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The colours of the Higgs boson: a study in creativity and science motivation among high-school students in Italy

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article

Abstract

With the increasing shift from STEM to STEAM education, arts-based approaches to science teaching and learning are considered promising for aligning school science curricula with the development of twenty-first century skills, including creativity. Yet the impact of STEAM practices on student creativity and specifically on how the latter is associated with science learning outcomes have thus far received scarce empirical support. This paper contributes to this line of research by reporting on a two-wave quantitative study that examines the effect of a long-term STEAM intervention on two cognitive processes associated with creativity (act, flow) and their interrelationships with intrinsic and extrinsic components of science motivation. Using pre- and post-survey data from 175 high-school students in Italy, results show an overall positive effect of the intervention both on the act subscale of creativity and science career motivation, whereas a negative effect is found on self-efficacy. Gender differences in the above effects are also observed. Further, results provide support for the mediating role of self-efficacy in the relationship between creativity and science career motivation. Implications for the design of STEAM learning environments are discussed.

Keywords: STEAM, Science, Education, Creativity, Motivation, Self-efficacy, Gender, Italy

Introduction

Recent years have seen a growing emphasis on the added benefits of arts-based approaches in inquiry science teaching and learning (Buck et al., 2019; Chappell et al., 2019; Conradt & Bogner, 2019). Integrating the arts and STEM (Science, Technology, Engineering, and Mathematics) is suggested to make school science subjects more appealing to a wider variety of learners including the non-STEM inclined (Henriksen, 2014; Ng & Fergusson, 2020). It is also found to have a positive impact on female students' interest in pursuing STEM degrees (Wajngurt & Sloan, 2019).

Central to the increasing shift to STEAM (Science, Technology, Engineering, Arts, and Mathematics) education is the notion of creativity. According to a recent position paper of the Organisation for Economic Co-operation and Development (OECD), creativity

and creative thinking are considered among the most important skills for 2030's learners and, as such, their development is recommended to be a curriculum priority (OECD, 2018). Relatedly, an increasing number of STEAM-centric school initiatives are emerging mainly in the US (Khine & Areepattamannil, 2019) but also in Europe and other parts of the world (Bahrum et al., 2017; Harris & de Bruin, 2017; Quigley & Herro, 2016) to boost learning outcomes, as well as to broaden equitable participation in science and science careers and, ultimately, to improve young people's scientific literacy (Conner et al., 2017).

Despite this progress, relatively little research has yet shed empirical light on the actual impact of STEAM practices on student creativity (Cremin & Chappell, 2019) and even less has explored the creativity pathway to science learning outcomes (Perignat & Katz-Buonincontro, 2019). This study addresses this gap in three ways. First, it assesses the impact of a long-term STEAM intervention with high-school students in Italy on two distinct cognitive processes associated with individual creativity, namely act and flow (Conradty & Bogner, 2018, 2019). Second, it examines gender differences in creativity and science motivation. Finally, it seeks to untangle the interrelationship between creativity and science motivation by testing a pathway model according to which self-efficacy is hypothesised to mediate the relationship of the two facets of creativity (act, flow) with science career motivation. In doing so, the study corroborates and expands upon recent empirical work on STEAM education (Conradty & Bogner, 2019, 2020; Conradty et al., 2020; Mierdel & Bogner, 2019; Salmi et al., 2021; Thuneberg et al., 2018) thereby contributing to a better understanding of the potential role of STEAM-enhanced creativity in stimulating science learning and careers.

Background and theoretical framework

Based on the assertion that creativity and imagination are embedded in the production process of new scientific knowledge (Lederman, 1992; Liu & Lederman, 2007), several scholars have long argued that school science can also offer a fertile ground for the development of twenty-first century skills, including creativity (Hadzigeorgiou et al., 2012; Kind & Kind, 2007). The synergies between science education and creativity have since been the subject of empirical research, including large European studies in pre-school and primary settings (Cremin et al., 2015; Stylianidou et al., 2018) but also national-level studies in secondary schools (Levenson, 2013; Liu & Lin, 2014; Meyer & Lederman, 2013). Theoretical and empirical progress has also been made from the creative education literature in identifying key pedagogical features that characterise arts-based approaches to science teaching and learning (Chappell et al., 2019; Hetherington et al., 2020). Taken together, this body of research has recently been bundled under the umbrella term of STEAM education.

As is often the case with umbrella constructs (Hirsch & Levin, 1999), STEAM education is at the excitation stage of its life cycle. As such, it is characterised by a rapidly growing literature but also a lack of consensus on a common definition (Perignat & Katz-Buonincontro, 2019). There is nevertheless an agreement among educators that STEAM practices may enhance creativity and thinking skills (ibid.). In particular, the rising popularity of STEAM is largely premised on the view that it holds strong potential for lowering barriers in student engagement with science (Henriksen, 2014). Integrating

the arts into science teaching is argued to unlock students' imagination and wonder, motivating them to apply creative thinking to STEM subjects and, as a result, helping them identify and enact evidence-based connections between STEM-centric skills and real-world phenomena and challenges (Liao, 2016; Marmon, 2019). Concurrently, arts integration into STEM curricula is suggested to promote inclusive and gender equitable classrooms (de Vries, 2021), thereby helping reverse current trends marked by persistent gender disparities in STEM disciplines (Ertl et al., 2019; Legewie & DiPrete, 2014; Wajn-gurt & Sloan, 2019).

Developing environments that support STEAM: the CREATIONS pedagogical framework

Situated within the emerging STEM to STEAM movement, this study has been conducted in the framework of CREATIONS (<http://creations-project.eu/>), a three-year H2020-EU funded project implemented in 11 European countries. Probably the most innovative aspect of the project was a synthesis of open inquiry-based science instruction models (Sotiriou et al., 2017) with creativity-enhanced teaching approaches (Chappell et al., 2015), leading to the development of a palette of STEAM good practices aimed at sparking student interest in science learning and science careers. As a result, more than 100 STEAM interventions were designed and piloted in primary and secondary schools across Europe. A major challenge, though, for the effective implementation of such interventions is always the context of implementation that is highly related with the pedagogical framework and the school environment.

While these interventions vary in terms of subject domain (e.g., physics, biology, mathematics), type of activity (e.g., in-school, out-of-school), duration, and setting (formal, non-formal, informal), they are underpinned by a common pedagogical framework for encouraging creativity in science teaching and learning (Craft et al., 2016) rooted in the concept of possibility thinking (Craft & Chappell, 2014). By shifting attention from 'what is' to 'what could be' and 'what if' type of questions, possibility thinking serves as a foundation for the development of school learning environments open to imaginative opportunities that encourage students to: experiment with different activities, people, and identities; take action and make themselves visible change agents; and play, self-create, and co-create in an emotionally rich learning setting (Chappell et al., 2015; Craft, 2015). For the purposes of CREATIONS project, creativity is thus defined as 'purposive and imaginative activity generating outcomes that are original and valuable in relation to the learner' (Chappell et al., 2019: 297).

The design of STEAM interventions in CREATIONS has been informed and guided by a set of eight pedagogical features: dialogue; interdisciplinarity; individual, collaborative, and communal activities for change; balance and navigation; empowerment and agency; risk, immersion, and play; possibilities; ethics and trusteeship. In turn, these features are embedded in and interact with distinct phases of the inquiry science learning cycle as specified in the 5E instructional model: engagement, exploration, explanation, elaboration, and evaluation (Bogner et al., 2011; Sotiriou et al., 2017). As detailed in Chappell et al. (2015), this interaction is effectively a dialogical process between teachers and students, allowing the former to choose the extent to which an inquiry is student-led or teacher-led. As observed in practice, the majority of interventions within CREATIONS leaned towards the open, student-led end of Inquiry-Based Science Education (IBSE) by

incorporating elements of creativity and the arts to extend STEM to STEAM (Conradty & Bogner, 2019).

Taken together, the CREATIONS pedagogical framework has sought to provide science teaching practice with a relational, humanising context for helping students embark on what Chappell et al. (2012) describe as ‘journeys of becoming’. These refer to incremental creative changes embedded in the particulars of everyday schooling that may be experienced differently by individual students. Yet, cumulatively they are not unimportant as they can lead to ‘quiet revolutions’ against the backdrop of the tension line between, on one hand, the economic need for more young people to pursue STEM disciplines and careers and, on the other, the declining science identity trajectories of students due to their perceptions of science as a personally irrelevant and non-creative endeavour (Archer et al., 2013; Chappell et al., 2019; Osborne & Collins, 2001).

Developing an open schooling culture by bridging formal with non-formal as well as informal learning activities has been integral to the design of STEAM learning environments in the context of CREATIONS (Rocard et al., 2007). The recent OECD re-schooling scenarios also claim that the open schooling culture is a strong driver for developing the future paths for schooling that build on the strengths of both formal and informal learning (OECD, 2020). ‘Opening the ‘school walls’ connects schools to their communities, favouring ever-changing forms of learning, civic engagement and social innovation’ (ibid: 49). Such environments have the capacity to act as open schooling hubs (European Commission, 2015), incubators for the development of twenty-first century skills by promoting horizontal connectedness across areas of knowledge and subjects as well as to school and other communities (Istance & Dumont, 2010). This is a promising approach to transform schools to innovation hubs within their local communities. In an open schooling hub, external ideas need to challenge traditional internal views and, in turn, to benefit its students and the community it serves. Such engaging environments may vitally contribute to their community when student projects introduce real needs into a community outside of school, present them publicly, and enrich local expertise. Additionally, such environments may foster learner independence – and interdependence – through collaboration and the provision of opportunities for learners to understand and interrogate their place in the world.

Relatedly, out-of-school science learning activities, as defined by Eshach (2007), have been found to be associated with an increased level of engagement and intrinsic motivation among young people (Mahoney et al., 2005). Systematic evidence suggests that the exposure of students in other settings beyond the school enhances their creative skills (Davies et al., 2012). Forging interdisciplinary partnerships with external stakeholders, including science/art centres and museums, research centres, and universities, may also contribute substantially to a creative STEAM learning environment (Grant & Patterson, 2016; Jeffrey, 2006; Kisiel, 2014). Collaborating with external stakeholders from the world of science and the arts allows students to not only be exposed and familiarise themselves with diverse ways of thinking and understand the importance of discipline-relevant methodologies, materials, and practices (Chappell et al., 2015), but also recognise that while creativity may interact differently with these discipline knowledge bases, its added value to society derives from exchange and synthesis of different systems of knowledge in a way that can result in transformational change, enabling novel ways of thinking in

relation to societal challenges (European Commission, 2015). In these environments, the aforementioned CREATIONS interventions became part of curriculum-led learning (integrating/embedding them in the everyday school practice) while extra-curricular activities (e.g., visits to museums, science centres, research centres, field trips and exhibitions) were coupled with home- and community-centred (informal) learning experiences. Each site of implementation brought together representatives from industry and civil society associations who—in cooperation with the school community—scanned the horizons, analysed the school and community needs, and cooperated to design common projects and to propose innovative solutions.

Key partners in the aforementioned ‘journeys of becoming’ are the teachers themselves. The CREATIONS approach respects and relies upon teachers’ professional wisdom, a notion that recognises their wealth of teaching expertise and intrinsic motivation manifested in actionable knowledge and creative confidence to navigate between openness and structure in their everyday practice (Chappell et al., 2015). Previous research in project-based learning has shown that teacher intrinsic motivation is associated with student intrinsic motivation both directly and indirectly through perceived instructional support (Lam, Cheng, & Ma, 2009). In the CREATIONS context, teachers were thus expected to transcend the outdated role of information transmitters and content deliverers by enacting their professional wisdom to support their students to get immersed in creative, life-relevant STEAM activities conducive to the arousal of their intrinsic motivation in the science learning experience.

Untangling the relationship of STEAM-enhanced creativity and science motivation

In response to the dearth of empirical studies on measuring and assessing creativity as part of STEAM education (Perignat & Katz-Buonincontro, 2019), the CREATIONS project developed an evaluation framework aimed, first, at monitoring creativity (Conradty & Bogner, 2018) and, second, at examining the creativity pathway to science career motivation as a result of students’ participation in STEAM interventions designed and implemented according to the pedagogical principles described above (Conradty & Bogner, 2019, 2020; Conradty et al., 2020).

Central to this framework is the distinction between two types of personal creativity, namely act and flow (Conradty & Bogner, 2018, 2019; Csikszentmihalyi, 1990, 2000; Miller & Dumford, 2016). The former covers conscious, active and trainable cognitive activities including imagery, analogical thinking, and idea generation and manipulation, which cumulatively promote imaginative problem-solving (Conradty & Bogner, 2019). The latter captures the mental state beyond fear and boredom, and is characterised by the simultaneous experience of three components: concentration, interest, and enjoyment (Shernoff et al., 2003: 161). First, flow is characterised by intense concentration in an activity. Previous research in educational contexts has shown that deep absorption in activities, and especially in those activities that require complex mental tasks, leads to optimal learning experiences for students (Csikszentmihalyi et al., 1993). Second, flow is mirrored in elevated intrinsic interest in an activity by which individuals become engaged with a task for its own sake (Deci & Ryan, 1987). Interest is considered a basis for sustained motivation and curiosity, increasing the ability to solve complex tasks (Shernoff et al., 2003). Finally, flow is accompanied by a feeling of enjoyment and

satisfaction inherently linked to the activity itself. To note that according to flow theory (Csikszentmihalyi, 1990), concentration may prevail over enjoyment during the actual engagement with a task, and therefore enjoyment may occur retrospectively. The mental state of flow is perceived as closely related to intrinsic motivation and is suggested to be experienced especially at young ages, with a declining trend later in adolescence partly due to the constraints imposed by prescribed high-school curricula that prioritise teacher-driven and testable knowledge acquisition over student-led purposeful and inherently enjoyable activities (Csikszentmihalyi, 2000; Pink, 2009).

It is important to note that the primary focus of both cognitive processes associated with creativity is on assessing the creativity capacity of the individual. Yet, as found in Miller and Dumford's (2016) study, act and flow differ in terms of their relative sensitivity to the environment, with the former being more sensitive to changes in the learning context, whereas the latter as a parameter measuring a mental state related to emotion appears to be more stable. Therefore, act and flow can be considered appropriate proxies for measuring the creative potential of students by taking into account the learning context within which they experience STEAM activities (Aguilera & Ortiz-Revilla, 2021).

Based on the distinction between act and flow, recent longitudinal work by Conradty and Bogner (2019) examined the interrelationships of the two creativity subscales and intrinsic components of science motivation among late primary school students (11–12 years) engaged in a short-term biology-related STEAM intervention. The results of this study showed that both act and flow were correlated with students' intrinsic motivation, self-determination and, more strongly, with self-efficacy, suggesting that creativity and science motivation are interrelated. Building on these results, further work by Conradty and Bogner (2020) in the context of a medium-term physics-related STEAM intervention again with late primary school students (Alexopoulos et al., 2019) provided support for a model in which science self-efficacy was hypothesised to mediate the relationship between the two creativity subscales and science career motivation. The same model was validated in a randomised sub-sample of nearly one thousand primary and secondary school students that took part in five selected STEAM interventions across various subjects (physics, biology, and maths) in the framework of CREATIONS (Conradty et al., 2020). Taken together, these studies corroborate previous findings on the strong association between student's self-efficacy and their career trajectories (Bandura et al., 2001; Lent et al., 1994) but also reveal a previously unreported pathway from STEAM-enhanced creativity to science career motivation via self-efficacy.

However, despite this important new evidence, the above studies found no significant changes in students' science career motivation as a result of their participation in the respective STEAM interventions. In addition, no gender differences at any variable at any time were reported. These results were mainly attributed to the young age of the respondents ($M=12.5$ years in Conradty et al., 2020; $M=10.5$ years in Conradty & Bogner, 2020). In contrast, recent work by Salmi et al (2021) on the effect of a 'Math and Art' short-term intervention for 12-year-old pupils in Finland found a significant drop in science career motivation but only in female students. The present study contributes to this line of research by examining the creativity pathway to science career motivation in the context of a long-term STEAM intervention, namely, 'Art and Science across Italy', addressed to senior high-school students. Consistent with previous work by

CREATIONS colleagues (Conradty & Bogner, 2020; Conradty et al., 2020), the overarching hypothesis is that STEAM—in this case the ‘Art and Science across Italy’ intervention—will increase students’ creativity which, in turn, will have a positive effect on their science career motivation through a mediated effect of self-efficacy. Accordingly, the study has three research objectives: (i) to monitor differences in students’ reported creativity, self-efficacy, and career motivation before and after their participation in ‘Art and Science across Italy’; (ii) to test for potential gender effects in these differences; and (iii) to examine the interrelationships between creativity, self-efficacy, and career motivation.

STEAM intervention: ‘Art and Science across Italy’

Organised by the Italian National Institute for Nuclear Physics (INFN) in collaboration with the European Organization for Nuclear Research (CERN) and the support of CREATIONS project, the ‘Art and Science across Italy’ programme was established in 2016 with the aim to serve as a springboard for engaging high-school students in Italy with scientific discoveries and technological innovations that stem from frontier research in particle physics and related fields such as astroparticle physics and cosmology. The project essentially acts as a bridge between schools and large research infrastructures to integrate learning in formal and informal settings, fostering students’ creativity, inquiry, and enjoyment in science learning. Situated within the STEAM movement, the project is premised on the view that, since “science is an activity that involves creativity and imagination as much as many other human activities” (Osborne et al., 2003: 702), arts-based activities may constitute a suitable approach towards integrating creativity, imagination, and science in school settings (Hadzigeorgiou & Fotinos, 2007). Questions such as “If the Higgs boson had a colour, what would that colour be?” provide the starting point for wider student engagement with cutting-edge science in large research infrastructures such as CERN and INFN through the use of art as a universal language to approach, study, represent, and communicate scientific ideas and phenomena, irrespective of students’ gender, educational performance, prior discipline knowledge, and dispositions towards science and the arts.

Following the guidelines of the CREATIONS pedagogical framework, ‘Art and Science across Italy’ represents a long-term hybrid intervention combining face-to-face and virtual activities enriched with technology. The project consists of four consecutive phases with a total duration of about 16 months. In the first phase, students take part in out-of-school activities that have been found to be effective in raising student interest and motivation in science (Bell et al., 2009; Hayden et al., 2011). These activities include real and virtual visits to science and art centres and museums, as well as seminars and workshops hosted in science labs of local and national universities. During this phase, which lasts about four months, students have the opportunity to meet and interact physically or virtually with scientists, science educators, and communicators, as well as professional artists and art educators, and get exposed to out-of-school inspiring and interdisciplinary settings. For example, students become familiar with research in particle physics through workshops that make use of simulations with real open data, as well as simple lab activities and interactive games. They also have the opportunity to visit interactive exhibits and installations in science centres and museums. Throughout this phase, students are encouraged and stimulated to ask questions and engage in dialogue that helps

them conceptualise similarities and differences in the way that creativity is viewed and employed in the course of the scientific and artistic process respectively (Chappell et al., 2015). At the end of this phase, students are expected to have formed rough preferences for the scientific topics with which they will work in the next phase.

The second phase is structured around project-based learning (Ubben, 2019). Students form small groups of about three to four members each. Under the guidance of their assigned teachers, scientists, and artists, they then work collaboratively to conceive, design, and create artistic compositions inspired by a scientific topic of their choice. Students have about four months to complete their artworks both during and out of school hours. The products of this phase range from drawings, sculptures, and collages to 3D object models, videos, digital narratives, and audiovisual installations.

The third phase consists of the communication of students' works through the organisation of local art and science exhibitions in collaboration with INFN institutes, local educational authorities, and other stakeholders such as municipalities. This is the phase where the competition element of the programme is introduced. The inclusion of a competition element is supported by evidence suggesting a positive association between student participation in STEM competitions and interest in STEM-related careers (Miller et al., 2018). The best artworks per participating city, as selected by a national jury of scientists, artists, and communication professionals, qualify to enter the last phase, that is, the national competition. The prize for the winning student teams is a week-long art-science Masterclass at CERN or in one of the INFN institutes in Italy.

Methods

Participants

The survey data for the present study were collected from high-school students in four cities (i.e., Milan, Naples, Padova, Venice) in Italy that participated in the 'Art and Science across Italy' STEAM intervention implemented from September 2016 until April 2018. Out of 2,758 students who were invited to complete the same survey at two time points (i.e., before and after the completion of the intervention), 883 pre- and 345 post-surveys were returned, with a response rate of 31% and 12%, respectively. List-wise deletion of cases with missing values reduced the final sample to 175 students with complete and matched pre- and post-surveys. The average age of students within the final sample is 17.4 years ($SD=0.65$, range 16–19 years). 58.9% of the students are females. 75.4% of the students are enrolled in scientific lyceums, 14.3% in artistic lyceums and the remaining 10.3% in classical lyceums. To note that the distribution of the sample by school type reflects the distribution of the population of students enrolled in Italian lyceums (about 70% scientific, 20% classical and 10% artistic) as extrapolated from data provided by the Italian Ministry of Education (Ministero dell'Istruzione).

Design

Aligned with the overall evaluation framework of CREATIONS (e.g., Conradt et al., 2020), a two-wave survey design is used in this study to capture differences in students' ratings of the focal constructs before (T0) and after (T1) the intervention. This also allows testing the stability of those constructs across time. In addition, the 16-month period between the pre- and post-test reduces the likelihood of memory effects. Both

pre- and post-test surveys were administered online, assuring the participants of the anonymity and confidentiality of their responses. The participants were also reassured that taking part in the surveys would by no means be considered as a class test nor be used for their assessment in any of the subjects taught at school.

Measures

All constructs are measured with validated scales. First, creativity is measured with Miller and Dunford's (2016) cognitive processes associated with creativity (CPAC) questionnaire in which two self-reported creativity subscales are identified, namely, deliberate and intuitive processes. Further validation work by Conradty and Bogner (2018) has relabelled the two subscales as act and flow, respectively. Both measures are rated on a 4-point Likert-type scale (1 = *never* to 4 = *very often*). The creativity act subscale (C_{ACT}) comprises seven items that quantify the extent to which respondents are consciously and actively engaged in trainable cognitive processes of imagery, analogical thinking, idea generation, and manipulation. A sample item from that scale is, "I joined together dissimilar concepts to create a novel idea". The internal reliability of C_{ACT} yielded a Cronbach's alpha of 0.66 for the pre-test and 0.79 for the post-test. The creativity flow subscale (C_{FLOW}) comprises three items that are "typical elements of a flow experience" (Conradty & Bogner, 2018: 235) and, as such, are considered closely related to intrinsic motivation. A sample item from that scale is, "I felt that work was automatic and effortless during an enjoyable task". The Cronbach's alpha of C_{FLOW} was 0.60 both for the pre- and the post-test.

Second, the present study uses Glynn et al's (2011) science motivation questionnaire II (SMQ II) to measure two components of students' extrinsic and intrinsic science motivation: career motivation (CM) and self-efficacy (SE), respectively. These are considered as mutually supporting components that contribute to the development and sustenance of science-learning behaviour (ibid.). Both scales are rated on a 5-point Likert-type scale (1 = *never* to 5 = *always*). Given the strong factor structure of SMQ II, it was deemed appropriate to include the four best-loading items out of the five items that originally comprise each of the two scales to improve scale applicability (Ferdous & Plake, 2016; Schum & Bogner, 2016). As a cognitive component of extrinsic motivation, the CM scale measures the extent to which students perceive learning science as a means to a career. A sample item from that scale is, "Learning science will help me get a good job". The Cronbach's alpha of CM was 0.80 for the pre-test and 0.89 for the post-test. The SE scale, which is associated with intrinsic motivation, measures students' beliefs that they can perform well in science. A sample item from that scale is, "I believe I can master science knowledge and skills". The Cronbach's alpha of SE was 0.86 for the pre-test and 0.87 for the post-test.

Data analysis procedure

All statistical analyses were carried out with IBM SPSS Statistics 26.0. Pre- and post-changes in all main variables were analysed with *t*-tests. Independent samples *t*-tests were used to examine gender differences. A canonical correlation analysis (CCA) was conducted to evaluate the multivariate shared relationship between science motivation and creativity, each of which operationalised in the variable sets of CM and SE,

and C_{ACT} and C_{FLOW} , respectively, at two time points (T0, T1). Accordingly, the latent variable of science motivation derived from the four observed variables of CM T0, CM T1, SE T0, SE T1, while the latent variable of creativity derived from the four observed variables of C_{ACT} T0, C_{ACT} T1, C_{FLOW} T0 and C_{FLOW} T1. It is noted that, while in CCA one variable set is often identified as predictor and the other variable set as criterion, CCA is used here to identify the strength of the correlation between the latent variables of science motivation and creativity that are weighted based on the relationships between the observed variables within the sets (Sherry & Henson, 2005). Multiple linear regression analyses were used to explore further the association between the two subscales of creativity and the two components of science motivation. Finally, the mediating effect of self-efficacy on the association between creativity and career motivation was tested with the PROCESS macro path analysis modelling tool for SPSS (Hayes, 2018).

Results

Descriptive statistics for mean scores of all variables of interest by gender and pre/post-test are presented in Table 1.

To examine the overall effect of the STEAM intervention on students' changes in creativity and science motivation, a series of t-tests were performed to compare pre- and post-test differences in the respective variables. Results indicate that students' reported levels of C_{ACT} increased significantly after the intervention ($t(174) = -2.813$, $p < 0.01$), though no significant changes are observed for C_{FLOW} ($t(174) = -0.795$, $p = 0.428$). Concerning changes in students' science motivation, a significant positive difference was observed for CM ($t(174) = -2.188$, $p < 0.05$). In contrast, students' reported SE was significantly decreased ($t(174) = 1.984$, $p < 0.05$) after the intervention.

Gender differences are evident for CM and SE in the post-tests, with male students demonstrating higher levels than female students in both variables (CM $t(173) = 2.325$, $p < 0.05$; SE $t(173) = 3.417$, $p < 0.001$). A gender-separated analysis was also performed, with the results of paired t-tests indicating significant positive changes in male students' mean ratings between before and after the STEAM intervention for C_{ACT} ($t(71) = -3.354$, $p < 0.001$), C_{FLOW} ($t(71) = -2.004$, $p < 0.05$), SE ($t(71) = -2.035$, $p < 0.05$), and CM ($t(71) = -4.320$, $p < 0.001$). Based on the same

Table 1 Descriptive statistics for mean scores of all variables by gender and pre/post-test

Measure	Group	C_{ACT}			C_{FLOW}		CM		SE	
		N	M	SD	M	SD	M	SD	M	SD
Pre-test	Male	72	2.54	0.41	2.53	0.56	3.55	0.83	3.52	0.80
	Female	103	2.51	0.45	2.57	0.67	3.55	0.73	3.59	0.77
	Total	175	2.52	0.43	2.55	0.68	3.55	0.77	3.56	0.78
Post-test	Male	72	2.71	0.47	2.69	0.60	3.85	0.83	3.69	0.82
	Female	103	2.56	0.67	2.53	0.65	3.55	0.94	3.25	0.85
	Total	175	2.66	0.91	2.59	0.63	3.67	0.90	3.43	0.86

C_{ACT} = creativity subscale act; C_{FLOW} = creativity subscale flow; CM = career motivation; SE = self-efficacy; M = mean; SD = standard deviation

analysis, it was found that the only variable in which female students' mean ratings differed significantly before and after the STEAM intervention was that of SE, where post-test mean scores were substantially lower than pre-test mean scores ($t(102) = 3.945, p < 0.001$).

The CCA yielded four functions with squared canonical correlations of 0.344, 0.076, 0.007, and 0.002 for each function. The full model across all functions (Function 1) is statistically significant (Wilk's $\lambda = 0.601, F(16, 510.83) = 5.798, p < 0.001$). This indicates that the full model explains almost 40% of the variance shared between the variable sets. The canonical correlation between the two latent variables is 0.587. The dimension reduction analysis indicated that the other three functions are not statistically significant (Function 2, $F(9, 409.02) = 5.798, p = 0.093$; Function 3, $F(4, 338.00) = 0.401, p = 0.808$; Function 4, $F(1, 170) = 0.356, p = 0.551$). Table 2 presents the standardised canonical coefficients, the structure coefficients, and the squared structure coefficients for each observed variable for Function 1.

The largest contributions to the latent variable of science motivation are made primarily by SE T1 and CM T0. This is supported by the large correlation coefficients and their consistency with the values of the structure coefficients (r_s) and squared structure coefficients (r_s^2). An exception appeared to be CM T1 which had a modest correlation coefficient (-0.224) but a comparatively large structure coefficient (-0.848). This is likely due to multicollinearity that CM T1 had with other observed variables within the same set. Concerning the latent variable of creativity, the largest contribution is made by C_{ACT} T1, with C_{FLOW} T1 and C_{ACT} T0 making secondary contributions.

The results of bivariate correlations (Table 3) show that age is negatively correlated with SE in the pre-test ($r = -0.218, p < 0.01$). Gender is negatively correlated both with CM ($r = -0.165, p < 0.05$) and SE in the post-test ($r = -0.251, p < 0.01$), thus corroborating gender differences in students' levels of CM and SE after the intervention as indicated above. The creativity subscales of C_{ACT} and C_{FLOW} correlates with CM and SE at both testing times. Highly significant correlations ($r > 0.70$) between CM and SE both in the pre-test ($r = 0.718, p < 0.01$) and the post-test ($r = 0.741, p < 0.01$) are observed, suggesting a complex interplay between the two variables.

Table 2 Canonical solution for Creativity and Science Motivation

Variable	Function 1		
	Coef	r_s	r_s^2 (%)
CM T0	-0.51	-0.85	72.42
CM T1	-0.22	-0.85	71.91
SE T0	0.09	-0.61	37.08
SE T1	-0.48	-0.89	78.32
R_c^2			34.41
C_{ACT} T0	-0.30	-0.67	44.62
C_{ACT} T1	-0.61	-0.92	83.72
C_{FLOW} T0	-0.15	-0.49	24.21
C_{FLOW} T1	-0.24	-0.72	51.12

$N = 175$. Coef = standardized canonical function coefficient; r_s = structure coefficient; r_s^2 = squared structure coefficient; R_c^2 = squared canonical correlation. C_{ACT} = creativity subscale act; C_{FLOW} = creativity subscale flow; CM = career motivation; SE = self-efficacy; T0 = pre-test; T1 = post-test

Table 3 Bivariate correlations

	Age	Gender	CMT0	SET0	C _{ACT} T0	C _{FLOW} T0	CMT1	SET1	C _{ACT} T1	C _{FLOW} T1
Age										
Gender	− 0.02									
CMT0	− 0.14	0.00	(0.80)							
SET0	− 0.22**	0.05	0.72**	(0.86)						
C _{ACT} T0	− 0.11	− 0.03	0.37**	0.32**	(0.66)					
C _{FLOW} T0	0.03	0.03	0.29**	0.33**	0.36**	(0.60)				
CMT1	0.07	− 0.17*	0.62**	0.47**	0.30**	0.19**	(0.89)			
SET1	− 0.10	− 0.25**	0.55**	0.47**	0.33**	0.26**	0.74**	(0.87)		
C _{ACT} T1	0.03	− 0.14	0.43**	0.27**	0.43**	0.26**	0.49**	0.48**	(0.79)	
C _{FLOW} T1	− 0.01	− 0.13	0.35**	0.21**	0.23**	0.33**	0.35**	0.38**	0.59**	(0.60)

N = 175. Two-tailed tests. * $p < .05$. ** $p < .01$. Internal reliabilities are shown along the diagonal in parentheses

C_{ACT} = creativity subscale act; C_{FLOW} = creativity subscale flow; CM = career motivation; SE = self-efficacy; T0 = pre-test; T1 = post-test

Table 4 Multiple regression models for the relationships between the creativity subscales, self-efficacy and career motivation

	β	B	SE	95% CI	<i>p</i> value
<i>Model 1: SE as dependent variable</i>					
Age	− 0.12	− 0.15	0.10	− 0.32, 0.02	0.077
Gender (female)	− 0.18	− 0.32	0.13	− .055, − 0.09	0.006
C _{ACT}	0.38	0.63	0.13	0.37, 0.89	< 0.001
C _{FLOW}	0.13	0.18	0.11	− .034, 0.40	0.098
$R^2_{adj} = 0.27$, $F = 17.29$, $p < .001$					
<i>Model 2: CM as dependent variable</i>					
Age	− 0.01	− 0.01	0.07	− 0.14, 0.14	0.980
Gender (female)	0.03	0.05	0.10	− 0.14, 0.24	0.610
C _{ACT}	0.18	0.31	0.12	0.09, 0.54	0.007
C _{FLOW}	− 0.01	− 0.01	0.09	− 0.18, 0.17	0.969
SE	0.66	0.70	0.06	0.57, 0.82	< 0.001
$R^2_{adj} = 0.56$, $F = 45.52$, $p < .001$					

N = 175. *B* = unstandardised coefficient; β = standardised coefficient; *SE* = standard error; *CI* = confidence interval;

R^2_{adj} = adjusted R^2 . C_{ACT} = creativity subscale act; C_{FLOW} = creativity subscale flow; CM = career motivation; SE = self-efficacy

To examine the directionality and type of the association between creativity and science motivation, multiple regression analyses were carried out. In particular, two models were fitted to test the mediating role of self-efficacy in the association between the two creativity subscales and career motivation while controlling for age and gender at the post-testing time point (Table 4).

As shown in Table 4, gender has a negative and significant association with SE (Model 1, $\beta = -0.183$, $p < 0.01$). C_{FLOW} has no significant association either with SE (Model 1) or CM (Model 2). In contrast, C_{ACT} is found significantly and positively associated both with SE (Model 1, $\beta = 0.378$, $p < 0.001$) and CM (Model 2, $\beta = 0.180$, $p < 0.01$). In addition, SE is found positively associated with CM (Model 2, $\beta = 0.662$, $p < 0.001$). To test whether SE has a significant indirect effect on the relationship between C_{ACT} and CM, a Sobel test was used. The result of the Sobel test is significant

(Sobel $Z=4.341$, $p<0.001$), indicating that SE partially mediated the association between C_{ACT} and CM.

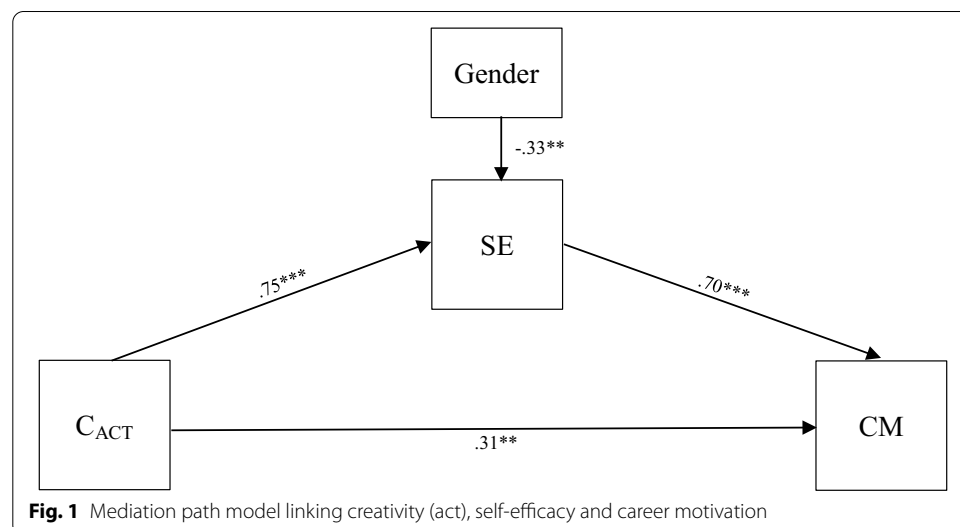
Based on the regression analysis results, a path model was finally tested, in which C_{ACT} was treated as the independent variable, CM as the dependent variable, and SE as the mediating variable in the association between C_{ACT} and CM. The model also included gender as covariate. Following the recommendations of Preacher & Hayes (2008), the bootstrapping method (5,000 iterations for this study) was used to examine indirect effects. The bootstrapped p values were also used to assess statistical significance of the indirect and total effects. The mediation path model is presented in Fig. 1.

Discussion

In response to calls for more research on assessing the impact of STEAM learning environments on creativity and its association with science learning outcomes (Cremin & Chappell, 2019; Perignat & Katz-Buonincontro, 2019), the present study was designed with three aims: (1) to monitor changes in students' creativity and science motivation before and after their participation in a STEAM intervention; (2) to ascertain whether gender differences do exist with respect to creativity and science motivation; and (3) to untangle the interrelationship between creativity and science motivation by testing a pathway model according to which self-efficacy was hypothesised to mediate the relationship of two distinct cognitive processes associated with creativity (act, flow) with science career motivation (Conradty & Bogner, 2020; Conradty et al., 2020).

STEAM effects on creativity and science motivation

The results show that students' cognitive creativity (i.e., act) is positively affected by the STEAM intervention. On the other hand, the creativity subscale of flow remains uninfluenced by it. A possible explanation for this may lie in the age of the participants ($M=17.4$ years) confirming the view that flow, a creativity component closer to the affective domain, is likely to decline as students progress in their schooling (Csikszentmihalyi, 2000; Hagenauer & Hascher, 2014). Overall, the above results are consistent



with those reported by Conradty et al. (2020) regarding averaged changes in students' creativity across five different interventions, including the one under study.

Regarding changes in the two components of science motivation, students' participation in the 'Art and Science across Italy' STEAM project had an overall positive effect on their science career motivation. Comparing this result with previously published related studies in the framework of CREATIONS (Conradty & Bogner, 2020; Conradty et al., 2020), this is to our knowledge the first study that reports such a positive effect. However, and contrary to what has been reported in the aforementioned studies, it was observed that students' average ratings of self-efficacy after the intervention were significantly lower than before. Explanations for these discrepancies are discussed below.

Gender differences

While previous relevant work in the area (Conradty & Bogner, 2020) reported no gender effects, the results of this study show gender differences primarily for self-efficacy and to a lesser but still significant extent for career motivation, with female students reporting lower levels than male students in the post-tests. Gender-separated analysis clarified further gender effects by showing that the STEAM intervention has an overall positive effect on male students' creativity (act and flow), self-efficacy and career motivation. However, female students' average ratings do not differ significantly before and after the intervention, except for self-efficacy where a substantial drop occurred, an effect that possibly accounts for the overall decrease of self-efficacy in the sample.

While surprising at first, the gender gap in both components of science motivation observed in this study may partially be attributed to socio-cultural factors that have been argued to be influential in conditioning students' career choice decisions and, consequently, their academic interest and self-efficacy (Bandura et al., 2001; Pajares, 2007). According to Biemmi (2015), the Italian school educational system tends to reproduce a traditional and stereotypical view of gender role orientation that sustains and perpetuates gender segregated career paths that, in turn, appear to determine students' field of study choices. The sample of this study is formed mainly (75.4%) by students enrolled in lyceums with a specialisation in science (Licei Scientifici). A post-hoc analysis appeared to confirm Biemmi (2015) by showing that there is a significant association between gender and type of school ($\chi^2(1, 175) = 14.554, p < 0.001$). Moreover, a school type pre-post analysis shows that self-efficacy dropped significantly only in those students enrolled in non-scientific schools ($t(42) = 3.010, p < 0.01$), while career motivation increased only among those student enrolled in scientific schools ($t(131) = -1.992, p < 0.05$).

Given the above information, it can be speculated that the gender gap in science motivation and creativity observed in this study may have also been accentuated by the motivating function of the competition element in the STEAM intervention. Although students' interest in science careers has been found to be positively associated with their participation in STEM competitions (Miller et al., 2018), research has shown that, according to their gender role orientation, female and male students may respond differently to external incentives, and specifically competitions, with masculine pupils becoming more intrinsically motivated and creative when competing than feminine ones (Conti et al., 2001). Notably, this difference is pronounced when students perform tasks in gender-segregated groups (ibid.). For male students the prospect of winning a prize

as part of their participation in the STEAM project could thus be interpreted as adding to the excitement and inherent challenge of the creative activity itself by boosting their intrinsic motivation to perform well. Since self-efficacy, a typical element of intrinsic motivation (Bandura & Schunk, 1981), has been found to correlate with both types of creativity, and especially with act (Conradty & Bogner, 2019), the gender gap in science motivation and creativity observed in this study may not be as unexpected as it first may seem.

STEAM pathway of creativity to science career motivation

The main hypothesis of this study was that students' participation in the 'Art and Science across Italy' STEAM project would increase their creativity which, in turn, would have a positive effect on their science career motivation via self-efficacy. It is also argued that participating in the project, students understand the role of creativity in science and no longer view the set of "laws" as established once and forever, yet they are the result of a creative process of abstraction inferred from experimental data. The results are generally in line with previous work (Bogner & Conradty, 2020; Conradty et al., 2020) by providing support for a pathway of creativity to science career motivation that is partially mediated by self-efficacy. Yet in the present study, while cognitive creativity (i.e., act) and flow correlate strongly with each other, it is the former that is found to have both a significant direct and indirect effect on career motivation. Relatedly, the results of canonical correlation analysis shows that creativity is primarily determined by cognitive creativity (i.e., act) after the intervention. In the same analysis, it is also found that science motivation is largely determined by self-efficacy after the intervention and to a lesser extent by career motivation before the intervention. Taken together, these findings highlight the key role that self-efficacy may play in the internalisation process of extrinsic motivational factors, in this case career motivation, towards the pleasure of science learning (Shin et al., 2017). Coupled with the finding that students' career motivation increased significantly after their participation in the STEAM intervention, it can also be inferred that the relationship between self-efficacy and career motivation is positively and mutually reinforcing (Bandura et al., 2001; Nauta et al., 2002).

However, the mediation path model is not "gender-free", as shown by the negative effect of gender (i.e., female) on self-efficacy. This finding suggests that in the present study the relative mediation strength of self-efficacy was contingent upon gender. Post-hoc gender-separated tests of the mediation path model confirmed that in the case of male students, self-efficacy mediates fully the pathway of cognitive creativity to career motivation, whereas in the case of female students the same pathway is partially mediated by self-efficacy. This difference implies the possibility of an alternative mediator variable in the pathway of creativity to career motivation that may be more pertinent to female students. Previous research (Glynn et al., 2011; Schumm & Bogner, 2016) has shown that self-determination, a distinct component of intrinsic motivation defined as the feeling of autonomy and self-control students have over their learning of science (Black & Decci, 2000), is perceived higher by female than male students, thus compensating for the lower self-efficacy often reported by the former. Since self-determination is considered a key factor in the internalisation process of career motivation towards

science learning behaviour (Ryan & Decci, 2000), it may have also acted as a mediator in the relationship between creativity and science career motivation.

Limitations

This study is subject to several limitations. First, while the operationalisation and measurement of personal creativity along the two distinct cognitive processes of act and flow instrument contributes to filling the existing gap in the literature about assessing the impact of STEAM learning environments on students' creativity, the use of thematic-oriented measures of creative activity such as artistic and scientific creativity (Kaufman et al., 2009) may provide additional insights into this line of research. Second, science motivation in the present study was approached by focusing on two of its sub-components, namely, self-efficacy and career motivation. A better understanding of the impact of creativity on science motivation will benefit from considering additional science motivation dimensions, such as self-determination mentioned above. Finally, considering the socio-cultural context within which STEAM learning environments develop is important for understanding better how cultural norms and expectations interact with student gender identity characteristics towards affecting their science motivation. For example, considering the gender role of masculinity and femininity can add significant explanatory power to the gender differences often observed in self-efficacy in the STEM domain (Huffman et al., 2013).

Several methodological limitations should also be acknowledged. Response shift bias can often be associated with the pre-test/post-test research designs (Howard & Dailey, 1979) such as the one used in the present study to evaluate the impact of an educational programme on students' perceptions of creativity and science motivation. Response shift bias often underestimates differences in students' ratings of the same constructs before and after their experience with an educational programme (Drennan & Hyde, 2008). Yet while retrospective pre-tests are useful in identifying response shift bias, they are not recommended as replacements for post-tests since they are associated with social desirability bias, poor memory, and maturational effects (Shadish et al., 2002). Moreover, due to the long duration of the intervention, adding a third intermediate time point to the research design would help capture potential fluctuations in students' responses across time. Furthermore, the study would benefit from a control group against which the impact of the STEAM intervention on the sample could be evaluated. The lack of a control group together with the relatively low response rate of the online post-survey (12%) may limit the generalisability of the results. Another limitation of this study is that it is Italian specific. Therefore, the generalisability of the results in other settings cannot be ascertained. Future studies are also encouraged to develop multilevel research designs to account for group- and school-level effects. In studies such as this one, controlling for the gender composition of student groups would help delineate whether gender differences in self-efficacy and career motivation varied between gender-segregated and gender-integrated groups. Finally, the present study would have benefited from the employment of qualitative approaches, such as the use of open questions responses from students and teachers, that could contribute to a more nuanced interpretation of the statistical findings on the contextual factors that promote or hinder STEAM-enhanced creativity and science motivation.

Implications for the design of STEAM learning environments

The study holds implications that can inform educational practice in the design of STEAM learning environments. Developing such environments cannot be seen as an isolated “project”—it demands a root-and-branch rethink, not just in pedagogy, but in every aspect of the way the school is organised: its structure, culture, the school curriculum, and the context of implementation. The STEAM learning environments should be designed taking into account that there are many opportunities for learners to develop and deepen their relationship with science and art in a variety of formal and informal learning settings. Such an action asks for knowledge area integration, effective and closed cross-institutional collaboration, and organisational change in the field of education (in the classroom, outside the classroom as well as in formal educational institutions). A successful environment needs to facilitate the process for envisioning, managing, and monitoring change in school settings by providing a simple and flexible structure to follow (Patton, 2012). Innovative ways not simply automate processes, they need to inspire, to engage, to connect, and to provide a framework for school leaders to engage, discuss, and explore (Martinez & McGrath, 2014). They need to offer answers to how schools can evolve, transform, and reinvent; how schools facilitate open, more effective and efficient co-design, co-creation, and use of educational content (both from formal and informal providers), tools and services for personalized learning and teaching; how schools can become innovation incubators and accelerators (Winthrop et al., 2017). The role of technology is very crucial in such interventions as it acts as catalyst in the interaction between science and art, and creates the necessary links between different environments. In the framework of our study numerous technological applications were used including visualisations, augmentations, and 3D object modeling to effectively introduce in the school curricula the key concepts of the microcosm and findings from frontier research in particle physics.

The present study has demonstrated that those STEAM learning environments that are scaffolded by creativity-enhanced pedagogical features framed around the concept of possibility thinking (Craft & Chappell, 2014) may provide rich opportunities for students to develop positive perceptions of the value of science learning through purposeful engagement in imaginative creative activities conducive to the development of science career-related self-efficacy beliefs. With a focus on the visual arts, the ‘Art and Science across Italy’ project encouraged students to make artistic products, such as paintings, sculptures, video installations, and models, based on scientific principles and observable as well as unobservable phenomena inspired by research in particle physics, astrophysics and cosmology. Evidenced by positive changes in students’ active creativity, the project represents good practice as it can provide students with opportunities to generate new ideas, use imagery and analogical thinking and develop problem-solving skills as well as to collaborate with each other and communicate their joint creations to the public. In this sense, art and aesthetics can be powerful means to represent ideas, including big ideas in and of science (Hadzigeorgiou, 2016; Tsourlidaki et al., 2016).

However, as the present study has shown, STEAM projects are not a magic bullet in tackling the persistent problem of gender disparity in science careers, for students’ motivational beliefs in science learning and achievement are shaped both by in- and out-of-school experiences early in their schooling (Philip & Azevedo, 2017). This does not

prevent teachers from being aware of stereotypic and gender-biased representations of science as often depicted in popular fiction and films (Christidou, 2011) but also from genuinely addressing their own and sometimes implicit biases related to gender assigned qualities and characteristics of scientists as well as artists. Professional development scaffolds that support teachers to face and work through their own but also their students' biases related to gender are recommended. A study by Thomas (2017) has shown that a teacher's implicit associations of science with masculine traits can hinder female students from choosing a STEM major at university. Since a strong masculine image of science and mathematics can decrease significantly the likelihood of choosing a STEM major among female students, overcoming gender disparities in STE(A)M also requires a change of image of science as depicted in school textbooks at all educational levels (Makarova et al., 2019), and especially at primary level as gender stereotypical beliefs about science and scientists start to form at an early age (Archer et al., 2013). Teachers, educators, scientists, artists, and others involved in STEAM practice are also encouraged to use role models of both genders and a variety of sociocultural backgrounds. Importantly, their use to motivate, for example, girls to follow STEM fields should consider that the presented role models are perceived not only as successful but also desirable and attainable (Morgenroth et al., 2015). As a last remark, it may be worth emphasising the need for careful attention to how the gender composition of groups may trigger different motivational processes of their members when STEAM projects entail a competition element. In the present study, for example, if teachers were aware that the motivational effect of competition on creativity is contingent upon the gender composition of student teams, they would have considered the formation of gender-integrated teams which, as Conti et al's (2001) research has shown, are less likely to undermine girls' intrinsic motivation and creativity compared to gender-homogenous groups.

Conclusion

The study contributes to the emerging field of STEAM education by shifting attention to the importance of hybrid, cross-collaborative learning activities for the design of effective STEAM learning environments, building on an open schooling culture that embraces not only smart technological applications, but also the flexibility provided by the combination of formal and informal learning opportunities for students. In such environments, as this study, STEAM teaching and learning extends beyond the school by forming bridges with informal science and art education institutions. These organisations have the capacity to offer enrichment experiences for both students and teachers through the utilisation of technology that is necessary to optimise the creative dialogue between science and art by linking different environments to help achieve curriculum knowledge area integration. Our study, despite various limitations and constraints, provides supporting evidence for the potential of hybrid STEAM learning environments to promote student creativity and science career motivation. Further work is, of course, necessary to establish the significance of this finding in other settings; to understand better the gender effect that was found in our study; and finally to delve deeper into examining additional pathways through which STEAM learning environments may affect the process, context, and product dimensions of student creativity.

Abbreviations

C_{ACT}: Creativity Subscale Act; C_{FLOW}: Creativity Subscale Flow; CCA: Canonical Correlation Analysis; CM: Career Motivation; CPAC: Cognitive Processes Associated with Creativity; IBSE: Inquiry-Based Science Education; OECD: Organisation for Economic Co-operation and Development; SE: Self-efficacy; SMQ: Science Motivation Questionnaire; STEM: Science, Technology, Engineering, and Mathematics; STEAM: Science, Technology, Engineering, Arts, and Mathematics; T0: Pre-test; T1: Post-test.

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Authors' contributions

Conceptualisation, ANA; theoretical framework, ANA, SAS; methodological design, FXB; data acquisition, PP, TD, MF, DM, MM, SP, FS; data preparation and analysis, ANA; writing-original draft preparation, ANA; writing-review and editing, ANA, PP, SAS, TD, MF, DM, MM, SP, FS; funding acquisition, FXB, TD. The authors read and approved the final manuscript.

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Availability of data and materials

The dataset used and analysed in the current study is available from the corresponding author on reasonable request.

Declarations

Competing interests

The authors declare that they have no competing interests.

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