, $df_{1,2} = 1.85$; $F = 6.25$; $sign = 0.014$). The model also shows that students with a high ability in comprehensive reading do better in terms of the proportion of elaborated contributions than students who have a lower comprehensive reading ability, but this relation did not remain significant in a simple ANOVA.

5. Conclusions and discussion

The design of this CSCL study was aimed at ensuring access for all students to both the social and the socio-cognitive opportunities of group work, focussing on the active participation of all students as well as on the socio-cognitive activities (e.g. elaboration) that are theoretically linked to achievement.

Before presentation of the conclusion and discussion some remarks need to be made about the limitations of this study. Research was restricted to the *process* of participation. Although many theories assume that these kinds of processes are related to the outcomes of learning, this article was not aimed at establishing such a relation. The only conclusion relates to whether the intervention stimulated the (quality of the) participation of students.

A second limitation refers to the kind of measures that were used. Participation was measured by 'formal' categories such as the degree (in terms of words per message) and the quality (in terms of elaboration of the responses). We cannot claim that these responses were correct or wrong in domain-specific terms. Students' explanations and justifications were coded as elaborations regardless of their sub-

ject-related content. In addition to the theoretical assumptions, there is an indication from studies (e.g. the work of Webb and Gillies) that these kinds of interaction categories are related to learning outcomes in domains of, respectively, world orientation and mathematics.

The investigation was based on the following research questions:

a. What are the general (main) effects of an experimental CSCL programme, aimed at stimulating elaborated contributions, on the participation of students as compared to their counterparts in a control programme?

b. What are the differential (interaction) effects of the programme on the participation of various student categories?

In the experimental (elaboration) programme, all students were explicitly expected to provide elaborated contributions, i.e. providing explanations, asking (high-level) questions and elaborating on their acceptance or rejection of each others' contributions. We expected this experimental intervention to give rise to a more intense participation (a higher number of words per message) and to a better quality (type) of contributions.

The results of the study clearly show the expected effects of the programme. Students who participated in the elaboration programme not only wrote longer messages, but also they wrote more elaborate types of messages. Two differential effects were found in addition, however. First, students from minority backgrounds appeared to benefit less from the programme than majority students with respect to degree of participation. Second, boys benefited less than girls from the programme in terms of the contribution of elaborate responses (quality of participation).

An explanation of these differential effects may be found in the language prerequisites for successful participation in CSCL programmes. The targeted interactions in the experimental condition require high proficiency in Dutch; in this respect, the programme may have been more demanding for minority students, who often do not speak Dutch at home. This may have impeded their participation. An additional explanation might be found in cultural differences in communication codes. The emphasis on explicit agreement and disagreement, asking questions and explaining one's position, may not match the communication patterns in which some minority students are socialised at home. Neither line of reasoning, however, explains the fact that no differential effect was found for minority students in terms of elaborated contributions. Minority students do not write a smaller proportion of elaborated contributions than majority students, which in itself is a hopeful finding. Since asking elaborate questions was one type of interaction included in the measure for elaborated contributions, it might be that minority students compensate by asking many questions. This remains to be shown.

Concerning the interaction effect found for gender, one could argue that in CSCL-environments girls are more easily able to show their potential and more fully exploit their language capacities than in face-to-face communication, since they may be less hampered by role conflicts and status expectations. However, the higher profit girls have from participation in the elaboration programme is to a large extent caused by their asking more (elaborated) comprehension questions. This is in line with gender-stereotyped communication patterns found in earlier research in which girls are found to ask more questions than boys.

It should be noted that multi-level analysis did not result in group level effects, even though group level effects might have been expected. The absence of this variance might be explained by the way the groups were composed. The attempt to generate heterogeneous groups that would not differ in composition according to gender, achievement level and socio-cultural background seems to have been adequate.

We conclude that it is possible to create and implement a programme, based on a socio-cultural and cognitive elaboration perspective, which enhances the overall (quality of) student participation in CSCL. We are also aware of the fact, however, that special attention needs to be paid to the participation of minority students, since they tend to participate less in such programmes than majority students, and to stereotyped differences in the contributions of boys and girls. Further research should assess the need and possibilities for further programme development directed to enhancing the participation of minority students and the quality of boys' participation in CSCL learning environments. Further research should also show whether the improved participation realised in the elaboration programme translates into improved learning outcomes, and whether the participatory differences between girls and boys, immigrant and non-immigrant students are related to differences in learning outcomes.

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