Open Schooling Matters: Student Effects in Science Motivation, Intrinsic Motivation and State Emotions

Franz X. Bogner
University of Bayreuth

Sotiriou S.
Ellinogermaniki Agogi, Pallini

Open-schooling as an innovative management construct combines formal and informal stakeholders for joining forces for supporting schools. By highlighting this complex frame from a European vantage point, an experimental study of 316 open school environments with 1642 students was completed by applying the psychometric constructs of science motivation (SMOT), intrinsic motivation (IM) and state emotions (SE). SMOT contained five subscales: intrinsic motivation, career motivation, self-determination, self-efficacy, grade motivation; IM is using four subscales: interest, perceived competence, pressure and perceived choice; and SE contained three subscales: well-being, interest and boredom. In total, gender and self-determination produced a difference before participation as girls showed higher scores. This difference vanished later on which points to a positive catch-up for boys. IM scored high in all subscales while pressure and perceived choice competence was more present in boys. The same was true for state emotions of well-being and interest as well as low ones in boredom. In sum, SMOT subscales correlated positively for the state emotions of well-being and interest and negatively with boredom.

Keywords: open schooling, education engagement, gender, science motivation, intrinsic motivation, state emotions, European project

INTRODUCTION

"Rethinking education. Towards a common global goal?" (UNESCO 2015) labels a worldwide initiative which was designed to change the educational world by successfully coping with current levels of complexity and contradiction. As education systems are expected to act as agents to prepare individuals, communities need be prepared by giving them the capacity to adapt and respond. Overcoming the nowadays' complex societal challenges will require all citizens to have a better understanding of science if they are prepared to participate actively and responsibly in science-informed decision-making and knowledge-based innovation. The actual policy of the European Commission is keeping up this challenge within the initiative "Science Education for responsible citizenship" (EU 2015). Nevertheless, there is growing concern about student engagement levels in science learning at school especially regarding dropout rate reduction, poor achievement levels, and disengagement with what many perceive as a boring and irrelevant experience (Earley & Greany 2017). However, focusing on dropout students masks a bigger issue, as it only takes account of the visibly disengaged. There is an even larger group of students doing reasonably well at school but do not become self-motivated, self-directed learners. They may appear to succeed in exams but struggle when left to their own devices at university or at work. Additionally, many disengaged achievers do not favor the way of current classroom science education and, even though they would have the requisite qualifications, decide upon avoiding science carries. Two obvious questions arise from this: What are the main characteristics of the environments that are engaging for students? What implementation features might we need to reach more students become (or remain) deeply engaged?

The concept of open schooling supports an innovation agenda to assure a (science) learning continuum between a formal and informal setting (Sotiriou et al. 2017; Sotiriou et al. 2021). More specifically, (i) it promotes collaboration between non-formal and informal education providers to ensure relevant and meaningful engagement of all societal actors with science and increase the uptake of science studies and science-based careers, employability, and competitiveness (Goddard et al. 2015; Wenner & Campbell 2017). Thus, it encourages science students to see real science working in practice outside of classrooms and better understand how science is applied in real life. (ii) It supports schools to become an agent of community well-being by developing projects that propose solutions to the needs of their local communities. To do so the notion of well-being of school students needs exploration (including the concepts of equity, gender inclusion and empowerment). By establishing a model of collaboration with local stakeholders and by using activities that require the involvement of different triggers, open schools are seeking linkage with local communities on a much deeper level. Schools thus aim to “act locally but think globally”, a well-known motto but still far from the reality of most schools in Europe today (Stilgoe et al. 2017). (iii) It promotes partnerships that foster expertise, networking, sharing and applying science and technology research findings and bringing real-life projects into the classroom. It aims to analytically map the effective usage scenarios as part of curriculum-led learning (integrating /embedding them into the everyday school practice) and/or extra-curricular activities (e.g. visits to museums, science centers, research centers, field trips), coupled with home- and community-centered (informal) learning experiences (Stilgoe et al. 2017). (iv) It focuses on effective parental engagement by building on the notion of the science capital within students’ families. Although science and technology in general is of great interest to young adolescents, such a disposition is not reflected in student engagement with school science. Girls often are less interested in school science and only a minority of girls pursues careers in science and engineering. The reasons for this situation are complex as many influences besides interest in science may exist. Many students with high levels of interest in science may not choose science subjects because: a) they think that choosing science leads only to working in a laboratory; and, b) that science is for other people. These are issues of identity of science and of the students themselves. Additionally that study suggests the role of students’ families in career decisions as much stronger than previously expected. (v) It encourages teaching science with the specific intent to foster students' understanding, to decrease competitiveness in science classes and to contribute to girls' better participation (Sotiriou et al. 2017). It recommends replacing the competitive-type classroom environment with a more girl-friendly instructional approach where inquiry is the lesson focus which sharing ideas, arguing and asking questions in a collaborative manner.

More specifically, a proposed standardization process was expected to achieve within a three-fold manner. (i) By adaptation and integration of informal and formal educational experiences in order intervene to reverse traditional patterns of low participation; to encourage girls' interest, enthusiastic participation, and election of continued study in math and science; to increase confidence; and to give girls positive images of math and science learning and careers (Grau et al. 2020). (ii) By encouraging integrated awareness of gender bias in educational environments, with an intent to change organizational commitment, policy, and action to remedy under-representation through student and faculty programs, for example, under-graduate departments in engineering, science, or computer science in order to make a concentrated effort to increase recruitment and retention. (iii) By adoption and integration of new curricula that are gender-neutral or appeal particularly to girls and women. For example, it encourages ways of teaching math that utilize girls' verbal skills, sequencing material in computer science to introduce real-world applications of technology first before getting into the intricacies of programming languages, and teaching young girls the principles of engineering design and invention in everyday life (Sotiriou et al. 2016).

Inclusion of gender is a specific issue on different levels: cultural – country level, institutional – school level, interactional – student-teacher and student-student level and individually for each student. The assumption that girls and boys belong to distinct, internally homogeneous groups based on their biological sex creates a stereotype of girls and boys (Brickhouse et al. 2000). However, various programs had shown that science cannot produce culture-free, gender-neutral knowledge (Brickouse 2015). In fact, STEM initiatives often are constructed in a rational, intellectual, independent way, however aligned with masculinity (Due 2014; Faulkner 2000; Phipps 2007). Thus, individuals - whether boys or girls - who do not identify with such characteristics, might not choose a position within STEM (Due 2014). Open schooling addresses this issue and aims to overcome the above-mentioned identified barriers that hold back a great number of students from following science-related careers.

Science motivation, intrinsic motivation and state emotions expectedly play a major role of open-schooling environments. In our view, open-schooling provides more challenging, authentic and higher-order learning experiences, more opportunities for students to participate in scientific practices and tasks, using the discourse of science and working with scientific representations and tools (Sotiriou et al. 2017). Monitoring all that issues empirically will overburden one single questionnaire with its need to limit scale items. In consequence, a selection to the constructs of motivation and emotion provides a promising pilot study. For the first, the study of Kleinginna and Kleinginna (1981) highlights three major pillars of motivation consisting of an internal component (i), a functional process (ii) and a global component (iii). The study of Deci and Ryan (1985) further complements the concept with three psychological requirements: competence (i), autonomy and relatedness for self-motivation (ii), mental health and well-being (iii). In the study of Pintrich and De Groot (1990), motivation is associated with self-efficacy beliefs as well as with having duties. Self-efficacy can also influence academic success (Pajares 2002). Key to enhancing motivation is self-regulated learning according to Zimmerman (2000) and it is worth the effort, since self-efficacy is one of the best predictors of learning outcomes and student motivation. Motivation is supposed to leading to activation and readiness to finish a task (Ryan & Deci 2000). Not feeling inspired or willing to do something, on the contrary, is characterized as being unmotivated. Hereby, high or low motivation scores for one task is possible leading to different goals and focus points of motivation. For instance, students are highly motivated but their underlying reasons are different: some are motivated, because they are interested, want impress their parents or want to achieve a good grade. In all cases, motivation levels are the same but the source of motivation is different. The study of Deci and Ryan (1985) distinguishes between intrinsic and extrinsic motivation: Intrinsic motivation describes an inner urge to act, which is why the execution of tasks is satisfactory. Intrinsically motivated people do not require external rewards or constraints to act. Rather, they are interest-driven and rewarded by their voluntary execution of tasks. This also leads to enhanced knowledge gains and different skills (Deci & Ryan 1985). Extrinsic motivation, however, is supposed to be determined by external rewards and constraints only. If, for instance, students only complete homework to avoid punishment (by teachers or parents) or to reach a specific extrinsic goal, just acting upon instrumental values (Deci & Ryan 1985).

Science Motivation generally is regarded as an "internal state that arouses, directs, and sustains science-learning behavior" (Glynn et al. 2011; p.1160]. Science learning is thereby not restricted to classroom students. As everyone is subject to scientific events and they become scientifically literate meaning they enhance their understanding of the sciences, scientific skills and scientific phenomena (DeBoer 2000). They engage with intellectually demanding scientific topics and gain competences in the respective realms Laugksch (2000). Although science is an integral part of the world, according to Ardis and colleagues (2015), interest in science declines over the course of a student's education and is considered as something boring (Glynn et al. 2011). Thus, only a small number of students choose science careers or enter STEM careers although they often enjoy out-of-school science activities (Dabney et al. 2012). To tackle this problem, innovative learning environments, for instance integrative STEM approaches to enhance knowledge gains and thinking skills are needed (Schumm & Bogner 2016b; Fan & Yu 2017). STEM schools are supposed to address that problem and attract more students (Eisenhart et al. 2015). Project-based science learning could foster interest in STEM education but would require changes in curricula and more rapid changes in students' views and attitudes towards science learning (Dickerson et al. 2014). One example into this direction may offer the recently introduced classroom subject “Nature & Technology” within the Bavarian syllabus, where STEM topics are earmarked to specifically foster scientific learning (ISB 2017). Age-appropriate science lessons may build positive attitudes, which is why teachers should innovate and redesign their STEM lessons (Wolters, 1989). Within this context, previous intervention studies clearly showed the potential of inquiry-based modules (e.g., Sturm & Bogner 2008; Schumm & Bogner 2016b; Conradty et al. 2020). Science motivation is a good point of reference for monitoring the status quo of student motivation and its progress after implementation of new educational concepts (Glynn et al. 2011).

Trade emotions and state emotions are the foundation of attitudes (Chakravarti et al. 1997). Emotions, such as anxiety or interest, are indispensable for learning processes (Randler et al. 2011). They can be distinguished into trait (biographically generated) and state (caused by situational context) (Ainley 2006). Animals, for instance, can trigger emotions in two different ways: either an interest in animals was aroused because people have grown up with animals (trait emotions) or people come into contact with animals later in life via wildlife park or zoos for example (state emotions) (Fröhlich et al. 2013). Positive situational emotions such as interest, well-being or joy, seem to influence learning processes positively, whereas negative situational emotions such as boredom do the contrary. Emotions are also a part of motivation and cognition processes, which is why they need consideration in educational instructions (Randler et al. 2011).

Gender differences play an important role in the realm of STEM (e.g., Pöhnl & Bogner 2012; Schmid & Bogner 2015) as STEM careers are traditionally male-biased (Riegle-crumb et al. 2017). One stereotypical explanation is that women prefer social work and do not enjoy scientific during adolescence and pervade other professional areas but are already observable in school. From early childhood on, boys and girls are stereotyped, including the toys they play with as well as their leisure activities (Brown, 1993). Children take up those stereotypical roles from their parents (Eccles et al., 1990). This leads, for instance, to more positive attitudes towards science learning in boys (Lin et al. 2001; Gormally et al. 2009) as well as they often achieve better in science (Miyake et al. 2010). Even at university, males outperform females with more positive attitudes towards science learning (Seyranian et al. 2018). Therefore, it is no surprise that women in scientific careers often display a lower academic self-concept (Steiner et al. 2000). In addition, women in scientific or STEM careers frequently feel discriminated against in a male dominated scientific world (Steele et al. 2002). Keeping this in mind, gender differences regarding STEM careers also affect career choices in adulthood, which is why less girls apply for scientific professions (Beede et al. 2011). One striking problem is also the incompatibility of career expectations and family formation in the scientific professions (Frome et al. 2006).

The open schooling approach recommends replacing competitive classroom environments with girl-friendly instructional approaches. Sufficient time and space to think, inquire, and understand thoroughly are considered key elements, for instance, which may be accomplished by group work that enables them to share ideas, argue, ask questions and analyze data. In consequence, the research questions of our study were three-fold:

1. How does an open-schooling environment affect the science motivation, state emotions and intrinsic motivation of students?
2. Does gender produce a difference in science motivation, state emotions and intrinsic motivation in an open-schooling environment?
3. What is the relationship between the science motivation and intrinsic motivation of students in an open-schooling environment?

METHODOLOGY

Schools involved were acting as innovation hubs in their local communities in focusing on local challenges and problems. All activities were presented on a common platform (https://portal.opendiscoveryspace.eu/osos). For our present study, due to logistic reasons just students from schools in Germany and Greece were involved. Altogether, our sample size consisted of 1,642 matched pre-/post-test samples and were the basis of analysis. The average of the students age was M=13.42 years (SD=±1.94), more girls than boys participated (n=891 versus n=751).

Assessing the effectiveness of our open schooling approach, first we applied a Self-Reflection Tool (SRT) to school principals in order to monitor the organizational change during implementation (Sotiriou et al. 2021). It focused on three identified areas of 'growth' – school management, school process and teachers' professional development–and allowed to describe the actual school situation by translating the findings to specific recommendation for future actions (Sotiriou et al. 2021). The school environments were evaluated for one full academic year by following a pre-/post-test schedule (completing two measurements, one before their involvement and one after their engagement in the transformation journey). Due to space limitations, all SRT data are published elsewhere. Second, for the students involved, we applied a pre-/post-testing design monitored science motivation (SMOT), intrinsic motivation (IM) and state emotions (SE).

All data were collected electronically via the OSOS platform. The first, Science Motivation (SMOT) consisted of via five subscales (Glynn et al. 2011; Schumm & Bogner 2016a): intrinsic motivation (IM), self-efficacy (SE), self-determination (SD), career motivation (CM) and grade motivation (GM) by following a theory of human learning (Bandura, 1986). Pre-tests were completed two weeks before intervention, post-tests directly after interventions. The response pattern followed a 5-digit Likert scale pattern. Applying that testing methods are supposed to identify potential improvements in science motivation. Intrinsic motivation (IM) covered four subscales: namely interest, perceived competence, pressure and perceived choice (Deci & Ryan, 1985). State Emotion (SE) by focusing on short-term emotions addresses the subscales well-being, interest and boredom (Randler & Bogner 2009; Randler et al. 2011). Although all scales in the past had repeatedly shown its reliability and validity, we reassured the hypothesized factor structure by applying a principal component factor analyses.

Participating schools put in place an open-schooling strategy to involve their communities in innovative projects with the cooperation of external stakeholders. The projects focused on local needs and challenges while students had to use their creativity to propose innovative solutions and plans as a response to those local issues (Conradty & Bogner 2019). The schools represented both urban and rural schools. School heads developed their localized open-schooling plans addressing the relevant needs of their schools and the local communities. Workshops, webinars and/or training materials provided appropriate guidance and support. Examples of good practices acted as reference points. Opportunities to enrich professional contexts were offered through cooperation within and between schools, universities, science centers and museums, local industry and research institutions. The communities of practice implemented their innovative projects, involving external stakeholder.

All statistical analyses were using SPSS statistics version 24.0 (IBM, Armonk). The central limit theorem is implied, and we assume normal distribution because the sample size was large enough.

RESULTS

Science Motivation scored for all subscales above average: 3.65 (±1.00) (Self-Determination), 3.79 (±1.01) for IM (Intrinsic Motivation), 3.64 (±1.09) for CM (Career Motivation), 3.82 (±.98) for SE (Self-Efficacy), and 3.94 (±.97) for GM (Grade Motivation). Intrinsic motivation also scored above average for interest (3.38±.67), Perceived Choice (3.39 ±.96) and perceived competence (3.45±.78) while pressure scored low (2.71 ±.81). For the State Emotions, well-being (3.92±1.05) and interest (3.83±1.02) scored above average while boredom marked very low (2.32±1.13).

FIGURE 1
SUBSCALE MEAN SCORES FOR THE SMOT, IMI AND ST SCALES

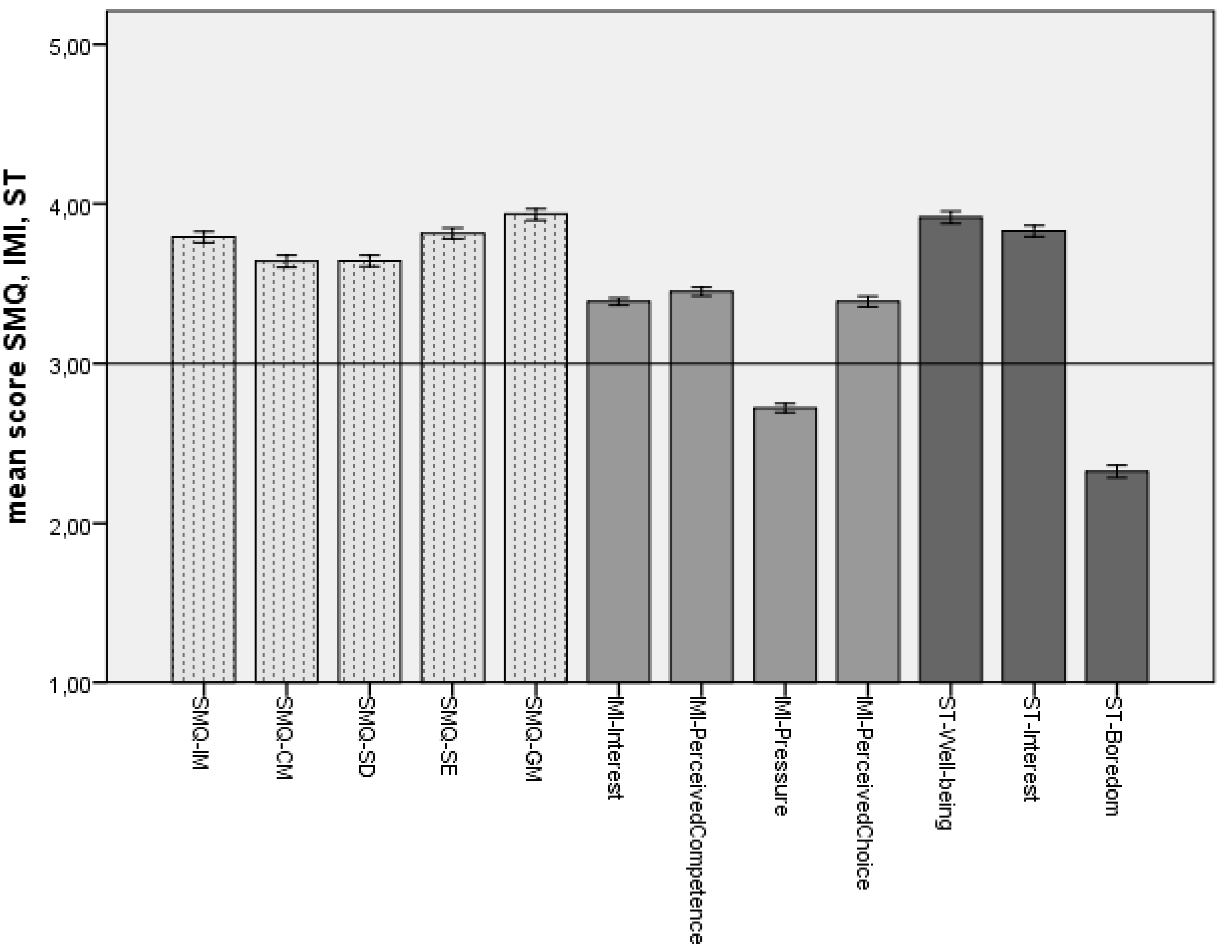


TABLE 1
SMOT MEAN SCORES, STANDARD DEVIATIONS AND T-TESTS FOR GIRLS AND BOYS AT THE POST-TEST LEVEL

	Science Motivation Subscales				
	IM	**CM**	**SD**	**SE**	**GM**
♀ (M±SD)	3.82±.97	3.70±1.04	3.74±.95	3.82±.93	3.98±.91
♂ (M±SD)	3.82±1.00	3.71±1.03	3.66±.98	3.92±.93	3.98±.93
t-test	t(1642)= -.218 p=.777	t(1642)= 0.992 p=.285	t(1642)= 1.82 p=.083	t(1642)= -2.17 p=.762	t(1642)= -.026 p=.127

Both gender scored similarly for Science Motivation. However, it produced differences in the intrinsic motivation subscales: interest and perceived competence as well as in pressure and perceived choice (Table 2): While boys scored higher in the latter, girl scored lower in relation to the pressure subscale. State emotions only produced a gender difference in the boredom subscale where boys showed higher scores.

FIGURE 2
SCIENCE MOTIVATION (SMOT) SUBSCALES PRE-/ POST-TEST (*=P<.001) (SE ARE SHOWN)**

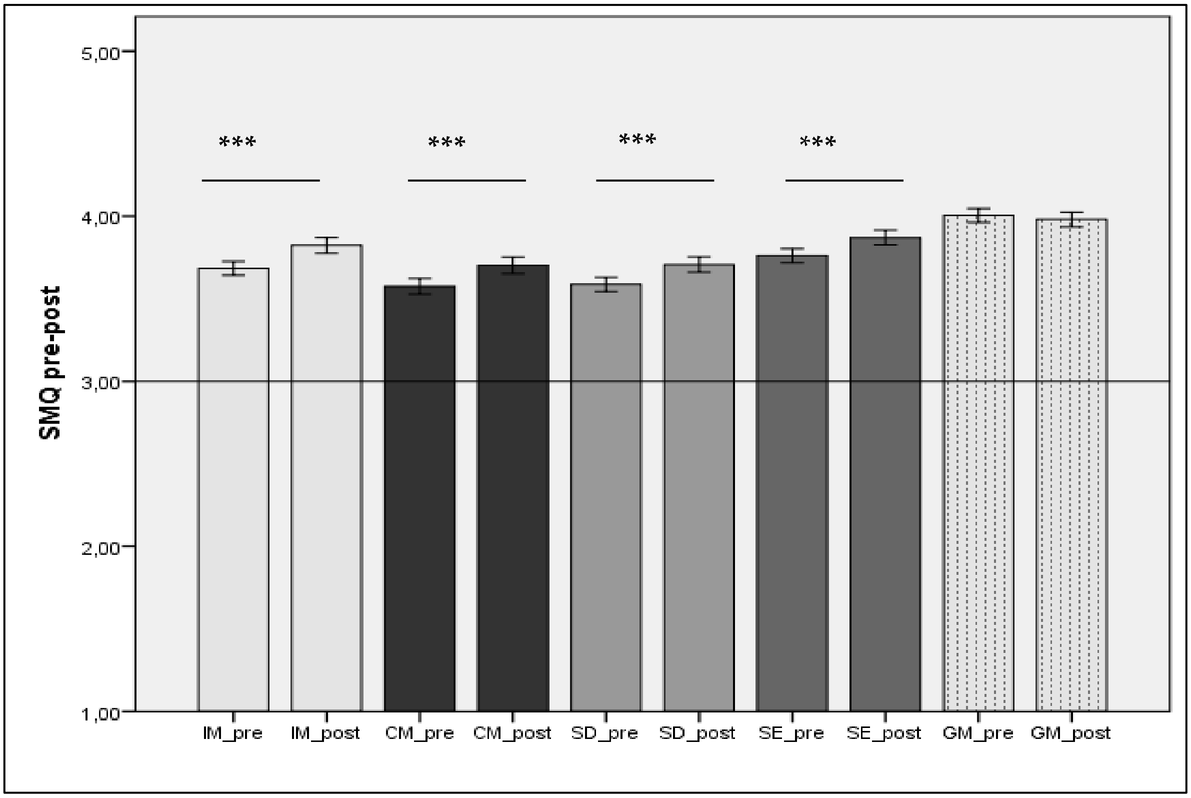


TABLE 2
IM-MEAN SCORES, STANDARD DEVIATIONS AND T-TESTS FOR GIRLS (♀) AND BOYS (♂) AT THE POST-TEST LEVEL

	Interest	Perceived Competence	Pressure	Perceived Choice
♀ (M±SD)	3.43±.60	3.45±.74	2.71±.76	3.37±.94
♂ (M±SD)	3.41±.69	3.48±.80	2.80±.84	3.49±.98
t-test	t(1642)=.615; p=.539	t(1642)=-.744; p=.457	t(1642)=-2.048; p=.041*	t(1642)=-2.632; p=.009**

TABLE 3
SE-MEAN SCORES, STANDARD DEVIATIONS AND T-TESTS FOR GIRLS (♀) AND BOYS (♂) AT THE POST-TEST LEVEL

	Well-being	Interest	Boredom
♀ (M±SD)	3.99±.96	3.90±.96	2.19±1.07
♂ (M±SD)	3.91±1.05	3.80±1.01	2.36±1.20
t-test	t(1642)=1.749; p=.080	t(1642)=2.157; p=.031*	t(1642)=-2.929; p=.003**

TABLE 4
T-TESTS OF A SUBSAMPLE OF 367 PARTICIPANTS FOR THE COMPARISON OF PRE-AND POST-TEST LEVEL

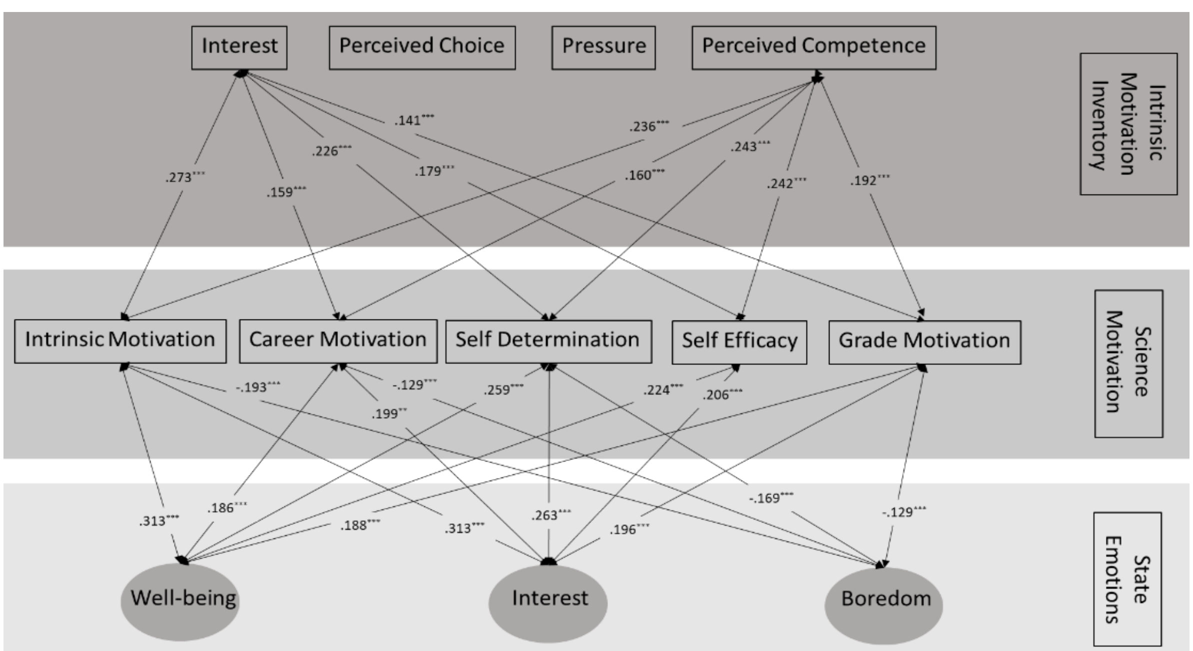
	Science Motivation Subscales				
	IM	**CM**	**SD**	**SE**	GM
t-test	t(1642)= -6.04; p=<0.001***	t(1642)= -5.01; p=<0.001***	t(1642)= -5.02; p=<0.001***	t(1642)= -4.74; p=<0.001***	t(1642)= -1,07; p=.284

TABLE 5
SMOT MEAN SCORES, STANDARD DEVIATIONS AND T-TESTS FOR GIRLS (♀) AND BOYS (♂) (PRE-TEST LEVEL)

	Science Motivation Subscales				
	IM	**CM**	**SD**	**SE**	GM
♀ (M±SD)	3.67±.84	3.59±.97	3.68±.86	3.73±.86	4.02±.84
♂ (M±SD)	3.67±.90	3.56±1.01	3.48±.93	3.78±90	3.90±.88
t-test	t(1642)=.629; p=.101	t(1642)=.414; p=.318	t(1642)=4.494; p=.008**	t(1642)=-1.223; p=.142	t(1642)=.879; p=.091

Only Science Motivation revealed a difference within pre-post-test comparison despite already high pre-test scores: SD (Self-Determination): 3.51 (±.97), IM (Intrinsic Motivation): 3.62 (±.93), CM (Career Motivation): 3.51 (±1.06), SE (Self-Efficacy): 3.71 (±.95), GM (Grade Motivation): 3.94 (±.95). Although all scores showed an above average level (over 3), a significant increase appeared in the intrinsic motivation, career motivation, self-determination and self-efficacy subscales (see Table 4) while not producing gender differences except in self-determination (Table 5).

FIGURE 3
GRAPHICAL PRESENTATION OF CORRELATIONS BETWEEN SCIENCE MOTIVATION AND INTRINSIC MOTIVATION AND STATE EMOTIONS



Due to the sample size, we presume normal distribution as according to Field (2013) that "as sample sizes get larger, the less the assumption of normality matters because the sampling distribution will be normal regardless of what a … sample data look like". Thus, we calculated the Pearson correlation scores, as graphically shown in Fig.3. A positive relationship appeared between science motivation and interest after participation, and the same with the Science Motivation subscales (IM, CM, SD, SE, GM) and the Intrinsic Motivation subscales "interest" and "perceived competence". Additionally, the latter showed high correlations with the State Emotions subscales. The well-being and interest subscales indicated positive correlations as opposed to the boredom subscale.

DISCUSSION

The open-schooling- environment provides a space where students have the opportunity to get involved in real-life projects and to interact with external stakeholders. Such an environment apparently affects many students' soft skills. Intrinsic motivation for instance - although quite high for the participating students - was bolstered even further. This is of special interest as it is regarded a main domain of self-determination (Ryan & Deci 2000). The same is true for perceived competence or perceived choice, another subscale of it. Integrating new learning approaches - and thus modifying teaching strategies - apparently counts (Dole et al. 2016). For another example, a student-centered learning approach showed internally motivating (Sturm & Bogner 2008) while Gerstner and Bogner (2010) reported no connection between motivational aspects between traditional and student-centered learning approaches. The study of Randler and Bogner (2009), however, within this context successfully generated more enjoyment as well as more self-determination. Cooperative learning forms generate positive relations to attitudes in the "interest and enjoyment" subscale (Geier & Bogner 2011). The study of Goldschmidt and Bogner (2015) reported higher motivational scores for students with higher short-and long-term knowledge in an outreach laboratory unit. Another student-centered study about the risks of smoking also reported that in a creative learning setting intrinsic motivation could be raised (Hedler & Bogner 2013). Intrinsic motivation apparently catches someone's interest and enlarges it. Similarly, positive teacher feedback can influence intrinsic motivation especially in science (Burns et al. 2019). In summary, the more open the learning environments the better the learner's motivational indicators score.

Short-term emotions show significant relations to motivation, to learning outcomes as well as to achievements, which is why they always need consideration when developing new learning methods (Pekrun et al. 2002). Student-centered methods (and more open-schooling methods) generally are better generating positive feelings and well-being scores than traditional learning circumstances achieve (Schaal & Bogner 2005). This is quite in line with our results as our students score high in well-being and interest as well, indicating high satisfaction. As we measured two kinds of "interest", one as state emotion and the other as intrinsic motivation, our monitoring is more complex: the latter screens the interest and enjoyment of an activity, the former did so with interest with a better focus on feelings and the perceived relevance of a topic. Not surprisingly, both interest scales show a high relationship to each other. Similarly, Schönfelder and Bogner (2018) showed the importance of positive feelings during an activity. Emotions play an important role in the short-term learning process, but apparently also influence achievement accomplishments (Randler et al. 2011). Although many learning activities still concentrate on content knowledge, other aspects like social or affective learning circumstances need (and increasingly receive) consideration (Pintrich et al., 1993). For instance, positive emotions like well-being and interest influence the learning process enormously in a positive way and even positively affects intrinsic motivation (Schönfelder & Bogner 2018) as well as positive ecological behavior (Fröhlich et al. 2013). High emotions during an educational intervention apparently show the highest gains (Allen 2010). The study of Randler and colleagues (2011) had shown boredom and anxiety as associated with low school achievement while Pekrun and colleagues (2002) did this with negative intrinsic motivation and low attention levels of the students. Because of this, boredom in our study scored very low indicating that students felt good.

An open-schooling environment fosters interest and even raises intrinsic motivation for science although both variables scored high even before participation. We know from the study done by Geier and

Bogner (2011) that interest and motivation beliefs are higher when students are satisfied with the learning circumstances. Another major issue is that intrinsic motivation seems influenced in a positive way by interactive actions in behavioral skills (Wilson et al. 2006). This relationship might explain our significant differences between pre- and post-testing. According to Ryan and Deci (2000), intrinsic motivation is a key personal domain related to the learning process, individual creativity as well as the personality building process. A good learning environment with low stress was flagged up as a necessary condition for this (Koka & Hein 2003), just as a self-regulatory concept (Nichols 2006). What makes interest and motivation in classroom STEM so important, is its forecast potential for subsequent career choices (Dabney et al. 2012). The STEM sector will become more and more important in the next working generations and therefore schools need preparation for that (Eisenhart et al. 2015). Openness of schools and teaching methods with inclusion of experts seems to promote individual interest levels and influences the career motivation, the parental and family factor besides (Sáinz & Müller 2018). The latter was regarded one main pillar in our initiative, as opening the school mechanism also tries to include parents more in the schooling context as well in out-of-school activities. Similarly, career motivation could be influenced by students' own self-efficacy beliefs (Zeldin & Pajares 2000). Self-Efficacy is defined as "people's beliefs about their capabilities to produce effects" (Bandura, 1994; p.71) and is regarded a predictor in science learning (Zimmerman & Shunk 2008). Similarly, it supposedly predicts the level of school achievement, as especially gifted students' show high self-efficacy beliefs and less anxiety (Pajares, 1996). The study of Bandura (1997) showed high self-efficacy as leading to more consistent achievement potential, resilience and persistence. Self-efficacy therefore could be one of the most promising factors of learning and motivation (Zimmerman 2000) as well as of academic performance (Pajares 2002). Self-determination often leads to self-regulated learning (Pajares, 1996), leading to confidence in different areas and contributing substantially to the motivation-building process (Deci et al. 1991; Benabou & Tirole 2002). Self-confidence in this case could be a predictor of performance of a task (Kleitman & Stankov 2007) delineating a main key to good performance and hard work. Raising self-determination in classrooms may contribute to skill development as well as to an increase of self-efficacy and intrinsic motivation (Guskey 2003). The connection between these different constructs is theoretically laid out in the self-determination theory (Ryan & Deci 2000). In our study, intrinsic motivation in particular had shown its raising ability through the project and the efforts of the teacher, experts, and families. Extrinsic motivation is driven by external circumstances meaning learning belongs in this case to reward or punish. Although we did not ask students to report their individual grades, we can use grade motivation as a hint: This subscale did not change over the lifetime of OSOS and that is why we consider it necessary to exclude extrinsic motivation as an impulse affecting participation in our intervention. Science is supposed to be learned not only in the content of knowledge, but should also be more like an enhancement of perception in order to reach motivational levels.

The STEM sector still has a gender gap (Riegle-crumb et al. 2017; Marth & Bogner 2019; Mierdel & Bogner 2019). The apparent difference originates almost in the kindergarten, where boys play more with technical based toys than girls (Brown, 1993). Also in school, boys often show more interest in the STEM sector (Marth & Bogner 2017). Not surprisingly, it continues in the labor market where more males are working in the STEM sector (Beede et al. 2011; Kanny et al. 2014). In the STEM sector, gender differences are often known as a gap problem, where girls and young women often have worse achievement results (Stout et al. 2011; Marth & Bogner 2018). Because of this, we compared science motivation scores and identified females as significantly higher scoring when it comes to self-determination. This is an amazing fact, as females are mostly under-represented in the STEM sector and often show lower self-concept scores (Macphee et al. 2013). Self-efficacy for women is regarded an important issue in male-dominated fields and supposedly influences academic and career choices (Zeldin & Pajares 2000). For self-efficacy beliefs gender differences are often existent, although gifted girls often show no gender gap in this regard (Pajares, 1996). Interestingly, we found no gender difference in the post-testing either for self-efficacy or for all other subscales. That means that the gender gap disappeared due to participation in the module, which is in line with the literature where for instance technology-supported learning environments (Brickman et al. 2009) or out-of-school activities (Dabney et al. 2012) reported such effects. Similarly, the study by Marth and

Bogner (2017) showed no gender gap in the scientific and technology area for students. Other studies pointed to a continuation of this trend when there were summer professional development programs with science teachers (Marth et al. 2018).

As expected, nearly all selected constructs relate to each other. Enjoyment considerably correlates with interest or with science motivation, here in all sub-domains, namely intrinsic motivation, career motivation, self-determination, self-efficacy and grade motivation. High scores in intrinsic motivation also produced high scores in interest. The same is true for career-motivated students. In addition, those who have high scores in self-determination, grade motivation and self-efficacy beliefs, also have high interest. High competence beliefs also showed high intrinsic motivation and career motivation as well as high self-determination, self-efficacy and grade motivation.

Emotions are significant triggers for motivation. Because of that, emotions need considering in learning processes (Pekrun et al. 2002). Emotion, cognition and motivation are complex intertwined constructs (Burić et al. 2016). This supports our study result that intrinsic motivated students felt very good and interested leading to positive correlation of the motivation subscale “intrinsic motivation” with the emotions subscales “well-being” and “interest”. High levels of boredom are associated with negative intrinsic motivation (Pekrun et al. 2002). This is also in line with our results. The same trend appears in science motivation towards well-being and interest while boredom does this negatively: The higher a level of science motivation the higher the well-being and interest and the lower the level of boredom among students.

CONCLUSION

Open schooling with schools in cooperation with other stakeholders offers an agent of community well-being, as it is being promoted in current educational reforms across Europe. Families are being encouraged to become real partners in school life and activities. Professionals from enterprises and civil and wider society are actively becoming involved in bringing real-life projects into the classroom. Relevant policy makers are also involved, to encourage policy buy-in and the mainstreaming of good practices and insights into policies, and hence sustainability and impact beyond the lifetime of funding. Additionally partnerships may help to transfer science research findings across different enterprises and pass them into all society levels. Within this framework, open-schooling environments seems to offer a great opportunity for students to increase their interest and motivation in science. They offer an environment where STEM approaches do not increase cognitive overload (Scharfenberg & Bogner 2010). They offer new ways to establish effective cooperation schemes between school communities and external stakeholders. Students are involved in real-life projects and they are able to understand the connections between the theoretical knowledge of science with the world around them. Such environments are creating effective bridges between formal and informal education. There are numerous benefits of such a process. Although extrinsic motivation (including the motivation to earn good grades) seems to provide a good predictor of school success, outreach interventions alone cannot promise such contexts but they offer a chance to raise (intrinsic) general motivation for science. The latter as part of the self-confidence concept in combination with self-efficacy is exploitable with appropriate activities such as field days, extracurricular programs or out-of-school courses. Innovative issues such as Bionics may interact with the variables described (at least our study supported this). When students are interested in STEM in the classroom, they were able to take it home and persuade parents or friends of the need for science in modern society, and this potentially affects the science capital of the local communities. Even if they only inspire themselves, STEM education plays a major role for the young generation.

LIMITATIONS AND RECOMMENDATIONS

Our chosen variable set provides a first screen shot for a likely more complex picture. As a pilot study, of course, just a core pattern of variables was analyzable due to the usual load limitation when questionnaire are applied. As we cannot rely on earlier studies, our assessed factors offer just a first view, while other variables such as social skills may contribute their parts to the whole portray. Subsequent studies usually build upon pilots and enlarge the knowledge body, for instance by concentrating on potential differences among urban and rural students or on students with different achievement levels or school traditions. Moreover, to provide rigorous statements, later on long-term studies also may provide more holistic answers. Due to GDPR compliance, we refrained from including socio-biographical parameters to assess their influence on our assessed factors.

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