International Journal of Science Education

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tsed20

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**To cite this article:** Italo Testa, S. Galano, L. Palazzo & G. Ragozini (24 Apr 2025): The effects of perceived relevance of participation in science-oriented out-of-school time activities on university students' performance and persistence, International Journal of Science Education, DOI: 10.1080/09500693.2025.2493372

**To link to this article:** https://doi.org/10.1080/09500693.2025.2493372

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION
https://doi.org/10.1080/09500693.2025.2493372



# The effects of perceived relevance of participation in science-oriented out-of-school time activities on university students' performance and persistence

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**ABSTRACT**

Literature has shown that Out-of-School-Time (OST) activities are important experiences for developing interest in science careers. However, while participation in science-oriented OST activities has become widespread in secondary education, their role on subsequent undergraduate career remains largely underexplored. In this longitudinal study, we explored how the perceived relevance of the participation in science-oriented OST-activities affects students' early performance and later persistence in an undergraduate course. A sample of N = 565 Italian students from six science and technology majors (biology, biotechnology, biochemistry, computer science, mathematics, physics) who participated during high school in science-oriented OST programmes was involved in the study. The results show that the perceived relevance of OST activities positively affects both directly and indirectly, through motivation to persist, the students' early performance at first year and later persistence at the third year. Moderation analysis shows that gender affects these relationships, and that the moderation effect depends on the chosen undergraduate major. Specifically, while for biology, biotechnology, biochemistry courses such relationship is statistically significant only for male students, for physics, maths and computer science courses, the effects are significant also for female students. Results support the relevance of OST activities in the choice and persistence in a science undergraduate course.

**ARTICLE HISTORY**
Received 27 August 2024
Accepted 5 April 2025

**KEYWORDS**
Out-of-school-time activities; self-determination theory; academic progress

## Introduction

Out-of-School-Time (OST) activities have traditionally been considered fundamental to students' development, well-being, and academic performance (Feldman & Matjasko, 2005; Shulruf, 2010). In general, OST activities allow for the extension and deepening of specific content that is otherwise difficult to teach in the school curriculum (Young & Young, 2018; Zhang & Tang, 2017). Furthermore, participation in OST activities is

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/09500693.2025.2493372.

often voluntary, which facilitates student engagement (Essex & Haxton, 2018) and the development of soft skills (Feraco et al., 2023). Coupled with a supportive classroom climate and teaching practice, free OST activities can overcome differences due to students' socio-economic status (SES) (Holzberger et al., 2020).

On this basis, over the past two decades, scholars and science institutions have advocated science-related OST activities as a means to increase students' interest (Dabney et al., 2012), motivation (Jensen & Sjaastad, 2013; Vennix et al., 2018) and attitudes (Gibson & Chase, 2002) in a variety of science, technology, engineering and mathematics (STEM) disciplines. Specifically, science-oriented OST activities were found to have long-lasting positive effects on students' interest towards science-related careers (Baran et al., 2019; Kitchen et al., 2018). For instance, retrospective studies involving science graduate students and researchers have confirmed the importance of the participation in science-related OST activities at a young age in the decision to start a science career (Jones et al., 2011; Maltese & Tai, 2010; Nazier, 1993). A possible reason is that science-related OST activities can spark interest in STEM careers (Halim et al., 2023), develop scientific attitudes (Davidson et al., 2009) and increase the students' perception of self-competence in mathematics and science (Goff et al., 2020; Taskinen et al., 2013).

However, to date, no study has examined the extent to which the perception of the relevance of past participation in science-oriented OST activities for enrolment in a university course actually affects the motivation to persist in the chosen course and the academic progress. Using a longitudinal design, this study addresses this issue by testing a path model which posits that the retrospective perception of the relevance of participation in science-oriented OST activities for enrolment in a science university programme directly and indirectly affect students' academic progress through the mediation of motivation to persist in the chosen undergraduate programme. Given the underrepresentation of women not only in specific science-related careers (Lock et al., 2019) but also in specific science-oriented OST activities (Butcher et al., 2023), we also investigated whether there are differences in the structural relationships related to gender for the whole sample and for two groups of undergraduate courses. The findings may shed light on the relationship between students' participation in OST activities and their subsequent academic experiences, thereby adding to the field's knowledge of how to promote effective student trajectories in science at undergraduate level.

## Background

### *Science-oriented out-of-school time activities*

OST refers to hours in which school-age students are not in school and are doing something other than activities mandated by school attendance (Lauer et al., 2006, p. 276). A widely accepted notion of OST activities is that they include programmes that may, or may not, be aligned with school curricula (Meyers, 2023), have variable duration (Noam et al., 2020), and take place either after school hours or in the summer when schools are closed (Noam & Shah, 2014, p. 201). Typical objectives of OST activities are to enrich learning and provide opportunities for students to improve their knowledge of specific topics (Martin et al., 2016). A common feature of OST activities is their organisation, which differs from the formal school setting. In particular, two types of OST activities are usually identified: unstructured and structured (Dabney et al., 2012). Unstructured OST activities do not involve a formal curriculum and can be undertaken independently by students (Burns et al., 2023). Unstructured OST activities may require active involvement by participants (e.g. interactive exhibitions) or allow for more passive participation (e.g. seminars or videos on the Internet). Examples of unstructured science-oriented OST activities include visiting museums, science centres and observatories, cultivating science-related hobbies, participating in science clubs, entering science and mathematics competitions, and consuming science through a variety of media such as television, books, or the internet (Bonnette et al., 2019). In contrast, structured OST activities feature a specific sequence of activities and are often organised by universities. While structured OST activities share similar characteristics with unstructured activities, such as the emphasis on active participant involvement and voluntary participation, the former are often focused on a specific theme and linked together to form a coherent programme or a kind of small curriculum (Burns et al., 2023). Examples of structured science-oriented OST activities include summer camps to improve students' initial preparation (Bachman et al., 2008) and hands-on sessions in university laboratories to show how science and scientific inquiry work (Kácovský et al., 2023). Previous studies suggest that structured activities are beneficial in supporting student motivation, engagement and achievement (Schmäing & Grotjohann, 2023) and are associated with interest in future science (Dabney et al., 2012) and STEM careers (Young et al., 2017). For instance, Boedeker et al. (2015) report that the participation in summer enrichment programmes can be positively associated with university enrolment and academic performance. Similarly, Wünschmann et al. (2017) compared the effectiveness of a structured OST activity in a reptile and amphibian zoo with traditional classroom instruction on the same topics. Results indicate that the group involved in the OST activity achieved significantly higher scores than the classroom group immediately after the intervention and during the follow-up. Finally, participation in OST activities can also contribute to students' own science capital (Archer et al., 2015) by developing and sustaining their motivation towards a science career (Bonnette et al., 2019) or improving self-perceptions and healthy behaviours (Fadigan & Hammrich, 2004; Grossman et al., 2011), particularly for marginalised and minoritised students (Archer et al., 2021; Young & Young, 2018).

## *Perceived relevance of out-of-school time activities*

In this study, we will focus on the perceived relevance (PR) of participation in OST activities. Many studies suggest that science professionals often consider these activities as relevant for their career choice. For instance, Maltese and Tai (2010) investigated the role of early experiences in sparking interest in science among 116 graduate students and scientists. The results indicate that, for most participants, their interest in science began before middle school, with a relevant role played by teachers, school-based activities for females and OST activities for boys. Jones et al. (2011) investigated the pathways that lead 37 individuals to become scientists and engineers. Through semi-structured interviews, the authors found that OST activities such as tinkering, model building, and independent exploration were considered as the main trigger of the interviewee's long-term interest towards science. Such results were confirmed in the study by Venville et al. (2013) in which New Zealand and Australian science graduates were asked to indicate an experience that proved to be a relevant influence to study science. Results show that outdoor unstructured activities and extra-curricular activities were among the most rated experiences. In a retrospective study with 149 high school and undergraduate students assessing their perceptions of how early experiences influenced their interest in STEM, VanMeter-Adams et al. (2014) found that hands-on OST experiences were the most significant initial attractors to STEM and were also crucial for maintaining their interest in STEM fields. Similarly, in a later study, Jones et al. (2017) investigated the lifelong science learning experiences of 107 adult active amateur astronomers and birders, focusing on how these unstructured OST activities influenced individuals' engagement with science over time. Findings indicate that most participants valued early exposure to OST activities as pivotal in sparking their interest in science, fostering a stronger science identity and encouraging lifelong learning. Such results were confirmed also in a longitudinal study by Saw and Agger (2021), which showed that OST educational experiences were valued by rural and small-town students as relevant to develop STEM-oriented aspirations, despite the scarcity of availability and difficulty in participating in these kinds of activities.

However, while the above studies generally support a positive perception of OST activities for the development of subsequent motivation for science, we note that such findings may be related to a self-selection mechanism, i.e. subjects participate in a science-oriented OST activity because of pre-existing motivation for science (Bachman et al., 2008). When adjusting for self-selection mechanism, the positive effects of OST activities seem less evident. For instance, in a study with a sample of 20,970 students in the US, Chan et al. (2020) found that the participation in OST activities at middle school level did not predict the participation in similar activities at 9th and 11th grade and that the participation in OST activities during high school was not associated with motivation to enrol in a STEM field at university level.

## *The role of gender in participation in science-oriented OST activities*

In terms of participation in general OST activities, literature suggests that gender differences are manifested in the choice of the type of OST activity (Oller et al., 2020). Such differences are also evident in science-oriented OST activities, where gender disparity in participation starts as early as 3rd and 6th grade (Caspi et al., 2023) and extends to older students. For example, through a systematic review, Steegh et al. (2019) found that, at various school levels, boys are more likely to participate in math and science competitions, with the exception of the biology Olympiad, where girls' participation is higher. One possible reason for this result is that, when participating in math and science competitions, girls might be more susceptible to stereotype threat (Pronin et al., 2004). Stereotype threat refers to the activation of negative stereotypes inherent to contextual factors that are beyond the students' control (Inzlicht & Ben-Zeev, 2000; Murphy et al., 2007). Prior studies report that stereotype threat may contribute to explain differences in perceived ability and actual performance between boys and girls in both physics and math (Appel & Kronberger, 2012; Ganley et al., 2013; Marchand & Taasoobshirazi, 2013; Spencer et al., 1999). Similarly, in a study with 203 students participating in science- and engineering-oriented OST activities, the authors found that boys were more engaged with the activities' materials when they perceived the activity as challenging, whereas the perception of challenge and relevance did not affect girls' engagement in the activities (Schmidt et al., 2020). Finally, in a study with high school students in China, Wang et al. (2023) found that male students have more access to OST activities than female students, resulting in a greater influence of OST activities on the decision to enrol in a science/STEM course for boys. However, other studies suggest that structured OST activities also have the potential to reduce the gender gap in science-oriented career interest (Price et al., 2018; Stringer et al., 2020). For example, Butcher et al. (2023) explored how engagement in geek pop culture (such as digital games and live-action role-playing) can increase women's interest in science careers by increasing their self-efficacy. The authors found that inclusive experiences and increased efficacy mediated the relationship between geek culture engagement and science career interest. These findings highlight the importance of a welcoming environment in OST activities to support women's aspirations in science.

### Academic motivation

In this study, we adopted Self-Determination Theory (SDT) as theoretical framework to describe the underlying motivational mechanism by which PR of science-oriented OST activities may influence the persistence and progress in a science undergraduate career. According to SDT, motivation is the mechanism underlying the conscious intention to pursue a basic need or a specific learning goal (Krapp, 2002). Such a mechanism can be described by a hierarchical, multidimensional model with three basic components: *intrinsic motivation*, *extrinsic motivation* and *amotivation* (Diefendorff & Seaton, 2015; Vallerand & Ratelle, 2002). Intrinsic motivation involves engaging in an activity for the pleasure and enjoyment inherent in the activity, with the aim of satisfying three basic needs: competence, autonomy, and relatedness, regardless of the consequences. This form of regulation underlies individual's interest and perceived pleasure in the behaviour being performed. Extrinsic motivation refers to the need for compensation, coercion or avoidance of negative consequences and involves different degrees or regulations of self-determination, which can be ordered hierarchically. The first level is external regulation, which refers to behaviours that are guided, for example, by external demands, the desire to obtain a material reward, or to avoid criticism and punishment. The second level is introjected regulation, which involves some form of duty or guilt avoidance, but also the enhancement of self-perception as the main driving force behind a particular behaviour. The third level is identified regulation, which involves a conscious and autonomous perception of the value associated with the behaviour that is perceived as relevant to the achievement of a personal goal, although the behaviour is not yet perceived as inherently interesting or enjoyable. The most autonomous component of extrinsic motivation is integrated regulation, which refers to a conscious perception of the importance and usefulness of the behaviour performed in terms of achieving a personal goal. Finally, amotivation refers to the lack of control over the enacted behaviour and the will not to continue the commitment in a given situation.

We adopted the SDT framework in the present study because literature has shown that OST activities may help students maintaining their motivation towards science (Yildirim, 2020) due to the fit of OST learning environments to the students' needs of intellectual growth, autonomy and relatedness (Gutman & Eccles, 2007; Habók et al., 2020; Jones et al., 2011). Finally, motivation serves as a precursor of student academic engagement

(Bowden et al., 2021; Esposito et al., 2021; Passeggia et al., 2023), self-regulated learning (Zimmerman, 2001) and it is negatively correlated with the intention to withdraw from an undergraduate programme (Behr et al., 2020; Girelli et al., 2018a). However, few studies have investigated the association between motivation and gender at university level adopting the SDT framework and findings are inconsistent. For instance, in a study with 1133 Italian and Russian university students, Cabras et al. (2023) found that, for the whole sample, female students had significantly higher levels of identified regulation and intrinsic motivation than male students, the latter having significantly higher levels of amotivation. A similar result was also reported by Ajlouni et al. (2022). Differently, using a person-centred approach with a sample of 1072 university students, Litalien et al. (2019) found a not significant association between gender and the five emerging motivational profiles: *controlled* (namely, students with moderately high levels of extrinsic motivation, average levels of autonomous motivation, and low levels of amotivation); *multifaceted* (namely, students with moderately to high levels on most types of motivation, and low levels of amotivation); *unmotivated* (namely, students with low levels of autonomous and extrinsic motivation, high levels of amotivation); *knowledge-oriented* (namely, students with high levels of intrinsic motivation, low levels of amotivation, and average levels on the other types of motivations); *hedonist* (namely, students with high levels of amotivation coupled with equally high levels of intrinsic motivation). No significant association between motivation and gender was also found in a recent study that investigated self-regulated learning and motivational orientations of 476 Italian students using latent profile analysis (De Vincenzo & Carpi, 2024).

### *Academic progress at undergraduate level*

Progress in higher education, or academic progress, is generally understood as the continued enrolment of students toward completing their degree programmes (Behr et al., 2020). Academic progress is often contrasted with dropout, which is defined as an involuntary, long decision-making process, which leads to leaving a university without obtaining a degree (Tinto, 1975). The dropout phenomenon is complex and typically results from a variety of factors, including non-institutional (e.g. financial pressures, family influence), institutional (e.g. high academic demands, lack of satisfaction with the degree programme) and personal ones, as lack of motivation (Heublein, 2014; Suhre et al., 2007). The latter is relevant to the present study. An early study (Ethington, 1990) used expectancy-value theory to explore how students' expectations of success and their valuation of a higher education degree influence their academic progress. The findings indicate that students who believe in their academic abilities and perceive a high value in obtaining a degree were more likely to remain enroled. More recent studies collectively highlight the critical role of motivation, psychological traits, and satisfaction in influencing student persistence in higher education. For instance, Van Bragt et al. (2011) found that conscientious students tended to achieve higher academic credits and are less likely to drop out. Conversely, students exhibiting ambivalence and a lack of regulation were more prone to withdrawal, thus highlighting the importance of fostering positive psychological traits to support student retention. Similarly, Brandstätter et al. (2006) explored the role of resilience and self-control in student persistence. The findings indicate that students with higher levels of resilience were better equipped to handle academic challenges and are less likely to drop out. While most of the studies acknowledge the role of students' motivation on academic progress, few studies have investigated the direct relationship between motivation dimensions and intention to persist. For instance, Girelli et al. (2018b) investigated the factors influencing academic progress among 388 first-year Italian university students, focusing on the roles of autonomy support, autonomous motivation, and self-efficacy. Using a structural equation modelling approach, the authors found that more autonomous motivational regulation negatively influenced dropout intentions and positively affected academic progress.

Several studies investigated gender differences in academic progress. For instance, Aina (2013) found that female students with higher parental education levels are less likely to withdraw from university compared to male students. A study carried out in male- and female-dominated programmes in the Netherlands (Severiens & Ten Dam, 2012) found that men have significantly higher dropout rates in female-dominated fields due to lack of support from peers and family. Differently, analysing data from Norwegian universities, Mastekaasa and Smeby (2008) found that male students' dropout rates are not significantly influenced by the gender composition of their programmes, while women tend to have higher dropout rates in male-dominated fields, primarily due to lack of motivation. Finally, Van Bragt et al. (2011) found that female students generally exhibit higher levels of motivation and better study habits compared to their male counterparts, which contributes to their academic success and lower dropout rates. Such results are overturned when looking at science courses (Isphording & Qendrai, 2019). Specifically, while female students may possess stronger preparation in science subjects, they have a dropout rate approximately 23% higher than their male counterparts. This may be due to a competitive environment (Kugler et al., 2021), the lack of role models (Bottia et al., 2015), as well as to the lack of early educational experiences related to science (Speer, 2017). Notably, prior work carried out in different national contexts suggest that dropout rates are in general the highest in science areas, while fields such as Arts, Law, and Social Sciences exhibit significantly lower dropout rates (Korhonen & Rautopuro, 2018; Lassibille & Navarro Gómez, 2008). However, while most of these studies acknowledge the role of autonomous motivation to deal with the demands of these fields of study, particularly during the critical first year of study, no study to our knowledge has yet identified precursors of such motivation.

## Purpose of the study

Participation in Science-oriented OST activities has been retrospectively identified by science graduates and professionals as an important trigger for the decision to enrol in a science or a STEM career (Jones et al., 2011; Maltese & Tai, 2010). However, when the participation in science-oriented OST activities is perceived as a relevant factor for actual enrolment in a science or STEM degree programme (VanMeter-Adams et al., 2014), the issue of whether this perception affects the motivation to persist and the actual progress in the chosen degree programme has not been yet addressed.

In response to this lack of research, this study takes a longitudinal perspective and explores the direct and indirect relationships between PR of participation in science-oriented OST activities, motivation to persist and progress in an undergraduate course for a sample of students who chose a science or technology degree programme. Specifically, building on existing research results at high-school level according to which participation in OST activities can maintain student motivation in science (Yildirim, 2020) and affect achievement (Cooper et al., 1999), as well as findings that support a positive link between motivation and progress at undergraduate level (Buizza et al., 2024), we tentatively constructed the model in Figure 1 in which PR of participation in science-oriented OST activities acts as precursor, the students' progression in a university science course acts as dependent variable, with motivation to persist acting as a mediator. Lacking clear prior empirical evidence about such specific relationships, our study was first guided by the following open research question:

RQ1: What are the relationships among the perceived relevance of the participation in science-related OST activities, motivation to persist and progress in a university science course?

Secondly, based on literature about the relationship between gender and participation in science-oriented OST activities (Steegh et al., 2019; Stringer et al., 2020), as well as studies showing that female students have higher probability to leave science and STEM undergraduate courses than male students (Isphording & Qendrai, 2019) and that gender moderates the effects of several predictors of students' academic career (Hauspie et al., 2023; Nùnez-Pena et al., 2016; Ruffing et al., 2015), we also aimed to investigate whether gender could affect the relationships of the model in Figure 1. Hence, the second research question that guided the study was:

RQ2: Are the relationships between the perceived relevance of the participation in science-related OST activities, motivation to persist and progress in a university science course different for female and male students?

Finally, based on previous studies showing that science-oriented OST activities may promote the students' interest in specific disciplinary areas differently according to their gender (Cohen et al., 2021; Kaleva et al., 2023; Neher Asylbekov & Wagner, 2023; Schürmann & Quaiser-Pohl, 2022), as well on studies that show that women in specific male-dominated science and STEM fields are more likely to drop out in response to poor early performance compared to males (Astorne-Figari & Speer, 2018; Kugler et al., 2021), this study also aimed at investigating whether the moderating effect of gender on the relationships in Figure 1 differed according to the chosen undergraduate science courses. Hence, the third research question that guided the study was:

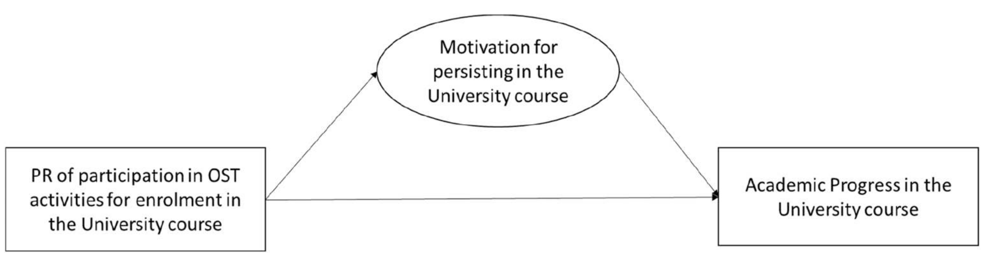


**Figure 1.** Schematic representation of the hypothesised mediation model of the study. OST = Out-of-School Time; PR = Perceived Relevance.

RQ3: How does gender affect the relationships between the perceived relevance of the participation in science-related OST activities, motivation to persist and progress in different university science courses?

## Methods

### Structured OST activities examined in the study

For this study, we considered a specific type of structured science-oriented OST activities carried out in Italian high schools, namely those aimed at supporting the increase of enrolments in the university system and at the same time ensuring that students make an informed choice of their study path to increase the chances of its successful completion (Anzivino & Rostan, 2017). These activities are typically organised by schools with the support of a local university, last 30 h, involve the whole class (25–30 students), are gratuitous and may include: practical sessions and workshops carried out in university laboratories; lectures at school and at university; meetings with researchers at school and at university. The practical sessions and workshops usually exploit a variety of science-related teaching approaches such as problem solving, modelling of real-life situations and critical observation of scientific phenomena, interaction through group work or other means of socialising knowledge. Meetings with researchers are mainly aimed at promoting positive attitudes towards science and scientists by illustrating career opportunities in science and STEM in general. During these activities, students are also invited to ask questions about the organisation of the undergraduate courses in which they are particularly interested. No assessment or evaluation of students' knowledge or skills is carried out during or after the participation in these activities. For the present study, we considered activities in the following disciplinary areas: biology, biotechnology, biochemistry, computer science, mathematics and physics. These disciplinary areas correspond to the undergraduate courses included in this study (see below). Examples of science contents covered in the activities and workshops organised by our university are: genetics (biology); physiology of neurones (biotechnology); spectrometry and materials analysis (biochemistry); image processing (computer science); cryptography (mathematics); motion and force and celestial motion (physics).

### Procedure

The study was conducted at the authors' university, starting in the second half of the 2018–2019 academic year (May 2019). First, the authors requested formal permission to access their university's data warehouse in order to extract the data needed for this study (see Measures subsection). Then, the authors contacted the coordinators of the specific degree programmes corresponding to the areas in which the OST activities were carried out: biology, biotechnology, chemistry, computer science, mathematics and physics. After receiving permission to conduct the study with the first-year students, the researchers contacted the lecturers of the courses to arrange a suitable time slot for administering the study survey (see Measures Section and Appendix) during their classes. The researchers then went to the lecture rooms at the agreed time and explained the study's objectives to the students, who were given a consent form to sign. Students who did not wish to participate in the study were allowed to leave the room. Participating students were asked to report at the end of the survey their university identification number and the gender in which they identified (open question). Data about teaching approaches and exam modalities of the courses were not collected. We separately collected the consent forms and the surveys to ensure anonymity. To collect data on academic progress, at the end of the first year (October 2019), the researchers accessed the university's data warehouse to extract the number of credits earned by students who had signed the consent form to participate in the study. The matching of data was carried out using the university identification number. Then, after three years (October 2021), the researchers accessed the university's data warehouse again to collect information on whether the students involved at the beginning of the study were still regularly enroled or whether they had dropped out. See Measures Section for more details.

## Participants

Overall, we collected 1060 consent forms, with 625 students reporting to have participated in at least one of the science-oriented OST activities described above during high school. Out of the 625, 25 students answered to the gender self-identification question 'other', 'prefer not to say', 'non-binary'. Due to their small number (4%), we excluded these subjects from subsequent analyses. Furthermore, 35 students did not answer to more than half of the survey, resulting in a final sample of n = 565 students. The students' demographic information are shown in Table 1.

## Measures

*Perceived relevance of the OST Activities.* To retrospectively measure the PR of the OST activities for the enrolment in the chosen university course, we developed an ad-hoc survey (reported in the Appendix). First, the students were asked about the activity they had attended. To ensure content validity of the instrument, as students could participate in these activities in a variety of ways, we provided in the survey some examples to illustrate the type of OST activities they were asked to refer to. The examples were discussed and agreed with three voluntary university researchers who carried out the activities examined in this study and included, e.g. measuring, classifying, experimenting, analysing data and drawing reasonable conclusions about the phenomena under investigation. Note that we excluded unstructured OST activities such as summer camps, visits to museum, competitions or field trips, as they are not compulsory, and participation may be driven by family or other contextual factors. Then, participants were

**Table 1.** Students' demographic information.

| | Disciplinary Area of the University Course | | | | | | |
|---|---|---|---|---|---|---|---|
| Gender | Biology | Biotechnology | Biochemistry | Math | Physics | Computer Science | Total |
| Female | 143 | 20 | 54 | 39 | 35 | 5 | 296 |
| Male | 55 | 24 | 40 | 37 | 72 | 41 | 269 |
| Other | 8 | 2 | 4 | 5 | 6 | 0 | 25 |
| Missing | 15 | 4 | 3 | 5 | 8 | 0 | 35 |
| Total | 211 | 50 | 101 | 86 | 121 | 46 | 625 |

asked to rate, using a 5-item scale developed by our group, the extent to which a particular feature of the attended OST activity – e.g. the targeted topic, the visit to the university laboratories – was perceived as either *very relevant* or *not relevant* for the enrolment. The OST activity features were selected, discussed and agreed with the same three voluntary university researchers.

*Motivation to persist in the university course.* Then, to measure the motivation for persisting in the chosen university course, we included in the study survey the Italian version (Alivernini & Lucidi, 2008) of the *Academic Motivation Scale (AMS)*, developed by Vallerand and Ratelle (2002). We used the following five subscales (total items = 20, see Appendix), each corresponding to a type of motivational regulation described above: (1) amotivation, (2) external, (3) introjected, (4) identified and integrated regulation; (5) intrinsic motivation. The Italian version of the AMS has a robust factor structure, and good reliability (Alivernini & Lucidi, 2008). To account for all the possible motivational regulations in persisting in the attended degree course, we used all the five dimensions of the AMS.

*Academic Progress.* To quantify students' academic progress, we extracted the following information from the university's data warehouse: academic performance at the end of the first year of enrolment (*early performance*); status at the end of the third year (*regularly enroled* or *dropped out*). The number of university credits (ECTS) at the end of the first year was used as a proxy for students' early performance. In Italy, the maximum number of ECTS that can be obtained in the first year of university is 60. To calculate the number of ECTS, only exams for which students receive a specific grade were taken into account, which in Italy ranges from 18 to 30. ECTS earned through certification exams, namely foreign languages and basic computer skills, were not taken into account because students do not receive a grade for these exams. The academic status at the end of the third year was reported in the data warehouse as either 'student regularly enrolled' or 'student dropped out' and was coded as 0 if the student was still regularly enroled and 1 if the student dropped out between the first and third year of the university course.

### *Data analysis*

First, we conducted a multiple correspondence analysis (MCA) of students' responses to the 5-item perceived relevance scale. MCA is a generalisation of principal component analysis to categorical variables and aims to identify patterns of association that exist between different modalities of item responses (Abdi & Valentin, 2007). As in exploratory factor analysis, MCA synthesises students' responses to a given instrument into a smaller number of latent variables, called *dimensions*, which preserve the relationships in the original data (Blasius & Greenacre, 2014). One of the advantages of using MCA is that, similarly to factor analysis, it allows for calculation of a standardised factorial score (mean = 0, SD = 1) for each respondent and for each modality on the extracted dimensions. Factorial scores reveal the associations between modalities and the similarities between each respondent's data points (Husson & Josse, 2014). Another advantage of MCA is that the sign of the factorial scores on the extracted dimensions indicates the direction of the association. For example, if a modality has a positive (negative) coordinate on a given dimension, it means that this modality is associated with other modalities that also have positive (negative) coordinates on the same dimension (Le Roux & Rouanet, 2010). The value of the coordinate reflects the strength of this positive (negative) association, which allows the interpretation of the extracted factors (Di Franco, 2016). In our case, the MCA can reveal dimensions that differentiate between the perceived 'relevance' and the 'non-relevance' of OST activities. For example, categories such as 'practical work very relevant' and 'group work very relevant' might have positive coordinates on this dimension, while 'going to university not relevant' and 'discussing with university researchers not relevant' might have negative coordinates. In our case, if the factorial score obtained from the MCA is positive (negative) and significantly different from zero, it means that the student considers participation in the OST activity to be relevant (not relevant) to enrolment in the undergraduate course. The reason for using the MCA for the perceived relevance scale is that the items used two modalities (not relevant; very relevant) and were categorical in nature in that they referred to different features of the activities, so calculating a mean score was not meaningful. The obtained factorial score was used in the model to perform the required calculations.

We then examined the factorial structure of the AMS instrument using confirmatory factor analysis (see Supplementary Material) and calculated the Relative Autonomy Index (RAI; Vallerand & Ratelle, 2002). The RAI synthesises information from the four dimensions of motivation, from less autonomous to more autonomous regulation. Thus, to calculate the index, the score in the Intrinsic Motivation dimension was given a weight of +2 because it represents the highest level of self-determined motivation, the score in the Identified/Integrated Regulation dimension was given a weight of +1, the score in the Introjected Regulation dimension was given a weight of −1, and finally, the score in the External Regulation dimension was given a weight of −2, representing the lowest level of self-determined motivation. Descriptive statistics of the calculated RAI are reported in the Supplemental Material.

Finally, to answer our RQs, we used path analysis, which is a model testing approach that allows complex models to be analysed and compared (Streiner, 2005). Path analysis allows to determine both direct and indirect effects between measured variables. Statistical significance of the differences between the direct paths for the moderating variable was inspected through critical ratio (CR) index. CR values greater than $|1.96|$ indicate that the paths are significantly different. The significance of indirect and total effects was tested using a bootstrap procedure to obtain bias-corrected confidence intervals for the estimated regression paths. If the confidence interval does not include zero, the path is statistically significant.

Specifically, to answer RQ1, we first conducted a path analysis using the ECTS earned at the end of the first year as the outcome variable, the RAI index as mediator, and the factorial score obtained from the MCA of the perceived relevance of OST activities scale as an antecedent. Then, we applied the same model using the academic status at the third year as outcome variable.

To answer RQ2, we carried out a multi-group path analysis using gender as moderating variable. Overall differences in regression paths were tested also by inspecting the change in $\chi^2_{min}$ values.

To answer RQ3, given the uneven distribution of students across undergraduate courses and the focus of the study on students' academic progression, we first decided to group students according to the exams they had to take during the first year. By analysing the institutional curricula, we identified two groups of courses corresponding to two broad disciplinary areas: biology, biochemistry and biotechnology courses (coded as 0); physics, mathematics or computer science courses (coded as 1). The first group was characterised by the following exams: introductory mathematics, biology, chemistry and physics. For the second group, the exams are: calculus, algebra, introductory physics and computer science. We note that gender was significantly associated with the two emerging groups of university courses, with an over-representation of girls in the first group and an over-representation of boys in the second group ($\chi^2 = 38.012$, *d.o.f.* $= 1$, $p < .001$). Then, we carried out two separate multi-group path analyses using gender as moderating variable separately for the biology/biochemistry/biotechnology and physics/mathematics/computer science courses, respectively. As for RQ2, differences in regression paths were further tested by inspecting the change in $\chi^2_{\min}$ values.

Statistical analyses were performed using IBM SPSS v.29, while multigroup path analysis, including calculation of indirect paths and bootstrap procedures, was performed using IBM AMOS v.29.

## Results

### *Descriptive statistics*

Table 2 reports the sample students' early performance and their status at the end of the third year, according to gender and attended undergraduate course.

Concerning students' early performance – at end of the first year – the average number of ECTS gained is not significantly different between female and male students, and between students of the Biology-Biotechnology-Biochemistry courses and Physics–Math–Computer Science courses. As expected, the correlations with the factorial score in the Relevance of OST activities scale and with the RAI are positive and significant, Pearson $r = 0.123$, $p < .01$ and $r = 0.202$, $p < .001$, respectively. Concerning the status at the end of the third year, the average number of students who dropped out is about one fourth of the total sample. We note that there are no statistically significant differences between female and male students and between the two groups of undergraduate courses. As expected, students who eventually dropped out had gained significantly less ECTS at the end of the first year than the students who persisted, $M_{dropped} = 20.1$, $M_{persisted} = 35.7$, $t = -10.032$, $df = 563$, $p < .001$. Similarly, students who eventually

**Table 2.** Descriptives statistics for the Academic progress variable: performance at the end of the first year of enrolment, status at the end of the third year.

| | Whole sample (N = 565) | Girls (N = 296) | Boys (N = 269) | | B-B-B [a] (N = 336) | M-P-CS [b] (N = 229) | |
|---|---|---|---|---|---|---|---|
| Average gained ECTS (SD) | 31.8 (16.9) | 31.1 (15.9) | 32.6 (17.9) | $t = -1.051^{ns}$ | 33.1 (14.9) | 29.8 (19.2) | $t = 2.191^{*}$ |
| Number of students who dropped out (%) | 23.9 | 23.6 | 24.2 | $\chi^2 = 0.021^{ns}$ | 23.5 | 24.5 | $\chi^2 = 0.066^{ns}$ |

[a]B-B-B: Biology–Biotechnology–Biochemistry.
[b]M-P-CS: Math–Physics–Computer Science.
[ns]Not significant.
* $p < .05$.

dropped out had a significantly less autonomous motivation in persisting than the students who persisted, $M_{dropped} = 8.9$, $M_{persisted} = 10.4$, $t = -4.007$, $df = 563$, $p < .001$.

### MCA of the relevance of OST activities scale

The distribution of the students' responses to the five items of the PR of OST activities scale is reported in Table 3.

We note that the feature of the OST activities most appreciated by the participating students was the opportunity to discuss with researchers (80%), while visiting the university laboratories and working in groups was considered relevant to enrolment by about 40% of the students. The topic taught during the activities was considered relevant to enrolment by only a quarter of students. Gender differences are only significant for the features 'group work' and 'discussion with university researchers'. Specifically, group work was more important for boys, while discussion with university researchers was more important for girls. Differences between undergraduate programmes are significant for the features 'topic', 'group work' and 'going to university'. In particular, 'topic' and 'group work' were more relevant for students of mathematics, physics and computer science, while 'going to university' was more relevant for students of biology, biochemistry and biotechnology.

The MCA identified 5 factors. After applying Benzecri's re-evaluation formula (Abdi & Valentin, 2007), the first dimension explained 96% of the variance and the second only 2%. For this reason, we kept only the first dimension, which, as expected from the descriptive statistics described above, was mainly characterised by the features 'topic' and 'group work', which were considered very relevant (negative direction) or not relevant (positive direction). For the sake of clarity, we have inverted the factorial scores in the following analysis in order to make the correlations with the other measured variables more intuitive. The second dimension was mainly characterised by the characteristics 'talking to researchers' and 'going to university' being very relevant (negative direction) or not relevant (positive direction). However, as our aim was to identify the main characteristics that explained most of the variance, we dropped this second dimension from the subsequent analysis.

### Path analyses

The results of the path analysis for the whole sample are shown in Figure 2. First, we note that a higher perception of the relevance of OST activities predicts a higher motivation to persist in the chosen course, which in turn predicts a higher number of credits obtained at the end of the first year at university. Both the direct and indirect paths from the perception of the relevance of OST activities to early performance are significant, with no statistically significant difference between them ($p = .178$). Total effect is also significant ($p < .01$). Differently, autonomous motivation to persist in the chosen course acts as a full mediator in the relationships between PR of the OST activities and persistence at the end of the third year ($p < .001$). Given the opposite sign of the PR → RAI and RAI → 'Dropout within the third year' paths, the total effect is not significant ($p = .943$). Explained variance of the models are 5% and 3%, respectively.

**Table 3.** Descriptives statistics for the relevance of OST activities scale.

| | Whole sample (N = 565) | | Girls (N = 296) | | Boys (N = 269) | | | B-B-B [a] (N = 336) | | M-P-CS [b] (N = 229) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OST Activities' feature | Very Relevant (%) | Not relevant (%) | Very Relevant (%) | Not relevant (%) | Very Relevant (%) | Not relevant (%) | $\chi^2$ | Very Relevant (%) | Not relevant (%) | Very Relevant (%) | Not relevant (%) | $\chi^2$ |
| Topic | 24.2 | 75.8 | 23.6 | 76.4 | 24.9 | 75.1 | 0.121 | 20.2 | 79.8 | 30.1 | 69.9 | 7.256** |
| Practical work | 35.0 | 65.0 | 38.2 | 61.8 | 31.6 | 68.4 | 2.678 | 35.7 | 64.3 | 34.1 | 65.9 | 0.163 |
| Group-work | 41.9 | 58.1 | 36.1 | 63.9 | 48.3 | 51.7 | 8.583** | 35.4 | 64.6 | 51.5 | 48.5 | 14.517*** |
| Going to the university | 43.4 | 56.6 | 44.6 | 55.4 | 42.0 | 58.0 | 0.384 | 47.6 | 52.4 | 37.1 | 62.9 | 6.115* |
| Discussing with university researchers | 80.2 | 19.8 | 83.4 | 16.6 | 76.6 | 23.4 | 4.180* | 80.7 | 19.3 | 79.5 | 20.5 | 0.119 |

[a]B-B-B: Biology–Biotechnology–Biochemistry.
[b]M-P-CS: Math–Physics–Computer Science.
* $p < .05$; ** $p < .01$; *** $p < .001$.

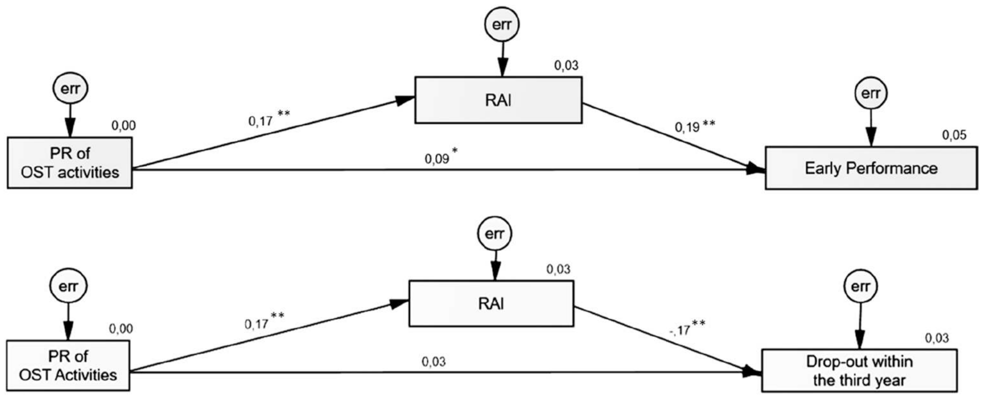


**Figure 2.** Path analyses for the mediation models in Figure 1 for the whole sample. PR = Perceived Relevance; OST = Out-of-School Time; RAI = Relative Autonomy Index ** $p < .01$; * $p < .05$. Estimates are standardised. Explained variances of dependent variables are also reported.

*Multi-group analyses.* We first inspected differences in structural weights for the models in Figure 1. The results are shown in Table 4.

We find that when the structural weights are constrained stepwise for the whole sample, the fit changes significantly ($p < .05$). While statistical significance was expected due to the sample size, such result suggests that gender may differently moderates the relationships of the model in Figure 1. To evaluate such moderating effects, we calculated the direct, indirect and total effects separately for female and male students. The results are shown in Table 5.

In terms of direct effects, the paths from RAI to early performance and from RAI to dropping out before year 3 are significant and, as expected, of opposite sign for both girls and boys. However, the path from PR of OST activities to RAI and to early performance is significant only for boys. The path analysis also shows that for girls there is no indirect effect of participation in OST activities on early performance, whereas, for male students, motivation to persist also acts as a full mediator of the relationship between PR of participation in OST activities and early performance and dropout. In terms of overall effects, only that of PR of OST activities on early performance is significantly higher for male students than for female students. There are no significant gender differences for the overall effect of PR of OST activities on the decision to drop out. When looking at the gender differences in the two groups of university courses, and structural weights are constrained stepwise, the fit for the two groups does not change significantly ($p > 0.05$), due to the reduced sample size in both groups. However, similar differences in

**Table 4.** Multi-group analysis models comparison by gender and by university courses: regression paths constant (base = unconstrained).

| | Whole sample (N = 565) | | | B-B-B [a] (N = 336) | | | M-P-CS [b] (N = 229) | | |
|---|---|---|---|---|---|---|---|---|---|
| Dependent variable | $\Delta\chi^2$ | *df* | *p* | $\Delta\chi^2$ | *df* | *p* | $\Delta\chi^2$ | *df* | *p* |
| First Year University performance | 13.996 | 3 | .003 | 8.242 | 3 | .041 | 7.116 | 3 | .068 |
| Drop-out at third year | 13.676 | 3 | .003 | 7.295 | 3 | .063 | 5.622 | 3 | .132 |

[a]B-B-B: Biology–Biotechnology–Biochemistry.
[b]M-P-CS: Math–Physics–Computer Science.

**Table 5.** Parameter estimates for standardised direct, indirect and total effects by the moderating gender variable.

| Path | Whole sample (N = 565) | | | | B-B-B [a] (N = 336) | | | | M-P-CS [b] (N = 229) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Direct effects* | Girls | Boys | CR [c] | Δ | Girls | Boys | CR | Δ | Girls | Boys | CR | Δ |
| Perceived relevance of OST Activities → RAI | 0.025 | 0.309** | −3.654 | | −0.023 | 0.260** | −2.635 | | 0.089 | 0.331** | −2.709 | |
| RAI → First Year University performance | 0.201** | 0.160* | 0.417 | | 0.228** | 0.317** | −0.708 | | 0.188 | 0.076 | 0.935 | |
| RAI → Drop-out after third year | −0.176** | −0.158* | 0.373 | | −0.214** | −0.276** | 0.513 | | −0.077 | −0.032 | −0.402 | |
| Perceived relevance of OST Activities → 1st year University performance | 0.065 | 0.124* | 0.746 | | −0.020 | 0.071 | −0.825 | | 0.352** | 0.176* | 1.220 | |
| Perceived relevance of OST Activities → Drop-out at 3rd year | 0.050 | −0.004 | 0.623 | | 0.129* | 0.074 | 0.352 | | −0.205* | −0.074 | −1.016 | |
| *Indirect effects* | | | | | | | | | | | | |
| Perceived relevance of OST Activities → RAI → 1st year University performance | 0.005 | 0.050** | | * | −0.005 | 0.082** | | ** | 0.017 | 0.025 | | ns |
| Perceived relevance of OST Activities → RAI → Drop-out at 3rd year | −0.005 | −0.049* | | * | 0.005 | −0.072** | | ** | −0.007 | −0.011 | | ns |
| *Total effects* | | | | | | | | | | | | |
| Perceived relevance of OST Activities → … → 1st year University performance | 0.070 | 0.174** | | * | −0.024 | 0.153 | | ns | 0.369** | 0.201** | | ns |
| Perceived relevance of OST Activities → … → Drop-out at 3rd year | 0.045 | −0.053 | | ns | 0.134* | 0.003 | | ns | −0.212* | −0.085 | | ** |

Notes: Critical ratios (CR) for direct effects and bootstrap probabilities for path differences (Δ) of indirect and total effects are also reported.
[a]B-B-B: Biology–Biotechnology–Biochemistry.
[b]M-P-CS: Math–Physics–Computer Science.
[c]CR values greater than |1.96| indicate that the paths are significantly different.
* $p < .05$.
** $p < .01$.
[ns]: *not significant.*

the paths for female and male students when considering the two groups of university courses separately can be still identified. For instance, for the biology, biotechnology and chemistry courses, the path from the PR of OST activities to the RAI is significant only for male students, while the paths from the RAI to both early performance and dropping out after the third year are significant for both boys and girls. We also note that for girls the path from the PR of OST activities to drop out at the third year is positive and significant. The indirect effects are only significant for boys, with autonomous motivation to persist acting as a full mediator of the relationship between PR of OST activities and academic progress, while the only significant total effect is the positive path from perceived relevance of OST activities to dropout for girls. For the Physics–Mathematics–Computer Science group, the direct effect of the PR of OST activities on early university performance is significant for both female and male students, while the total effect on dropout is negative and significant only for girls.

## Discussion

In this longitudinal study, we examined the relationship between students' retrospective perceived relevance of participation in structured science-oriented OST activities during high school for their enrolment in a university course, their motivation to persist in the chosen course and their academic progress (RQ1). We also explored how this relationship is moderated by gender: in the whole sample (RQ2); and in two different groups of university science and technology courses (RQ3). Regarding RQ1, our findings confirm those of recent studies on the potential role of pre-university experiences to sustain student's long-term interest in pursuing a science degree (Behr et al., 2020; Chi & Wang, 2023; Goff et al., 2020; Sahin et al., 2023; VanMeter-Adams et al., 2014). One possible interpretation in light of SDT is that participation in structured science-oriented OST activities, such as those described in this study, primarily enhances autonomous motivation mechanisms, as the independence in experimenting with science contents (Jones et al., 2011). In turn, these mechanisms are likely to activate cognitive processes that enable students to overcome the difficulties and obstacles that may be encountered during the transition from secondary to higher education (Kyndt et al., 2019). While such an interpretation is grounded in prior literature, future studies may further investigate whether the above hypothesised mechanism may have an impact on academic progress or the likelihood of students leaving the chosen major. A second possible interpretation is that the OST activities described in this study were suitable sources for students' science capital by providing students with meaningful and relevant contexts to motivate them in pursuing a career in the specific discipline (Hagger & Hamilton, 2018; Neher Asylbekov & Wagner, 2023; Stringer et al., 2020).

With regard to RQ2, for the whole sample, our findings support extant research that suggests that the participation in science-oriented OST activities have a positive relationship with classroom performance for boys, while this may not be the case for girls (Cortright et al., 2013). Such finding is in agreement with recent studies in that the described OST activities might not be those that girls are more likely or willing to engage in when dealing with science (Cohen et al., 2021), which in turn results in a lower persistence in choosing a science-related university career (Ladewig et al., 2020). A possible explanation is that some feature of the OST activities exposed girls to a stereotype threat (Inzlicht &

Ben-Zeev, 2000; Schuster et al., 2015) that lead them to a different perception of the relevance of these activities. Future studies may delve into such hypothesised mechanism to identify specific features of OST activities that may activate the stereotype threat. Alternatively, participation in OST activities might cause girls distancing from a science career aspiration due to their perception of a lower preparation in this disciplinary area (Stout et al., 2011) or to a lower recognition by peers and teachers (Lock et al., 2019). To this concern, students who participate in science-oriented OST activities in high school are usually selected by teachers, who themselves may hold stereotypical views about which students can fruitfully participate in these OST activities (Muntoni & Retelsdorf, 2018). Specifically, teachers may judge science-oriented OST activities as less attractive for girls, leading to gender-based selection bias (Carlana, 2019). Therefore, future studies could examine the role of teachers in selecting students to participate in science-oriented OST activities. Overall, according to the SDT framework, our findings suggest that science-oriented OST activities should be carefully designed to increase girls' autonomous motivational regulations by resembling more authentic experiences that address the basic needs of competence, autonomy, and relatedness, in order also to better align the perceived value of a particular science field with intrinsic motivation towards that field (Habig & Gupta, 2021). Moreover, if one considers science-oriented OST activities as a mean to promote girls' science capital, their participation should be encouraged as early as middle school (Chan et al., 2020).

With regard to RQ3, we found that the PR of OST activities predicted the motivation to persist in both groups of the considered undergraduate science courses but only for male students. In contrast, the indirect effect of the PR of OST activities on early performance at the end of the first year and persistence at the end of the third year was significant for male students in the Biology–Biotechnology–Biochemistry courses, whereas this was not the case for male peers in the Computer Science, Physics and Mathematics courses. A possible reason for this result is that the former courses are female-dominated, so the sense of belonging for male students may be lower, and therefore, according to the SDT framework, mechanisms based on autonomous motivation can be at play to persist in these courses (Graham et al., 2023). Note that the effect of the PR of OST activities on third year dropout is significant for girls in both groups of undergraduate courses, but in the case of Biology–Biotechnology–Biochemistry courses the effect is positive, while for the Math–Physics–Computer Science courses the effect is negative. Specifically, for girls enroled in Biology–Biotechnology–Biochemistry courses, a higher retrospective PR of OST activities for enrolment is associated with a higher dropout rate within the third year, whereas the opposite is true for girls enroled in Math–Physics–Computer Science course. A possible explanation for this is that Biology–Biotechnology–Biochemistry students, especially more motivated girls, might be more likely to decide to change their course after the first year and enrol in the medicine programme, which has very similar exams and in Italy is considered to be more prestigious and rewarding from a professional point of view (Aina et al., 2011). Finally, we note that the direct effect of the PR of OST activities on early university performance is significant for female students of Math–Physics–Computer Science courses but not for the female students of Biology–Biotechnology–Biochemistry courses. A possible reason is that for girls enroled in the former, male dominated, courses, some features of the structured OST activities as 'Practical work' and 'Discussing with university researchers', might have increased perceived self-efficacy and sense of belonging (van Lamoen et al., 2024). Such findings suggest that science-oriented OST activities can be improved, for example, by promoting social interaction and peer learning in more inclusive and equitable settings that allow girls to successfully engage with challenging topics, problems and ideas in the scientific disciplines (Ladewig et al., 2020; Sundstrom et al., 2022), also through the relationship with the staff that lead the activities (Price et al., 2018). In such a way, science-oriented OST programmes can become hybrid spaces where different and new identities are negotiated (Calabrese Barton et al., 2008) and in which learning science becomes a horizontal process across a variety of contexts and spaces (Gonsalves et al., 2013).

## Limitations

While this longitudinal study has addressed an under researched issue in the literature on persistence in science undergraduate courses, it has also several limitations. First, due to COVID-19 pandemics, the sample attended most of the second-year lectures in remote-teaching modality, which poses a limitation on the generalisability of the findings. Second, to maximise response rate, we administered the survey in paper and pencil format, so it is possible that our sample is biased towards more motivated and engaged students who are more likely to attend lectures in person. In addition, our sample consists mainly of students enroled in science undergraduate courses. Different results might have been obtained if we had also included students from engineering undergraduate courses. To the same concern, we acknowledge that identifying only two groups within our sample to investigate effects of the field of study may have hidden more nuanced effects that could have been measured had we included a larger sample. Moreover, the selection of only five features to characterise the OST activities in the measurement instrument construct might have skewed the results of the MCA, considering also that the scores were significantly different between the chosen features. A scale with more items might have mitigated such an effect. Finally, we did not examine other types of structured OST activities, such as competitions, training courses, visits to museums and science centres (Kong et al., 2014) and unstructured science-oriented OST activities involving family, friends and childhood experiences (VanMeter-Adams et al., 2014). Thus, future studies could investigate whether the findings of the present study also apply to these experiences.

## Conclusions and implications

Despite its limitations, our study adds to the field by showing the long-term effects of science-oriented OST activities on students who actually enroled and persisted in an undergraduate programme that was disciplinarily coherent with the activities they participated in. Specifically, this study has produced three main findings. First, the PR of OST activities for enrolment in the chosen university course has a direct significant effect not only on students' motivation to persist in their undergraduate career, but also on their early performance and the decision to (not) drop out. Second, we found that the structural pathways of our model are moderated by gender. In particular, the PR of OST activities has a positive significant effect on motivation to persist throughout the undergraduate career, as well as a significant direct effect on early performance in the first year and persistence in the third year only for male students. Thirdly, we found that gender moderates the regression paths of our model differently depending on the chosen university course. In particular, the effect PR of OST activities on early performance and dropout is fully mediated by motivation to persist for boys who chose Biology–Biotechnology–Biochemistry courses, while it is fully direct for girls who chose the Math–Physics–Computer Science courses. From these findings, we can infer that early science-oriented OST activities can be effective in promoting students' persistence and reducing attrition rates in science undergraduate courses, if they are designed to provide equitable opportunities that are better aligned with the ways in which female and male students choose to engage with science and STEM disciplines in general. This is essential in order to affect long-term interest, sense of belonging and self-efficacy in the specific disciplinary area targeted by the activities. Informing education policies and initiatives with the findings of our study could be particularly important at a time when higher education institutions around the world are increasingly spending massive resources to attract new students by offering a variety of structured and unstructured OST activities.

## Ethics statement

The research with human subjects described in this study was conducted in accordance with the Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects and the ICMJE guidelines on Protection of Research Participants. Approval by local research ethics committee was not required since no medical treatment was carried out and participants were anonymised. Informed consent forms were signed before the beginning of the activities for study participation and research purposes, in order to fulfil the requirements of Italian law. Refer to the following document for the Italian regulation of this matter:

https://www.garanteprivacy.it/documents/10160/0/Regolamento+UE+2016+679.+Arricchito+con+riferimenti+ai+Considerando+Aggiornato+alle+rettifiche+pubblicate+sulla+Gazzetta+Ufficiale++dell%27Unione+europea+127+del+23+maggio+2018

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

This study was funded by the Ministry of Instruction, University and Research under the framework of the Piano Nazionale Lauree Scientifiche, years 2017–2019.

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## Appendix

### *Study survey*

1) Please indicate if you have attended during high school one of the 30-h courses organised by our University in the following STEM areas. Please thick the box ONLY if: – at least one of the activities of the course was carried out at the University; – at least one of the activities was lead by a university researcher; – at least one of the activities was devoted to any of the following tasks: measuring, classifying, experimenting, analysing data, drawing conclusions about phenomena. Do NOT thick the box if the activities simply involved seminars and were carried out by persons who were NOT researchers.

❑ Biology
❑ Biotechnology
❑ Biochemistry
❑ Math
❑ Physics
❑ Computer science

2) Please give as much detail as possible about the specific topic of the activities (e.g. genetics, neurones, spectra, forces, etc.)

________________________________________________________

________________________________________________________

3) Now, please indicate to what extent you think that each of the following features of the activities you attended was relevant for the enrolment in the university course you have chosen using the following scale: 1 = not relevant; 2 = very relevant

1. The topic of the activity ☐
2. The practical work of the activity ☐
3. The group-work carried out during the activity ☐
4. Going to the university to carry out the activity ☐
5. Discussing with university researchers ☐

4) Please indicate to what extent you agree on each of the following statements using the following scale 1 = completely disagree; 7 = completely agree

1. I really do not know why I persist in attending this degree course ☐
2. I persist in attending this degree course because someone else asked me to ☐
3. I persist in attending this degree course for no reason, something will have to be done anyway ☐
4. I persist in attending this degree course to prove to myself that I can graduate ☐
5. I persist in attending this degree course because it is useful for my future career ☐
6. I persist in attending this degree course because it is useful for achieving my goals in life ☐
7. I persist in attending this degree course because someone else wants me to do it ☐
8. I persist in attending this degree course to prove that I can succeed in this ☐
9. I persist in attending this degree course because, after all, I like the degree course I have chosen ☐
10. I persist in attending this degree course because the things done in this degree course interest me ☐
11. I persist in attending this degree course because it is what others want from me ☐
12. I persist in attending this degree course because finishing this degree course would make me feel proud of myself ☐
13. Honestly, I persist in attending this degree course just because I am forced to do so, if it was up to me, I wouldn't do it ☐
14. I persist in attending this degree course Because I need it for what I want to do in life ☐
15. I persist in attending this degree course because I like the subjects and disciplines being studied ☐
16. I persist in attending this degree course because in this way I make someone else happy ☐
17. I persist in attending this degree course because by finishing this degree course I can show what I am worth ☐
18. To be honest I don't know why I persist in attending this degree course, I feel that I am only be wasting my time ☐
19. I persist in attending this degree course because it is important for what I have chosen to do ☐
20. I persist in attending this degree course because it is nice to learn new things in this field ☐

5) Please indicate the undergraduate programme you are attending: ______________________________

6) Please indicate your university identification number: _____________
7) Gender in which you identify: ___________________