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The effects of a Full-Year Pedagogical Treatment Based on a Collaborative Learning Environment on 7th Graders' Interest in Science and Technology and Conceptual Change

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Abstract: The growing popularity of collaboration in our school and its possible educational potential has led us to carry out comparative research with 7th grade students. Using a longitudinal approach over an entire school year and using a cross-lag design, we were able to test the effects of this learning environment on science misconceptions and interest. Using two questionnaires, we were able to perform an analysis of the results showing a possible positive causal link between collaborative learning and the development of scientific conception. However, we found no direct connection between collaborative learning and interest. The analysis of the cross-lag leads us to see conceptual change as a mediator of the students' interest in science.

Keywords: *Collaboration learning, Conceptual change, Interest.*

Context

One of the main difficulties that educators encounter when they teach science and technology has to do with the misconceptions that students have and which interfere with their teaching. Misconceptions are representations about how the physical world works that are in complete or partial contradiction with the knowledge to be taught (Baser, 2006; Bryan, 2000). Throughout the years, many conceptual change models have been proposed by science education research and psychology. These models were designed in order to favour students' acceptance of scientific models at the expense of their initial conceptions. Most of them encompass the general idea that student's misconceptions first have to be identified, and then be put in explicit conflict with scientific knowledge, through oriented observation, logical arguments, demonstrations, experiments, etc. Even if there is a rather large variety of models, most will integrate these two prerequisites: (1) identification and (2) conflict.

Despite the many verified benefits of interventions based on conceptual change models, like the use of refutational texts (Diakidoy et al., 2003), bridging analogies (Clement, 1993), discrepant events (Nussbaum & Novick, 1982) and other means, the introduction of such practices in the classroom sometimes appears to be difficult because of the individual and multiple differences that exist between students' conceptions.

> "[…] in a real class context, with crowded classrooms, teachers do not always have time to develop pedagogy that implements socio-constructivist models right to the end or the full benefit of each of their students" (Potvin et al., 2012, p. 414)

Indeed, the identification of all misconceptions to be targeted is sometimes simply impossible. If for certain topics, a few and widespread misconceptions can be listed, for others, there is just no saturation. In certain cases, there are almost as many misconceptions as there are children in a class, assuming that there could only be one for each, which is unlikely. Another difficulty is that teachers are always outnumbered in class setting. Thus, even if a complete conceptual catalogue could be drawn up, it appears very difficult for one- or a few teachers working together- to anticipate and address them all within ordinary class time.

It is for such reasons that *collaborative learning* might possibly offer a solution. Indeed, collaborative learning suggests that interactions between students, triggered by the need to solve targeted and well-defined problems, will occupy most of class time. These multiple interactions constrained by the need for the establishment of a consensus required for resolution, have the potential to generate many conceptual conflicts between students in addition to those between students and a supporting teacher. This possibility, however, does not guarantee that discussions will necessarily provoke constructive conflicts, nor that conflictual information will be easily recognized as such by students, nor that they will necessarily result in conceptual changes that are in the intended directions. Nevertheless, the large number of possible discussions, the continuous presence of an interlocutor for all students, and their possible ability to make these conflicts authentically cognitive or epistemic (and avoid turning them into adversity conflicts) suggest that there could be great potential in this approach for favouring conceptual changes. Of course, it also suggests that students can have at least partially rational conducts, which is not always easy to achieve. In fact, collaboration learning can also bring, as indicated by Rojas-Drummond (2003), misbehaviour and indiscipline from students who can sometimes see an opportunity to socialize rather than learning. This innovative teaching approaches can also sometimes cause more stress and anxiety for students and teachers (Shachar & Fischer, 2004). Collaboration learning can be challenging for teachers and not easy to implement at first try.

Collaborative approaches can be defined as active, learner-centred approaches where learners have a common and shared goal that is achieved by encouraging students to express their ideas, articulate their thoughts, develop their own representations, elaborate their cognitive structures and make social validations of this new knowledge (Henri & Lundgren-Cayrol, 1998). For many years, they have been considered as potentially beneficial in many ways, among which they are supposed to trigger and sustain the development of interest (Akinbobola, 2009). Interest can sometimes be considered as valuable for itself, because it is a legitimate target, and has often been correlated with achievement. But it is also known to facilitate conceptual changes, and this perhaps even more than cognitive conflict (Kang et al., 2010).

Conceptual Framework of the Study

Collaborative Learning

There are many definitions in the scientific literature of the concept of "collaborative learning". We can first indicate the fairly widespread existence of a certain confusion between collaboration and cooperation. While some authors consider them as synonyms, others perceive a clear distinction between the two. In the context of this research, we will establish a rather clear distinction.

Palincsar (2002) defined collaborative learning as happening in a group in which members share the cognitive responsibility for a common task. In class, five conditions must be put in place to foster the emergence of collaborative learning. First, the environment must (condition No. 1) encourage and valorize exchange, conflict and consensus in the team (Kirschner et al., 2009). The selected tasks must (condition No. 2) be completed with the participation of all members. They must also (condition No. 3) be "open" (Van Boxtel, 2000). Students should dispose of a certain amount of (condition No. 4) freedom and responsibility in their search for information, on how to complete the task. Finally, the teacher should (condition No. 5) encourage discussion and questioning (Furberg & Arnseth, 2009). If students have difficulties, he/she must not provide answers right away. He/she can, however, provide hints at appropriate times in order to help the members of the group reconsider their conceptions, their thinking and suggest alternative paths to explore.

In the particular context of technology-supported learning environments, it is often mistakenly assumed that fertile interactions will occur only because the environment allows it (Kreijns et al., 2003). On the contrary, as indicated above, fertile interaction can only be secured through a certain number of conditions, among which are positive interdependence, responsibility, promotive interaction, etc. (*Ibid.*; also see above). Our study should therefore be very attentive and proactive in connection with such pedagogical / didactic conditions. Another trap that is usually recommended to avoid would be to reduce interactions to cognitive considerations. The behaviour of the students is obviously cognitive, and the cognitive benefits are those which are sought. However, students are also affective subjects, susceptible to being affectively injured by conceptual conflicts, even when they have intentions of cognitive action. Establishing a climate of trust is therefore essential and student learners "feel a sense of warmth and belonging, and feel close to each other before they engage willfully in collaboration and recognize the collaboration as a valuable experience" (Kreijns et al., 2003, p. 341). We believe that such a climate of trust allows the advent of dialectics and evidence-driven argumentation that appears necessary for conceptual change. Indeed, Asterhan & Schwartz (2009) had already shown that such dialectic argumentation was more powerful than the mere research of consensus, in order to drive conceptual change.

Conceptual Change

Learning a concept is not limited to the memorization of its definition, but rather as positioning it in a network of knowledge that makes sense for the learner (Reuter et al., 2013). This way of considering the notion of a concept is based on the idea that the learner often has an initial knowledge of scientific concepts. Indeed, confronted with a natural phenomenon, humans spontaneously try, sometimes unconsciously, to find an explanation and build an understanding. Thus, people construct, often automatically, their conceptions from their observations and with the mobilization of their previous knowledge.

This previous knowledge is often seen, at first, "to make sense" and as having power to explain observed phenomena. However, some of these initial explanations are sometimes incorrect or incompatible with scientific conceptions to be taught. This situation represents one of the major challenges of science education (Bryan, 2000). From the fact that students are coming in class with a background of personal knowledge and beliefs (Eryilmaz, 2002; Posner et al., 1982), we can predict that the acquisition of new knowledge will be influenced by them. Harrison et al. (1999) demonstrated that even university-level students in physics have scientific preconceptions. These are often called, according to the authors, false conceptions, erroneous conceptions, initial conceptions, misconceptions, etc.

The fact that students have such preconceptions leads to consider science education in a different way that will thus require successfully operating *conceptual changes* (DiSessa, 2006). Within this commitment, learning a new concept can no longer be seen only as a conceptual addition, but as a process by which the learner must reorganize his knowledge in order to move from preconceptions to scientific ones (Vosniadou et al., 2001). Preconceptions, which seem to explain relatively well phenomena that surround students, are considered to be very resistant to teaching efforts (Tao & Gunstone, 1999). Cognitive conflict, explaining preconceptions and discussion between students are some of the methods often stated in order to produce conceptual change. Eryilmaz (2002) demonstrated that students who were encouraged to discuss their preconceptions at the end of the process had fewer misconceptions, compared to a control group. In the same way, Baser (2006) has shown that sharing the misunderstandings and anomalies observed can have a beneficial effect on conceptual change. It is mainly this aspect of communication, explanation and confrontation of conceptions that would allow collaborative learning to lead to better conceptual change. Indeed, students working in a classroom providing a collaborative learning environment are quickly placed in a situation where the argument, debate and consensus are encouraged and even explained. In order to be able to record conceptual changes, one must first evaluate the presence/absence of preconceptions. This is usually done through the use of questionnaires that contain conceptual distractors. If students are “contaminated” by misconception, they are then presumed to fall in such conceptual traps. A classic example of a conceptual test is the “Force concept inventory”, which has been developed and validated in the 1990s in order to evaluate the presence of widely spread misconceptions about force and movement (Hestenes & Halloun, 1995).

Interest in Science and Technology

Interest in science and technology, considered by many authors as a predictor of success (Gottfried et al., 2009; Krapp & Prenzel, 2011; Pan & Gauvain, 2012) has been studied for many years (Osborne et al., , 2003). Unlike motivation, interest is usually presented as a relationship between an object and an individual (Krapp, 2007). This relationship is based on affective, cognitive and personal value judgments (Hidi & Renninger, 2006).

Many factors seem to influence students' interest towards science and technology. Several of them have been investigated. Potvin and Hasni (2014a), in their meta-analysis of the student's interest in science, identified *teacher and teaching methods* as one of the most important factors. Indeed, many studies seem to indicate a positive relationship between the interest of students and teachers showing enthusiasm, encouragement and closeness to their students. Türkmen (2008) mentioned a positive effect on students' attitudes towards science when teachers encourage students to be curious, to ask questions and to test their ideas and theories. Like Tükmen, Nolen (2003) mentioned that students' perception of their teacher greatly influences their productivity as well as their motivation to perform required tasks. Several other authors also identified the teacher as the primary factor influencing students' interest in science (Osborne et al., 2003).

Therefore, open teaching method, such as problem solving, practical tasks (hands-on) and learning environments that promote autonomous research and reflection are apparently appreciated by students (Potvin & Hasni, 2014b). Problem-based learning has also been the subject of many studies. Most of them indicate a significant impact on science learning and interest (Areepattamannil, 2012). The effect also appears to be larger when this type of pedagogical approach is frequently used (Potvin & Hasni, 2014b). Like problem-based learning, collaborative learning is often considered to have a positive effect on interest in science (Akinbobola, 2009; Potvin & Hasni, 2014b). In contrast, competition and comparison-based teaching methods have shown negative effects on interest (Nolen, 2003).

We observe globally a decline of interest in science and technology. Although this decline is observed throughout the school years, it is more pronounced during the transition from primary to secondary school (Braund & Driver, 2005; Reid & Skryabina, 2002; Sorge, 2007). Quebec, a Canadian province, is no exception, as students' interest in science and technology decline is also observed in the transition from elementary to secondary school and in the third year of secondary school (Potvin & Hasni, 2014a).

Similar Studies

Despite a general shortage of studies linking collaborative learning and conceptual change (Eymur & Geban, 2016), some have obtained promising results and offer some exploration base.

Küçüközer (2013) conducted a study on 33 future science teachers. Despite the absence of a control group, the author mentions, through observations and interviews, the beneficial effect of the interactions and the questioning of knowledge made possible through the implementation of collaborative learning. Another study comparing a control group (N = 35) to an experimental group (N = 37) conducted by Eymur (2016) suggests that collaborative learning leads to a better understanding and the disappearance of misconceptions in chemistry. In addition, semi-structured interviews have shown an effect on student motivation. Based on these results, the author Eymur (2016) concludes that "cooperative learning based on the conceptual change method increases students' understanding of chemical bonding concepts and improves students' motivation for learning." (p. 870) However, he notes that the results of this experiment may have been influenced by the short duration of the experiment (6 weeks), producing a possible novelty effect on students.

Starting from the same hypothesis (that collaboration would facilitate conceptual change in science), authors Leman et al. (2016) conducted research with 341 9-year-old students. When the authors compare the results they obtained by gender, boys showed improvement on conceptual questions, while girls did not (Leman et al., 2016, p. 179). It was thus suggested, at the overall conclusion of this research, that the promotion of conceptual elaboration and the negotiation of student understanding could have had a positive effect on conceptual change in collaborative learning activities. However, gender issued should be explored more in depth.

The results of such studies and of other relevant ones (Tao †, 2004; Tao & Gunstone, 1999) lead us to consider collaborative learning as a possible way to facilitate conceptual change in science. However, the limited number of studies conducted on the subject combined with the short duration of the interventions and the often low number of participants demonstrate the importance of conducting research on the effect collaborative learning.

Collaborative learning, timidly implemented in the Canadian province of Québec (Kingsbury, 2012), has recently become a bit more popular, and lead us to wonder if collaborative learning environments indeed (research question 1) influence the interest in science and technology of young students and (research question 2) lead to more positive conceptual changes.

Based on the literature, we will thus test the following hypotheses: A collaborative learning can have

1. a positive (or negative) effect on students' interest in science and technology; and
2. a positive (or negative) effect on conceptual change in science.

We include negative hypotheses because some previous studies have also suggested that collaborative learning can sometimes have negative effects on certain perceptual constructs (Potvin & Hasni, 2016) and on conceptual change because of a possible contamination effect (students sharing or promoting misconceptions within discussions) (Hynd et al., 1994).

Methodology

In order to measure the effect of collaborative learning on conceptual change and interest in science, two classes (1 experimental class + 1 control class) of secondary 1 students (7th graders) from the same school with an average age of 12 years of age were compared and tested with the same tools with an intact (unequal) group comparison with pre-tests, intermediate tests and post-tests. We chose a public school where the collaboration learning was already in place for many years. We, however, have no further guarantee that these school or students are representative of the whole school population. The control group (randomly assigned) was composed of 27 students (24 participants in the study) and 28 students of the experimental group (26 participants in the study) and there was no gender difference between groups. The pre-test results reveal that the students in the experimental group and the control group showed no initial (October) significant difference in terms of scientific knowledge and interest in science. To our knowledge, the groups did not have any other notable difference in collaborative learning experience.

Both groups were taught by the same teacher, reducing the possibility that the results could be due to "teacher effects". The students in the control group were taught the science and technology program classroom with a lecture-type teaching focused primarily on verbal presentations and exercises. This teaching method was intended to produce a conceptual change mainly by using textbooks and the workbooks as pedagogical tools. Students also completed guided experiments aimed at testing and verifying the notions that were addressed during theoretical classes. Students in the experimental group were instead exposed for the first time to a collaborative learning environment. Over the school year, these students were asked and guided to solve open-ended problems, overcome challenges and realize projects to secure collaboration, thereby developing their scientific knowledge and promoting conceptual change.

Here is an example of activity that illustrates how the treatment is linked to the five conditions that foster the emergence of collaborative learning: To teach students the phenomenon of the day-and-night alternation, the teacher can start the first lesson by explaining that there are locations in the world where, during a certain period of the year, we hardly see the sun. After this short introduction, the teacher asks students, placed in groups of four or five, to explain this phenomenon using drawings ("open task": condition No. 3). The teacher can also give students links to videos so they can see the phenomenon. While some groups might start their explorations with an internet search to document the phenomenon of polar nights, other teams might start with a brainstorm while others can try to sketch a picture on their interactive board using only their initial ideas in astronomy ("freedom and responsibility in the search": condition No. 4). After leaving students strive for a few minutes, the teacher can begin to go around the teams to witness the evolution of provided explanations and to observe possible misconceptions. The teacher can then challenge some defective proposition and encourage students to mobilize useful concepts like the previously studied properties of light ("valorize exchange and conflict": condition No. 1). Faced with the students being persuaded to have produced a good explanation, but whose answer still contains misconceptions, the teacher might tell them that it is possible to observe the opposite phenomenon during the summer. This new information can lead students to discuss and reconsider their model and to better understand their previous errors (encourage discussion and questioning": condition No. 5). Finally, after having allowed students to work together for two periods on the explanation and illustration of the phenomenon, the teacher can present to the class the scientific concepts using for example, a flashlight and a globe and with the help of a short video. Through the entire activity, the teacher will have encouraged all students, especially the apparently most passive ones, to engage with the task ("participation or all": condition No. 2).

In order to avoid measuring a novelty effect that could have been associated with the use of a learning environment that is rather very different from those to which students are used to, this research project was carried out on a whole school year. This choice was also based on the fact that collaborative learning, by its original character, may require an adaptation phase of a few months before students develop the reflexes and the autonomy needed to productively perform collaborative learning and perceive its possible positive effects (Durocher, 2016).

Two questionnaires were used in this research project. Students in the control group and the experimental group had to complete both at the beginning, middle and end of the school year. The first one was adapted from the "*Chantier 7 Project - Improving Students' Conceptual Understanding of Science and Technology"* project managed by Asghar et al. (2016) of McGill University. This 60 multiple-choice questionnaire aimed at assessing cycle 1 (secondary 1 and 2 levels (7th and 8th grade) students' conceptions (by using conceptual distractors) with regard to the national curriculum. For example, one of the questions in this questionnaire allowed us to find out the students' incorrect concepts regarding the relationship between mass and volume. "Jonathan has three beakers each containing 50 ml of liquid. The first contains alcohol, the second contains water and the third contains maple syrup. Will they have the same mass?" The students had to choose from four answer choices presenting conceptions often encountered in 7th grade students. "A. Yes, they will all have the same mass as the three have a mass of 50 ml. B. Yes, they will all have the same mass as they have the same volume. C. No, they will not have the same mass, because two of the liquids are clear while the maple syrup is dark in colour. D. No, they will not have the same mass, because they are filled with different substances." (Correct answer is D).

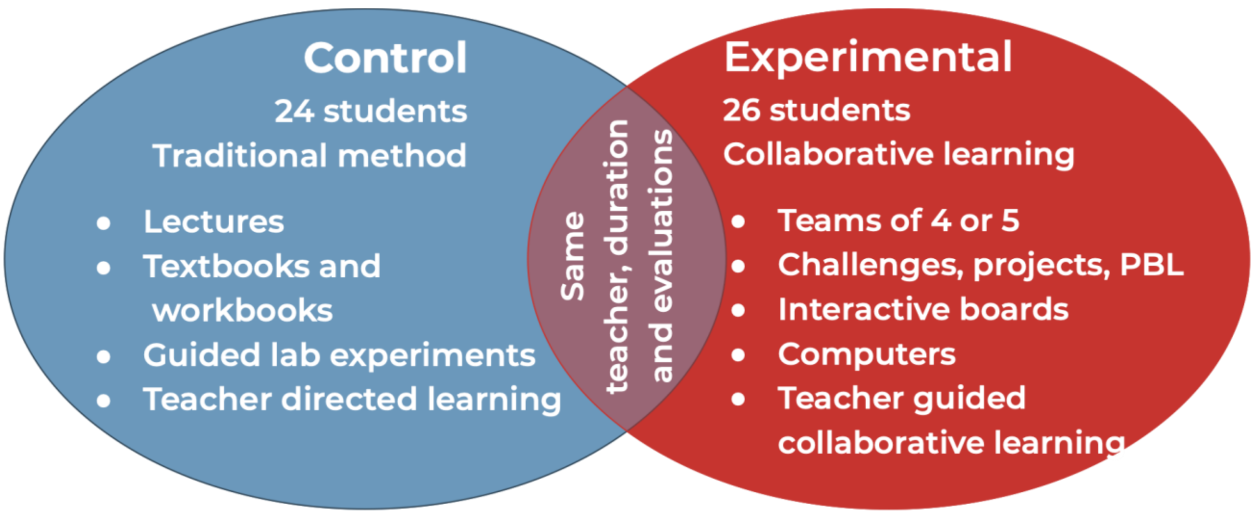

Figure 1

Comparison Between Control and Experimental Group (should be above)

In order to evaluate the level of student's individual interest in science and technology, we chose to use the 2016 longitudinal questionnaire of the *Research Chair in Youth Interest in Science and Technology (CRIJEST)* developed by Hasni and Potvin (2015). Composed of 48 questions of the "Likert scale" type, which allowed students to express their agreement with statements with agreement items like: "I look forward to S&T activities"; "School S&T is interesting"; "We should spend more time in S&T at school"; etc. The items always propose six or four agreement choices (strongly disagree → strongly agree), in order to avoid neutral answers and thus constrain reflection from the student. The questionnaire also contained self-concept items (like "Compared to all other students, I consider myself to be... Very weak in S&T, Low in S&T, More or less weak in S&T, More or less good in S&T, Good in S&T, Very good in S&T". We did not have any particular hypotheses about self-concept, but since it is important to distinguish its effect from interest, we used this construct as control (see Fig 2).

Thus, the general hypothesis for our cross-lag design can be expressed as in Figure 2. This design, which will use the partial-least square (PLS) method of analysis, tests for the predictive power of all available and immediately preceding constructs for all variables (at T1 and T2) that are relevant to our research questions (*Concept*, *Interest* and *Collaborative environment* [and *Self-concept* as control variable]). This kind of design is well adapted to our needs, because it allows a longitudinal evaluation of the effects of each variable in the subsequent states of each one of the others, while controlling every time for covariable effects.

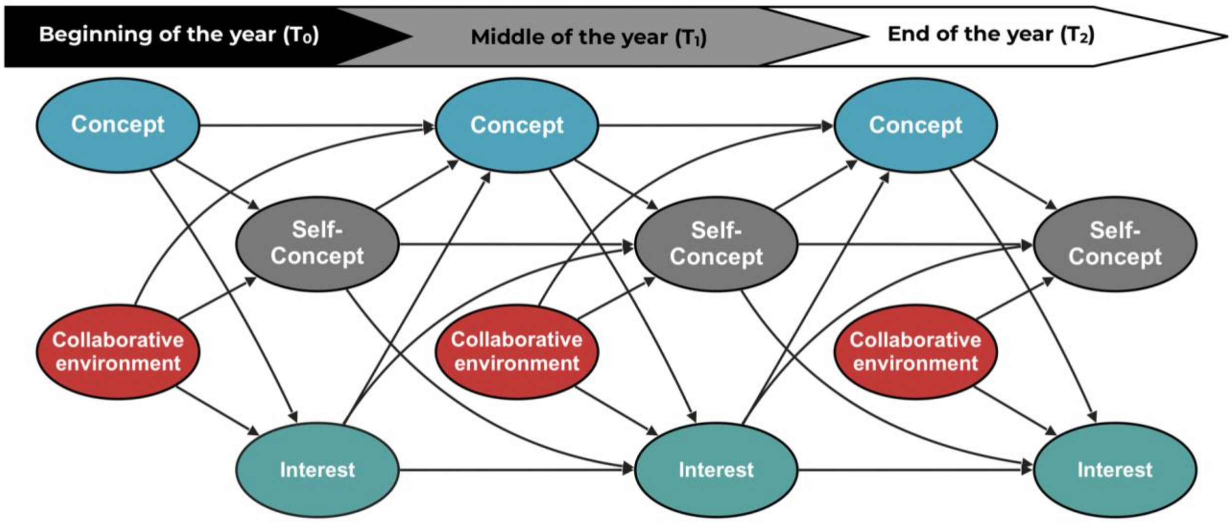

Figure 2

Our General Hypothesis for the Cross-Lag Design – should be above

Results

To begin, let mention that the research methodology was respected throughout the school year. The pupils of the two groups learned the same scientific concepts with the same number of periods, the teaching method is the only component which differed. In addition, no student, with the exception of the initial refusals, has dropped out or been absent for a long period which would lead exclusion from the research protocol. The analysis produced as part of this research project tracks the evolution of two groups of students over a period of one school year. This longitudinal study, in addition to compare the level of interest and the scientific conceptions of the students of each group, allows us to measure their evolution over time. Using a multiple linear regression statistical test and a cross-lag design analysis, we attempted to answer our research questions aimed at measuring the effect of a collaborative learning environment on science's conception understanding and students' interest towards science and technology.

The data obtained using the questionnaire of interest in science and technology will here be identified by the variable *Interest* (Cronbach's alpha = 0.92) and the results of the scientific conceptions test will be represented by the variable *Conceptions* (Cronbach's alpha = 0.81). The type of education received by the control group and the experimental group will be designated as the Collaboration environment variable (0 or 1). We will use the abbreviation T0 to identify the beginning of the school year (first week of October 2016), T1 to the middle (last week of January 2017) and T2 for the end (beginning of June 2017).

First, we were interested in measuring a possible gain of interest. A t test on the gain in interest between T_0 and T_1, T_1 and T_2 and T_0 and T_2 (Table 1) revealed a decrease of interest for the students of both groups. There was no significant difference between the control and the experimental group. It is therefore not possible to say beyond a reasonable doubt that collaborative learning has produced a greater effect on the interest in science and technology than the control group.

Table 1

Comparison of the Gain of Interest During the School Year

Time of the school year	***Group***	***N***	***M***	***SD***	***sig. (2-tailed)***	***d***
$T_0 \rightarrow T_1$	*Control*	24	-0.21	0.80	.225	0.36
	Collaboration	26	0.07	0.74		
$T_1 \rightarrow T_2$	*Control*	24	-0.36	1.32	.746	0.09
	Collaboration	26	-0.25	0.98		
$T_0 \rightarrow T_2$	*Control*	24	- 0.41	0.98	.433	0.23
	Collaboration	26	- 0.19	0.96		

Note : * $p \leq 0.05$ ** $p \leq 0.01$

The *Conceptions* scores of students in both groups were not significantly different at the beginning of the experiment (p = .382). As with the interest, we focused on the conceptual gain between the three data sets of the year in order to get a clearer picture of the evolution of the state of the conceptions. When we focused on the conceptual gain between T_0 and T_1 (Table 2), we observed a significantly greater gain (M = 5.77, p<.001, d=1.03) for the experimental group than for the control group (M = 0.65, p<.001, d=1.03 [Large effect (Sawilowsky, 2009). As for the conceptual gain measured between T_1 and $T_{2,}$ it was not significantly different from one group to the other. However, the total gain (T_2 - T_0) was significantly different, being higher for the experimental group (M = 9.50, p=.008) than for the control group (M = 4.86, p=.008) with a Cohen's d of 0.81, which is considered a large effect according to Sawilowski (2009).

We were also interested in identifying the factors that influenced the considered variables: *scientific concepts, self-concept, collaborative environment* and *interest*. To do this, we have produced a series of three linear regressions at each moment of the year (Figure 3).

The first significant links that appear in the analysis are the stability paths which allow to note that scientific *concepts*, *self-concept*, and *interest* are always significant and strong predictors of their subsequent states. Since we used validated questionnaires, these results were to be expected. The arrows that give us more educationally valuable information are the ones between different variables (cross-lag paths). Two significant collinearity results were found and catch our attention.

Table 2

Comparison of Conceptual Gains During the School Year

Time of the school year	*Group*	*N*	*M*	*SD*	*sig. (2-tailed)*	*d*
$T_0 \rightarrow T_1$	*Control*	*24*	*0.65*	*4.97*	*<.001***	*1.03*
	Collaboration	*26*	*5.77*	*4.95*		
$T_1 \rightarrow T_2$	*Control*	*24*	*4.04*	*4.91*	*.811*	*-0.07*
	Collaboration	*26*	*3.73*	*4.17*		
$T_0 \rightarrow T_2$	*Control*	*24*	*4.86*	*5.72*	*.008***	*0.81*
	Collaboration	*26*	*9.50*	*5.81*		

Note : * $p \leq 0.05$ ** $p \leq 0.01$

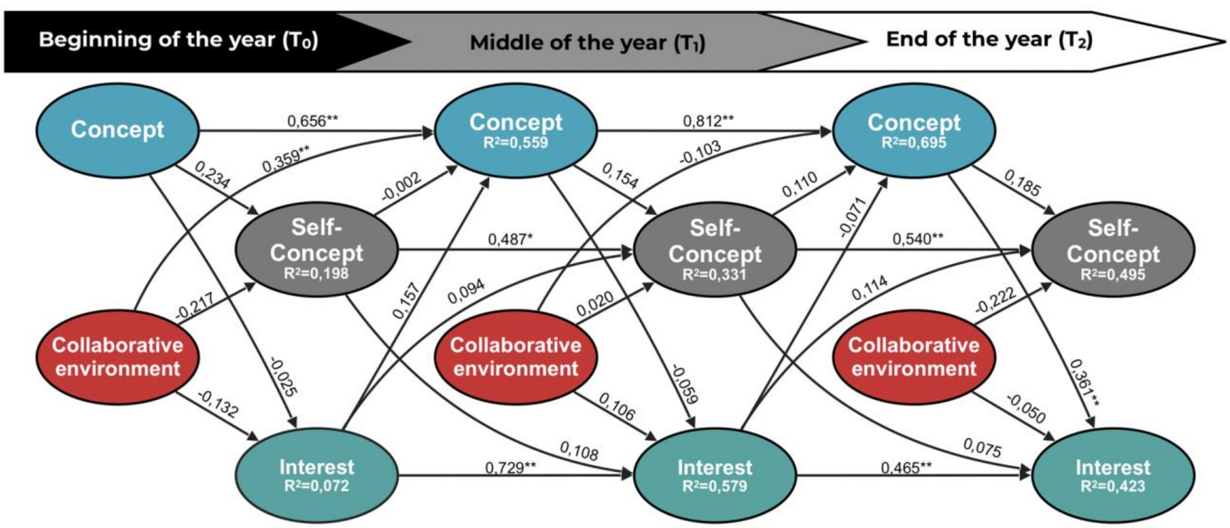

Figure 3

Our Cross-Lag Design with all Results – should be above

The Cross-Lag design analysis (see Figure 4, which retains only significant links) indeed first highlights the significant influence of collaborative learning on conceptual change as recorded at the middle of the school year, thus supporting our hypothesis that associates collaborative learning with better conceptual change. The influence factor of scientific knowledge is also consistent with the analysis of means and results of the t-tests presented earlier. The second significant collinearity result appears between the conceptual understanding as recorded at the middle of the school year and the expressed interest at the end. We will now discuss these results further.

Discussion

The implementation of both treatments was generally carried according to plan (see methodology). With very few exceptions, both groups experienced the same content coverage in the same amount of time, and all students attended courses as diligently as they would have in a regular school year. The difference between treatments was a bit difficult to implement in the first days, but eventually, with a bit of coaching, the experimenter was able to administer both treatments with no presumed prejudice to one group to another, while materializing a true pedagogical difference. The experimenter confessed that planning twice as much as usual was challenging. However, contrary to what is usually expected, and since the experimenter is a regular user of collaborative pedagogy, it is the control treatment that required more work from his part.

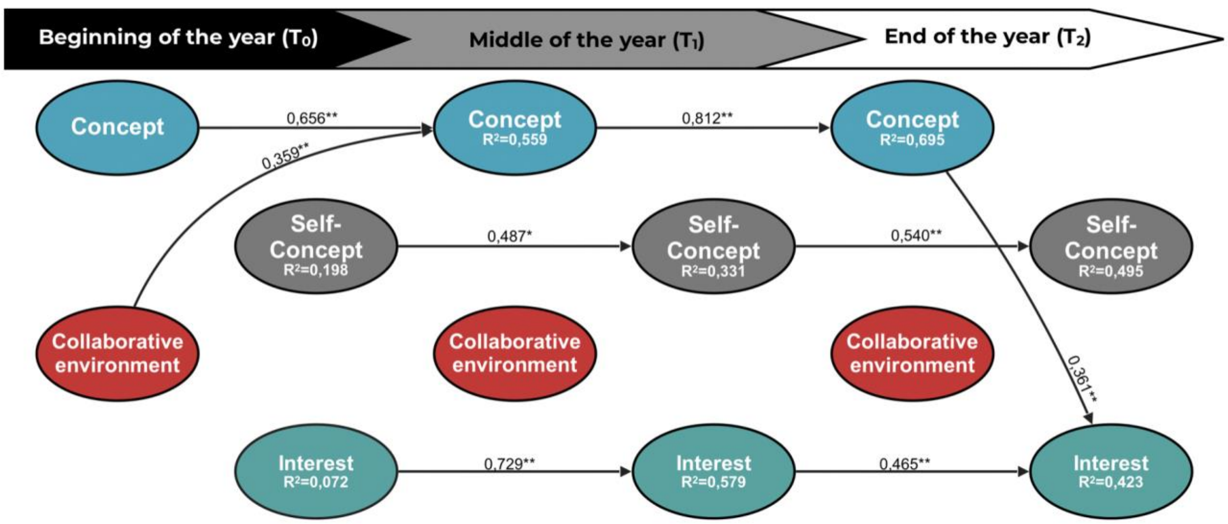

Figure 4

Our Cross-Lag Design with only the Significant Results

The results of this research allow us to observe a decrease in interest during the school year for both groups. This first observation is consistent with the results of several studies measuring a decline in the interest of students entering secondary school (Osborne et al., 2003; Potvin & Hasni, 2014a), but not consistent with the conclusions of Akinbobola's research (2009) who measured a greater interest from students evolving in a collaborative environment, which our data do not allow us to confirm, since the differences between the two groups are not significant. Students achieving learning in a collaborative environment, according to our results, produced much more conceptual changes compared to more transmissive teaching, especially during the first half of the experiment. Indeed, an effect size of 1 or more is usually considered large and educationnaly important by most standards (Hattie, 2009; Sawilowsky, 2009). In addition to generating better scientific knowledge, collaborative learning has led participating students to initiate the desired conceptual change processes more early.

The cross-lag design shows us an interesting link between the understanding of scientific concepts during the year and the final interest of students in science. Indeed it appears that producing conceptual changes and having a better understanding of scientific concepts are factors that positively influence students' interest in science and technology. While it is impossible for us, through our results, to directly associate collaborative learning with a greater interest, it is reasonable to believe that learning collaboratively, which leads to more conceptual changes, has had an indirect but positive effect on interest. This indirect link implies that beyond the chosen teaching method, it is the impact that these methods have on conceptual changes that ultimately arouse interest. According to this hypothesis, the development of interest would be one of the effects that a better understanding can produce, but not necessarily the opposite (interest → better understanding), while no regression showed any significant longitudinal link coming from the variable interest (besides the initial state of interest).

Nevertheless, the small number of participants in the two groups represents a limit to this research. For logistical and organizational reasons, it was impossible for us to carry out this research with more than one control group and one experimental group. Despite this rather small sample, we believe that the ten-month intervention period may help to offset the small sample size. Indeed, it is unusual to study the effects of treatments that are administered on such long periods. Usually, treatment used in research is much shorter (generally days, much less weeks). Thus we believe our research to be an interesting contribution.

It is, however, important to mention the dual role played by the researcher, who was also the science teacher of both groups. This methodological choice had the advantage of ensuring that the treatment administrator understood the objectives of the research and the nature and the application of the two treatments. To favor compliance with the research protocol and the objectivity of administration of selected treatments, several meetings have conducted with the research team. But there remains a possibility that the treatments were subjected to biases because of this.

Conclusion

Although collaborative learning requires a major transformation in teaching practice, our results support the adoption of educational interventions based on collaborative learning in science and technology in secondary school. However, since we were able to record variations that are shorter than a school year (conceptual gains in the first half of the school year; and interest gains in the second), that our design is merely quasi-experimental and that the research was not double-blind (the teacher was aware of the conditions and the research aim), we believe that our conclusions should be taken with caution, and that further research efforts have to be conducted to explore the effects of such shorter variations, and also to test for effectiveness over longer periods. We believe that a more robust validation of collaborative methods depends on this, among other things.

In addition to getting students to be active in their learning, to question the validity of the information read or transmitted by their peers and to question their own perceptions, it is nevertheless suggested here that the establishment of a collaborative learning environment could promote accelerated (and maintained) conceptual changes, in comparison with lecture-based methods (keeping in mind the above-mentioned limitations).

The relations revealed by the cross-lag design between collaborative learning, conceptual change and interest allowed us to consider interesting future implications for research related to young people's interest in science and technology. These results seem to indicate that beyond pedagogical practice, it is the production of conceptual changes that has recorded the most, while indirect influence on interest. Thus, we believe it is relevant to encourage research aimed at establishing links between the realization of conceptual changes and interest.

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