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EFFECTS OF SENEGAL'S SCIENCE AND TECHNOLOGY CURRICULUM ON THE INTEREST AND SELF-CONCEPT OF MIDDLE-SCHOOL STUDENTS

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ABSTRACT
The present study aimed to explore the students' middle-school interest for science and technology (S&T) but also the evolution of this interest while comparing two science and technology curriculum. In this study, the researchers collected data through a questionnaire on interest and self-concept in S&T. Four hundred and seventy-one middle-school students from general middle schools (known as "collèges d'enseignement moyen" [CEMs]) and specialized science and technology schools (known as "blocs scientifiques et technologiques" [BSTs]) in Dakar, Senegal responded to our questionnaire. Data analysis included a two-way repeated analysis of variance (ANOVA) measurement with time as a repeated factor and the group as a fixed factor. The results of the analysis of variance show that the interaction is significant for students' interest in S&T at school. The simples effect interpretation shows that a significant difference (p = .002) between the levels of interest expressed in the pre-test and at the post-test by the BST group and the comparison of means shows that the BST group expresses scores of interests in the post-test that are lower than those expressed in the pre-test (ΔM = -.260). Furthermore, the analysis of the results also shows a significant difference (p <.001) between the interest scores expressed in the pre-test and at the post-test by the CEM group. Contrary to what is observed with the BST group, the comparison of the means shows that the CEM group expresses a higher post-test interest compared to the pre-test (ΔM = .596). The results show that the self-concept scores expressed by the BST group are therefore different from those expressed by the CEM group regardless of the time and in favour of the CEM group both in pretest (M = .36) and in the post-test (M = .46).

Background: Over the past few years, several international studies have addressed the issue of student interest in science and technology (S&T). The findings of these studies describe the phenomenon of declining interest the higher the level of education. Senegalese education system is not an exception to this rule. Several studies in that country refer to the factors that contributes to this decline.

Purpose: The present study aimed at exploring the effect of a special science and technology curriculum on students' middle-school interest.

Sample/Setting: Stakeholders set consist of eleven experienced secondary science teachers (6 classes in each school). We asked them to teach as usual without changing their practice. We submitted a survey to their respective students to take measures of their interest at the beginning and at the ending of the session. The total sample size is of 471 students.

Design Methods: A pre-post comparison of student interest and self-concept scores was performed. A repeated-measure analysis of variance made possible to monitor the evolution of student interest and self-concept in the two curriculum cases (CEM and BST).

Results: The results suggest that the interest and the self-concept toward S&T expressed by CEMs' students evolved positively. Interest expressed by students who have experienced the BSTs' S&T curriculum has declined. This does not reflect the expected results from the beginning.

Conclusions/Implications for classroom practice and future research
Even though BSTs were intended to be an opportunity to teach science and technology under suitable conditions, it does not appear that science and technology courses are always provided as indicated when the initiative was created. Indeed, these conclusions suggest that we investigate the effect of the quality of S&T courses on student interest and self-concept.

Keywords*: Science and Technology, Interest, Self-Concept*

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1 INTRODUCTION

S&T is broadly understood to play an important role in the evolution of societies. Indeed, poor S&T education can result in major challenges for any modern society. However, despite a growing need for qualified S&T workers, interest in S&T studies is declining (OECD, 2006, 2008). PISA study shows that this is true for several countries (OECD, 2006), and Senegal is no exception (Academy of Science and Technology of Senegal (ANSTS), 2003; Sane, 2009a, 2009b; National Council for Scientific and Technological Development/ CNPDEST, 2010a; Department of Education (MEN), 2014).

Anticipating the problems that could arise from students' lack of interest in S&T, Senegal's education authorities have introduced various strategies. One of such initiatives, introduced by the Senegalese government, was the creation of BSTs, educational institutions dedicated to teaching S&T in the middle school live1 (CNREF, 1984). The aim of these schools was to improve conditions for students and teachers by reducing class size (24 students per class compared with an average of 50 students per class in CEMs) and to optimize the use of existing teaching staff, materials, and infrastructure by featuring rotational classes (CNPDEST, 2010b). The BST program also encourages the use of pedagogical approaches that are more open, such as inquiry-based science teaching. Admission to this special S&T program is based primarily on students' grades in mathematics and in life and earth sciences, and secondly on their choice to pursue S&T. Despite having its importance confirmed by all preliminary evaluations, the BST initiative has had a relatively low impact on the system. In fact, the enrolment rate among middle-school students dropped from 25 percent in 1980, when the program was created, to under 10 percent in 2009 (Sane, 2009b). Therefore, not only are BSTs currently unable to accommodate all the students in the zone they are supposed to cover, but they are also seeing fewer new students. Moreover, these schools are not evenly spread throughout the country, and some regions do not have any (Sane, 2009b). According to Sane (2009 b), the recommendations resulting from the evaluations favoured expanding the program throughout the education system while linking the BSTs with secondary-school labs (CNPDEST, 2010b). Intended to ensure a consistent presence of experience-based teaching at all levels, these recommendations are currently being implemented with the creation of 20 new BSTs (MEN, 2014).

However, although CEM and BST students alike readily acknowledge the importance and relevance of S&T for understanding and explaining the natural world, few of them express a desire to pursue a career in these fields (ANSTS, 2003; 2013). The same observation has been made in various reports on Senegal (MEN, 2009, 2014; CNPDEST, 2010d). We can therefore conclude that the way S&T is currently taught does not appear to be effective (CNPDEST, 2010d). Yet, several authors feel that a heightened interest in S&T among students could have the positive effect of making them more engaged in S&T classroom tasks and more motivated to develop their S&T culture (Hide & Harackiewicz, 2000; Khoo & Ainley, 2005).

2 RESEARCH BACKGROUND

2.1 Interest

Interest, as it is understood in this study, refers to the psychological state of engaging or the predisposition of an individual to re-engage with activities that involve having contact with an object (Hidi & Renninger, 2006). Interest can be directed towards a field of knowledge, a specific domain, a theme, or an activity (Krapp & Prenzel, 2011). In this respect, this state leads to focused attention, increased cognitive functioning, persistence, and affective involvement in relation to the task (Krapp & Prenzel, 2011). Interest is characterized by the fact that it is related to specific content (Hidi, Renninger & Krapp, 2004; Krapp, 2007; Krapp & Prenzel, 2011; Renninger & Hidi, 2011) but also by its relational nature (Hasni & Potvin, 2015). For Krapp, "an interest represents or describes a more or less enduring specific relationship between a person and an object in his or her life space" (2007, p. 8).

The study of interest examines its affective and cognitive components, as well as the value placed on the object of interest (Hidi, 2006; Hidi & Renninger, 2006; Krapp & Prenzel, 2011). Furthermore, several authors (Ainley, Hillman & Hidi, 2002; Hidi, Renninger & Krapp, 2004; Krapp, 2007; Krapp & Prenzel, 2011; Renninger & Hidi, 2011) look at two levels of interest: situational interest and individual interest. Our questionnaire-based study will focus on the latter, as it is independent of the specific contexts or situations that trigger it and refers instead to a persistent state.

Individual interest is characterized by an intrinsic desire to enter into a relationship with and understand a particular object (Hasni & Potvin, 2015). It is based on pre-existing knowledge, personal experiences and emotions, and the value placed on the object of interest. Usually, this type of interest develops slowly and, for some learners, can last for a long time (Krapp, 2007; Krapp & Prenzel, 2011; Renninger & Hidi, 2011; Schraw & Lehman, 2001).

2.2 Self-Concept

Self-concept refers to students' perceptions of their ability to understand scientific and technological concepts or to perform specific tasks in scientific and technological activities (Taskinen, PH, Schütteb, K. & Prenzel, M., 2013, Bong & Skaalvik, 2003). Therefore, self-concept can have effects on students' interest. Thus, several authors (Bong & Skaalvik, 2003; Hasni & Potvin, 2015) also suggest paying particular attention to

[1]Middle-school education follows primary education. It is offered at middle schools (CEMs), BSTs (S&T schools), and high schools, and includes the equivalent of grades 8 through 11 (grades 10 and 11 for BSTs).

students' self-concept when it comes to accounting for their interest. Indeed, self-concept is a good predictor of students' interest (Hasni & Potvin, 2015). This is in line with other authors' conclusions (Ainley & Ainley, 2011) that show that more students feel able to understand scientific concepts and solve problems, more they are interested in activities that are offered to them. Considering all the recommendations of the authors cited above, in this research, individual interest will be measured then considering students' self-concept.

Given the above characteristics, interest is a key part of a successful S&T education. We feel that it is crucial to examine the impact of the BST project on student interest by comparing it to how S&T is taught in CEMs, which constitutes the non-specialized stream for young Senegalese students. Our research therefore centres on the following questions:

1. What is the individual interest in S&T among Senegalese CEM and BST students when they begin their studies at these institutions?
2. Is there a difference between how individual interest develops in students who attend BSTs and in those at CEMs?

In light of the current state of S&T education in Senegal, we advance the following hypotheses. Regarding question 1, and given that BST students go through a certain selection process, that these students will have a higher means interest and self-concept than CEM students (hypothesis A). Regarding question 2, and since the main purpose of BSTs is to foster interest, these same students will experience greater scores with respect to the interest and self-concept than CEM students (hypothesis B).

3 METHODS AND DATA

3.1 Participants

A total of 11 teachers from BSTs and CEMs in the Dakar area and 471 of their students from 12 different classes (6 classes in each school) agreed to take part in this study. The teachers were recruited based on years of experience (five) and level of interest in our project. The BST teachers who participated in this study all received support training to improve their practices and comply with the program's goals. The students were between the ages of 15 and 16 and were in the final two grades of middle school. They were studying science (physics/chemistry, life and earth sciences, family economics, technology) at either CEMs or BSTs. Consent was obtained from both the parents and the students. Their consent was the only criteria used when selecting students.

3.2 Materials

We used an adapted version of the general questionnaire developed by the research chair in the interest of young people in science and technology (CRIJEST) (Hasni & Potvin, 2015), which tests various sub constructs of interest, motivation, confidence, and other factors. For the purpose of this study and to answer our research questions, we used the "interest in S&T at school" sub construct, which is measured using six items (Cronbach's $\alpha = 0.89$), such as "I can't wait for the next S&T activity"; "at school, S&T is boring" (reverse worded); "there should be more S&T at school" and "if I had a choice, I wouldn't go to any more S&T classes" (reverse worded). We also used the sub construct "school S&T self-concept," which is also measured using six items (Cronbach's $\alpha = 0.82$), such as "compared to other students, I think I'm (good) in S&T" and "compared to my friends, I find S&T (easy)." This sub construct was studied because it sheds light on how interest develops and makes it possible to control any possible effects of implementing new pedagogical approaches (such as the scientific inquiry–based teaching approach on which the BST project is based). The same questionnaire was used pre- and post-test with both the CEM and the BST groups. An overall picture of the groups was established, gains were calculated, and the differences between the groups were analyzed.

3.3 Procedure

Data was gathered over five months, i.e., from October 2015 to February 2016. The collection process was overseen by the lead researcher. The participating teachers were asked to give their S&T courses on the usual themes and without changing their usual practices. The questionnaire was given to the students at the beginning and end of the collection period. Students were asked to answer the various items in the questionnaire as honestly as possible based on the courses they had taken with their science teachers. They were told that only the researchers would see their answers.

3.4 Analysis

To answer our research questions, we analysed the group-based development of individual interest and that of students' self-concept pre-test and the post-test. We carried out a two-way repeated analysis of variance (ANOVA) measurement with time as a repeated factor and the group as a fixed factor. As we have two periods (pre-and post), it was not necessary to verify the sphericity hypothesis of the variance matrix. When the interaction is significant, we are interested in simple effects. Significant interaction implies that the effect of time on the dependent variable (students' interest in science and technology or students' self-concept at school) is different depending on the group and vice versa. However, when the interaction is not significant, it means that the effect of time on students' interest does not differ according to the group. The analysis will focus on the overall effects. Therefore, we interpret the times and group interaction. When time interaction appears to be significant, this indicates therefore that there is a difference between the pre-test and post-test, regardless of the group considered, and when group interaction is significant, it will show that there is a difference between the BST and CEM groups, regardless of the time (pre-test or post-test).

4 RESULTS

Table 1 provides a general breakdown of our sample.

Tab. 1. Descriptive statistics

Constructs	Groups	N	Pre-test M	Pre-test SD	Post-test M	Post-test SD
Interest in S&T at school	BST	232	4.87	.91	4.61	1
	CEM	148	4.67	.90	5.26	.96
Self-concept in S&T at school	BST	270	4.24	.91	4.36	.77
	CEM	182	4.60	.83	4.82	.82

4.1 Interest in science and technology at school

The results of the analysis of variance show that the interaction is significant (F (1.378) = 40.994, p <.001, η_p^2 = .098) for students' interest in S&T at school, although it is a small effect size according to the standards of Cohen (1988). Consequently, we will interpret the simple effects. These results are presented in tables 2 and 3.

Tab. 2.

	Interaction	*Simple effects: groups*	*time I*	*time J*	*(J-I)*	*p*
Interest in S&T at school	*F (1,378) = 40.994, p <.001, η_p^2 = .098*	*BST*	*Pre*	*Post*	*-.260*	*.002*
		CEM	*Pre*	*Post*	*.596*	*<.001*

Note. *, p <.05; **, p <.01; ***, p <.001

The results in Table 2 show the change in the student's interest in the two groups between the pre-test and the post-test. Indeed, the analysis of the results shows a significant difference (p = .002) between the levels of interest expressed in the pre-test and at the post-test by the BST group. The comparison of means shows that the BST group expresses scores of interests in the post-test that are lower than those expressed in the pre-test (ΔM = -.260), that is to say less than a quarter of a point on a scale of Likert at 6 levels. Furthermore, the analysis of the results also shows a significant difference (p <.001) between the interest scores expressed in the pre-test and at the post-test by the CEM group. Contrary to what is observed with the BST group, the comparison of the means shows that the CEM group expresses a higher post-test interest compared to the pre-test (ΔM = .596), more than half a point on a 6-level Likert scale. This could mean that the results obtained also present a situation contrary to our prediction (hypothesis B), according to which the students of the BST would present scores of average interest higher than they would present those of the CEM.

Tab. 3.

	Interaction	*Simple effects: groups*	*time I*	*time J*	*(J-I)*	*p*
Interest in S&T at school	*F (1,378) = 40.994, p <.001, η_p^2 = .098*	*Pre*	*BST*	*CEM*	*-.202*	*.035*
		Post	*BST*	*CEM*	*.653*	*<.001*

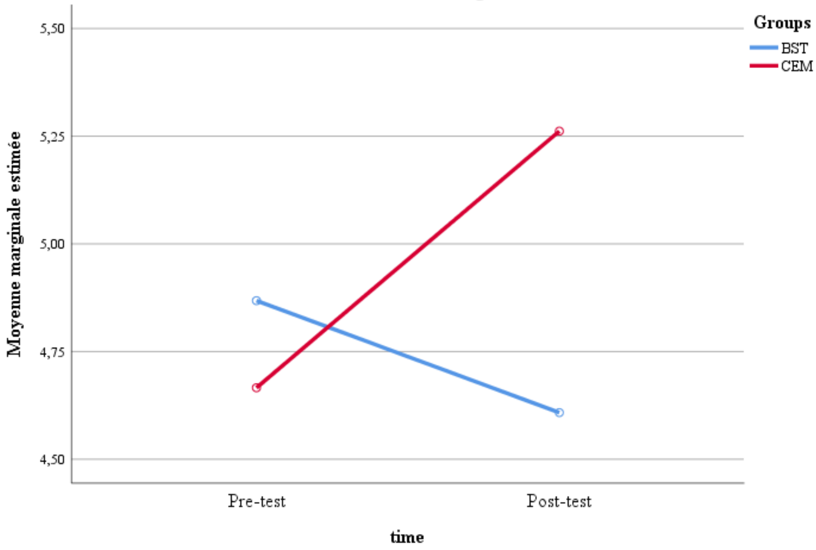
Note. *, p <.05; **, p <.01; ***, p <.001

The results in Table 3 show at the pre-test a significant difference (p = .035) between the two groups.

In fact, the comparison of the means shows that the BST group expresses a slightly higher interest than that expressed by the CEM group (ΔM = -.202), a difference of less than a quarter of a point on a scale of Likert at 6 levels. In accordance with our expectations, these results confirm the first part of our hypothesis (A) that the BST students present when they enter the program a higher average interest than that of the CEM students.

Furthermore, the results reveal, at the post-test, a significant difference (p <.001) between the interest scores expressed by the two groups. In fact, the comparison of the means makes it possible to see that the CEM group expresses higher interest scores than those of the BST group (ΔM = .653), i.e., a difference of more than half a point on a scale of Likert at 6 levels. These results seem to disconfirm our prediction (hypothesis B) described in relation to the analysis of the results in Table 2. Figure 1 shows the differences in interest scores of the two groups and the development of these between the pre-test and the post-test.

Figure 1



4.2 School science and technology self-concept

The results of variance analysis show that the interaction is not significant (F (1,450) = 1.033, p = .310, η_p^2 = .098) for the self-concept construct. Consequently, we will interpret the overall effects, the results of which are presented in Table 4.

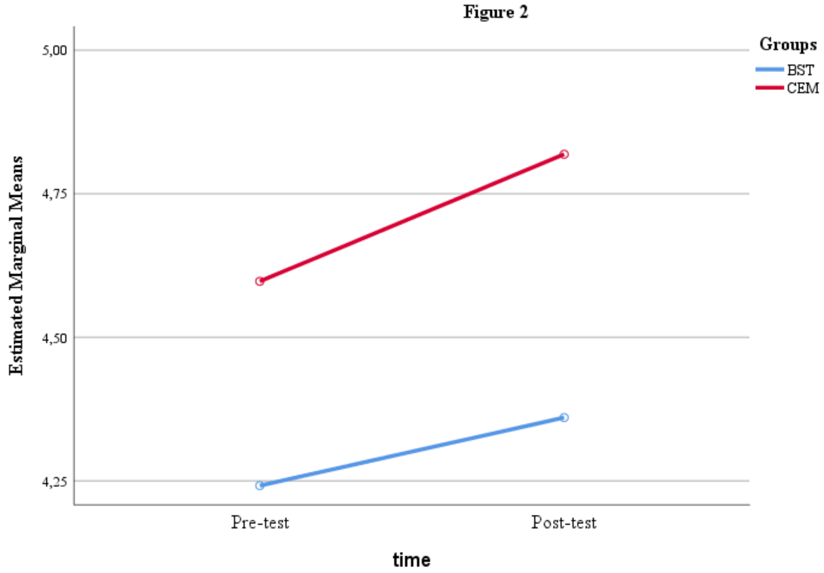
Tab. 4.

	Interaction	*Overall effects*	
		time	*groups*
Self-concept in S&T at school	*F (1,450) = 1.033, p = .310,* η_p^2 = .002	*F (1,450) = 11.315, p = .001,* η_p^2 = .025	*F (1,450) = 42.565, p <.001,* η_p^2 = .086

Note. *, p <.05; **, p <.01; ***, p <.001

The results show that the effect of time is significant (F (1,450) = 11,315, p = .001, η_p^2 = .025) with a large effect according to the standards of Cohen (1988, 2013). Hence, there is a significant difference between the pre-test and the post-test regardless of the group considered. The results also present a situation contrary to our prediction (hypothesis A), that students of BST would have self-concept scores higher than they would have those of CEM. Indeed, the average obtained by CEM students' self-concept is higher than that obtained by BST students (ΔM = .36). Furthermore, the results in Table 4 also show that the group effect is significant regardless of the time (pre-test or post-test). The size of the effect (η_p^2 = .086) observed between the two groups is very large according to the standards of Cohen (1988, 2013). This suggests that the self-concept scores expressed by the BST group are therefore different from those expressed by the CEM group regardless of the time and in favour of the CEM group both in pre-test (ΔM = .36) and in the post-test (ΔM = .46). These observations also indicate a situation contrary to our predictions (hypothesis A and B), according to which the students of BST would present self-concept scores superior to those of CEM regardless of the time considered. Figure 2 shows the differences in the self-concept scores expressed by the two groups and the evolution of these between the pre-test and the post-test.

Figure 2



5 DISCUSSION

In this article, we have provided an overview of middle school students' interest in S&T and how it evolved over the course of a semester. We gathered data from the BST and CEM students of the participating S&T teachers regarding their interest and self-concept in S&T. Since the goal of the study was not to test the impact of specific practices on students' interest (but rather to see the institutionalized effect of implementing a program), we instructed the participating teachers to conduct their S&T courses without changing their usual practices.

The results show that middle school students record a relatively high interest in S&T. In accordance with our predictions, BST students show a slightly higher interest than their CEM peers at the start of the session. These results are not so surprising given that, at the outset, the selection of BST students was made on the basis, among other things, of their choice to follow scientific and technological courses. However, what seems surprising to us is the decline (figure 1) that we have recorded in the interest of BST students. The difference in the means of the average score expressed by the BST group (M = -.202) between the pre-test and the post-test is indeed much lower than that obtained by their CEM peers (M = .653) which, however, did not go through the special program and therefore experience a positive gain.

These results cannot be attributed to statistical effects such as "ceiling effects." Ceiling effects sometimes occur when initial scores are high and therefore more difficult to increase further by any means. Accordingly, comparisons (without statistical correction) of the means are always debatable. However, here, we record a negative difference in averages for one of our groups and vice versa for the other.

These results cannot be attributed to the ceiling or other statistical effects. Ceiling effects sometimes occur when initial scores are high and therefore more difficult to increase further by any means. Accordingly, comparisons (without statistical correction) of positive gains are always debatable. But here, we observe negative gains for one of our groups and inverse gains for the other.

These results therefore seem to support certain conclusions from studies (Sane, 2009a, 2009b; CNPDEST, 2010a; ANSTS, 2003, 2013) on how S&T is taught in Senegal. More specifically, even though BSTs were intended as an opportunity to teach S&T under more favourable conditions, it does not appear that S&T courses are always conducted as set out in the creation of the initiative. One study notes that "genuine experiment-based teaching is inexistent or rare, as experiments are almost exclusively performed by teachers while their students observe" (CNPDEST, 2010a, p. 4). This reality raises questions about the administrative effectiveness and the contradictions of the BST program, especially with regard to its ability to foster an adequate education.

Another possible explanation for this situation is the number of S&T teaching hours, which, based on our superficial observations and informal conversations with teachers, seem to be insufficient for putting greater emphasis on instructional practices that are known to positively impact interest, such as the inquiry-based approach (Areepattamannil, 2012; Ainley & Ainley., 2011; Bolshakova, Johnson & Czerniak, 2011; Kloser, 2014; Krapp & Prenzel, 2011). It is important to remember that one of the goals of BSTs is to prioritize inquiry-based teaching in S&T. Yet, introducing such approaches would likely require more S&T teaching hours in BSTs. According to official documents, there are discrepancies between how weekly teaching hours are allocated at BSTs and CEMs. In fact, according to the study conducted by Sane (2009 b), CEM students benefit from more S&T teaching hours than BST students. For instance, CEM students are taught three hours of physics/chemistry per week, whereas BST students receive only two hours to learn the same material. The same is true for teaching hours allocated to life and earth sciences in CEMs and BSTs. These discrepancies could affect teaching methods, which might become less focused on experiments-based techniques than originally intended when the BST project was created. This could cause disappointment among students admitted to the program who were hoping not only that the program would allow them to study more science but also that experiment-based learning would help them find answers to their questions.

The results also suggest that, compared to their CEM peers, the BST students felt less competent in S&T at the beginning of the data collection period. As previously pointed out, the discrepancies between the hours allocated to S&T courses in the BST and CEM programs could have an impact on the quality of the education received by the students. In fact, since the science teachers in the BSTs have less time (periods) than their CEM peers to teach the same program, they tend to use guided inquiry practises, as noted by Sane (2009 b). Since the quality of the education that students receive can affect their self-concept, it is not impossible that the nature of BST teaching practices might have an impact on students' self-concept. Once self-concept is accepted as a good predictor of students' interest, we can understand the decrease in individual interest among the BST students.

When all is said and done, we believe it would be worth examining how the number of S&T periods affects the quality of the practices used by BST teachers. Given that BST teachers receive support to improve their current methods and to meet the BST program's goals, it made sense to believe that these efforts could have a positive impact on students' interest in S&T. However, our findings seem to point to the opposite. The constant efforts and demands required of an inquiry-based approach could be challenging for teachers. Since BST teachers have fewer periods than CEM teachers to expose their students to innovative practices, such as the inquiry-based science teaching approach, their practices end up leaning more towards a guided inquiry approach. This could have a negative impact on their students' self-concept and, consequently, their interest. Therefore, it is possible that S&T teaching under the BST program should involve more class time so that students have the opportunity to experience enough positive experiences. This could positively influence their interest, as suggested by some authors (Jocz, Zhai & Tan, 2014; Cheung, 2018). It is for that reason that we feel it is essential for future studies on students' interest and the effectiveness of the BST program to consider not only the intentions expressed in official documents, but also certain realities about S&T programs, such as the number of teaching periods allocated to S&T subjects.

In future studies, it will be possible to examine all these issues through observations, interviews with the authorities in charge of S&T programs, and interviews with teachers and students to get a better idea of the factors behind the declining interest in students admitted to the BST program.

Although the results of this study raises questions about the BST project's ability to generate interest among students, we must not ignore the limitations of our research. It is important to note that these results were obtained from students who responded to our questionnaire on individual interest. We therefore believe that our protocol should be considered in future studies with a larger sample in order to validate the findings related to the effectiveness of the BST program. It would also be useful to develop an experiment that could compare the education received by students in the BST program with that received by CEM students. Such a comparison would make it possible to better assess the effectiveness of the program and its impact on students' individual interest.

Lastly, our data-gathering technique did not account for the possibility of observing actual practices. It could therefore be worthwhile to analyse the actual practices implemented by BST teachers in detail and measure the students' situational interest at the end of the S&T courses being observed. These considerations would probably help the researcher understand the extent to which teaching practices in BSTs comply with the initiative.

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