frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 17 May 2023
DOI 10.3389/feduc.2023.1158041

OPEN ACCESS

EDITED BY
Zara Ersozlu,
The University of Newcastle, Australia

REVIEWED BY
Eduardo Hernández-Padilla,
Autonomous University of the State of Morelos, Mexico
Carlos Hervás-Gómez,
Sevilla University, Spain

*CORRESPONDENCE
Ainur Karimova
✉ ainur.karimova@ayu.edu.kz

RECEIVED 03 February 2023
ACCEPTED 25 April 2023
PUBLISHED 17 May 2023

CITATION
Balta N, Japashov N, Karimova A, Agaidarova S, Abisheva S and Potvin P (2023) Middle and high school girls' attitude to science, technology, engineering, and mathematics career interest across grade levels and school types.
Front. Educ. 8:1158041.
doi: 10.3389/feduc.2023.1158041

Middle and high school girls' attitude to science, technology, engineering, and mathematics career interest across grade levels and school types

Nuri Balta[1], Nursultan Japashov[1,2,3], Ainur Karimova[4]*, Shakhrizat Agaidarova[5], Sholpan Abisheva[6] and Patrice Potvin[7]

[1]Department of Pedagogy of Natural Sciences, Suleyman Demirel University, Kaskelen, Kazakhstan, [2]Solid State Physics and Nonlinear Physics Department, Al-Farabi Kazakh National University, Almaty, Kazakhstan, [3]Physics Department, Nazarbayev Intellectual School of Chemistry and Biology, Almaty, Kazakhstan, [4]Physics Department, Faculty of Natural Science, Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkistan, Kazakhstan, [5]Language Education Department, Suleyman Demirel University, Kaskelen, Kazakhstan, [6]Chemistry Department, Nazarbayev Intellectual School of Chemistry and Biology, Almaty, Kazakhstan, [7]Département de didactique, Université du Québec à Montréal, Canada, Montréal, QC, Canada

The aim of this study is to examine Kazakh female students' interest in STEM professions. A convenient sampling method was used to determine the participants from 10 girls' schools in Almaty city in Kazakhstan. 522 girls from grades 7th to 11th provided answers to the "STEM Career Interest Survey" which was administered online. Collected data was analyzed to see how girls' STEM carries interest change according to the type of school and grade level, along with locating the correlations between their interests and their end-term marks in each STEM subject. MANOVA analysis showed that girls' career interests in different STEM subjects are changing for different school levels across types of schools. Through ANOVA analysis we showed that only girls' math interest significantly changed across school levels. *Post-hoc* analyses indicated that seventh level students' interest in math was statistically higher than eighth and ninth level students. For the school type variable, ANOVA analysis showed that only girls' technology and engineering interests were significantly different across school types. In other words, girls in Nazarbayev Intellectual Schools (NIS) were significantly more interested in technology and engineering careers than public school girls while for science and mathematics there was no difference between the two types of schools. Additionally, at the 8th and 11th school levels NIS girls have a higher interest in science while at the 10th level public school girls have higher scores. Finally, we detected significant correlations of modest amplitude between girls' STEM were analyzed rest and their achievement in physics, math, chemistry, and biology. This study will allow supporting teachers and school administrators in their efforts to encourage girls to pursue STEM studies and careers, and we hope it will also help researchers to orient their efforts in providing them with fertile and durable solutions.

KEYWORDS

girls and STEM, Kazakhstan girls' STEM education, STEM education, STEM career interest, factors of STEM career interest

1. Introduction

Major universal policy documents such as the United Nations Convention on the rights of the child state that all children, regardless of gender, ethnicity, ability, or age, have the right to an education. Moreover, the Legislation of the Republic of Kazakhstan on the rights of the child is in agreement with the above convention asserting that all children have equal rights regardless of different social identities. Though all children have equal opportunity to receive a high-quality education, gender discrepancies in science, technology, engineering, and mathematics (STEM) fields are one of the school system's key issues (Dubrovskiy et al., 2022).

Science, technology, engineering, and mathematics is one of the fields that require further investigation. The growth of STEM fields is crucial to every nation's economic prosperity. Various initiatives in STEM and contributions to its development are critical for a country's security, economic competitiveness, prosperity, and scientific growth (Fisher and Margolis, 2002). For the economic progress of the country and its competitiveness with other countries skilled labor qualified in a STEM career is required. However, many countries are experiencing a STEM shortage, particularly among women as stated by Salmon (2015). Equal career possibilities for women in STEM fields contribute to reducing the gender wage gap, enhancing women's financial security, ensuring a skilled and diverse STEM workforce, and avoiding bias in these fields (Halpern et al., 2007; Goy et al., 2018; Román-Graván et al., 2020). According to UNESCO (2016) report, despite increasing female involvement in higher education, the proportion of women entering STEM education is still decreasing. Labeled as the "leaky STEM pipeline" the phenomenon of women leaving the STEM disciplines has been a major reason for concern in academia (Whitelegg, 2001; Clark Blickenstaff*, 2005; Hill et al., 2010; Mim, 2019; Syzdykbayeva, 2020; Cohen Miller et al., 2021). While some of these studies revealed that girls drop out of STEM majors during their university education, others found that girls get less often involved in STEM-related school activities than boys, thus eventually leaving STEM fields (Mim, 2019; Cohen Miller et al., 2021). Another UNESCO report (UNESCO, 2017) on girls' STEM schooling claims that gender disparity begins in the early school years when girls start getting messages according to which STEM disciplines are not for them (Almukhambetova and Kuzhabekova, 2020). According to Rose and Smith (2018) research has revealed that children begin to divide in preschool, with boys playing violently with boys in larger groups and girls playing cooperatively with other girls in smaller groups. Other research discovered that gender-related gaps begin as early as infancy when parents unintentionally promote their children's behavior with gender-specific games and toys (Culhane and Bazeley, 2019).

1.1. Students' career interest in STEM

Career interest was described by Osipow and Fitzgerald (1996) as a person's propensity to engage in particular activities that provide them happiness and fulfillment. According to Bryant et al. (2006), the development of career interest begins in early childhood when they start discovering their abilities and interests that will be useful in choosing future work. However, Wiebe et al. (2018) found that children's career interests fluctuate throughout elementary school and, for some, only stabilize throughout secondary school. Moreover, the strongest predicting factor of students' career interest at school graduation was students' career interest at the start of high school (Sadler et al., 2012). With this in mind, it is critical to stimulate middle school students' career interest in STEM subjects, before they start high school, through various extracurricular activities in order to boost the number of students pursuing STEM disciplines (Tekin and Mustu, 2021). Developing students' career interests is an important aspect of understanding how to contribute to and keep students involved in STEM subjects as documented by Blustein et al. (2013). And the factors as socialization, educational experiences, and environmental factors (Savickas and Spokane, 1999), out-of-school activities (Dabney et al., 2012) and beliefs (Wang, 2012) are the ones that shape students' career interest to different fields.

Considerable research has been undertaken to demonstrate the significance of investigating students' career interests from many perspectives in order to provide adequate guidance on STEM occupations, examine influencing factors, improve career counseling, and reduce STEM pipeline leakage. The study done by Kong et al. (2014) and Dabney et al. (2012) investigated the impact of out-of-school time science activities on students' career interest. For example, Kong et al. (2014) found that eighth-grade middle school students who participated in scientific summer camps were more likely to pursue a career in science. Furthermore, this longitudinal study, which included almost 1,500 high school students, discovered a link between gender and career interest. Boys were shown to be more likely than girls to have a career interest in STEM, which is consistent with earlier studies (Bonous-Hammarth, 2000). On the other hand, Dabney et al. (2012) conducted quantitative study at the university level examining the relationship between students' career interest and structured and unstructured out-of-school time science activities. Out-of-school science activities are classified as structured and unstructured by the scholars. Structured activities are those that are arranged or scaffolded by the school, teachers, or are included in the curriculum, whereas unstructured activities are those that are specific to the student's interests. The results indicate that respondents who participated in out-of-school science activities were 1.5 times more likely to choose a STEM-related career in university than those who did not participate in such activities (Almukhambetova and Kuzhabekova, 2020). Moreover, gender also plays a role: male students are more likely than female students to be interested in STEM careers in a university context, which is consistent with earlier findings (Kjærnsli and Lie, 2011; Dabney et al., 2012; Wang, 2012; Kenneth, 2021).

Recent studies have focused on a number of factors that influence students' career interest. For example, Hazari et al. (2013) investigated five common factors that may influence female students' career interest in physical science: single-sex physics classes, female scientist guest speakers, a female physics teacher, discussion of female scientists' works, and discussion of women's underrepresentation in science. Hazari et al. (2013) used a quantitative approach to survey more than 7,500 students from 40 institutions in order to get data from a diverse group of students. Participants comprised both participants who were and were not interested in physics. The findings show that there was no correlation between students' career interests and single-sex physics classrooms, a female scientist guest speaker, a female physics instructor, or discussion of female scientists' work. The results, however, emphasize the importance of highlighting female students' underrepresentation in physics, which effects students' self-realization in education. The researchers explain those findings by noting that the discussion is predominantly student-centered, whereas the preceding four factors are primarily teacher-centered. On the other hand, Japashov et al. (2022) evaluated other characteristics such as the correlation of students' career interests with gender, their parents' employment, parents' education, family size, school type, and its location. In terms of gender and its relationship to students' career interests, the findings support prior studies showing boys had more positive views about science subjects than girls. While students' end-of-term grades had a beneficial influence on their future career interest, there was no significant association between individuals' career interest and family size, parents' employment, or education (Japashov et al., 2022).

Despite the wealth of empirical data on students' career interest and its correlation with various factors, a number of questions remain incompletely covered. Overall, the research above focused on students' career interests and their relationships to characteristics such as gender, underrepresentation of female scientists, family size, parents' education and employment, and STEM views, with the majority of studies using a quantitative method (Blustein et al., 2013; Yerdelen et al., 2016; Japashov et al., 2022). Qualitative study with interviews being the main research instrument by Blustein et al. (2013) documented that out-of-school time summer STEM camps positively impact students' future STEM career interest. Furthermore, findings revealed that participants after STEM summer camps reported "a strong sense of pride and comfort with their racial and ethnic identities" (Blustein et al., 2013).

1.2. Students' career interest and end-term marks

Numerous studies exist regarding career interest and its relation to different factors as out-of-school time activities (Dabney et al., 2012; Kong et al., 2014); gender (Sadler et al., 2012; Peel et al., 2018); family involvement (Japashov et al., 2022) and school environment (Hazari et al., 2013). Only limited number of studies focus on career interest and its correlation with end-term marks (Timothy, 2014; Mohd Zaini et al., 2021; Japashov et al., 2022). Japashov et al. (2022) reported a strong and positive connection of students' career interest with their end-term marks in their quantitative study. However, Bonous-Hammarth (2000) discovered that students' perseverance was more closely related to their choice to specialize in STEM subjects than their average high school performance scores. Nieva (2022) and Wang (2012) explored the relationship between students' career interests and academic achievement, but in terms of academic ability differences. The relationship between career interest and end-term marks has also been explored in prior study by Negru-Subtirica and Pop (2016). The scholars conducted three-wave longitudinal quantitative approach to investigate the link in those characteristics in adolescence. Interestingly, the results of this study show that students' career interests were not motivated by their grades over the period of one academic year. Scholars suggest to investigate the relationship between career interest and other types of career-related activities, such as extra-curricular activities, or other domains outside of school (Negru-Subtirica and Pop (2016)). To summarize, the literature analysis uncovered multiple studies on career interest and its relation to end-term marks, however those studies do not address the research issue of this study. Moreover, a literature review revealed a dearth of empirical data and a lack of methodologically adequate research in STEM in the Kazakhstani context. Nonetheless, some local studies have discovered several variables influencing females' decisions to enroll in or drop out of STEM disciplines. These studies are detailed below.

1.3. Stem research in Kazakhstan

Factors that contribute to females' underrepresentation in STEM are prevalent in many countries of the world, including Kazakhstan. It is a unique landscape, being a post-soviet country with a historically and culturally oriented society that strongly affected women's perception of STEM. Those historical and sociocultural factors unavoidably influence female students' decision to pursue STEM studies. Such factors have been pinpointed in the qualitative study conducted by Almukhambetova and Kuzhabekova (2020). They were classified by the researchers into three categories: micro, mezzo, and macro levels. Micro level factors relate to individual factors such as self-efficacy, self-confidence, attitudes towards STEM, personal abilities and knowledge of the chosen field (Dabney et al., 2012; Almukhambetova and Kuzhabekova, 2020; Balta et al., 2023; Japashov et al., 2022). Another study, this time quantitative, was also conducted by Japashov et al. (2022) and found that boys had more favorable attitudes toward studying STEM fields than girls, and that this disparity resists recorded changes over academic years. In contrast, Syzdykbayeva (2020) discovered, using a mixed method approach, that 56% of female respondents chose STEM majors by basing their choice on their individual interests, whereas 35 and 31% opted for better work options and a high probability of receiving a state grant, respectively. Interestingly, the same survey found that 59% of respondents believed that some disciplines are essentially gender-dependent, meaning that some majors appear more suitable for males while others are more ideal for females (Syzdykbayeva, 2020). Overall, the micro-level factors the micro-level female students' enrolment or withdrawal from STEM fields are profoundly grounded in their perceptions, self-confidence, and personal abilities, which are molded within the mezzo level mentioned below.

The mezzo-level comprises of family-related and school-related factors that affect girls' decision related to STEM disciplines. According to Almukhambetova and Kuzhabekova (2020), school related factors such as STEM-focused curriculum, extra-curricular STEM clubs, teaching style, school culture, and peer support are among the major factors that positively affect female students in pursuing STEM fields at university level. For instance, participants who took part in STEM Olympiads and science projects further intended to choose STEM majors afterwards. Moreover, it is noteworthy that students' end term marks positively correlate with students' STEM career interest; which is in agreement with the findings in this field (Dabney et al., 2012; Japashov et al., 2022).

Despite the fact that school-related activities have a beneficial impact on females' STEM pursuits, family-related factors have considerable discrepancies. To start with, Kazakhstan is rich and diverse in traditions and culture. Three categories of families were spotted by Almukhambetova and Kuzhabekova (2020) as having varying influences on the STEM careers of their daughters. First, fathers from such homes treat certain girls like sons by dressing them

10.3389/feduc.2023.1158041

in boyish attire, teaching them how to ride a horse and shoot a bow, and later by encouraging such daughters to major in STEM. Second, a family with only one parent. These families also urge their girls to specialize in STEM since it provides better chances for future employment and better pay than other humanitarian-related careers. Third, the most common families are those in which parents or other elder family members are opposed to females majoring in STEM professions, claiming that STEM is not appropriate for girls (Almukhambetova and Kuzhabekova, 2020). In the study conducted by Japashov et al. (2022) neither the size of the family nor the educational background of the parents had any discernible or substantial effects on the choice of a STEM major by the child.

As previously stated, among the family-related challenges that can be linked to mezzo level, we can include household responsibilities, childcare, work-life balance, gender stereotypes, and reintegration after maternity leave (Tsakalerou et al., 2022). The findings of the Kazakhstani study by Tsakalerou et al. (2022) are convergent with those other studies which revealed that female faculty members of STEM field often experience stress due to the household responsibilities, childcare, and work and life balance. These difficulties might impede the advancement of female academic members' careers or possibly lead to their resignation (Christensen, 2018; Didenko et al., 2019; Tsakalerou et al., 2022). Back-integration after maternity is also regarded as a crucial factor influencing female faculty members' careers in STEM fields. Tsakalerou et al. (2022) discovered that some employers do not hire female employees following a maternity leave, which hinders women's retention.

A case study done by Cohen Miller and Lewis (2019) about gender equity in STEM Higher Education in Kazakhstan revealed a number of issues that can be attributed to mezzo level factors, as provided by Almukhambetova and Kuzhabekova (2020). First, while women's enrolment rates may be the same as men's in STEM fields, their following paths differ; the ascent of women from junior to senior positions is more difficult than that of men (Cohen Miller and Lewis, 2019). Second, a gender analysis of Kazakhstan's formal curriculum in higher education indicated that merely 15% of all provided reading materials were had women as authors, inadvertently delivering the impression that knowledge mostly comes from males (Cohen Miller and Lewis, 2019). Third, the enrolment of girls fluctuated within STEM disciplines and academic years at Nazarbayev University (NU). For instance, women's enrolment percentage increased from 13% in 2015 to 36% in 2020 in Master of Science in Mechanical Engineering, but it decreased from 67% in 2018 to 30% in 2020 in MS in Civil and Environmental Engineering (Cohen Miller and Lewis, 2019). Fourth, a descriptive examination of the School of Engineering and Digital Science's faculty revealed that only 6% of the 105 full-time faculty members are female, showing that there may be strong sociocultural, historical, or institutional reasons why they are underrepresented (Cohen Miller and Lewis, 2019). Lastly, according to Tsakalerou et al. (2022), workplace climate is not inclusive enough, meaning that women might not be participating much in decision-making process related to STEM field.

Cultural differences, economy and labor market, gender expectations, stereotypes, and societal constructs are factors at the broader macro level. In terms of history and culture, Kazakhstan is exceptional. Before the Soviet Union, women were seen as the wife, mother, and daughter-in-law who took on the whole responsibility of the household and seconded her husband. The status of women marginally improved when Kazakhstan joined the Soviet Union, allowing access to healthcare, education, and employment opportunities (McLaughlin, 2018). According to Akiner (1997), despite modern women's standing improving, the old stereotype of women as a wife, mother, and daughter-in-law still permeates in Kazakhstani society. Another dominant stereotype is that STEM fields are masculine profession and are thus unsuitable for girls (Akiner, 1997). Overall, we can argue that society's image of the role of females in society is strongly rooted in history and culture, with the belief that women are essentially caregivers. However, there are some improvements depending on the region. For instance, it was more acceptable for females from central, northern and eastern parts of Kazakhstan to major in technical fields, which are regarded more liberal to women's rights. However, there is a negative attitude in less industrialized and more populous southern regions (Almukhambetova and Kuzhabekova, 2020). Additionally, Japashov et al. (2022) found that STEM majors are more appealing to rural school pupils than to urban ones, suggesting that STEM education might help with the social and economic issues that rural regions face.

Overall, the review of literature reveals a scarcity of studies that are not central enough to satisfy our research questions. It was discovered that the STEM profession is clearly biased against women. The key factors influencing female to major in STEM are classified into three levels of significance. Each level appears to be linked to others, making an eventual solution more complex and challenging. Further research is required to determine the impact of each level, to assess girls' interest in STEM careers, and measure societal perceptions of girls in STEM in order to contribute to eventually solve the problem of underrepresentation of females in STEM.

1.4. Secondary education in Kazakhstan

Secondary education is compulsory in Kazakhstan, and attendance at public schools is mandatory and free of charge at this level. According to an OECD report (OECD, 2015), Kazakhstan has a highly centralized top-down educational system that gives schools limited authority. The Ministry of Education and Science develops educational policies and programs, while regional and district authorities are in charge of implementing them. Secondary education is required for students aged 6–15, which corresponds to school levels 1 through 9. Kazakhstan has around 7,450 schools of different kinds, including international schools, private schools, Daryn schools, Nazarbayev Intellectual Schools (NIS), Bilim-Innovation Schools (BIL), ungraded schools (located in rural areas where classes have students from different school levels, like in one class the students of 1, 2, 3 levels study together, because of the lack of students and teachers as well), and public schools. 76.3% of 7,450 school units are located in rural regions, with limited resources, poor facilities, and different class sizes (Kultumanova et al., 2012).

Among other objectives, this study focuses on how Kazakhstani girls' STEM career interests differ, according to their school type. Indeed, two very different types of school exist in Kazakhstan, public schools and NIS. Their differences are so radical that in order for our analysis to make sense, it will be necessary to disaggregate the data between the two.

Key distinctions between these two types of schools are detailed below. In Kazakhstan, public schools are free of charge. The schools are run by the state, and all public schools, regardless of location, follow the same curriculum. In certain locations, public school class sizes reach at least 25 children, with more than two shifts. The funding of public schools is determined by the region. Depending on the school, the language of instruction is Kazakh or Russian. If a trilingual education strategy is employed in such public schools, two of the subjects, such as biology, chemistry, informatics, and physics, may be taught in English. Local teachers make up the teaching staff. Nazarbayev Intellectual Schools (NIS) is a chain of state-funded schools located in the country's major cities. NIS is named after Kazakhstan's first president, Nursultan Nazarbayev, and is intended to implement new programs in secondary education (AEO NIS, 2016). With a separate law regulating the status of these institutions, NIS has complete authority in their operations. The Autonomous Educational Organization is in charge of them (AEO). The AEO NIS creates its own curriculum, learning resources, assessment and monitoring system, and programs for teacher professional development (Karabassova, 2021). NIS receive far more support than public schools (OECD, 2015). At NIS schools, most scientific subjects are taught by foreign teachers who team teach with local teachers. Furthermore, admission is exceedingly selective, with no more than 24 students per class and one shift.

1.5. Education in public schools of Kazakhstan

Governmental public schools students study according to the Republican educational standards approved by the Ministry of Education of the Republic of Kazakhstan (MERK, 2022). All children of school age in Kazakhstan must complete at least nine school levels, after 9th-level students have a choice of entering college (an alternative specialized educational institutions) or continuing their studies at high school to obtain a final certificate at the end of 11th level. After the 11th level, all students who have graduated from school can take a state exam to continue their studies at universities and choose their majors.

Students start learning all STEM subjects (biology, physics, chemistry, and mathematics) from the 7th level. According to the Kazakh curriculum, the subjects of biology, physics, chemistry and mathematics are conducted separately, i.e., they are not integrated into the Science subject. However, the content of these courses is very close to the content of international standards for teaching middle and high school students (Toybazarova and Nazarova, 2018).

As it is known that one of the most important components of STEM education is Technology lessons. In Kazakhstani public schools, technology lessons start from the 5th level for middle school students and are taught until graduation from school. The content of the curriculum provides for the study of material in five cross-cutting educational lines: visual art (classical and contemporary art, digital art—photography, animation, media); decorative and applied creativity (materials, tools and technologies of arts and crafts); design and technology; culture in the house; culture nutrition.

Interestingly, in many public schools in Kazakhstan, girls and boys are divided into two groups depending on gender in technology lessons (Sputnik, 2022). For example, the Technology lessons program provided for boys in the study of design and technology includes the following components: basic structural, natural, artificial and non-traditional materials; tools and equipment for material processing; processing materials in various ways; design of products from various materials; manufacturing technology of national household items; monuments of world and Kazakhstani architecture; prototyping; Interior Design. The program for girls contains: basic textile, natural, artificial and non-traditional materials; tools and equipment for processing textile materials; processing of textile materials in various ways; design of products from textile materials; fashion industry, style and image, manufacturing technology of national clothing elements. Correspondingly, when boys study about "culture in the house" they learn about general information about the sources of electrical energy, the use and repair of electrical appliances and household appliances; repair and household work, organization and planning of the interior. Content of the program for the girls when they study "culture in the house" is: personal hygiene, home ecology; basics of crop production, decorative floriculture, landscape design; care and storage of clothes.

1.6. Education in Nazarbayev Intellectual School

"Nazarbayev Intellectual Schools (NIS)" is an autonomous educational organization accredited by The Council of International Schools (CIS), which was founded in 2008 at the initiative of the first president of the Republic of Kazakhstan. This is a series of educational institutions; there are currently 22 Nazarbayev intellectual schools across the country (NIS, 2022).

Nazarbayev Intellectual schools are designed to become an experimental platform that carries out development, monitoring, research, analysis, testing, and implementation of modern models of educational programs at the following levels: primary school (including preschool education and training), elementary school and high school.

For admission to the NIS for the middle and high school program, students must pass a special republican selection based on an exam that tests the mathematical and language skills of students at the end of the 6th level. Applicants who have passed the selection begin their studies at NIS from the 7th level. In NIS all students are provided with free 5 meals a day, school uniform, students who live outside regions of Almaty city are provided with free dormitory.

This educational institution can independently determine the training program, set evaluation criteria and requirements for applicants. Despite the fact that NIS are adapted the curriculum of the University of Cambridge A and AS-Level for middle and high schools, the STEM subjects here such as biology, physics, chemistry, math and technology, as well as in public schools, are taught separately.

In NIS, in technology lessons students are not divided into groups. In this lesson, students learn drawing technologies, design, learn to create different projects using different techniques and art materials. The complexity of using materials and techniques increases depending on the type of project, theme, features of the design of the product and its functional purpose. In addition to the STEM subjects, the subject "Global Development Perspectives" is taught at the NIS, where students discuss their role in society and acquire the basic skills necessary for global citizenship. In this lesson, students also openly talk about gender inequality and express their point of view. Also, as a one factor that helps to students to choose right career in the future is professional orientation work. Here, person who are responsible for the students' professional orientation inform students about choosing a career, help them when entering a university, organize various seminars and invite guests from various industries so that graduating students make the right choice when entering a university.

Additionally, each NIS school in the Republic has its own engineering laboratories, where students are engaged in developing scientific and engineering projects at an extracurricular time. After completing their projects, students participate in various national and international competitions on projects and robotics.

Overall, the literature review included significant topics such as STEM research in Kazakhstan, Kazakhstani educational system, students' STEM career interests and various influencing factors. Research has shown that incorporating women into the STEM careers boosts diversity, improves financial and academic outcomes, and provides a diversity of perspectives. There have been numerous studies to investigate various factors that affect female students' pursue STEM career (Dabney et al., 2012; Hazari et al., 2013; Kong et al., 2014). For instance, those studies tested how various factors such as out-of-school science activities, female guest speakers, female teachers, discussion of female scientist's work and single sex classes may impact female students' career choice. On the other hand, STEM research undertaken in Kazakhstan were classified into three levels: micro, mezzo, and macro. These levels represent the influence of internal and external variables on female students' career aspirations in STEM. The next three paragraphs outline Kazakhstani secondary education and two school types: public and NIS, where the current research was conducted. Although studies have been conducted by many authors, the female students' career interest towards STEM careers in Kazakhstani context is still insufficiently explored. To fill the literature gap, this paper seeks to answer the following research questions:

- How do Kazakhstani girls' STEM career interests differ across secondary school grade levels?
- How do Kazakhstani girls' STEM career interests differ according to type of school?
- How do Kazakhstani girls' STEM career interest relate to their end-term marks in STEM subjects?

2. Methodology

In this study, we aimed to find out Kazakhstani middle and high schools girls' interest toward STEM careers. We determined girls' interest using the STEM-CIS survey (Kier et al., 2014) and recorded how it changed according to type of school and grade level, along with locating the correlations between their interests and their end term marks in each STEM subject.

2.1. Instrument

We used the STEM-CIS survey (Kier et al., 2014). STEM-CIS was developed by a group of authors to reveal students' career interests toward STEM fields. There are four dimensions of the survey which are designed to measure participants carrier interests in science, technology, engineering, and mathematics. Based on social cognitive career theory, each dimension is further divided into six subdimensions, that is, self-efficacy, personal goal, outcome expectations, interest, contextual support and personal input. Because of three reasons we did not interested in these social variables. First, the "personal input" has only one item in each dimension and all other subdimensions are presented with only two items which is not appropriate to measure for example self-efficacy with only two items. Second, the main aim of this study is to reveal students' carrier interests in STEM subjects. Third, the developers of the survey (Kier et al., 2014) suggest to use the each dimension as a single measure:

The STEM Career Interest Survey developed in this study was shown to be psychometrically sound for each of the subscales of science, technology, engineering, and mathematics. Because some researchers will be interested in student interest toward more than one of these content areas, we also explored how these four subscales worked together as a single measure (Kier et al., 2014, p. 472).

Originally this survey was evaluated on a sample of 1,061 students from grades 5–8 in seven schools in southeastern United States. For the development of the scale items, the authors used Clark and Watson's six-stage approach (Clark and Watson, 2016): (1) analysis of existing literature; (2) development of a broad item pool to identify target aspect; (3) preliminary pilot testing of items; (4) structural analysis to eliminate irrelevant items from the pool of items; (5) factor analysis; and (6) creation of subscales.

This survey includes 44 science, technology, engineering, and mathematics items. Some examples of these items include: I am able to get a good grade in my science class, I am able to complete my science homework; I plan to use science in my future career; I will work hard in my mathematics classes, I do well in mathematics classes, it will help me in my future career, My parents would like it if I choose a mathematics career; I like to use technology for class work, I have a role model who uses technology in their career, I know of someone in my family who uses technology in their career; I would feel comfortable talking to people who are engineers and I am able to do well in activities that involve engineering.

The reasons behind using this survey are (1) its reliability, because the psychometric properties of the survey were searched with more than 1,000 students, (2) originally its sample was middle school students that is the most suitable for our sample, (3) it is clearly written and well designed, (4) in the development of STEM-CIS, strong statistical analyses have been conducted, and finally (5) it measures science, technology, engineering, and mathematics subscales.

Also, in the present study we calculated the internal consistency of the 44 items of the Career Interest Survey and found that Cronbach's alpha for the survey was 0.95; for the Science sub-scale was 0.86, for the Math sub-scale was 0.88, for Technology sub- scale was 0.91 and for Engineering sub-scales was 0.93.

2.2. Participants and procedure

The present study was conducted with 10 girls' school in Almaty city in Kazakhstan. In this study, we used convenient sampling method.

The survey was sent through email to about 800 students at the two NIS and eight public schools in Almaty in Kazakhstan. The online survey was provided to the students, where they were first asked to provide responses for some demographic information (their type of the school, grade level, and end term marks at each STEM subject) and then asked to answer a set of 5-point Likert scale questions (5 = "Strongly Agree," 1 = "Strongly Disagree") showing their interest towards STEM careers. Finally, 522 girls from grades 7th–11th provided answers. Among the respondents: 220 were from two NIS, 302 students from public schools: 7th graders—$n = 104$, 8th graders—$n = 81$, 9th graders—$n = 59$, 10th graders—$n = 108$, 11th graders—$n = 170$. All participants were asked to consent for their volunteer and anonymous participation, and the survey was approved by the institution's internal review board as meeting all ethical standards.

2.3. Data analysis

The analysis of data was carried out with Jamovi[1] and MS Excel. First, we analyzed the internal consistency of each scale (STEM-CIS consists of four subscales) and observed acceptable levels of reliability for all scales (see instrument section). Then, we presented descriptive statistics along with tables and graphs.

Then, we used a 2 × 4 MANOVA to understand whether there were differences in girls' science, math, engineering, and technology carrier interests based on school type and school levels. Thus, the four dependent variables are girls' scores on the survey for science, math, engineering and technology subjects, whilst the two independent variables are "school type" which has two levels; NIS and Public, and "school level" which has five levels; 7th, 8th, 9th, 10th, and 11th.

The main aim of the factorial MANOVA is to see if there is an interaction between the two independent variables on the two or more joint dependent variables. MANOVA was carried out for the four scales of the STEM-CIS. By decreasing the number of tests done, multivariate analyses are healthier and reduces the possibility of Type 1 error (Gomes and Marques, 2013). Before conducting the MANOVA, we checked for the assumptions and no problems found in most of the variables tested (see "Results" section). MONAVA was followed by a series ANOVAs and post-hoc tests to further clarify the differences between groups.

Finally, we looked for any correlations between students' grades on science subjects (physics, math, chemistry, and biology) and students' scores on the dimensions of the STEM-CIS.

3. Results

3.1. Descriptive statistics

An initial analysis of our data is done through delivering descriptive statistics. Table 1 presents statistics such as number of students, mean, standard deviation, and students' STEM-CIS scores, split by school type and school level. The mean score of each dimension (science, math, tech, and engineer) was calculated by averaging the five-point Likert type responses provided for each question of each dimension. Figure 1 represents the change in girls' scores across school levels for school types.

Figure 1 indicates that science and math scores are waving between NIS and Public schools while technology and engineering scores of NIS girls are higher than that of public schools.

3.2. Inferential statistics

We carried out MANOVA which tests multiple dependent variables, and at the same time reduces type I error. The first two research questions will be answered through MANOVA results. Before conducting MANOVA we checked for conformity with initial assumptions. First, there should be absence of multicollinearity, that is the dependent variables cannot be excessively correlated to each other. Table 2 presents the correlation matrix for the dependent variables.

As it is known there is no correlation that should be exceeding $r = 0.90$ for multicollinearity. As seen from Table 2 all correlations are below 0.60. Second, the variance between groups, that is homogeneity of variance, should be equal. Box's M Test is used to assess this assumption. Table 3 shows the Box's M Test results.

Since Box's M test is significant, Pillai's trace criterion is used for multivariate test because it is more robust to departures from assumptions. The MANOVA outputs (Multivariate and Univariate tests) from Jamovi are presented in Tables 4 and 5.

As seen from Table 4, there was a statistically significant interaction effect between school type and the school level of students on the combined dependent variables, $F(16, 2048) = 1.99$, $p = 0.011$; Pillai's Trace = 0.0613. An interaction effect suggests that the effect of one variable depends on the other variable. When interaction effects are detected, it implies that interpretation of the main effects can be inadequate or deceptive. Our result suggests that girl's career interests for different STEM subjects are changing for different grades across NIS and public schools.

To reveal whether there is a difference between girls' scores on any of the dependent variables, separate ANOVAs for school level and school type were performed (Table 5).

Three inferences can be deduced from Table 5. First, the school level variable through ANOVA analysis showed that only girls' math interest significantly changed across levels, $F(4, 512) = 2.89$, $p = 0.022$. Since there are more than two school levels, an additional *post-hoc* analysis was carried out to locate where the differences exist. Since there were unequal variances we used Games-Howell *post-hoc* Test to indicate the differences between groups. *Post-hoc* test results are presented in Table 6.

According to results presented in Table 6, seventh level students' interest in math ($M = 3.68$) is statistically higher than eight ($M = 3.37$) and ninth ($M = 3.11$) level students.

Second, for the school type variable ANOVA analysis showed that only girls technology and engineering interests were significantly different across school type (for technology $F(1, 512) = 21.051$, $p = < 0.00$, and for engineering $F(1, 512) = 12.959$, $p = < 0.00$). Girls' means scores were NIS = 3.496, public = 3.232 for technology and NIS = 3.012, public = 2.778 for engineering. This suggests that girls in NIS schools are significantly more interested in technology and engineering carriers than public school girls while for science and mathematics there is no difference between the two types of schools.

Third, for science scores there is an interaction of school level and type of school ($F(4, 512) = 4.141$, $p < 0.003$). As seen in Figure 1 in 8th

1 https://www.jamovi.org/

TABLE 1 Descriptive statistics for dimensions of STEM-CIS.

Statistics	School	School level	Science	Math	Tech	Engineer
N	NIS	7	44	44	44	44
		8	27	27	27	27
		9	37	37	37	37
		10	52	52	52	52
		11	60	60	60	60
	Public	7	60	60	60	60
		8	54	54	54	54
		9	22	22	22	22
		10	56	56	56	56
		11	110	110	110	110
Mean	NIS	7	3.6	3.56	3.4	2.99
		8	3.79	3.57	3.65	2.96
		9	3.65	3.4	3.25	2.94
		10	3.49	3.39	3.53	2.99
		11	3.74	3.53	3.65	3.18
	Public	7	3.66	3.76	3.28	2.88
		8	3.41	3.27	3.09	2.8
		9	3.54	3.43	3.26	2.7
		10	3.73	3.55	3.32	2.79
		11	3.41	3.57	3.21	2.72
SD	NIS	7	0.63	0.59	0.46	0.52
		8	0.69	0.73	0.54	0.83
		9	0.52	0.48	0.72	0.7
		10	0.68	0.81	0.83	0.89
		11	0.59	0.66	0.7	0.8
	Public	7	0.66	0.62	0.74	0.79
		8	0.59	0.67	0.59	0.74
		9	0.43	0.48	0.65	0.68
		10	0.7	0.72	0.83	0.86
		11	0.76	0.78	0.75	0.91

Number of students in each school level changes between 27 (8th level) and 60 (11th level) for NIS, and 22 (9th level) and 60 (7th level) for public school. The mean of students' scores on STEM-CIS across subjects vary between 2.96 (8th level—engineering) and 3.79 (8th level—science) for NIS, and vary between 2.70 (9th level—engineering) and 3.76 (7th level—math) for public school.

and 11th school levels NIS girls have higher interest in science while in 10th level public school girls have higher scores.

Finally, to respond to the third research question, we conducted correlational analyses between students' responses on the dimensions of the STEM-CIS and their end term marks in physics, math, chemistry and biology.

As seen in Table 7, all correlations are positive and statistically significant. In other words, there are significant correlations of modest (*small*) amplitude between girls' STEM carrier interest and their achievement in physics, math, chemistry and biology.

4. Discussion

In light of the obvious equality problem that girls face in the Kazakhstani educational system with regard to the place they hold in STEM studies and careers and considering all sorts of challenges young women face at micro, mezzo and macro levels in this strong culturally-driven society, we aimed at establishing a descriptive portrait of Kazakhstani (specifically from Almaty City) girls' STEM career interests. We believe this portrait to be relevant to lay the first stones (Blustein et al., 2013) of a diagnosis that will, we hope, eventually reduce the problems of justice that one can observe (Japashov et al., 2022).

Our questionnaire (STEM-CIS) study obtained career interest scores (using Likert-scale agreement items) of middle- and high-school attending girls and examined their variations through what we found to be most interesting, namely grade levels (research question No. 1) and types of school attended (research question No. 2). These variations were also disaggregated between all components of S-T-E-M. Having access to the academic achievements of the participating students, our study was also able to examine possible

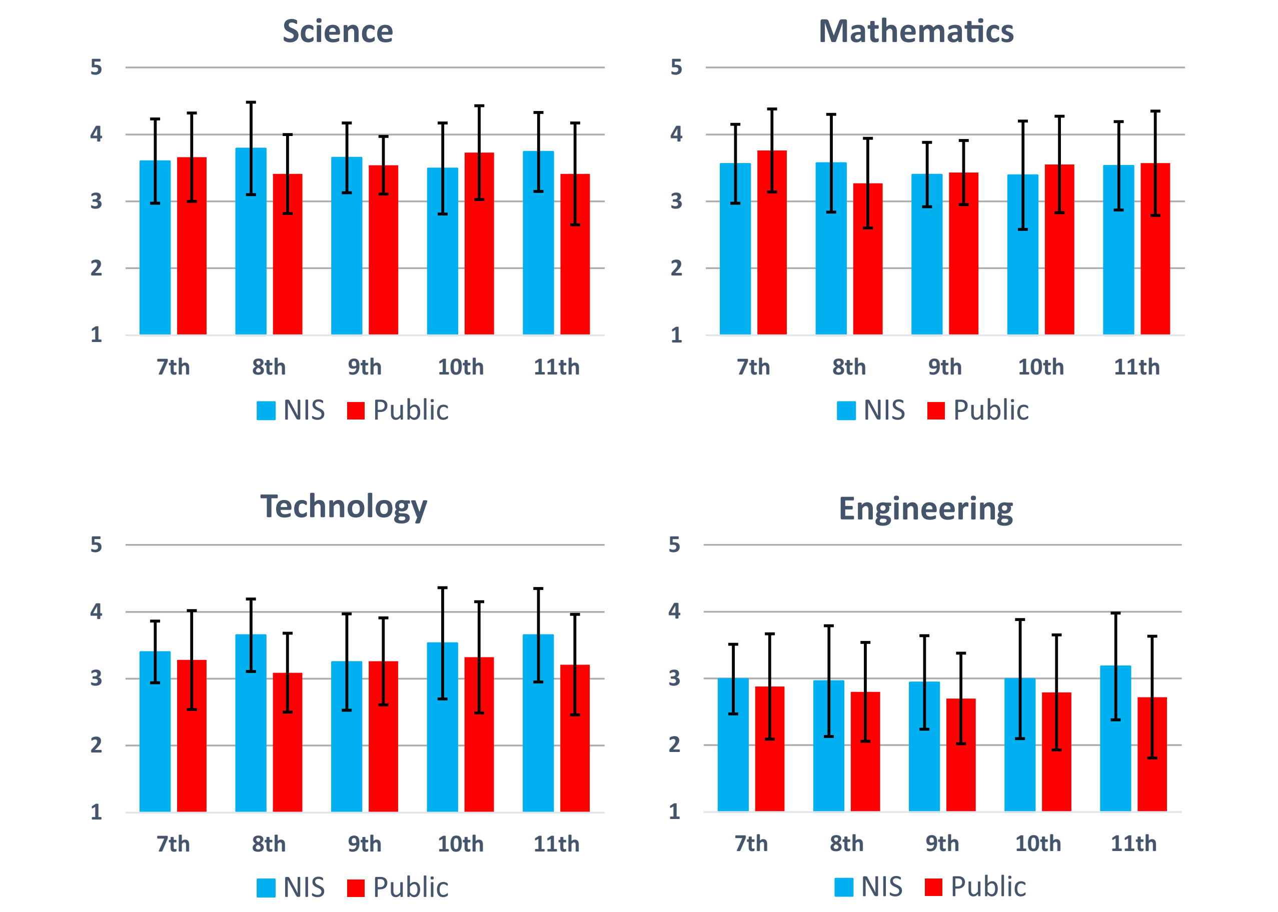

FIGURE 1
Scores across school levels for school types.

TABLE 2 Correlation between students' scores on the dimensions of the STEM-CIS.

		Science	Math	Technology
Math	Pearson's r	0.539	–	
	Value of p	< 0.001	–	
Technology	Pearson's r	0.51	0.501	–
	Value of p	< 0.001	< 0.001	–
Engineering	Pearson's r	0.458	0.41	0.542
	Value of p	< 0.001	< 0.001	< 0.001

links between these achievements (end-term marks) and career attractiveness. In both cases, we were able with this research to bring element of responses to the two research questions.

4.1. General analysis

A cursory and preliminary analysis of the results revealed rather high scores of career interest with little variation. This small variation appears to confirm observations by Wiebe et al. (2018) that career interest appears to stabilize during the secondary levels and that initial career interest at the entry may remain the strongest predictor at graduation (Sadler et al., 2012). This small variation made recording differences rather difficult. It is possible that participants responded this way because of strong and consistent social desirability. Social desirability often causes participants to respond in ways that satisfy the adult or societal expectations, and which distracts answers from authentic accounts. Thus, some participants may feel social pressure that discourage them from stating that they do not feel an attraction to STEM (Japashov et al., 2022). It is also possible that the format of the questionnaire (items all worded positively) resulted in responses that would not be as deeply introspective as desired, or in responses that are based on hope and intentions ("I will work hard in my mathematics classes"), instead of on perfectly honest statements of facts. It is also possible that other items referred to career intentions that students had not necessarily reflected much about (e.g., "I plan to use science in my future career"), especially for younger ones. To record stronger variations, we believe it might be interesting to eventually opt for items that put participants in a stronger reflective tension (Potvin et al., 2020).

Nevertheless, it is not impossible that the rather high scores (near maximums), also often seen in other cultures (Bybee and McCrae, 2011; Hasni and Potvin, 2015; Potvin et al., 2017), that we have recorded be due to a genuine attraction to- or willingness to enter-STEM careers, in which case our results would challenge previous existing studies (Japashov et al., 2022) or suggest that the "leaky

TABLE 3 Box's homogeneity of covariance matrices test.

χ^2	*df*	*p*
170	90	< 0.001

TABLE 4 Multivariate tests for type of school and school level.

		Value	*F*	*df1*	*df2*	*p*
School level	Pillai's Trace	0.0445	1.44	16	2048	0.113
	Wilks' Lambda	0.956	1.44	16	1,556	0.113
	Hotelling's Trace	0.0456	1.45	16	2030	0.112
	Roy's Largest Root	0.0308	3.94	4	512	0.004
Type of school	Pillai's Trace	0.0711	9.74	4	509	< 0.001
	Wilks' Lambda	0.929	9.74	4	509	< 0.001
	Hotelling's Trace	0.0766	9.74	4	509	< 0.001
	Roy's Largest Root	0.0766	9.74	4	509	< 0.001
School level✻ Type of school	Pillai's Trace	0.0613	1.99	16	2048	**0.011**
	Wilks' Lambda	0.94	2	16	1,556	0.011
	Hotelling's Trace	0.0628	1.99	16	2030	0.011
	Roy's Largest Root	0.0349	4.47	4	512	0.001

pipeline" problem may eventually record decreases in the future, possibly at least at the micro level (individual; Almukhambetova and Kuzhabekova, 2020). This encouraging result would then be more in line with Syzdykbayeva's (2020) recent conclusions according to which females give importance to STEM careers strategic advantages. It also has been observed elsewhere, especially in the analysis of PISA tests, that interest in science is usually less correlated with performance in low-income countries (Tucker-Drob et al., 2014). It may then appear to students as an efficient way to access financial resources (better salaries), also as Syzdykbayeva's (2020) had suggested. In contexts where income is an existential question, science may thus be perceived as more attractive, sometimes even overestimated. However, the fine variations observed, especially in the post-hoc tests, do not allow us to interpret the overall trends (up or down) in scores, for the entire studied continuum of ages.

4.2. Type of school and interest in STEM careers

After securing statistical assumptions, we can however confirm that a few differences appear as significant. First, we can record differences between types of school (Public or NIS), at the advantage of NIS. This result, which resists between used types of tests, is a bit unsurprising since NIS schools show many advantages (selection of students through entry exams, special resources, teachers from abroad, etc.). In these schools, interest also appears to be stronger for technology and engineering. This observation may be attributable to the types of services (pedagogical, curricular, programmatic) that are offered in both types of schools. Indeed, a greater variety of pedagogical activities and services had already been identified as important for the development of career interest (Blustein et al., 2013). A more thorough (and possibly qualitative or documentary [programs, school materials, etc.]) research could be conducted to investigate further. Since it is known that pedagogy influences interest (Toybazarova and Nazarova, 2018), it is possible that differences in services provided reflect in differences in career interest. Thus, the engineering labs of NIS, for example, as well as the special and specific pedagogy that necessarily comes with them, may explain the recordable difference between public and NIS schools. However, we must remain cautious in our conclusions, since only two NIS schools were involved. Indeed, less data can lead to more erroneous conclusions (false positives).

4.3. Grade level and interest in STEM careers

Also, we can record statistically significant variations of girl's math interest in the first years of middle school (difference between level 7th and 8th and 9th levels). However, no convergence of the data in the other levels for that subject, as well as the absence of finer data on what happens during these years, make further interpretation difficult. We can nevertheless suspect here that students are experiencing difficulties of adaptation (from elementary) to the rigors of middle school mathematics. Such adaptations periods have also been observed elsewhere and identified as an important challenge (Potvin et al., 2020).

We also observe that for science, the interaction "Type of school X grade level" revealed significant, suggesting stronger variations, and possible important ones, possibly due to curricular considerations (year-to-year program differences between types of school). Indeed, 8th and 11th levels record stronger science interest for NIS girls, and at 10th level for students from publics schools. While they do not suggest any general convergence, these results allow us to consider that finer grain analyses and studies should investigate further. They also suggest that in fact, stronger variations of interest may be due to smaller, more intimate didactical or experiential events.

4.4. End-term marks and interest in STEM careers

Finally, by testing Pearson's correlations between end-term grades and declared interest, we were able to show that the two are always correlated, regardless of sub discipline (each S-T-E-M component being correlated with all others). This analysis appeared important because authors do not necessarily agree that clear connections exist between career interest and school marks. Indeed, while some authors argue that such a correlation can be seen (Japashov et al., 2022), other, using longitudinal approaches, have not been able to record it (Negru-Subtirica and Pop, 2016). Our own data however suggests that performance and interest indeed appear to go together. However,

TABLE 5 Univariate Tests for type of school and school level, by discipline.

	Dependent variable	Sum of squares	*df*	Mean square	*F*	*p*
School level	Science	1.12	4	0.28	0.647	0.63
	Math	5.471	4	1.3678	2.89	**0.022**
	Technology	1.579	4	0.3948	0.785	0.535
	Engineering	0.365	4	0.0912	0.141	0.967
Type of school	Science	1.328	1	1.3276	3.065	0.081
	Math	0.257	1	0.2567	0.542	0.462
	Technology	10.591	1	10.5908	21.051	**<0.001**
	Engineering	8.377	1	8.3769	12.959	**<0.001**
School level ✻ Type of school	Science	7.174	4	1.7935	4.141	**0.003**
	Math	2.975	4	0.7437	1.571	0.181
	Technology	4.489	4	1.1223	2.231	0.065
	Engineering	2.335	4	0.5839	0.903	0.462
Residuals	Science	221.749	512	0.4331		
	Math	242.353	512	0.4733		
	Technology	257.585	512	0.5031		
	Engineering	330.954	512	0.6464		

TABLE 6 Games-Howell *post-hoc* test—responses for math (NIS and public).

School level		8	9	10	11
7	Mean difference	0.302	0.268	0.199	0.117
	Value of *p*	**0.02**	**0.019**	0.22	0.612
8	Mean difference	–	−0.034	−0.103	−0.185
	Value of *p*	–	0.997	0.871	0.308
9	Mean difference		–	−0.069	−0.151
	Value of *p*		–	0.953	0.382
10	Mean difference			–	−0.082
	Value of *p*			–	0.902

we cannot say, through correlation, if interest supports good marks or if the opposite is true. The most reasonable hypothesis is probably that they are mutually reinforcing, but recent work might suggest that the "marks towards interest" could be prevalent since good marks generate scientific self-esteem, that in term encourages focused attention and sustained work (Potvin et al., 2020). Since self-esteem and interest often go undifferentiated, it is possible that we measured a self-concept while measuring interest with our questionnaire (STEM-CIS). Indeed, some questions appear to concentrate on evaluations of performance, like "I am able to get a good grade in my science class." Nevertheless, we believe this result to be useful because it suggests that when students experience successes, their chances of developing interest, and eventually career interests, could be positively influenced (Timothy, 2014; Mohd Zaini et al., 2021), possibly especially at specific periods in life (crossroads) in which students have to decide to pursue or not. Interest has been showed to play an important part in decision at these specific momenta, more than when this tension is relaxed or can still be postponed. Thus, teachers should be encouraged to find ways, without impacting quality, to make students feel performant and competent.

All these results should however be taken with caution because of the limitations our theoretical and methodological choices inevitably implicate. First, we believe some of our questionnaire items could have allowed our Kazakhstani girls to answer lightly, and thus make us record less significant variations. In previous work Potvin et al. (2020), have suggested that participants should be submitted to items that put them in more tension, requiring them to reflect more on their choice. For example, the item "I prefer science to arts" could generate more variability that "I like science." Negative items could also have been submitted to cultivate participant's vigilance. Second, we have chosen not to test boys. This choice allowed us to obtain a better portrait of girls, since we gathered more data on them. But a comparison between girls and boys could also have been very informative and might have resulted in more precise prescriptions. Third, we could also have proposed a more thorough analysis of the different subconstructs of our questionnaire. Not all our items can be solely associated to interest like it is usually defined in the literature (Hidi and Renninger, 2006), and in opposition with other possible constructs (attitude, enjoyment, etc.). We are committed to go further in such an analysis. Fourth, our study is limited to the context of Almaty city. While representative, this context remains local, and to obtain a more comprehensive portrait of the Kazakhstani heterogenous situation, other cities, as well as more rural areas, should have been investigated. We are committed to evaluate these contexts for eventual further regional comparisons.

However, our original results allow a first peek into STEM career interest of girls, in the Kazakhstani context (this is a first to our knowledge). They may offer a perspective that can lead to improvements, for example, by getting inspired by what happens in NIS schools. A further analysis of the approaches used in some levels

TABLE 7 Correlational analysis between interest and marks.

		Physics marks	Math marks	Chem marks	Bio marks
Science	Pearson's *r*	0.271	0.255	0.243	0.299
	value of p	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
Math	Pearson's *r*	0.218	0.309	0.109	0.105
	Value of p	**< 0.001**	**< 0.001**	**0.013**	**0.016**
Technology	Pearson's *r*	0.236	0.166	0.16	0.211
	Value of p	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
Engineering	Pearson's *r*	0.142	0.148	0.114	0.158
	Value of p	**0.001**	**< 0.001**	**0.009**	**< 0.001**

could also open new perspectives. But overall, the epistemic positioning of our study (interested in girls) also appears as a statement in the intention to correct justice problems of equity, and can thus contribute to a recognition of the problem.

5. Conclusion

In this research, we have attempted to provide a general (and rare) portrait of Kazakhstani girls' career interest through a questionnaire study. We believe it to be a contribution to the field by portraying the situation in the very special context of a Post-soviet country, with strong cultural values that do not always support the advent of girls in modern era work settings. Among other things, our study showed a few variations, and while these are a bit uneasy to interpret, they suggest that pedagogical or curricular treatments can produce them. Thus, the present situation can be tilted by modifications of those treatments, and eventually contribute to drying up the "leaky pipeline" (Clark Blickenstaff*, 2005). Our results also show that NIS generate more interest, especially in the direction of their design: based on selection with a focus on technology and engineering. Finally, our results suggest that when students experience successes, those are correlated with an eventual career interest.

As part of a larger research program, this study will allow supporting teachers and school administrators in their efforts to encourage girls to pursue STEM studies and careers, and we hope it will also help researchers to orient their efforts in providing them with fertile and durable solutions.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Ethical Committee of Suleyman Demirel University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

AEO NIS, (2016). Annual report AEO "Nazarbayev intellectual schools"—2016. Available at: https://www.nis.edu.kz/en/about/reports/?id=6351

Akiner, S. (1997). "Between tradition and modernity-the dilemma facing contemporary central Asian women" in *Post Soviet Women: From the Baltic to Central Asia*. ed. M. Buckley (Cambridge: Cambridge University Press), 261–304.

Almukhambetova, A., and Kuzhabekova, A. (2020). Factors affecting the decision of female students to enroll in undergraduate science, technology, engineering and mathematics majors in Kazakhstan. *Int. J. Sci. Educ.* 42, 934–954. doi: 10.1080/09500693.2020.1742948

Balta, N., Japashov, N., Mansurova, A., Tzafilkou, K., Oliveira, A. W., Lathrop, R., et al (2023). Middle-and secondary-school students' STEM career interest and its relationship to gender, grades, and family size in Kazakhstan. *Sci. Educ.* 107, 401–426. doi: 10.1002/sce.21776

Blustein, D. L., Barnett, M., Mark, S., Depot, M., Lovering, M., Lee, Y., et al. (2013). Examining urban students' constructions of a STEM/career development intervention over time. *J. Career Dev.* 40, 40–67. doi: 10.1177/0894845312441680

Bonous-Hammarth, M. (2000). Pathways to success: affirming opportunities for science, mathematics, and engineering majors. *J. Negro Educ.*, 92–111. http://www.jstor.org/stable/2696267

Bryant, B. K., Zvonkovic, A. M., and Reynolds, P. (2006). Parenting in relation to child and adolescent vocational development. *J. Vocat. Behav.* 69, 149–175. doi: 10.1016/j.jvb.2006.02.004

Bybee, R., and McCrae, B. (2011). Scientific literacy and student attitudes: perspectives from PISA 2006 science. *Int. J. Sci. Educ.* 33, 7–26. doi: 10.1080/09500693.2010.518644

Christensen, C. J. (2018). Factors influencing the retention of women faculty in STEM disciplines.

Clark Blickenstaff*, J. (2005). Women and science careers: leaky pipeline or gender filter? *Gend. Educ.* 17, 369–386. doi: 10.1080/09540250500145072

Clark, L. A., and Watson, D. (2016). Constructing validity: Basic issues in objective scale development. 7, 309–319.

Cohen Miller, A. S., and Lewis, J. L. (2019). "Gender audit as research method for organizational learning and change in higher education" in *Gender and Practice: Insights From the Field, (Vol. 27)* (Emerald Publishing Limited), 39–55.

Cohen Miller, A., Saniyazova, A., Sandygulova, A., and Izekenova, Z. (2021). "Gender equity in STEM higher education in Kazakhstan" in *Gender Equity in STEM in Higher Education* (Routledge), 140–157.

Culhane, L., and Bazeley, A. (2019). *Gender Stereotypes in Early Childhood: A Literature Review* The Fawcett Society.

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., et al. (2012). Out-of-school time science activities and their association with career interest in STEM. *Int. J. Sci. Educ. B* 2, 63–79. doi: 10.1080/21548455.2011.629455

Didenko, N., Ermolaeva, E., Kunitsyna, E., Medvedeva, I., and Vitman, R. (2019). "Features of academic careers of female physicists in Russia" in *AIP Conference Proceedings* (AIP Publishing LLC), 050032.

Dubrovskiy, A., Broadway, S., Jang, B., Mamiya, B., Powell, C. B., Shelton, G. R., et al. (2022). Is the STEM gender gap closing? *J. Res. Sci. Math. Technol. Educ.* 5, 47–68. doi: 10.31756/jrsmte.512

Fisher, A., and Margolis, J. (2002). Unlocking the clubhouse: the Carnegie Mellon experience. *ACM SIGCSE Bull.* 34, 79–83. doi: 10.1145/543812.543836

Gomes, A. R., and Marques, B. (2013). Life skills in educational contexts: testing the effects of an intervention programme. *Educ. Stud.* 39, 156–166. doi: 10.1080/03055698.2012.689813

Goy, S. C., Wong, Y. L., Low, W. Y., Noor, S. N. M., Fazli-Khalaf, Z., Onyeneho, N., et al. (2018). Swimming against the tide in STEM education and gender equality: a problem of recruitment or retention in Malaysia. *Stud. High. Educ.* 43, 1793–1809. doi: 10.1080/03075079.2016.1277383

Hasni, A., and Potvin, P. (2015). Student's interest in science and technology and its relationships with teaching methods, family context and self-efficacy. *Int. J. Environm. Sci. Educ.* 10, 337–366. doi: 10.12973/ijese.2015.249a

Halpern, D. F., Aronson, J., Reimer, N., Simpkins, S., Star, J. R., and Wentzel, K. (2007). "Encouraging girls in math and science" in *IES Practice Guide. NCER 2007–2003* (National Center for Education Research)

Hazari, Z., Sadler, P. M., and Sonnert, G. (2013). The science identity of college students: exploring the intersection of gender, race, and ethnicity. *J. Coll. Sci. Teach.* 42, 82–91. https://www.jstor.org/stable/43631586

Hidi, S., and Renninger, K. A. (2006). The four-phase model of interest development. *Educ. Psychol.* 41, 111–127. doi: 10.1207/s15326985ep4102_4

Hill, C., Corbett, C., and St Rose, A. (2010). *Why So Few? Women in Science, Technology, Engineering, and Mathematics*. American Association of University Women, Washington, DC.

Japashov, N., Naushabekov, Z., Ongarbayev, S., Postiglione, A., and Balta, N. (2022). STEM career interest of Kazakhstani middle and high school students. *Educ. Sci.* 12:397. doi: 10.3390/educsci12060397

Karabassova, L. (2021). English-medium education reform in Kazakhstan: comparative study of educational change across two contexts in one country. *Curr. Issues Lang. Plann.* 22, 553–573. doi: 10.1080/14664208.2021.1884436

Kenneth, A. (2021). Gender Gap in engineering and medical Colleges in India. *J. Res. Sci. Mathemat. Technol Educ.* 4, 225–237. doi: 10.31756/jrsmte.434

Kier, M. W., Blanchard, M. R., Osborne, J. W., and Albert, J. L. (2014). The development of the STEM career interest survey (STEM-CIS). *Res. Sci. Educ.* 44, 461–481. doi: 10.1007/s11165-013-9389-3

Kjærnsli, M., and Lie, S. (2011). Students' preference for science careers: international comparisons based on PISA 2006. *Int. J. Sci. Educ.* 33, 121–144. doi: 10.1080/09500693.2010.518642

Kong, X., Dabney, K. P., and Tai, R. H. (2014). The association between science summer camps and career interest in science and engineering. *Int. J. Sci. Educ. B* 4, 54–65. doi: 10.1080/21548455.2012.760856

Kultumanova, A., Medetbekova, G., Nogaybayeva, G., Kusidenova, G., Alshimbayeva, S., Turtkarayeva, A., et al. (2012). *National Report on the State and Development of Educational System of the Republic of Kazakhstan*. Astana: NCESA National Center for Educational Statistics and Assessment.

McLaughlin, K. (2018). Kazakhstan country gender assessment. Asian development bank; gender and youth employment in the commonwealth of independent states: Trends and key challenges. The Decent Work Technical Support Team and the ILO Office for Eastern Europe and Central Asia.

MERK (2022). Ministry of Education of Republic of Kazakhstan. Standards of Educational programs. Available at: https://www.gov.kz/memleket/entities/edu?lang=ru

Mim, S. A. (2019). Women missing in STEM careers: a critical review through the gender lens. *J. Res. Sci. Math. Technol. Educ.* 2, 59–70. doi: 10.31756/jrsmte.221

Mohd Zaini, S. N., Md Rami, A. A., Mohamad Arsad, N., and Mohd Anuar, M. A. (2021). Relationship of academic performance and academic self-concept with career decision-making among UPM undergraduate students. *Asian J. Univ. Educ. (AJUE)* 17, 50–61. doi: 10.24191/ajue.v17i2.13403

Negru-Subtirica, O., and Pop, E. I. (2016). Longitudinal links between career adaptability and academic achievement in adolescence. *J. Vocat. Behav.* 93, 163–170. doi: 10.1016/j.jvb.2016.02.006

Nieva, A. (2022). The relationship between career interests and academic achievements in English, mathematics, and science of grade 10 students. *Int. J. Arts Sci. Educ.* 3 Retrieved from https://www.ijase.org/index.php/ijase/article/view/122

NIS, (2022). Educational scholarship of the FIRST president of the REPUBLIC of Kazakhstan—ELBASY ORKEN". Available at: https://www.nis.edu.kz/en/about/history/

OECD, (2015). OECD reviews of school resources: Kazakhstan. Available at: https://www.oecd-ilibrary.org/docserver/9789264245891-5-en.pdf?expires=1588984432&id=id&

Osipow, S., and Fitzgerald, L. (1996). *Theories of Career Development*, *4th*. Boston, MA: Allyn and Bacon.

Peel, J. K., Schlachta, C. M., and Alkhamesi, N. A. (2018). A systematic review of the factors affecting choice of surgery as a career. *Can. J. Surg.* 61, 58–67. doi: 10.1503/cjs.008217

Potvin, P., Hasni, A., and Sy, O. (2017). Using inquiry-based interventions to improve secondary students' interest in science and technology. *Europ. J. Sci. Mathemat. Educ.* 5, 262–270. doi: 10.30935/scimath/9510

Potvin, P., Hasni, A., Ayotte-Beaudet, J. P., and Sy, O. (2020). Does Individual Interest Still Predict Achievement in Science and Technology When Controlling for Self-Concept? A Longitudinal Study Conducted in Canadian Schools. *Eurasia J. Mathemat. Sci. Technol. Educ.* 16:em1904. doi: 10.29333/ejmste/8938

Potvin, P., Hasni, A., Sy, O., and Riopel, M. (2020). Two Crucial Years of Science and Technology Schooling: A Longitudinal Study of the Major Influences on and Interactions Between Self-Concept, Interest, and the Intention to Pursue S&T. *Res. Sci. Educ.* 50, 1739–1761. doi: 10.1007/s11165-018-9751-6

Román-Graván, P., Hervás-Gómez, C., Martín-Padilla, A. H., and Fernández-Márquez, E. (2020). Perceptions about the use of educational robotics in the initial training of future teachers: a study on steam sustainability among female teachers. *Sustainability* 12:4154. doi: 10.3390/su12104154

Rose, A. J., and Smith, R. L. (2018). "Gender and peer relationships," in *Handbook of peer interactions, relationships, and groups*, eds. W. M. Bukowski, B. Laursen, and K. H. Rubin (The Guilford Press), 571–589.

Sadler, P. M., Sonnert, G., Hazari, Z., and Tai, R. (2012). Stability and volatility of STEM career interest in high school: a gender study. *Sci. Educ.* 96, 411–427. doi: 10.1002/sce.21007

Salmon, A. (2015). *A Complex Formula: Girls and Women in Science, Technology, Engineering and Mathematics in Asia*. UNESCO Bangkok.

Savickas, M. L., and Spokane, A. R. (1999). *Vocational Interests: Meaning, Measurement, and Counseling Use* Davies-Black Publishing.

Sputnik (2022). Is it necessary to divide the class between girls and boys for technology and physical education, answered the Ministry of Education. Available at: https://ru.sputnik.kz/20200913/delenie-klass-devochki-malchiki-trudi-miobrazovaniya-14941591.html

Syzdykbayeva, R. (2020). *Exploring Gender Equality in STEM Education and Careers in Kazakhstan* STEM Education for Girls and Women, 189.

Tekin, G., and Mustu, Ö. E. (2021). The effect of research-inquiry based activities on the academic achievement, attitudes, and scientific process skills of students in the seventh year science course. *Eur. Educ. Res.* 4, 109–131. doi: 10.31757/euer.416

Timothy, J. (2014). Career choice and academic performance of microbiology students in a Nigerian university. *Int. J. Sci. Technol. Educ. Res.* 5, 58–66. doi: 10.5897/IJSTER2013.0279

Toybazarova, N. A., and Nazarova, G. (2018). The modernization of education in Kazakhstan: trends, perspective and problems. *Bull. Natl. Acad. Sci. Repub. Kazakhstan* 6, 104–114. doi: 10.32014/2018.2518-1467.33

Tsakalerou, M., Perveen, A., Ayapbergenov, A., Rysbekova, A., and Bakytzhanuly, A. (2022). "Understanding the factors influencing Women's career trajectories in STEM education in Kazakhstan" in *Int. Conf. Gender Res.*, vol. 5, 230–239.

Tucker-Drob, E. M., Cheung, A. K., and Briley, D. A. (2014). Gross domestic product, science interest, and science achievement. *Psychol. Sci.* 25, 2047–2057. doi: 10.1177/0956797614548726

UNESCO, (2016). Institute for Statistics [internet]. *Women in Science*. Available at: http://www.uis.unesco.org/ScienceTechnology/Documents/fs34-2015-women%20in%20science-en.pdf

UNESCO, (2017). *Cracking the Code: Girls' and Women's Education in Science, Technology, Engineering and Mathematics (STEM)*. Paris, UNESCO.

Wang, M. T. (2012). Educational and career interests in math: a longitudinal examination of the links between classroom environment, motivational beliefs, and interests. *Dev. Psychol.* 48, 1643–1657. doi: 10.1037/a0027247

Whitelegg, L. (2001). Girls in science education. *Gende Sci. Read.* 373

Wiebe, E., Unfried, A., and Faber, M. (2018). The relationship of STEM attitudes and career interest. *EURASIA J. Math. Sci. Technol. Educ.* 14. doi: 10.29333/ejmste/92286

Yerdelen, S., Kahraman, N., and Yasemin, T. A. Ş. (2016). Low socioeconomic status students' STEM career interest in relation to gender, grade level, and STEM attitude. Journal of Turkish. *Sci. Educ.* 13, 59–74.