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A Closer Look at and Confirmation of the General and Study Interests of Future Computer Science Students

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Abstract. Many factors can indicate pupils' tendencies to be interested in specific fields of study in the future. Examples of such measures are personal interests, which can also evaluate and develop institutional programmes and interventions that can support pupils' education in computer science. In this work, we report on a study to document characteristic profiles in general interests and study interests, surveying pupil cohorts that attend different activities related to computer science: workshops (compulsory and non-compulsory) and contests related to computer science. We match these interest profiles with the interests of first-semester students of computer science. Pupils attending computer science activities in their leisure time show similar or higher interests in study fields related to studying computer science than the students, differentiating them from pupils attending compulsory workshops. We also show that the relations between general interests and study interests are uniform for pupils and students, helping teachers and syllabus builders promote encouragement towards the interest in computer science.

Keywords: Interests, K-12 education, STEM, student acquisition

1 Introduction

At the beginning of 2018, the European Union (EU) Commission presented the Digital Education Action Plan [1] and outlined how the EU intends to support educational institutions and education systems regarding digital transformation. According to the EU, the development of relevant digital competences is urgently needed in the age of rapid digital change, both professionally and privately. The Digital Education Action Plan focuses on the use of digital and innovative education practices and has three priorities: (a) making better use of digital technologies for teaching and learning, (b) developing relevant digital competences and skills for the digital transformation, and (c) improving education through better data analysis and foresight. The plan is also linked to the hope of getting more young people interested in technology and, ideally, inspiring them with a degree in, for example, computer science.

A lot of initiatives were started world-wide, by the EU and the European Countries. Also, at our university and department, we are trying to improve the situation at schools and universities by improving teaching quality [2, 3] and by providing motivating (gamely, inspiring) units of computer science and digital competencies [4] to pupils of different age groups. However, the critical question always remains: how sustainable

are our interventions and programmes, and can we thereby create enthusiasm for technology and computer science among our young learners? Our long-term goal is to survey the sustainability to improve the quality and effects of our interventions.

To achieve that it is essential to know what characteristics are present in the pupils' target group, if and how these characteristics can be influenced, and what the 'ideal' characteristic for our goal is. This paper focuses on surveying specific interests that are present in pupil and student cohorts¹ to be used as a basis for further research.

The data that is collected in schools is often limited to the pupils' achievement in certain subjects or topics (mapped to grades). This is continued at university. But achievement (experienced success and failure) is not the only factor that is relevant to pupil's interests and motivation, and we can observe that (a) the achievement may be influenced by the academic self-concept of the pupils or vice versa [5], (b) high achievement does not indicate high interest in the subject, and (c) the personality influences the interest (also in certain kinds of tasks and therefore certain subjects) [6]. Therefore, when trying to motivate students, we should consider additional variables like self-concept, interest and personality, and not only their achievements. When measuring these variables, we can gain more information about the students we want to motivate, to see what differs pupils that claim to be interested in computer science or not, and, in the best case, we are also equipped with a way to measure the effect of our classroom interventions to show that they are working as they should. With the help of a survey tool for long-term studies (that is also compliant with the basic data protection regulations of the EU), we can learn more about the characteristic traits of pupils. Results on the gender differences in *personality*, *interests* and *self-concept* in the pupils' results have already been shown [7].

The objective of this paper is now to describe the interest profiles of pupil cohorts attending different CS-related activities (compulsory and recreational CS workshops, CS-related contests) and to compare these profiles to first-semester CS students' interests to confirm findings in literature and present (site-specific) new findings. So, this paper focuses on pupils with (and without) a high interest in CS and CS students. Future work will also compare students with (and without) interest in CS.

2 Related Work

There are many factors that influence the personal achievement and the success in school, at university and the working environment. PISA studies show that pupils are interested in science and technology until the age of 10 [8] but education in school is not able to convey a positive image of technology [9].

Curricula, school activities and school material could be designed in a way to strengthen (or raise) interest of pupils during their schooldays and encourage them to choose a STEM study. There are many (local) initiatives that try to fill this gap but they are often not surveyed scientifically [10]. Our framework can be used to survey the

¹ In this paper we refer to school students as "pupils" and to university students as "students" to clearly distinguish the cohorts.

effects of interventions long-term and determine which interventions cause which effects on the interests.

Vocational interests (as defined by Holland [11]) are a known characteristic for many future life predictions, for instance educational choices and choice of work fields. Holland describes six areas of interest: *Realistic*, *Investigative*, *Artistic*, *Social*, *Enterprising* and *Conventional* (RIASEC). The fitting of the interest profile and the type of the (work) environment are important for the work satisfaction. These interests should not only be taken into account when evaluating work satisfaction: they can also be used in advance when choosing the field of study. In this work, we denote the vocational interests with the term **general interests**.

Some interests tend to be more stable than others over time: A three-cohort study with pupils of grades 7 to 12 indicates a more stable specification on interests in the areas denoted as *Investigative*, *Artistic*, *Enterprise* and *Prestige*. Older students have a higher interest in the areas *Realistic*, *Artistic*, *Enterprise* and *Conventional*. But the profile pattern of the interest showed stability over time [12]. A study of university students showed that increased scores in the interest *Investigative* increases the likelihood of the selection of a STEM study. Higher interests in *Artistic* and *Enterprising* decreased the likelihood. Males are generally more likely to choose a STEM study, especially if they have low scores in Social personality [13].

A study of pupils showed that high results on *Investigative*, *Artistic*, or *Enterprising* interests result in higher educational tracks than students that have high results in *Realistic*, *Social*, or *Conventional* interests. An explanation might be that pupils with a high interest in *Investigative* choose jobs in a higher social status because there they can pursue their interests [14].

When observing gender differences in the interests, girls have more interest in *Artistic* and *Social*: boys have more interest in *Realistic*. Regarding the STEM fields, the greatest difference in interests can be found in technology and engineering where boys are more interested. The same study observed the correlations between RIASEC interests and STEM interests, that were all positive [15].

Literature shows that there are interest profiles that advantage or disadvantage the future choice of a STEM study. We want to observe similarities and differences in these profiles of pupils and computer science students. So, we can identify if pupils currently interested in STEM activities have certain profiles, and if these profiles fit the profiles of computer science students. In this work, we chose to divide the cohorts only by age (pupils and students). The cohort of pupils is additionally divided by their STEM-related activity. We chose not to divide the cohorts by gender, which is a study focus in the future. Results for pupils divided by gender can already be found in [7].

3 Methodology

3.1 Research Objective

Our long-term objective is to learn more about key characteristics of pupils with (and without) a high interest in computer science. By using a test instrument supporting long-term studies, we set ourselves two goals, namely:

1. to demonstrate that (with our measuring framework) there are assessable differences between different pupil cohorts (pupils attending compulsory school workshops, non-compulsory recreational workshops and contests), and
2. compare these pupils' profiles with the results of first semester computer science students.

In this work, we report on differences in **general interests** [11, 16] and future **study interests**. We will use these results to investigate if and how relevant characteristics can be fostered and developed by classroom interventions in further studies.

To address the first goal, we investigate three questions. First, we investigate differences in the characteristics of different cohorts of pupils, to form a baseline of pupils' profiles regarding general interests and study interests. For this, we look closer at the following question:

- Q1: What are the differences between pupils who attend compulsory computer science workshops in their daily school life, and pupils who attend recreational workshops or contests related to computer science?

Second, we investigate if there are differences between the pupil cohorts and first semester students of computer science, with the assumption that interests of computer science students could be target interests when fostering pupils. Thus, our next question is:

- Q2: Are there measurable differences between the pupil cohorts' interests and interests of computer science students?

Third, aside from differences between cohorts, we investigate the relation between **general interests** and **study interests** in all cohorts. This way, we shed light on the cohorts from an inter-cohort and intra-cohort perspective. Our final question is:

- Q3: What is the relation between **general interests** and **study interests** in all cohorts?

We answer these questions by comparing responses to a long-term survey of personality, interests, and self-concept (Section 3.2) of different cohorts (Section 3.3). We compare mean values and confidence intervals and report correlations between **general interests** and **study interests** to detect differences and form profiles.

3.2 KAUA – Data Collection Framework

In this section, we briefly introduce the data collection framework used to survey the cohorts. KAUA (Košice and Alpen-Adria University Assessment) is an online survey system that was designed and implemented with the General Data Protection Regulation of the European Union² in mind. The framework contains a hashing service which converts personal data to unique ids, enabling anonymous longitudinal studies.

² <http://data.europa.eu/eli/reg/2016/679/2016-05-04>

Table 1. Dimensions and items collected by KAUA [7]

<i>Dimension</i>	<i>Items</i>	<i>Scale</i>
General Interests [11, 16]	Realistic, Investigative, Artistic, Social, Enterprising, Conventional	9-level Likert [-4, 4]
Personality [6, 17]	Dominant / Easygoing Formal / Informal	13-level Likert [-6, 6]
Self-Concept [18]	3x Verbal Self-Concept 3x Mathematical Self-Concept	4-level [1, 4]
CS Interest [7]	Computer Science Interest	6-level [1, 6]
Study Interests [7]	History, Art, Music, Literature, Language, Economy, Law, Social fields, Health, Natural sciences, Informatics (CS), Math, Engineering, None	yes / no [0, 1]

The data collection framework has already been used in studies [7, 19], and is explained in detail in [7]. In this work, we report on the first study that includes (undergraduate) students. Table 1 summarises the items included in the surveys:

- **General Interests:** Six dimensions of general interests following Holland (RIASEC) [11, 16]
- **Personality:** Two dimensions (Dominant / Easygoing, Formal / Informal) of the Five-Factor and Stress Theory [6, 17]
- **Self-Concept:** Verbal and mathematical self-concept, with formulations used in PISA surveys [18]
- **CS Interest:** Interest in Computer Science specifically [7]
- **Study Interests:** Interest in specific fields of study (now or in future) [7]

The purpose of the framework is to accompany pupils and students in their education. This includes specifically set activities and interventions that are great opportunities for informal learning. Such activities are popular but often not adequately accompanied scientifically [10].

3.3 Pupil and Student Cohorts

We have collected the following cohorts with the KAUA data collection framework:

- Participants of compulsory computer science workshops of years 2018-2020, organised by the Department of Informatics Didactics of the University of Klagenfurt and attended by whole school classes, comprise the cohort *School* (n=855, mean age=13.97±0.34).
- Participants of recreational computer science workshops of years 2018-2020, organised by the Department of Informatics Didactics of the University of Klagenfurt in Austria and attended by interested individual pupils, comprise the cohort *Recreational* (n=104, age=13.05±0.53).
- Participants of computer science related contests: winners of the Austrian Bebras contest 2018 and participants of the *School Contest Catalysts Coding Contest* 2018 and 2019 comprise the cohort *Contest* (n=90, age=15.30±0.73).

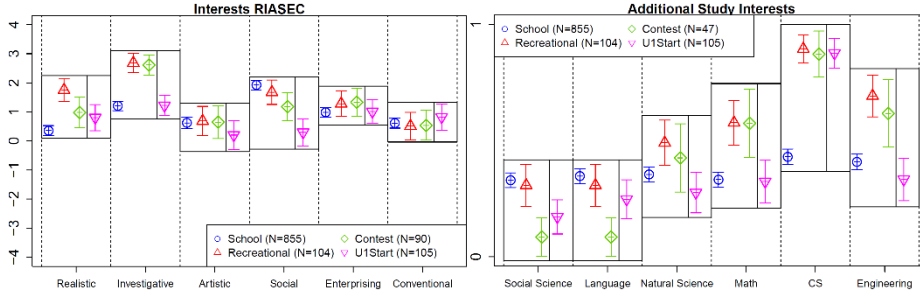


Fig. 1. Mean values and 95% confidence intervals of RIASEC and study interests of the cohorts

- First semester students of years 2018 and 2019, studying computer science at the University of Klagenfurt in Austria, comprise the cohort U1Start (n=105, age=24.54±1.61).

All participants have attended a university or school in Austria. Note that a part of the cohort *Contest*, the investigated winners of the Austrian Bebras contest 2018 (n=43), have been administered a former version of the survey, and have not been surveyed regarding their study interests. This leaves 47 participants in the cohort for those items.

4 Data Analysis

In this section we descriptively analyse and compare the responses of the described cohorts to the survey, focusing on general and study interests. We show mean values and 95% confidence intervals of the cohorts' survey responses in Figure 1 and significant differences in Table 2.

4.1 Differences between Pupil Cohorts [Q1]

First, we report on differences between the three cohorts *School*, *Recreational* and *Contest* regarding their **general interests** and **study interests**. Regarding the **general interests**, *School* pupils have a significantly lower *Investigative* interest than the other cohorts, and a significantly lower *Realistic* interest than *Recreational* pupils, but have a significantly higher *Social* interest compared to *Contest* pupils. There are no significant differences between the *Recreational* and *Contest* cohorts, although the latter features a lower mean in *Realistic* and *Social* interests. There are no significant differences for *Artistic*, *Enterprising* and *Conventional*.

For **study interests**, *School* pupils have a significantly lower interest in *Math*, *CS* and *Engineering* compared to both other cohorts. *School* pupils have a significantly lower interest in *Natural Science* compared to *Recreational* pupils, but have a significantly higher interest in *Social Science* and *Language* compared to *Contest* pupils. *Recreational* pupils have a higher interest in *Social Science* and *Language* compared to *Contest* pupils, but this difference is not significant.

Table 2. Significant differences, compared by mean values and 95% confidence intervals, between the cohorts regarding the collected items. The dimensions include, in order: general interests (gi), study interests (si). Superscript signs denote direction of the difference: lower (-) or higher (+) mean value for the row-cohort, compared to the column-cohort.

<i>Q1</i>	<i>Recreational (n=104)</i>	<i>Contest (n=90, n=47*)</i>
<i>School (n=855)</i>	(gi) Realistic ⁻ , Investigative ⁻ (si) Natural Science ⁻ , Math ⁻ , CS ⁻ , Engineering ⁻	(gi) Investigative ⁻ , Social ⁺ (si*) Social Science ⁺ , Language ⁺ , Math ⁻ , CS ⁻ , Engineering ⁻
<i>Recreational (n=104)</i>		(si*) Social Science ⁺ , Language ⁺
<i>Q2</i>	<i>U1Start (n=105)</i>	
<i>School (n=855)</i>	(gi) Social ⁺ , (si) Social Science ⁺ , CS ⁻	
<i>Recreational (n=104)</i>	(gi) Realistic ⁺ , Investigative ⁺ , Social ⁺ (si) Natural Science ⁺ , Math ⁺ , Engineering ⁺	
<i>Contest (n=90, n=47*)</i>	(gi) Investigative ⁺ , (si*) Math ⁺ , Engineering ⁺	

4.2 Differences between Pupil Cohorts and AAU Students [Q2]

We next report differences between the pupil cohorts and first-semester computer science students at the University of Klagenfurt (U1Start). Regarding their **general interests**, U1Start students have a significantly lower interest in *Social* than both School and Recreational pupils, a significantly lower interest in *Realistic* than Recreational pupils, and also a significantly lower interest in *Investigative* than both Recreational and Contest pupils. Again, there are no significant differences for *Artistic*, *Enterprising* and *Conventional* interests.

Looking at the **study interests**, U1Start students have a significantly lower interest in *Social Sciences*, but a significantly higher interest in *CS* compared to School pupils. U1Start students have a similarly high interest in *CS* compared to both Recreational and Contest pupils, but have a significantly lower interest in *Natural Science* compared to Recreational pupils, and a significantly lower interest in *Math* and *Engineering* compared to both Recreational and Contest pupils. There are no significant differences for *Language* interests.

The students show a more differentiated interest in STEM fields: They have the highest interest in *Computer Science* (their field of study) and lower interest in *Natural Science*, *Math* and *Engineering*.

4.3 Correlations between Interests [Q3]

We only report significant Spearman correlations ($p < .05$) with an absolute correlation value $\sigma \geq .20$ (indicating at least a weak correlation). We mark correlations with sufficient power with an asterisk, following a power test with $p < .05$, a power of .95, and the respective cohort size.

The correlations between **general interests** and **study interests** yield a uniform picture across the cohorts. There are no significant correlations for Contest pupils.

For non-technical **study interests** of the School cohort, the **general interest** *Artistic* is weak positively correlated to interest in *Social Science* ($\sigma=0.21^*$) and *Language* ($\sigma=0.27^*$). The **general interest** *Social* is weak positively correlated to interest in *Social Science* ($\sigma=0.34^*$).

In the Recreational cohort, *Language* is weak positively correlated to *Investigative*, *Artistic* and *Social* ($\sigma=\{0.21, 0.21, 0.22\}$), and *Social Science* is weak positively correlated to *Social* ($\sigma=0.28$). The U1Start cohort shows positive correlations of *Social Science* to *Social* and *Enterprising* ($\sigma=\{0.44^*, 0.20\}$), and of *Language* to *Artistic* ($\sigma=0.37^*$).

Regarding technical **study interests**, the **general interest** *Realistic* is positively correlated to the interest in *Natural Science* (Recreational: $\sigma=0.22$, U1Start: $\sigma=0.31$), *CS* (School: $\sigma=0.24^*$) and *Engineering* (School: $\sigma=0.40^*$, Recreational: $\sigma=0.27$, U1Start: $\sigma=0.42^*$). The **general interest** in *Artistic* is positively correlated to the **study interest** in *Natural Science* (Recreational: $\sigma=0.26$), but negatively correlated to *Math* (Recreational: $\sigma=-0.31$) and *Engineering* (Recreational: $\sigma=-0.32$, School: $\sigma=-0.21^*$).

The **general interest** in *Social* is weak negatively correlated to the **study interest** of *Natural Science* in the U1Start cohort ($\sigma=-0.23$), but weak positively correlated in the School cohort ($\sigma=0.16^*$). *Social* is weak negatively correlated to the interest in *Engineering* (U1Start: $\sigma=-0.20$). The **general interest** in *Enterprising* is weak negatively correlated to *Natural Science* (U1Start: $\sigma=-0.23$). The **general interest** in *Conventional* is weak positively correlated (only in the Recreational cohort) to **study interests** in *Math* ($\sigma=0.25$) and *CS* ($\sigma=0.21$), and (only in the U1Start cohort) weak negatively correlated to the interest in *Engineering* ($\sigma=-0.21$).

5 Discussion

In this section, we present a discussion and possible explanations for the differences of **general interests** and **study interests** of our cohorts. Many factors, such as socio-cultural ones, have an influence on these interests and can be assessed in studies. But educators can hardly change them in their classroom settings. We therefore only assess factors that we believe to be *malleable*, such as **general interests** and **study interests**. Pupils' learning can also be influenced by their peer group (e.g., see [20]) but in our study we see learners as individuals and aim to provide a baseline of interest measures, assessing the effects of classroom interventions in the future.

5.1 Differences between Pupil Cohorts [Q1]

With our first question (Q1) we were looking for the differences between pupils who only attend compulsory CS workshops (School), and pupils who attend recreational workshops (Recreational) or contests (Contest) related to CS.

Recreational pupils and Contest pupils show similarities in their interests. But these two cohorts show significant differences compared to the School pupils. So, pupils who attend computer science activities have a specific profile of interests. They can be distinguished from School pupils by these traits.

Recreational pupils and Contest pupils have a high **general interest** in the *Investigative* domain (a factor that is important for their choice of fields of study [13]). This is confirmed by their higher **study interests** in *Math*, *Computer Science*, and *Engineering*, compared to School pupils. This factor can also be seen as an essential factor for choosing to attend a computer science activity.

Given these differences in traits between pupils of compulsory computer science workshops and pupils who attend computer science activities, as a next step we plan to design workshops intended to influence the *Investigative* interest (and other traits) of pupils. With our framework, we can also survey changes of traits over time that will show us the effects of our interventions in the future.

5.2 Differences between Pupil Cohorts and AAU Students [Q2]

With our second question (Q2) we wanted to know if there are measurable differences between pupils' characteristics and students' characteristics.

Pupils of recreational workshops and contests show higher **general interest** in the *Investigative* area, which plays an important role for the choice of fields of study and is thus in line with current research [13]. Surprisingly, the students do not show such a high *Investigative* interest. We assume that the study specialisation offered at this university has an influence on that factor.

Recreational pupils and Contest pupils as well as U1Start students show higher **study interest** in *Computer Science* compared to School pupils. The pupils attend these activities because of their interest in the subject, whereas pupils in school workshops have to attend them regardless of their interest. The higher interest is thus expected. The other two pupil cohorts have a similar interest in *Computer Science* compared to the students.

The Recreational pupils and Contest pupils show a higher interest in *Natural Science*, *Math*, and *Engineering* than the students. Possible explanations are that the students already chose their field of study and therefore rate their interest in this field (CS) highest, or that they have more insight into different fields of study and their respective characteristics which allows them to give a more differentiated rating.

5.3 Correlations between Interests [Q3]

The *Artistic* interest is negatively correlated to some STEM studies (which is expected, see [13]), but not to *Natural Science*. It is possible that pupils have a different understanding of the fields of study of *Natural Science* compared to students (although the corresponding survey items account for different age groups). This could also be an explanation for the discrepancy observed between the pupils and students in the correlation of *Social* interest and *Natural Science*. The pupil cohorts show a positive correlation, the student cohort shows a negative correlation. There is no discrepancy on the

correlations of the *Social* interest and the study interest *Engineering*: the correlation is negative in all cohorts.

The *Investigative* interest is positively correlated to all study interests of School pupils ([0.07, 0.16]). Although this interest is seen as a predictive factor for STEM studies, our data shows that this factor has a (small) effect on different fields of study. The *Realistic* interest shows only positive correlations to STEM interests.

The correlations between **general interest** and **study interest** confirm results presented in literature. But it also shows differences between the cohorts. The (future) study interests of pupils are always dependent on their current knowledge of the field. Pupils may have a different imagination of a certain field of study, compared to students who actively chose a study.

6 Threats to Validity

When comparing vocational and study interests of pupils and students, social and cultural backgrounds could have uncontrolled effects on the investigated characteristics. In this study, all participants originate from Austria, mitigating this threat.

Potential threats to validity arise from the survey that was used to collect the data. Although the pupils and students participated in the same survey, the wording of the survey items are different to fit them to the age group. This may have an influence on the results. Moreover, answers of self-assessments are dependent on the personal perception of the question - this may be different for pupils and students. Pupils may have a different preconception of specific fields of study due to their level of knowledge about the field.

Another source of threats to validity arises from the division of pupils into cohorts. The pupil cohorts are divided by the kind of computer science activity they participated in. Our assumption is that the pupils attending recreational workshops are specifically interested in STEM activities. This may not be true: they may be registered as their parents want them to attend. However, the results support our assumption. Also, the cohort of pupils attending compulsory workshops is a heterogeneous group, with pupils that are interested in a wide variety of additional activities. The correlation analysis reveals that all relations between the interests are uniform between the pupil cohorts. Therefore, the cohort of pupils attending compulsory workshops forms a control group of all pupils, while still containing pupils with specific characteristics.

Regarding internal validity, we report significant findings with $p < .05$, and report correlations following a power test with $p < .05$ and a power of $.95$.

7 Conclusion

In this paper, we show the use of a survey tool for gathering specific characteristics (general interests and study interests) of pupils that indicate future interest in computer science. We compare pupil cohorts attending compulsory CS workshops, recreational CS workshops, and CS contests, and first semester students of computer science. We

demonstrate that there are differences in the profiles of interests between pupils attending compulsory and non-compulsory activities and student cohorts, and that there are uniform correlations between general interests and study interests.

It turned out that pupils of compulsory computer science workshops are significantly less investigative, and significantly less interested in numerous fields of study (Natural Science, Math, CS, Engineering) compared to pupils attending non-compulsory activities. This confirms the assumption that an Investigative interest is a possible influence on the choice of a STEM study.

Concerning the characteristics of first semester students, we learned that the study interest in CS was high, but the study interest in all other STEM fields (Natural Science, Math, Engineering) was lower than expected. Moreover, the interests in these STEM fields are lower compared to the pupil cohorts of non-compulsory activities. A possible explanation is that the pupils may have a broad interest in STEM and do not (or cannot) differentiate the characteristics of STEM fields, in contrast to the student cohort that already chose a study of their specific interest (and rejected the other choices).

Correlations between general interests and study interests show that the Investigative interest is very weak, but positively, correlated to all study interests, not only CS. An Artistic interest is negatively correlated to an interest in Engineering, making it a possible target of interventions to improve interest in STEM-related fields of study. Observed discrepancies between pupil and student cohorts (Social interest is positively correlated to Natural Science in the pupil cohort, but negatively correlated in the student cohort) can be attributed to different states of knowledge.

We demonstrate that it is possible to collect interest profiles of pupils' cohorts with our KAUA framework, and we confirm findings in literature that there are certain interests that influence the (future) choice of study in STEM-related fields (Artistic, Social, Enterprising). To improve enrollment in computer science and STEM-related fields, an avenue of future research is the design of interventions to convey holistic notions of those fields, attracting students who previously saw themselves as a bad fit.

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