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DEVELOPMENT OF A QUESTIONNAIRE TO MEASURE CO-REGULATED LEARNING STRATEGIES DURING COLLABORATIVE SCIENCE LEARNING

Abstract. *The purpose of this research was to develop a questionnaire that measures students' self and co-regulated learning processes during science learning. An instrument named Co-regulated Strategies for Learning Questionnaire (CRSLQ) was developed, and its validity and reliability were analysed. Factor analytic evidence from a sample (n=214) of science students indicated that the 21 items CRSLQ consists of four constructs: monitoring, help-seeking and help-giving, efforts regulation, and planning. Cronbach's Alpha (α) coefficients were calculated for the reliability of CRSLQ scales which ranged from 0.87 to 0.92 and 0.95 for the entire questionnaire. Additional analysis with a second sample (n=40) showed that CRSLQ was an effective instrument for measuring co-regulated learning strategies during collaborative science learning. According to these results, the CRSLQ can be used as a valid and reliable instrument in science education.*

Key words: *collaborative learning, co-regulated earning, efforts regulation, help-seeking and help-giving, monitoring, planning, science learning, self-regulated learning.*

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Introduction

Students' self and co-regulatory practices have been identified as instrumental in influencing the learners' engagement and interactions during learning processes in a computer supported collaborative learning (CSCL) environment. One of the objectives of science learning includes empowering students by nurturing the belief that they can succeed in science learning and developing learning strategies that will enable them to perform very well in their studies. However, science education literature around the world has highlighted the current crisis of disappointingly poor performance of students in science subjects as well as their enrolment in science courses at a tertiary level. This therefore, calls for major reforms of engaging students more actively in the science classrooms (Jegede, 2007; Olorukooba, 2007; Osborne & Dillon, 2008; Omorogbe & Ewansiha, 2013). According to Osborne & Dillon, (2008) and Kihwele, (2014), major factors contributing to students' failure in science learning include their inability to engage and interact actively in the science classroom. Also, other researchers have investigated how computer-based simulations can enhance better understanding of science learning (de Jong & Joolingen 1998; Boo & Watson, 2001; Blake & Scanlon, 2007; Olakanmi, 2015). Their conclusion was that computer-based simulations/a computer supported collaborative learning environment can serve as an effective learning tool in science education to improve the students' conceptual understanding of science.

In this research, science students' co-regulated learning strategy was examined with a view to understanding the factors that determine students' co-regulated learning strategy (CRL) in a CSCL environment when learning science subjects. It is worth noting that there is no way we can mention students' CRL strategy without describing self-regulated learning (SRL) strategy first. SRL refers to strategic and metacognitive behaviour, motivation, and cognition aimed towards a learning target. According to Zimmerman

(1989), students are regarded as self-regulated to the degree that they are metacognitively, motivationally, and behaviourally active participants in their own learning process. On the other hand, the concept of co-regulated learning (CRL) derives from the idea that, in an ideal learning context, learning is a naturally social act in which the participants talk among themselves and involve one another in the learning process.

McCaslin (2004) argues that the CRL approach involves inter-personal processes of motivation (including prior self-knowledge and future expectations), enactment (including overt and covert goal-coordination strategies), and evaluation. These processes are considered in the context of relationships with other participants, structural supports, and opportunities which have been afforded in the social environment. Although, the ultimate goal of CRL is to enable students to improve on their SRL strategies as individuals, students establish relationships with teachers, peers and their social environment during co-regulation. CRL engages students in challenging tasks and enables them to develop higher-order reasoning and problem solving skills (McCaslin, 2004). While previous work has established that the presence of SRL prompts in a technology enhanced learning environment promotes students' engagement and learning performance (Hadwin & Oshige, 2007; Olakanmi, 2008; Volet *et al.* 2009), this present research argues that CRL strategies are needed for the students to be successful especially when learning science subjects in a CSCL environment.

However, after reviewing the available literature, the development of instruments to measure co-regulated learning strategies that students use during collaborative science learning emerged as an urgent task if a meaningful contribution is to be made to the development of a greater understanding of CRL strategies among young science learners. In other words, the lack of an instrument limits the development of more empirical research on this important topic, and would explain why so little is known about CRL strategies among students, even though research on self-regulation has been carried out for many decades. Having an instrument that will measure students' co-regulated learning strategies in CSCL will enable the teachers to gather valid and reliable information about science students regarding their use of CRL strategy during science learning. This will guide the teachers in directing and focusing their teaching practices. It could also be used as an instrument for evaluating the effectiveness of educational programmes and materials designed to increase students' planning, monitoring and help-seeking behaviour in science as they progress through school.

Hence, the focus of this present research was to develop a questionnaire named co-regulated strategy for learning questionnaire (CRSLQ) that could be used to measure students' co-regulated learning strategies when learning science in a CSCL environment.

Theoretical Background

The literature review guiding this research is premised upon social cognitive and socio-cultural theories of regulation which provide insight into how learners develop, use, and refine regulatory processes in a collaborative context. Social cognitive theory explores how learners learn a number of strategies to regulate their cognition, motivation, behaviour and their characteristics (e.g. cognitive and motivational orientations) during learning processes. Social cognitive theory plays an important role in creating and sustaining model systems of educational activities. Barron (2003) and Volet *et al.* (2009) employed social cognitive theory to explain the nature and emergence of productive interactions when a group of students are engaged in collaborative learning activities. Social cognitive perspective seeks to understand groups' actual interactions in real time; it shows how groups negotiate collaborative learning.

Socio-cultural theory on the other hand, examines if and how a more able peer in a group co-regulates a learner's strategy use until the learner internalises these strategies and is able to self-regulate independently. It is worth noticing that when learners employ co-regulation in a collaborative context, several types of co-regulation are present: co-regulation can constitute a single more capable group member co-regulating another; each group member taking on the role of regulating others depending on the strengths of a particular learner, or several group members sharing together in regulating the groups' activities. Although available studies (Schunk, 2001; McCaslin & Hickey, 2001; Järvela & Järvenoja, 2007; Hadwin & Oshige, 2007) emphasise the role of the social context in the development of learners' regulatory processes, this research employs both social cognitive and socio-cultural theories in developing an instrument that will measure social forms of regulation (co-regulation) during science learning in a CSCL environment. By integrating these theories of regulation, this present research is suggesting that in a collaborative learning context, learners will engage in co- and self-regulatory processes to regulate their cognition, motivation, and behaviour which are the predictors of the learning outcomes.

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Developing and validating a questionnaire to measure co-regulated learning strategies is very important because co-regulated learning strategies have been shown to profoundly influence the quantity and quality of the students' interaction and their engagement during learning processes (Zimmerman, 1990; Zimmerman et al., 1992). Also, recent research and theory has suggested that the way students regulate their social learning processes may affect their learning outcomes on the given task (McCaslin, 2004; and Volet *et al.,* 2009). As regulating social learning is referred to as students' co-regulated learning processes in this research, it implies that co-regulated learning processes may also affect students' learning and achievement in the given tasks, it would therefore be advantageous to have an instrument available which accurately measures students' CRL strategies during collaborative science learning. In a nut shell, this research aims to develop Co-regulated Strategies for Learning Questionnaire (CRSLQ) for the purpose of this research as well as determining the effect of a CSCL environment incorporated with CRL and SRL prompts on students' CRL strategies.

Research questions

In order to achieve the aims of the research, there are three research questions guiding the research. They are as follows:

1. Is the Co-regulated Strategies for Learning Questionnaire (CRSLQ) developed for this research fit for the purpose of measuring the CRL strategies of Key Stage 3 students?
2. Does the CSCL environment with both co- and self-regulated learning prompts support Key Stage 3 students in regulating their learning strategies more effectively than using self-regulated learning prompts only?
3. Does the CSCL environment with both co- and self-regulated learning prompts result in a greater improvement in Key Stage 3 students' academic performance when learning scientific concepts than when using self-regulated learning prompts only?

Methodology of Research

Development of the Instrument

To develop the Co-regulated Strategies for Learning Questionnaire (CRSLQ) in a Likert format, an extensive review of the literature on co-regulated learning within the conventional classroom setting was carried out. Furthermore, literature on co-regulated learning in CSCL was also reviewed to identify instruments used in research studies. According to past studies, there was no tool available to measure students' co-regulated learning strategies in a CSCL environment. Therefore, a tool to measure the co-regulated learning strategy of secondary school students was developed. Analysis of the data was conducted in three ways: (a) determining content validity of the questionnaire items, (b) calculating total correlation estimates for item analysis in order to identify any faulty items, obtaining internal consistency and reliability estimates of the scale scores, and (c) testing the construct validity by exploratory factor analysis.

Instrument

The questionnaire was designed to measure students' CRL strategy in a CSCL environment. Based on the relevant literature on the self-regulated learning (SRL) and co-regulated learning (CRL) theoretical frameworks, measurement of seven dimensions was found to be desirable. These seven dimensions include; *planning*, *monitoring*, *evaluating*, *effort regulation*, *peer learning*, *time management* and *help-seeking and giving behaviours*.

Twenty-three items were generated for the initial pool a consensus was reached by three experts in the field, the school science teacher and the researcher reached a consensus as to the items' clarity, appropriateness and content validity. These items included different aspects related to the SRL constructs explained in the literature. Students were asked to answer each item using a 6-point Likert scale ranging from 1 "not at all true of me" to 6 "very true of me".

The newly developed questionnaire was expected to have the following characteristics: (1) developed on the premise of socio-cultural and social cognitive theoretical framework; (2) able to capture various categories of CRL strategies that students are expected to demonstrated when learning science in a CSCL environment (e.g., planning, monitoring and evaluating their learning goals); (3) able to distinguish between various categories of CRL; (4) had good psychometric properties. Given the above, the development and validation of a new instrument designed to measure CRL strategies appears to be necessary.

Samples and Data Analysis

This research employed mixed methods sampling techniques to investigate the research questions highlighted above. The research took place in a high school in Bedfordshire, UK. The school is a middle school for 8 to 13 year old students (i.e. is made up of Key stages 2 and 3 only). All the Key stage 3 students (n=254) participated in the research. Key Stage 3 is the first three years of secondary school education in England for pupils aged 11 to 14 years. The school has two computer suites with 22 to 24 computers in each. This met the technological needs of this research. A class of 40 students was purposeful selected to participate in the second stage of this research which involved using the school's computer suites. In order to examine item analysis and Cronbach's Alpha internal consistency coefficients of the scale as well as establishing the construct validity of the instrument by factor analyses, the draft questionnaire was administered to the remaining 214 students (98 female and 116 male).

The 40 students (21 male, 19 female) who were not involved in the first stage of the research formed the second sample on which the questionnaire was tested. This sample size (40) was based on the technology that is available in the school. The newly developed CRSLQ was used to examine students' co-regulated learning strategies when learning science in a CSCL environment. Students' SRL and academic performance were also investigated. This group of students were randomly assigned to either the experimental group or the control group. Each group consisted of 20 students. The students in the experimental group were prompted with CRL + SRL prompts during the computer supported collaborative learning (CSCL) while the students in the control group were prompted with SRL prompts only.

Procedures

The permission to carry out the research was obtained from the head of the science department in the school; students were given the information leaflet regarding the research, and they and their parents also signed consent forms. The participation was voluntary and students' confidentiality was guaranteed throughout the process. During the first stage, the questionnaires were administered to the students during science lessons. The entire questionnaire took them about 15 minutes to complete. During the administration of the questionnaire, both the science teachers and the researcher explained the objective of the research to the students again. While students were answering the questionnaire, the teacher and the researcher were there to deal with the students' questions as they were completing the questionnaire.

The second stage of this research was carried out using the validated co-regulated strategies for learning questionnaire (CRSLQ), as well as the self-regulated strategy for learning questionnaire (SRSLQ), knowledge test (KT) on a simple circuit (SC) and classroom observation.

The research was carried out in three separate 50-minute lessons. During the first lesson, the CRSLQ, SRSLQ, and pre- knowledge test on simple circuit (SC) were handed out to the students. They were given 15 minutes to complete each questionnaire and the knowledge test about simple circuits (SC). The second lesson took place in the computer suites in the school during which students were introduced to the Sunflower science simulation programme teaching the simple circuit (SC). Students sat in subgroups of five, each with their own computer and were encouraged to discuss the given task together as a group. Learning activity sheets with either CRL+ SRL prompts or SRL prompts only were designed for the purpose of this research and students were instructed to work collaboratively using a science simulation on simple circuits. Thereafter, they were asked to discuss their learning with other members in their group. Two versions of the learning activity sheets designed for the experimental and the control groups are described in the next section.

In order to investigate co-regulatory strategies employed by students when learning in a CSCL environment effectively, an additional qualitative approach was used. Participants in both groups were observed by the researcher and the science teacher as they learnt about simple circuits in a CSCL environment. Observing what the students were doing during the lessons provided a valid basis for accurate descriptions of what students were

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doing instead of what they remembered or thought they were doing (Turner, 1995). This approach was adopted in order to relate students' co-regulatory strategies to the conditions required by the tasks. The use of an observation technique helped in triangulating the questionnaires data.

The third lesson was used to administer post- CRSLQ, post-SRSLQ and post-KT on the SC. Thereafter, measurements of scores obtained by the participants in each of the instruments (CRSLQ, SRSLQ, and KT) before and after exposing them to the CSCL environment incorporated with either CRL+SRL or SRL prompts were reported. Content analysis was carried out on the observation notes to investigate the process and the nature of students' co-regulation in the groups.

The learning task

The learning task involves using computer simulation to learn a simple circuit. The researcher designed two different learning activity sheets for both the experimental and the control groups. The leaning activity sheets incorporated into the computer supported collaborative learning (CSCL) environment for students in the experimental (CRL+SRL prompted) group consisted of CRL+SRL prompts such as: *Can you all skim through whole activity before starting, to see how they are organised? Please set three learning goals for this activity. Please try and comment on goals of others in your group. It will also be good if you can all agree on three goals here. Can you all agree on the time you would like to spend on each goal? Note that you have only 50 minutes for the whole activity.* However, the learning activity sheets incorporated into the CSCL environment of students working in the control (SRL prompted) group consisted of SRL prompts only. These included the following: *Would you like to skim through the whole activity before you start? Please set three specific learning goals that you want to achieve after learning this topic. Indicate how much time you intend to spend on each goal? Note that you have only 50 minutes for the whole activity.*

Results of Research

Content Validity

Content validity was carried out by the researcher, three experts in the field of learning science and six teachers who reached a consensus, via a thorough review of the draft 23-item CRSLQ, as to its clarity, appropriateness and content validity in regard to the CRL theoretical framework. The experts are specialists in the field of science and science education, educational psychology, educational technology, collaborative learning in science classroom settings, and questionnaire design. The feedback from the nine experts resulted in deleting one item. "*When I can't understand the task, I ask other members of our group for help".*

This item was deleted because it was found that it was almost identical to another item in the CRSLQ. In addition, other items were revised to make them clearer. The experts also examined the CRSLQ for grammar and clarity with some items being adjusted accordingly.

Construct Validity

Construct validity is the extent to which an instrument is measuring exactly what it is supposed to measure. A principal axis factoring analysis (PAF) was conducted on the remaining 22 items of the questionnaire with direct oblimin rotation. Prior to the conduct of PAF, Kaiser-Meyer-Olkin (KMO) static and Bartlett's Test of Sphericity were performed. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO=0.78. Bartlett's test of sphericity $\chi 2$ (231) = 2909.55, $p < .001$. Based on the results, it was inferred that correlations between items were sufficiently large for PAF.

On the first run of PAF, five factors with eigenvalues greater than 1 were identified and these five factors explained 66.80% of the variance in the data. However, one of these components had eigenvalues less than 1.2, and the eigenvalues-one rule is known to overestimate the true number of components in a matrix of correlations because of sampling effects (Cliff, 1988). Finally, the four extracted components were submitted to oblique rotation, and the loadings of the 22 items on the four rotated components are shown in Table.1. The items in Table 1 have been re-ordered in order to make it easier to see the patterns of loadings. The first principal component can be identified with the *monitoring scale*; the second principal component can be identified with the *help-seeking and help-giving scale* while the third and fourth components can be identified with *effort-regulation* and *planning* *scales* respectively. The table shows that all the items had pattern matrix coefficients higher than 0.4, which was suggested to be satisfactory by Stevens (2002). Analysis of the data from this research was used to construct the final form of the CRSLQ with 21 items on four factors. Item 18 (*When working in our science group, I often feel so bored that I quit before we finish what we planned to do*) was finally deleted from the questionnaire because it loaded on component 2 and 3.

Table 1. Pattern loading matrix.

	Item	Loadings			
		1	2	3	4
1.	When working in our science group, I often remind others to contribute their ideas	**0.95**	0.02	0.04	0.07
2.	When there is disagreement in our science group, I either give up or do other things.	**0.93**	0.04	0.01	0.05
3.	When working in our science group, I often try to remind others of the time remaining to finish our work.	**0.92**	0.05	0.01	0.00
4.	When we are doing science group work, I make up questions to ask our group members to help find out whether we have understood the work	**0.91**	0.10	0.00	0.01
5.	When working in our science group, I often feel pleased if others remind me of the time remaining to finish our work.	**0.76**	0.01	0.02	0.06
6.	During our science group task, I often fail to contribute to the task because I'm thinking of other things	**0.60**	0.01	0.02	0.01
7.	When working in our science group I often ask for clarification if I do not understand something.	**0.58**	0.02	0.16	0.02
8.	When working in our science group, I often ask myself questions to find out whether I've learnt what I want to learn.	**0.52**	0.01	0.08	0.03
9.	When working in our science group, I often give feedback to contributions made by others.	0.04	**0.92**	0.11	0.06
10.	When working in our science group, I often try to explain the task to others,	0.02	**0.89**	0.05	0.05
11.	When working in our science group, I ask others to explain concepts I don't understand well.	0.06	**0.75**	0.09	0.04
12.	When working in our science group, I often try to work with others to complete our task.	0.02	**0.60**	0.13	0.03
13.	When working in our science group, I often help others who have difficulties in understanding the group task.	0.02	**0.59**	0.06	0.06
14.	When our science group's task is difficult, I either give up or do other things.	0.02	0.08	**0.87**	0.10
15.	When working in our science group, I often try to participate in the group discussions.	0.04	0.01	**0.70**	0.05
16.	When working in our science group, I work hard to do well even if I don't like what we are doing.	0.01	0.04	**0.61**	0.01
17.	When working in our science group and the task is not interesting, I often manage to keep on contributing my ideas until we finish the task.	0.02	0.03	**0.58**	0.05
18.	When working in our science group, I often feel so bored that I quit before we finish what we planned to do.	0.04	**0.57**	**0.55**	0.05
19.	When working in our science group, I try to make sure we all make efforts to achieve our set goals.	0.05	0.10	**0.49**	0.11
20.	I often think through our group's science task and decide what I am supposed to learn from it.	0.03	0.01	0.01	**0.73**
21.	When working in our science group, I often read quickly through the activities to see how they are organised	0.07	0.01	0.01	**0.69**
22.	When working in our science group, I try to make sure we set learning goals and allocate time for various activities.	0.05	0.01	0.04	**0.68**

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Reliability

The internal consistency of the four scales of the CRSLQ was estimated by Cronbach's Alpha coefficient. The reliability coefficients for the monitoring, help-seeking and help-giving, efforts regulation and planning were found to be 0.88, 0.76, 0.78 and 0.74, respectively and 0.95 for the overall scale. All of these values would be judged to be satisfactory by conventional research-based criteria (Nunnally, 1978; Robinson *et al*., 1991).

Furthermore, the average correlation between the items of the monitoring and the corrected-item total scores was 0.78 (range=0.38-0.95), suggesting that all of the items on this scale do, in fact, measure a common latent variable. The comparable values for the help-seeking and help-giving, efforts regulation and planning were 0.62 (range = 0.42-0.84), 0.64 (range = 0.29-0.55), and 0.56 (range = 0.45-0.53) respectively. Based on this data, monitoring, help-seeking and help-giving, efforts regulation and planning are all internally consistent measures.

Inter Scale Correlation Estimates

Table 2 represents the correlation matrices for the four original scales. For N=214, any correlation coefficient greater than .09 is statistically significant. Factors 2 and 4 show high correlation while Factor 3 shows little or no relationship with any other factors (the correlation coefficient is low), but all other factors are interrelated to some degree. The fact that these correlations exist shows that the constructs measured can be interrelated.

Table 2. Factor correlation matrix.

Factor	1	2	3	4
1	1			
2	0.10	1		
3	-0.01	0.16	1	
4	0.14	0.34	0.17	1

Effects of Co- and self-regulation Prompts on Students' Regulatory Strategies and academic performance in a CSCL

A double-multivariate analysis of variance (MANOVA) was used to examine the effects of co-regulated and self-regulated prompts on students' co and self-regulated learning strategies and academic performance when learning in a CSCL environment. MANOVA was performed on the three dependent variables (CRSLQ, SRSLQ and KT on simple circuit before and after exposing students to the intervention for each of the experimental and control group. The mean (M) scores and standard deviations (SD) of the dependent variables are reported in Table 3.

Table 3. Descriptive statistics.

Measures	Learning Conditions	Pre-Test Post-test			
		M	SD	M	SD
CRSLQ	CRL+SRL Group	73.80	16.73	100.30	8.16
	SRL Group	72.05	13.34	87.10	12.66
SRSLQ	CRL+SRL Group	102.10	14.56	129.95	17.04
	SRL Group	103.30	13.41	122.75	12.99
KT (SC)	CRL+SRL Group	8.10	1.21	11.30	1.13
	SRL Group	7.50	1.10	10.25	1.29

Looking at the CRSLQ scores, it is evident that there are significant differences in means between the control group (M = 87.10) and the experimental group (M = 100.30) on their post-test scores. Turning to the SRSLQ scores, there is no significant difference in the means of the control group (M = 122.75) and the experimental group (M = 129.95). Finally, knowledge test scores reveal significant differences between the means of the control group (M = 10.25) and the experimental group (M = 11.30).

Table 4 reports the multivariate tests of significance for the effect of the studied independent variables on the dependent variables. Results from the Pillai's Trace shown in Table 4 indicate significant effects of the two learning conditions (CRL+ SRL and SRL prompted conditions) and this is found to be p = < .05 on the combined dependent variables.

Table 4. Results of multivariate tests.

Pillai's Trace		F	P
Intercept	1.00	2977.99	0.00
Learning conditions	0.26	4.18	0.00

Univariate analyses, shown in Table 5, reveal that the dependent variables (scores on CRSLQ, SRSLQ, and KT on simple circuit) had significant main effects on the independent variables (CRL+SRL and SRL prompted conditions) in all tests except for the SRSLQ on the treatment groups. Moreover, univariate analysis results (Table 5) for CRSLQ score show that significant differences between the two learning groups exist (F = 4.33, p = < .05).

Table 5. Tests of between-subjects effects.

Source	Dependent Variables	Type III Sum of Squares	df	Mean Square	F	Sig.
Learning condition	CRSLQ	1117.51	1	1117.51	4.33	0.04
	SRSLQ	180.00	1	180.00	.66	0.42
	KT (SC)	13.61	1	13.61	8.18	0.01

Analysis of the results shows that the experimental group, on average, had a higher post-CRSLQ score (Table 3). The result of the post-SRSLQ score shows no significant difference (Table 5) between the CRL+SRL and SRL prompted groups on their usage of SRL strategies whilst learning the simple circuit in a CSCL environment (F = 0.66, p = 0.42 > .05). For the post-KT scores in simple circuits, the univariate analysis result (Table 5) shows that significant differences between the two learning conditions exist (F = 8.18, p = 0.01 <. 05). Students in the experimental group perform better on the knowledge test of the learning content (simple circuits) than students in the control group (Table 3).

In addition to quantitative results, students were also observed and notes were taking in both the experimental and control groups as they were learning in CSCL environment. This helped in gaining deeper in-sight into how students were co-regulating their learning processes in CSCL setting. ATLAS.ti was used to organise the qualitative data and systematic thematic content analyses generated a list of codes that were grouped together resulting in emerging themes. The emerging categories of CRL strategies demonstrated by the students in both the experimental and the control groups obtained from the observational data are presented as follows:

The first category was *students' cognitive strategies.* Prompting students with CRL+ SRL helped in improving the task and the team processes than prompting them with the SRL-prompts only. It was observed that experimental group used CRL+SRL prompts introduced into their learning activity sheets to develop a shared understanding of the team process and the task by asking other group members to clarify ideas they did not understand at every stage of the learning processes. This happened more often than in the control group who were prompted with SRL only. The control group students were just asking their teacher to clarify their ideas for them. The students in the experimental condition, for example, did try to agree on their planning in terms of goal setting, prior knowledge activation and time management skills before writing on their activity sheet. By contrast, the control group students did not really come to an agreement through discussions with other students in their group before writing on their activity sheets.

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The second category was *students' metacognitive strategies.* Supporting the experimental group students with CRL+SRL strategies enabled them to gradually take responsibility for their own group. Prompts were provided to them to enable them to plan how the group would go about solving the given problem, monitor the group's progress towards a solution and finally evaluate the effectiveness of their group learning processes. Students in the experimental group were observed to have settled down faster for their learning activity than did the control group. Most of the students in the experimental group read the prompts on their activity sheet and deemed it necessary to carry other students along with their planning in carrying out the task, monitoring and evaluating the learning goals. A lot of students in the control group just read the prompts on their activity sheets and interpreted it for individual regulation rather than group-regulation.

Discussion

Students' lack of interest and motivation towards learning science is a critical and imperative issue that needs to be addressed. The major contribution of the research was to develop and validate a questionnaire that could be used to measure students' planning, monitoring, help-seeking and giving and effort-regulation strategies which collectively contribute towards adaptive learning engagement in science**.** In order to ensure the validity of the instrument both content and construct validity requirements were fulfilled.

Based on the factor analysis, the scale reliability information, and the inter scale correlations the four scale CRSLQ instrument was constructed. The 21-item Co-regulated Strategies for Learning Questionnaire measures the following dimensions of co-regulated learning strategies when students are learning in collaborative learning settings: *monitoring; help-seeking and help-giving; effort-regulation* and *planning scales*.

Factor analytic evidence indicates that the items measure four unique dimensions of CRL. The PAF results showed that the factorial model of the scales of the CRSLQ that consists of four construct is at an acceptable degree of goodness of fit. Reliabilities of the scale scores, ranging from 0.74 to 0.88, are sufficiently high for making comparisons among groups of students. Cronbach's Alpha values were 0.95 for the overall scale. The validity of this self-report questionnaire was supported and its credibility was established. The final version of the questionnaire which has 21 items has high content, face, and constructs validity and it is suitable for measuring co-regulated learning strategies among secondary school students.

A further investigation was carried out with a group of 40 students in which the effect of supporting students with CRL+SRL-prompts were examined. The developed questionnaire was used for data collection along with other tools. The results of the research suggest that students in the experimental group engaged in a deeper level of collaborative activity, and were more metacognitive in activities within the learning environment compared to students in the control group (Tables 3 and 5). However, there was no significant difference between the experimental and the control group in regard to their usage of SRL strategies during learning of simple circuit in a CSCL environment (Tables 3 and 5).

These results are in agreement with other studies that explored the use of CRL processes by students in technological learning environments (Dettori & Persico, 2008; Volet et al., 2009; Kirschner et al. 2009; Pifarre & Cobos, 2010). The findings by these CRL researchers suggest that students who are not prompted with CRL strategies in a CSCL environment are at risk of being unable to use CRL strategies effectively. The benefit of deploying CRL prompts into a CSCL environment teaching simple circuits is reinforced with the resultant improvement in the construction of social knowledge by students (Kreijns et al., 2004). It is also pertinent to note that the success of the incorporation of CRL+SRL prompts into a CSCL environment for enhancing co-regulation could be ascribed to the fact that the designed CRL-prompts did not impose the burden of additional information processing that may interfere with the students' aim of concentrating on the to-be-learned information. Furthermore, because the designed CRL-prompted instructions were pedagogically integrated into the learning resources, they assisted the students to work towards achieving their target goals within the allocated time. Furthermore, the results show that there are differences in the students' academic performances when learning in a CSCL environment with CRL+SRL- and SRL-prompts. The results show that there was a greater shift in the pre- and post- means of the simple circuit knowledge test scores of the experimental group (3.20) in comparison to that of the control group (2.75) as shown in Table 3. Table 5 confirmed that there is a significant difference between the shift in the means of the test scores of the experimental group and the control group. This finding is supported by previous research outcomes on metacognitive behaviours during solo and collaborative learning processes which suggest that students who are provided CRL-prompted instructions display significant learning gains in different domains and scientific tasks

(Dettori & Persico 2008; Volet et al., 2009; Pifarre & Cobos 2010). This outcome contributes to the literature on the usage of a CSCL environment in the teaching of scientific concepts (e.g. simple circuits) to Key stage three students by illustrating that CRL+SRL-prompted instructions aimed at facilitating students' ability to co-regulate their learning processes is associated with improved test score attainment during learning with CSCL environment.

Conclusions

The developed CRSLQ has high validity and reliability scores. Therefore, it could serve as a useful tool for researchers and teachers for investigating important aspects of students' learning engagement during science learning. This information could guide classroom teachers in refocusing their teaching practices and provide opportunities for the development of students' motivational beliefs and co/self-regulation. Moreover, the questionnaire seems applicable not only to Key stage 3 students learning science collaboratively, but also to any group where the members have shared learning goals. For researchers, the use of this questionnaire in conjunction with other techniques such as interviews and observations could lead towards a more comprehensive understanding of students' co-regulated learning strategies in the classroom. Finally, an interesting direction for further work is investigating whether there might be cultural differences in how students respond to co-regulation. This research was carried out in the UK in the context of the English national curriculum. One possibility therefore would be to carry out a similar research within the African context.

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