Res Sci Educ (2020) 50:1075–1091
https://doi.org/10.1007/s11165-018-9723-x

Factors that Influence Students in Choosing Physics Programmes at University Level: the Case of Greece

Kalliopi Meli[1] · **Konstantinos Lavidas**[1] · **Dimitrios Koliopoulos**[1]

Published online: 12 April 2018

Abstract Low enrolment in undergraduate level physics programmes has drawn the attention of the relevant disciplines, education policy-makers, and researchers worldwide. Many reports released during the previous decades attempt to identify the factors that attract young people to study science, but only few of them focus explicitly on physics. In Greece, in contrast to many other countries, physics departments are overflowing with young students. However, there are two categories of students: those for whom physics was the optimal choice of a programme ("choosers") and those for whom physics was an alternative choice that they had to settle for. We suggest that the latter category be called "nearly-choosers," in order to be differentiated from choosers as well as from "non-choosers," namely those candidates that did not apply to a physics programme at all. We are interested in the factors that attract high school students to study physics and the differences (if any) between choosers and nearly-choosers. A newly formed questionnaire was distributed within a Greek physics department (University of Patras), and the students' responses ($n = 105$) were analysed with exploratory factor analysis and specifically principal component analysis so as to extract broad factors. Three broad factors have arisen: school-based, career, and informal learning. The first two factors proved to be motivating for pursuing a degree in physics, while the third factor appeared to have a rather indifferent association. *t* tests and Pearson correlations indicated mild differentiations between choosers and nearly-choosers that pertain to school-based influences and informal learning.

Keywords Physics education · Higher education · Motivation · Inspiring factors

✉ Kalliopi Meli
kmeli@upatras.gr

Konstantinos Lavidas
lavidas@upatras.gr

Dimitrios Koliopoulos
dkoliop@upatras.gr

[1] Department of Educational Sciences and Early Childhood Education, University of Patras, University Campus, 26504 Rio, Greece

Introduction

There has been much discussion regarding the drop of enrolment numbers in physics departments worldwide (Abraham and Barker 2015; Caprile et al. 2015; Fouad et al. 2010; Hazari et al. 2010; Office of the Chief Scientist 2012; Pronovost et al. 2016). Countries highly evolved in industry and research are concerned about this decline, since the relevant disciplines can no longer deliver the necessary number of well-educated staff to fulfil the research and development needs of industry (Venville et al. 2013). Moreover, every educational establishment around the globe needs to employ qualified physics teachers (Wang 2004), preferably enthusiastic about both science and teaching science (Rodd et al. 2013), in order to deliver scientific literacy and culture to their pupils and future scientists.

The problem of low enrolment numbers in physics departments has been common among European countries and has also spread in Australia and the USA during the last decades. In the UK, the decreasing in-flow of potential physicists has been a matter of concern since the late sixties (Dainton 1968). Further decline in enrolment numbers has been recorded, especially after the eighties, as mentioned in Rodd et al. (2013). Australia is one of the top countries regarding scientific literacy among 15-year-old students (OECD 2016). However, this remarkable score is inconsistent with the low numbers of students in certain science disciplines. The Office of the Chief Scientist (2012) confirmed that enrolment in university science programmes had mostly been flat for the period 2002–2007 resulting in a substantial shortage of qualified physics teachers (Harris and Farrell 2007). In the US, according to National Science Board (2008), the number of bachelor degrees in all science disciplines increased by 47% between 1983 and 2005, while the number of bachelor degrees in physics increased only by 11%, which is believed to be inefficient growth (Hazari et al. 2010).

Interestingly, that is not the case in Greece. In 2014, 22,158 students (about 25% of the candidates for higher education) indicated at least one of the five Greek physics departments as a preference for their undergraduate studies. However, only 1025 of those candidates were accepted into physics programmes (Ministry of Education Research and Religious Affairs 2014).

Some first thoughts about the Greek students' preference towards degrees in physics are the following. Their interest in physics may be related to the fundamental nature of physics as a science, in the sense that physics provides a solid foundation from which one can go on to pursue a number of jobs in industry and education or continue their studies in various related fields, in Greece or abroad. A different approach suggests that, since no profession can guarantee a successful future, due to the ongoing financial insecurity and enormous numbers of unemployed in all areas, most students are advised to "follow their heart" and choose a programme that they enjoy. The prospects and expectations of a career in physics, as well as the urge to "do physics for the sake of physics" are both documented as influential factors in the literature (Hazari et al. 2010, p. 994) and may be particularly prevalent in Greece due to special socioeconomic conditions. In addition, Greek physics departments are tailored to academically strong students, as their programmes are considered very demanding and rather prestigious. This perception that science is only accessible to highly intelligent people is confirmed by the accomplished scientists' "elitist tone" reported by Venville et al. (2013, p. 2226) for Australia/New Zealand and also by high school and non-science college students in USA (Masnick et al. 2010).

An even more exceptional finding in Greece is that, in every physics undergraduate programme, the number of students that truly wanted to study physics is almost equal to the number of students who more or less reluctantly ended up in the programme. This mixed picture is, to a great extent, a result of the highly selective system used for undergraduate student entry in Greek public universities (Papas and Psacharopoulos 1987), which we briefly describe here. Candidates throughout the country participate in a series of highly competitive examinations and receive an overall score based on their performance. They afterwards file an ordered list of undergraduate programme preferences to the Ministry of Education. The number of students that can be accepted into any programme is also fixed by the Ministry of Education. Students are distributed to the various programmes based on their overall score, their list of preferences and the number of places available. The process ensures that each candidate is offered a place in the first, in order of preference, programme that they “qualify for,” in terms of entry score. Ultimately, only a few candidates are accepted into their top choice programme (Papas and Psacharopoulos 1991), while most of them end up in less desired ones.

The above procedure yields an interesting mix of undergraduate students in physics departments, consisting of some students who have genuinely chosen to become physicists and others who have the qualifications (in terms of entry scores) to become physicists, but would have preferred to study something different. This phenomenon allows us to scrutinise the differences between these two groups and analyse the factors that influence candidates in choosing to study physics.

Theoretical Framework

Factors that Inspire or Discourage Students from Pursuing Degrees in Science

In the pertinent literature, physics is commonly integrated in the general term of science or placed under the umbrella of STEM (Science, Technology, Engineering and Mathematics). During the last three decades, many reports that examine the factors that influence students to select a career as a scientist, students’ attitudes towards science, and other relevant issues, have been commissioned and released. Some well-cited reports are the following (in chronological order of the initiation of the relevant projects): ACOST (Woolnough 1990), FASSIPES (Woolnough 1991, 1994a), TIMSS (Martin et al. 2008), IRIS (Henriksen et al. 2015; Holmegaard et al. 2014), ASPIRES (Archer et al. 2013), and OECD Global Science Forum (OECD 2016). However, only a few reports focus on physics in particular, for example UPMAP (Reiss et al. 2011; Rodd et al. 2013) and HOPE (Jones and Trippenbach 2016; Levrini et al. 2017).

Since the choice of a degree and career in science results from one’s inclination to science (Tytler and Osborne 2012), researchers struggle to determine the factors that either motivate or discourage students from pursuing degrees in science. There are some generic reports with random measurements, at an international level, that provide an all-purpose snapshot of the scientific literacy of high school students, such as PISA (OECD 2016), or the students’ attitudes towards science, such as ROSE (Schreiner and Sjøberg 2010). However, various researchers have also focused much more discriminately into specific education levels: their sample often consists of primary school (Kerr and Murphy 2012) and middle, upper, or non-compulsory high school pupils (Adamuti-Trache and Andres 2008; Cleaves 2005; Holmegaard et al. 2014; Lyons and Quinn 2010; Tytler and Osborne 2012; Woolnough 1994b). As for tertiary education, undergraduates, post-graduates (Hazari et al. 2010; Maltese and Tai 2010; Rodd et al. 2013), and even faculty members have also been questioned about their choices (Maltese and Tai 2010; Venville et al. 2013). Depending on the sample, these studies mainly relate one's attitudes towards science with their attraction to (or repulsion from) STEM courses, science studies, or directly a science career.

Holmegaard et al. (2014) examined the choices of upper secondary school students to either resume or to give up studying STEM after graduation and suggest a distinct division between *choosers* and *non-choosers*. Should we expand these two terms, the majority of relevant research focuses on *choosers*; namely, samples consist of people who have already taken a few steps or even gone all the way into a career in science. However, within this field of research, one can find very limited references to *non-choosers*, not only because most research has focused on the listing of positive factors but also because gathering a sufficient sample of *non-choosers* is a significantly harder task.

Venville et al. (2013) conducted research among scientists, aiming to identify the decisive factors that influenced them in making their career choices. They propose a categorisation of responses based on five factors: personal, school-based, informal learning, career-related, and family/friends reasons. It is our belief that these broad classes could include the results of other research groups as well, regardless of their focus on even broader categories, such as gender (i.e. Hazari et al. 2010; Hazari et al. 2012) and social aspects (i.e. Woodrow 1996) or on any different approaches, such as identity construction (i.e. Holmegaard et al. 2014) and preadolescent experiences (i.e. Cleaves 2005; Maltese and Tai 2010).

Combining the classifications suggested by Holmegaard et al. (2014) and by Venville et al. (2013), the present work attempts a categorisation of the most significant, well-documented factors that influence high school students and graduates in their selection of science/STEM studies. At the first level, the large variety of attitudes towards science is classified into the groups of *choosers* and *non-choosers*. At the second level, we divide the responses into personal, school-based, career-related, informal education, and family/friends reasons, though it should be noted that some overlap exists.

Choosers

The personal reasons that lead one to study science are mainly related to the individual's subjective need to "dig a little deeper" and to identity construction. As Levrini et al. (2017) mention, the main motivational factor is a blend of personal interest and curiosity; this outcome derived from 94 interviews of graduate physics students across the EU, which followed the HOPE project questionnaire survey (Jones and Trippenbach 2016), in which 2485 first-year physics students from 18 European countries scored higher than 4 out 5 in questions categorised as "personal interest". In research conducted by Venville et al. (2013) on scientists, the general category of "curiosity" also arose as the prevailing positive factor towards choosing science (22.4% of the scientists participating). Fouad et al. (2010) interviewed 113 students from different educational levels and report the urge to work hard mentally as another reason for pursuing science. Furthermore, *choosers* construct scientific identities (Hazari et al. 2010; Venville et al. 2013), especially by developing confidence-recognition schemes, in terms of self-efficacy in science (Fouad et al. 2010).

High school influences include the student's perception of the science subject itself, the student's performance, the interaction with the teacher, the classroom environment, and any other experiences within school. Hazari et al. (2010), having worked with a sample of 3200 university students, report statistically significant correlations ($p < .001$) between seeing oneself as a “physics person” and high school performance/competence ($0.18 < r < 0.30$ in various related subcategories). The importance of high school performance is also mentioned by Gill and Bell (2013) in relation to signing up for advanced level physics. Additionally, Abraham and Barker (2015) highlight that the expectancy of success in physics, among year-11 upper secondary school students, is the prime reason for staying engaged and enrolling in senior year-12 physics courses. *Choosers* find high school science courses attractive in one or more educational levels (Fouad et al. 2010; Venville et al. 2013). The teacher is an influential figure, especially if they use a variety of effective educational strategies (Fouad et al. 2010; Osborne et al. 2003; Rodd et al. 2013; Tytler and Osborne 2012; Venville et al. 2013). In the classroom, it is crucial for students to actively participate in the learning process and voluntarily assist weaker classmates; such actions can be very rewarding and nurture high achievement in high school science (Hazari et al. 2010; Osborne et al. 2003). Finally, science events (projects, exhibitions, etc.) within the school environment seem to have a positive contribution in choosing to pursue science-related subjects at the post-secondary level (Venville et al. 2013).

Reasons linked with career prospects are based on expectations for an interesting and fulfilling occupation as well as feelings of admiration for specific scientists. Hazari et al. (2010) mention a correlation between physics identities and physics career choices ($r = 0.54$; $p < .001$), as well as the existence of career outcome expectations that derive mostly from the desire for intrinsic reward. This finding is in agreement with the research by Maltese and Tai (2010), in which 45% of 116 graduates and scientists (mostly PhD-level researchers and post-docs) identified intrinsic interest as the motive for a career in science. *Choosers* also believe that becoming a scientist is a way to improve their prestige, earn higher salaries, and travel (Venville et al. 2013). However, they recognise that, although science is very interesting, it is quite difficult to follow (Osborne et al. 2003) and it may be an obstacle to the construction of intrapersonal relationships (Hazari et al. 2010). An accomplished scientist within one’s circle of family and friends, as well as famous scientists, can also serve as an inspiration for a young student. Additionally, young students often create a positive image for scientists at large (Rodd et al. 2013).

In the field of informal science education, *choosers* indicate that extra-curricular science-related activities play a decisive role (Woolnough 1994a), especially if initiated at a young age (Tytler and Osborne 2012). Venville et al. (2013) present quantitative results from 726 scientists who rank television as the strongest informal experience influencing factor, followed by books, museums/centres, films, and science competitions.

Finally, family and friends can also influence one in choosing to study and pursue a career in science. The support of either or both parents and other family members, sometimes influenced by their own culture and education (Adamuti-Trache and Andres 2008), can be a matter of great importance (Cleaves 2005; Fouad et al. 2010; Lyons 2006; Venville et al. 2013). Maltese and Tai (2010) note that 15% of their sample based their decision to pursue science on a family member. The influence of peers and of friends of the family can also be decisive (Hazari et al. 2010; Venville et al. 2013), especially if one is integrated into a social group that encourages science activities and prospects (Fouad et al. 2010).

Non-choosers

Non-choosers express only a few personal reasons that averted them from science; nevertheless, these reasons have certain significance as they relate to identity construction. More specifically, *non-choosers* indicate that one cannot form a desirable identity through studying science and that the relevant courses do not leave room for personal growth and self-control (Holmegaard et al. 2014).

The students that diverged from science have plenty to say regarding school science, especially in reference to the basic nature of the taught courses. According to Venville et al. (2013), *non-choosers* declare that their experiences from science within high school may be the only reason for diverting from this potential path. Generally, *non-choosers* consider science as one of the most difficult tasks one could undertake and believe that only “bright” people can understand it (Venville et al. 2013); therefore, even high-achieving students are often not confident enough to take science subjects (Cleaves 2005; Osborne et al. 2003). In the eyes of *non-choosers*, school science derives from distant authorities, who have built a dogmatic and inflexible construction, the elements of which have to be taken as given and learned by heart without further explanations. Consequently, these subjects often “do not make sense” and students fail to understand why they are taught at all, although they recognise that science at large is relevant to various aspects of real life (Holmegaard et al. 2014).

In relation to a scientist’s career, *non-choosers* express the belief that there is no real prospect or gratification in choosing science. *Non-choosers* find that there is no room for development in the field (Holmegaard et al. 2014) and that unemployment is considerably high and that income is low (Venville et al. 2013). Furthermore, in their point of view, being a scientist is rather boring, repulsive, and lonely, because it limits personal growth and socialising (Holmegaard et al. 2014). It should be noted, though, that *non-choosers* have limited knowledge of the specifics of working as a scientist and tend to form stereotypical opinions of the types of people that follow such career paths (Cleaves 2005).

According to Tytler and Osborne (2012), the impact of informal science education experiences on *non-choosers* is yet to be researched, as there is little available evidence of its possible undesirable effects. Rodd et al. (2013) mention that some of their interviewees had been involved in extra-curriculum projects that failed to bring them closer to science.

Fouad et al. (2010) have classified the influence of family and friends as a barrier for choosing science. Lack of encouragement and assistance in science courses from parents may avert students away from choosing science. Additionally, *non-choosers* may fear the lack of peer support and social integration, as well as possible rejection from social circles if successful in science (Fouad et al. 2010).

A Third Category in Between Choosers and Non-Choosers: Nearly-Choosers

In our point of view, there exists a third category that stands between *choosers* and *non-choosers*, which has not been separately examined in the literature up to this point. The new category includes candidates who ranked studying a particular science subject, such as physics, as one of their top choices, but not as their first choice. Therefore, they cannot be classified under *choosers*, in the sense that they would have rather chosen a different programme; they are not *non-choosers* either, because physics did exist among their choices and, under different circumstances, may perhaps have been a top choice for them. This group of young students may therefore be named *nearly-choosers*. For example, Holmegaard et al. (2014) and Rodd et al. (2013) mention that they interviewed students who did not study physics, although they did satisfy entry requirements and/or expressed a passion for physics. Such cases have been ultimately classified as *non-choosers*, but, in our opinion, *nearly-choosers* may be a better fit for some of them. Some interviewees stress that they did not choose to study physics because of the fixed and superficial way it is taught in universities, the lack of social interaction within the future work environment (Holmegaard et al. 2014), and the fact that "fun" projects that were supposed to influence them towards choosing physics did not have any effect on them after all (Rodd et al. 2013). However, since these results derive from a handful of people in studies that had different aims than extracting conclusions for *nearly-choosers*, any motivational or other characteristics of this new category have not been identified as yet at large. In most countries, contrary to Greece, the system of entry into university does not easily allow for the isolation of substantial or even small samples of *nearly-choosers*, in order to extract quantitative and/or qualitative results. Nevertheless, since *nearly-choosers* have the potential to study physics but hesitate in making the final step towards this option, this newly identified category is an ideal target group for researchers and policy-makers who seek ways to attract more students to physics programmes.

Research Objectives

It is clear that the vast majority of the literature does not focus on physics in particular, but rather include it under science or STEM. However, as mentioned earlier, even though the overall number of scientists, STEM students, and graduates may be unchanging, there is a worldwide shortage of physicists, with numbers constantly declining. The intention of this work is to focus solely on undergraduate programmes and careers related to physics for the case of Greece, in which physics still remains a desirable choice for a significant number of students. Our first goal is to examine the factors that encourage students towards studying physics, in order to contribute to the relevant field of research, which currently lacks such evidence. The way in which Greek tertiary education is organised serves this task ideally, because there exists a one-to-one correspondence between those graduating from physics departments and those becoming physicists (i.e. physics departments do not offer any programmes leading to degrees other than in physics and no other departments in the country offer physics degrees). Our second goal is to detect any differences between *choosers* and *nearly-choosers*. Greek physics programmes are ideal for this goal as well, because both categories are "trapped" inside physics departments, due to the rather inflexible system of entry into higher education. Our research questions are, therefore, the following:

> Which factors inspire high school students to pursue a degree in physics?
> Which qualities differentiate students who identify physics as their top preference (*choosers*) from those for whom physics was not a top choice (*nearly-choosers*)?

Research Methodology

The Questionnaire

A new questionnaire has been designed after a thorough review of the pertinent literature on the factors that affect students in their decision to pursue degrees in physics or STEM (see Appendix). The questionnaire consists of 22 closed-type statements with the responses categorised under a 7-point Likert scale (Cummins and Gullone 2000; Preston and Colman 2000) with "strongly agree" (value 3) and "strongly disagree" (value − 3) being the two furthest points. It also included two questions that requested the student's gender and their ranking of the physics programme in their ordered list of choices for undergraduate studies.

Concerning the content validity of the instrument (Franzen 2013; Waltz et al. 2010), we initially reviewed the relevant literature in order to identify all factors that influence a prospective student's decision to study physics. We then invited three researchers, who are also university counsellors, to assess our questionnaire items. More specifically, they were asked to use a 4-point scale (not relevant, somewhat relevant, quite relevant, very relevant) to evaluate the possible impact of each item in the questionnaire on students making the decision to study physics. The final version of the questionnaire included only those items that were assessed as at least "quite relevant" from two out of three researchers.

We also conducted a test-retest process, in order to ensure the reliability of the questionnaire. We asked 25 physics students to fill in the questionnaire twice within the same week. The outcome showed high correlation between the students' responses (at least 0.7), based on which, the questionnaire is assumed to be quite reliable (Franzen 2013).

The Sample

The questionnaire was distributed to first year physics undergraduates at the University of Patras (Greece) in 2014 at the end of a first semester mechanics lecture, which is compulsory for all to take but not to attend. Out of a total of 200 students accepted in the physics programme that year, 129 (74 males and 55 females) were present during the lecture and filled in the questionnaire. It should be noted that the overall enrolment of students, in a total of five Greek physics departments, was 1025; therefore, our sample consists of approximately 12% of all first year physics students in 2014. However, 16 students' responses (12%) have been excluded from our analysis by the method of listwise deletion due to missing values (at least 3 out of 22). This method is considered appropriate for this case of missing values, because they were missing completely at random (MCAR) (Tabachnick and Fidell 2007). The missing values did not form a particular pattern and additionally they corresponded to different variables with a rate below 3%. Another additional eight students' responses have not been taken into account, as they were multivariate outliers with critical values far beyond the Mahalanobis distance (De Maesschalck et al. 2000). A multivariate outlier is characterised by a combination of responses to all items that is far away from the centroid and must be excluded from the analysis. More explicitly, a case is an outlier if $1 - P[x^2(df, \text{Mahalanobis})] < .001$, where P is the cumulative probability of the chi-square distribution with $df = 22$ degrees of freedom (Tabachnick and Fidell 2007).

As a result, our final sample included 105 students (59 males and 46 females). Among those, 39% were *choosers* and the remaining 61% were *nearly-choosers*. This distribution does not appear to have a statistically significant difference (goodness of fit $x^2 = 3.18$; $df = 1$; $p > .05$) from the one that characterises the total enrolment in physics programmes across Greece ($N = 1025$), with the percentages of *choosers* and *nearly-choosers* being, respectively, 31 and 69% (Ministry of Education Research and Religious Affairs 2014). Among the students in our final sample, the ranking of the physics programme ranged between first and sixth places. Table 1 presents the students' distribution according to their ranking of the physics programme as a preferable choice for university studies.

Table 1 Frequencies and percentages of the students against their ranking (number of choice of preference) of the physics programme

Ranking	1	2	3	4	5	6	Total
Frequency	41	32	17	12	2	1	105
Percentage	39.0%	30.5%	16.2%	11.4%	1.9%	1.0%	100.0%

Method of Analysis

In order to discover the factorial structure of the students' responses ($n = 105$), we conducted an exploratory factor analysis (EFA) of the 22 questionnaire items (closed-type questions). As a preliminary step, we used principal component analysis (PCA) in order to extract factors, since there were at least five responses for each one of the 22 items (Pett et al. 2003), and we also determined the number of factors (Zumbo 2007). Subsequently, we applied variance-based structural equation modelling (SEM) and, in particular, partial least squares-SEM (PLS-SEM) analysis in order, on one hand, to confirm the factors extracted through PCA and, on the other hand, to establish structural validity (convergent and discriminant validity) and reliability. PLS-SEM is a contemporary multivariate method of analysis, which is commonly encountered in the social sciences research (Henseler et al. 2016), since it is considered appropriate for small samples and data that is non-normally distributed (Hair et al. 2017). The PLS-SEM analysis was conducted with SmartPLS statistical package (Ringle et al. 2015).

During the evaluation of the measuring model (Hair et al. 2017), we accepted loadings of approximately 0.7 and composite reliability (CR) and Cronbach's alpha higher than 0.7 for each factor indicator (item). We also tested for adequate convergent validity, namely that the average variance extracted (AVE) is higher than 0.5. We finally tested for adequate discriminant validity, namely that an indicator's loadings on a factor are greater than all of its cross loadings with other factors and, at the same time, that the AVE of each factor is higher than its highest squared correlation with any other factor (Hair et al. 2017).

In relation to the evaluation of the structural model (Hair et al. 2017), we examined (a) each set of predictors in the structural model for collinearity, namely that the value of the variance inflation factor (VIF) is higher than 0.2 and lower than 5 and (b) the significance of path coefficients among the factors, using 5000 samples in the bootstrapping settings.

Following the final formation of our factorial structure, we constructed new variables based on the scale (7 points) of the items constituting broad factors. Consequently, we proceeded to the following statistical tests: (a) *repeated measures test*, which detects any overall statistically significant differences between the related means of the broad factors, enhanced by the *Bonferroni correction* for multiple comparisons; (b) *independent samples t test* for the examination of any differences between the groups (*choosers* and *nearly-choosers*) for each broad factor (numerical variables); (c) *Mann-Whitney non-parametric test*, which examines the differences between the groups for each item (ordinal variables); and (d) *Pearson correlation coefficients*, in order to investigate the correlation among the extracted broad factors and the rate of preference of the physics department (Field 2009).

Analysis of Sample

Factors that Inspire High School Students to Pursue Degrees in Physics

When addressing our first research question, factor analysis and in particular PCA, as a factor extraction method, allowed us to glance at the range of the largest part of the responses and thus see the "big picture" on factors that inspire high school students to pursue degrees in physics. In terms of questionnaire items, question 3 (Q3) has been excluded from this analysis, because of its extremely weak correlation (up to 0.2) with the remaining variables. Varimax rotation suggested that our sample responses can be grouped into three broad factors (Barlett's test of sphericity $p = .0001$ and KMO = 0.736), accounting for 44.07% of the total variance (Tabachnick and Fidell 2007).

The factorial structure of the three broad factors extracted through PCA was tested through PLS-SEM analysis. As presented in Table 2, the first broad factor retained five indicators (items), while the second and third broad factors retained four indicators. All the indicators are near the acceptable level for loadings. The CR values of broad factors, as well as the corresponding Cronbach's alpha for each broad factor, demonstrate that they all have high levels of internal consistency reliability (Hair et al. 2017). The AVE values are above the required minimum level of 0.5, thus the measures of the three broad factors have high levels of convergent validity (Gefen and Straub 2005). The squared correlation among factors takes values between 0.050 and 0.232, which provide evidence for the discriminant validity of the construction (Gefen and Straub 2005; Henseler et al. 2015). Additionally, the collinearity among the predictors is not an issue of the structural model (VIF < 5) and all relationships within the structural model are significant at a 5% level (Hair et al. 2017). The final extracted broad factors are labelled: school-based (influences from primary and secondary education), informal learning (previous informal-learning experiences), and career (perception of a career in physics). The names of the broad factors derived from the retained indicators with highest loadings (Tabachnick and Fidell 2007), in light of the commonly used categories in the literature (i.e. Fouad et al. 2010; Jones and Trippenbach 2016; Venville et al. 2013).

Table 2 PLS-SEM. Final factorial structure, Cronbach's alpha, CR, and AVE for each broad factor

Questionnaire items	Factor 1	Factor 2	Factor 3
Q6 Favourite school subject	0.762		
Q8 Participation and assistance in class	0.760		
Q7 Excellent grades	0.729		
Q15 Encouragement from circle	0.724		
Q9 Inspiring physics teacher	0.665		
Q14 Physics-related family activities		0.781	
Q13 Scientific museums and/or activities		0.758	
Q4 Famous physicist as inspiration		0.703	
Q12 Scientific books and/or TV shows		0.663	
Q20 Prospect for career development			0.844
Q22 Vocational socialisation			0.763
Q21 Knowledge for common good			0.648
Q19 Spare time as a physicist for social life			0.646
Cronbach's alpha	0.779	0.718	0.709
CR	0.850	0.818	0.818
AVE	0.531	0.529	0.533

The “school-based” broad factor corresponds mainly to the items that reflect the students’ experiences with physics during their high school years. In our case, these are related to the subject itself (Q6), classroom practices (Q8, Q9), performance (Q7), and encouragement from one’s circle (Q15), which could include classmates and friends from school. “Informal learning” includes effects from activities that are people-oriented (Q4, Q14) and personal preferences (Q13, Q12). “Career” includes several aspects related to potential working conditions (Q22, Q20, Q19) and desired professional impact (Q21).

We can rank our three broad factors in order of intensity, based on the confidence intervals of their average scores. For the whole sample, career is the most intense factor ($M = 1.433$, $SD = 0.097$, CI 1.088 to 1.626) followed by school-based ($M = 1.322$, $SD = 1.205$, CI 1.088 to 1.555) and lastly informal learning ($M = -0.319$, $SD = 0.13$; CI -0.557 to -0.061). The ANOVA repeated measures test with Huynh-Feldt correction showed that the above classification was statistically significant ($F = 106.418$, $df = 1.87,194.09$, and $p < .001$). Additionally, using the Bonferroni correction, all the differences between the average scores were also statistically significant ($p < .05$). The average scores of the broad factors’ items further indicate that career and school-based reasons are prevailing due to strong agreement, and that informal learning is rather unappreciated or, at least, indifferent.

Differences Between Choosers and Nearly-Choosers

In order to address our second research question, we performed a test of independent samples (t test) to examine the degree of differentiation among the broad factors that influence high school students in pursuing physics degrees with regard to their ranking of the physics programme (first place vs other). The t test indicated that there are no statistically significant differences for each one of the broad factors (factor 1: $t = 0.497$, $df = 103$, $p > .05$; factor 2: $t = 1.445$, $df = 103$, $p > .05$; factor 3: $t = 1.151$, $df = 103$, $p > .05$).

However, when taking into account the extracted broad factors and the ranking of the physics programme for all students, Pearson correlation coefficients indicated that there is a statistically significant ($p < .05$) negative correlation between the ranking of the programme and the school-based and informal-learning broad factors ($r = -0.229$, $r = -0.202$, respectively) (the physics programme being a top choice has been assigned to the lowest value of selection, namely number 1). In other words, high scores in these two broad factors are correlated with an increased desire to study physics. There exists a trend of *choosers* scoring higher in these two broad factors, while the score of *nearly-choosers* diminishes as their ranking of the physics programme descends.

Furthermore, the Mann-Whitney test (which is similar to the t test and is used for ordinal variables such as items) for the indicators (items) that constituted each of the broad factors showed that there are statistically significant differences between two items, for the above-mentioned two broad factors (Table 3). Physics being a favourite school subject (Q6), which exemplifies the first broad factor (school-based reasons) as the item with the highest loading, is notably higher rated by *choosers* in comparison to *nearly-choosers* (Mann-Whitney $U = 970$, $p < .05$). In the same fashion, *choosers* score significantly higher than *nearly-choosers* (Mann-Whitney $U = 1024.5$, $p < .05$) in the item that refers to the impact of scientific museums and/or activities (Q13), which is a typical element of the second broad factor (informal learning) with considerably high loading.

Table 3 Mean and standard deviation of students' responses to two items with statistically significant differences between choosers ($n = 41$) and nearly-choosers ($n = 64$)

Broad factor	Item		Min	Max	Mean ± (*SD*)
1st: school-based	Q6 Favourite school subject	Choosers	− 3	3	2.1 ± (1.37)
		Nearly choosers	− 3	3	1.53 ± (1.58)
2nd: informal learning	Q13 Scientific museums and/or activities	Choosers	− 3	3	− 0.12 ± (1.78)
		Nearly choosers	− 3	3	− 0.78 ± (1.7)

Discussion and Conclusions

This study was concerned with the decline in enrolment numbers in physics programmes worldwide and attempted to investigate enrolment in Greece, a country with a stable and rather large number of potential physicists. We examined the relevant literature to identify the factors that differentiate *choosers* from *non-choosers*, namely those who choose to study science/STEM from those who do not. We claimed that a third category of students should be taken into consideration: *nearly-choosers*, who did choose to study physics but not as their top choice. In the majority of universities around the world, *nearly-choosers* are hard to isolate and examine separately, which may explain why this proposed intermediate category has not appeared in the literature yet. The uncommon system of university entry in Greece offers the opportunity to identify and further investigate *nearly-choosers*, which, in our point of view, is an opportunity that should not be missed, as *nearly-choosers* constitute the main leak in the physics disciplines' pipeline. In order to focus on factors that inspire pupils to study physics and to detect any differences between *choosers* and *nearly-choosers*, a survey was conducted in one of the Greek physics departments. We used EFA to interpret the results of our novel questionnaire that was distributed to first year undergraduate physics students.

In terms of reasons that influence students to pursue degrees in physics, three broad factors were extracted through quantitative analysis: (a) career prospects, (b) school-based reasons, and (c) informal learning experiences (ranked in order of decreasing intensity). All of these broad factors appear in the literature as influential to young students choosing to pursue STEM/science (e.g. Fouad et al. 2010; Maltese and Tai 2010; Venville et al. 2013) or more specifically physics (Hazari et al. 2010; Jones and Trippenbach 2016; Rodd et al. 2013; Woolnough 1994b) and were also found to be influential for students in Greece ((*authors 1*); (*authors 2*)). In more detail, Hazari et al. (2010) mention career expectations and school-based experiences as the main factors that positively relate to a student's physics identity. We also detected weak intensity of informal learning, in agreement with the results of Jones and Trippenbach (2016) and Rodd et al. (2013).

The first broad factor we identified was career prospects. Students in our sample expressed the belief that being a physicist would allow them to evolve professionally, as well as boost their social life. In the literature, career expectations are mainly associated with having an interesting and fulfilling job (Hazari et al. 2010; Jones and Trippenbach 2016) and with enhanced employment opportunities (Jones and Trippenbach 2016; Woolnough 1994b). In addition to the above, our sample believes that their choice of a career in physics will not lead to isolation from friends and family, but rather to further opportunities for socialising within a professional environment. This is in contradiction with the findings of other studies, in which the physics identity is negatively related to social life expectations (Hazari et al. 2010; Holmegaard et al. 2014). It is possible that our sample's positive perception of their own future career may be interwoven with their overall perception of the life of a modern scientist (in research, industry, or education).

The second broad factor we identified was experiences and influences from secondary education. It is clear that high school physics had a distinctive influence on our sample, as a large number of students described physics as their favourite high school subject and acknowledged qualities such as collaboration, performance, and interaction with their physics teacher as positive influences. Hazari et al. (2010) and Woolnough (1994b) acknowledge all of the above as critical for the construction of one's physics identity and strongly emphasise the influence of an enthusiastic teacher. In our opinion, the role of formal education is crucial, as it often proves sufficient in inspiring potential physics undergraduates; the possibility of further stimulation of students via improvements in formal education should therefore not be ignored.

Finally, informal learning, which we identified as the third broad factor, appeared to have barely inspired, if not discouraged, our sample. The relevant literature also provides weak evidence for correlating informal learning experiences with choosing to study physics. A recent report from HOPE network (Jones and Trippenbach 2016) mentions mediocre scores in interest in scientific TV/books and below-average scores in family involvement and museum visits, which are the two indicators that constitute our broad factor of informal learning. Furthermore, the dominant result of the study conducted by Rodd et al. (2013) is that informal education innovation activities do not seem to have an effect on choosing physics. In addition to the conclusions of the literature, the responses of our sample may, however, be partially explained by the fact that very few opportunities for informal learning of physics exist in Greece. Since this may be the case for other countries too, we suggest that the answers from our sample as well as the outcomes of other studies may not reflect neglect for informal learning, but rather the lack of opportunities for it.

Regarding the emerging differences between the groups of interest, namely *choosers* and *nearly-choosers*, the lack of statistically significant differences in the three broad factors illustrated that the students' basic trends are similar. We suggest that *nearly-choosers* share more similarities with *choosers* than *non-choosers*, because, firstly, their responses were similar to those of *choosers*, and, secondly, their differentiated answers did not show noteworthy similarities with *non-choosers*, as far as we could tell, when comparing to the literature. As mentioned earlier, the category of *nearly-choosers* is not distinct throughout the literature. The few statements we educed from diverse studies could not be directly compared to the results of our *non-choosers*-targeted study.

Our final finding is a tension between the ranking of the physics programme and the broad factors of school-based influences and informal learning experiences. More specifically, the *choosers* remarkably "outperform" the *nearly-choosers* in two specific questionnaire items: physics as their favourite high school subject and impact of science museum visits and/or other similar activities; the stronger the effect of these items, the higher the ranking of the physics programme. A passion for high school physics appeared to be an important factor not only for choosing to study physics but also to have potentially played a decisive role for students wavering between physics and other related disciplines. The difference in the scores of science museum visits/activities may also indicate the need for enhancing informal learning settings in order to attract more *nearly-choosers* to physics. It should be noted that such differentiations between *choosers* and *nearly-choosers* may emerge more clearly in a larger sample.

The case of Greece is distinct in comparison to other countries in sustaining numbers of enrolment in undergraduate physics programmes and therefore of potential physicists. Physics programmes across the country remain a well-respected option as a first or alternative choice and could serve as a guide for other countries in their attempt to attract more physics students. The unique way in which the students are accepted in tertiary education in Greece justifies the discrimination between *choosers* and *nearly-choosers* as target groups with special focus on *nearly-choosers*. The results of the present study are in agreement with the findings of the relevant field of research in terms of the factors that influence students to study physics, with certain differentiations that may have occurred due to the aforementioned particularities. More explicitly, we have found that experiences within the environment of formal education influence Greek students much more than informal learning experiences, while Greek students primarily focus on career prospects and express the belief that a physicist's career can easily integrate their social and personal needs.

Research Implications

The first issue we have raised is that attention should be drawn to each one of the faculties facing difficulties in attracting new students. In particular, the issue of shortages in specific majors, such as physics, needs to be tackled with focused research. Results of such focused research can prove helpful for both physics faculties seeking to attract more students as well as educational policy-makers in countries that face shortages of physicists.

A second issue is the type of sample used for research in this field. In regard to our first research question, we claim that those who were determined to become physicists (*choosers*) can contribute to our understanding of motivational factors and we therefore stress the need for more quantitative data regarding *choosers*. Concerning our second research question, we believe that the samples of *choosers* are not of direct interest when considering the declining number of students in physics programmes worldwide. Also, little can be inferred when researching samples of young people who never had any intention of becoming a physicist (*non-choosers*). Our proposal is that *nearly-choosers* are the right target group in order to fully comprehend the reasons that prevent them from becoming *choosers*. In addition, there may be a significant number of students who stand in between *choosers* and *nearly-choosers* in the sense that the physics programme was not among their choices at the end, but it is possible that they had considered it at same point as an option for their university level studies. These students would be even harder to trace, but their perspective would contribute essentially to our understanding of factors influencing the physics programme selection.

A better understanding of the characteristics that differentiate *choosers* and *nearly-choosers* is needed. Firstly, a larger sample of both groups can bring additional discriminating factors to the surface and either strongly confirm or reject the weak differences identified in the present work. Secondly, a longitudinal study following the academic achievements and dropout percentages of both groups can contribute to the confirmation or rejection of our original hypothesis, that there exist in fact some decisive differences between *choosers* and *nearly-choosers*.

Acknowledgements We would like to thank our colleagues from the Physics Department of University of Patras, Evagelos Vitoratos, and Ekaterini Pomoni, for assisting us with the distribution of the questionnaire, as well as our partners from HOPE Network for inspiring us to work on this research field.

Appendix

Questionnaire Items

Q1: I think of physics as a pleasant intellectual challenge.
Q2: My involvement with physics helps me develop my personality.
Q3: I believe that studying physics and working on physics is of interest to a specific group of people.
Q4: One or more famous physicists have inspired me to become a physicist too.
Q5: I believe that physics as a science is more interesting than the physics I was taught at high school.
Q6: Physics was my favourite subject in high school.
Q7: I used to have excellent grades in high school physics.
Q8: In high school, I used to actively participate in my physics class and/or I used to help my classmates.
Q9: My physics teacher was a significant inspiration for me to become a physicist too.
Q10: The strict methodology of physics helped me perform better in high school physics.
Q11: In high school, we often conducted experiments and/or other interesting activities in my physics class.
Q12: Scientific books and/or TV shows have influenced my choice of undergraduate studies.
Q13: Visiting museums and/or partaking in scientific activities has influenced my choice of undergraduate studies.
Q14: My family used to involve me in physics-related activities (games, discussions, excursions, etc.).
Q15: My family and friends were very encouraging regarding my skills and potential in physics.
Q16: A physicist in my family or in my circle has inspired me to become a physicist too.
Q17: High school physics helped me realise the variety of interesting professional paths available to physicists.
Q18: While choosing my programme of studies, I was well informed about the prospects of a career as a physicist.
Q19: If I work as a physicist, I will still have the time I need for my family and social life.
Q20: Studying physics can ensure a satisfactory career future (position, prospect, money).
Q21: One of my goals in working as a physicist is to produce knowledge and/or goods that promote the welfare of humanity.
Q22: If I become a physicist, I will have many opportunities for making professional contacts, collaboration, and travel.

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