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Investigation of STEM Subject and Career Aspirations of Lower Secondary School Students in the North Calotte Region of Finland, Norway, and Russia

Päivi Tomperi [1,*], Mona Kvivesen [2,*], Saeed Manshadi [2], Stig Uteng [2], Yulia Shestova [3], Oleg Lyash [3], Irina Lazareva [3] and Asya Lyash [3]

1 Department of Education, University of Oulu, 90570 Oulu, Finland
2 Department of Education, Faculty of Humanities, Social Sciences and Education, UiT The Arctic University of Norway, 9019 Tromsø, Norway; saeed.d.manshadi@uit.no (S.M.); stig.uteng@uit.no (S.U.)
3 Department of Mathematics, Physics and IT, Murmansk Arctic State University, 96101 Rovaniemi, Finland; shestova.yulia@masu.edu.ru (Y.S.); lyash.oleg@masu.edu.ru (O.L.); lazareva.irina@masu.edu.ru (I.L.); lyash.asya@masu.edu.ru (A.L.)
* Correspondence: paivi.h.tomperi@oulu.fi (P.T.); mona.kvivesen@uit.no (M.K.)

Abstract: This study investigates the suitability of the STEM Career Interest Survey (STEM-CIS) to measure secondary school students' aspirations towards STEM subjects and careers. A confirmatory factor analysis (CFA) was conducted to assess the initial structural validity of the adapted STEM-CIS survey, where the science subscale was extended to four science disciplines, to align with the way science is taught in Finland and Russia. The results indicate that the interest in STEM subjects in general is not at a high level in any of the countries. There is a traditional gender gap regarding STEM subjects in every dimension, which favors females in biology and males in technology and engineering. STEM stereotypes among students—due to low exposure to STEM professions at school—can explain students' low interest despite high self-efficacies. Our study shows that we must increase informal learning opportunities inside and outside school and improve career counselling for students so that they will be more informed of STEM career opportunities.

Keywords: STEM education; social cognitive career theory; gender gap; instrument validation

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1. Introduction

The STEM Career Interest Survey (STEM-CIS) was created for researchers, professional developers, and evaluators in measuring STEM career interest and the impact of STEM programs on changes in students' interest in STEM subjects, majors, and careers [1]. In this adapted STEM-CIS, science was divided into four disciplines, i.e., biology, chemistry, geography, and physics, and it was used to investigate the interest in STEM subjects and careers of those students in the lower secondary schools who participated in the "Development of Common Approaches to Involve Youth into Science and the Technical Sphere—BeTech!" project, organized in the North Calotte region of Finland, Norway, and Russia. This article represents a continuation of the study, devoted to the attitudes of schoolchildren to learning natural sciences and mathematics in the three countries of the North Calotte region, that identified the main factors forming attitudes towards studying and learning these disciplines, as well as the degree of teachers' and parents' influence on the formation of these attitudes [2].

The modern economic development of countries all over the world requires a fairly large number of specialists in the field of STEM disciplines—natural sciences, technology, engineering, and mathematics [3]. At the same time, secondary school students in different countries have different career aspirations, but there are certain global trends. International research shows that there is a strong interest in STEM disciplines among primary school children, but it declines between the ages of 10 and 11 years. The attitudes of lower secondary school students depend on the environment in which they live and study [4,5]. Research in the sphere of STEM interests shows that there is a wide gap between students' interests in STEM education and their desire to make efforts in study-related disciplines [6].

Much of the research on the career aspirations of school students is based on social cognitive career theory (SCCT). These research papers explore interest in science, technology, engineering, and mathematics based on the complex interaction between goals, self-efficacy, and expected results [7–9]. These three variables start key mechanisms that enable people to pursue personal activities and influence their own professional development. In addition to these three variables, SCCT includes environmental variables that weaken or facilitate personal control over a career, such as support systems and obstacles encountered [10]. Among the variables used in the SCCT, self-efficacy has attracted most research attention. Self-efficacy is considered in different aspects. For example, psychologists in the US and South Korea conducted a study based on a personality-centered approach of the influence of mathematical self-efficacy on interests and intentions in the field of STEM [11]. The findings of the study showed the importance of self-efficacy in mathematics when choosing a major in STEM. Dutch researchers [12] showed empiric argumentation of self-efficacy belief influence on STEM abilities beliefs.

Some studies [13–15] have investigated the personal goals of upper secondary school students and their impact on the assessment of goals achievement and well-being, showing that females set more goals in the areas of study, relationships, and self-realization than males. A significant part of these goals is directed towards future careers among upper secondary school students.

The work of [16] presents the results of a study on the stereotyped beliefs about STEM professions and their impact on the expected outcome of a future career in STEM, these results are of great interest. Students' stereotypical beliefs about STEM careers (boring professions, withdrawn, low communication) negatively influenced their self-efficacy in STEM activities and their expectations of career-related outcomes. This effect is due to a lack of understanding of STEM professions. However, students with high self-efficacy in STEM activities and expectation of career-related outcomes showed interest in STEM careers [16].

Based on PISA data in 2006, Han [17] examined the relationship between two types of education systems (stratified and systematized) and professional expectations in two STEM subfields: computing and engineering (CE) and health services (HS). For the stratified education system, STEM professional expectations were the same for males and females within both subfields and were lower in healthcare. For the standardized education system, professional expectations for females were lower in healthcare, while they were the same for males in both subfields.

A separate task is to analyze the interaction of factors, both among themselves and the influence of external factors on them. In a study [18] conducted among Spanish schoolchildren, it was noted that beliefs about one's own effectiveness influence expectations and interest in the result. At the same time, external factors such as parental support and gender stereotypes do not directly affect expectations or interest in the result [18].

An analysis of responses to a survey of high school students in Israel [19] shows that STEM learning experiences are positively associated with students' interest in pursuing STEM studies in higher education institutions, as opposed to non-STEM domains. Moreover, taking advanced science courses at secondary school reduces (but does not overcome) the gender gap, and removes the impact of family background on student interest in STEM areas in the future [19].

Interesting results have been obtained by analyzing career aspirations and factors that influence them when comparing research results between different countries. For example, comparison between Korean and Indonesian students' career aspirations in science, technology, engineering, and mathematics showed that the relationship between country, gender, and educational level significantly influenced STEM career motivation [20].

Overall, Indonesian students were more motivated to pursue STEM careers than Korean students. Korean students showed greater gender differences in motivation for STEM careers than Indonesian students [20].

One study, based on two independent samples of students from Taiwan and the United States, focused on studying factors that predicted STEM career aspirations among various sociocultural groups [21]. The findings indicated greater gender differences in learning experience, parental involvement, and self-efficacy among students from a collectivist culture compared with students from an individualistic culture. Logistic analysis results showed an opposite prediction of STEM career aspirations in two different cultural contexts [21].

Gender differences influence motivation for STEM education. Most researchers agree with the existence of gender inequality in the fields of science, technology, engineering, and mathematics [22–28]. According to Master [26], a child's belonging to a gender group with negative STEM stereotypes leads them to doubt their own abilities and makes it difficult to develop interest in this area. These processes begin in preschool age and intensify later in their future [26]. An unambiguous reason for this emerging gap has not been determined yet. Delaney and Devereux [22] believe that this can be explained by the different choice of subjects and grades in high school. They also note that the gender gap is smaller among high-performing students and among students at more prestigious schools [22]. Interesting results were obtained in an experiment conducted in the United States: When participants were told that STEM demonstrates gender equality, gender differences in the perception of STEM careers disappeared [27]. Several studies have attempted to identify factors that contribute to the development of the gender gap in STEM, such as differences in lifestyles between men and women [23–28], support for shared goals [24], and access to appropriate role models and mentors [25].

Teoretical Framework and Research Questions

STEM-CIS is derived from the theoretical constructs of the social cognitive career theory (SCCT) [8,9,29]. SCCT focuses on factors that are estimated to influence the processes through which people develop academic and career interests, make and revise their educational and vocational plans, and succeed in their academic and career efforts. The SCCT framework includes three interrelated models of career development—interest, choice, and performance [8]. The interest model examines the ways self-efficacy and output expectations develop students' interest, and the choice model explores the ways interest, self-efficacy, and output expectations influence choice goals, which then motivate choice actions [29].

In the SCCT, self-efficacy is constructed as a dynamic set of self-beliefs connected to particular performance domains (e.g., physics) and activities. The beliefs are subject to change and are receptive to environmental conditions, i.e., success experiences tend to raise self-efficacy, and repeated failures tend to lower self-efficacy [29].

Outcome expectations refer to beliefs about the consequences of a particular conduct. Whereas self-efficacy beliefs deal with an individual's capabilities, outcome expectations involve imagined outcomes of particular practices, e.g., "If I make an effort of doing this, what will happen?". A student can hold positive outcome expectations but avoids a choice or action if their self-efficacy in relation to a task or domain is low. It can also be the opposite, such that, e.g., a student is confident with their capabilities in math but avoids advanced study in math because of negative expectations of responses from their peers [29].

Personal goals refer to an individual's intention to engage in a particular activity or to produce a particular outcome [30]. SCCT distinguishes between choice goals (the type of career a student wants to pursue) and performance goals (the quality of performance a student plans to achieve within a given task) [29].

According to SCCT model, personal inputs, such as gender and grade, and background, such as family and school, influence individuals' learning experiences, which in turn affect their self-efficacy and outcome expectations. Contextual factors which are influenced by personal inputs also affect interest, goals, and actions. Guided by SCCT, the

STEM-CIS is developed to measure the six key constructs, or dimensions, of self-efficacy, personal goals, expectation of results, interest, contextual support, and individual inputs [1]. The research questions are outlined as follows:

1. Which STEM subjects do students from the participating schools have interest in?
2. Do the dimensions of the STEM-CIS indicate students' orientation towards certain STEM discipline as their future career?
3. Are there gender differences in the students' orientations towards certain STEM disciplines as their future careers?
4. Does the pilot version of the STEM-CIS possess adequate reliability and factorial validity?

2. Materials and Methods

There are three instruments which consider all STEM subjects (science, technology, engineering, and mathematics) and utilize the SCCT framework, namely the STEM-CIS [1], S-STEM [31], and SIC-STEM [32]. The STEM-CIS survey, developed by Kier et al. [1], was adapted for this study to investigate the interest in STEM subjects and careers of the students in the lower secondary schools that participated in the project in the three countries. STEM-CIS was chosen because it included both engineering and technology domains. Table 1 shows the demographic distributions of the students who answered the questionnaire. The extended STEM-CIS was set online, where students could access it by mobile, tablet, or computer in April 2021 during two weeks under the supervision of their teachers.

Table 1. Demographic distribution and exposure to STEM activities of students (n = 700) participating in the survey.

	Finland	Norway	Russia
Number of students	108	273	319
Males	49	129	129
Females	56	144	190
Unspecified gender	3	–	–
Age of students:			
13 years old	5%	18%	14%
14 years old	38%	36%	26%
15 years old	44%	36%	40%
16 years old	13%	10%	20%
Have you participated in any event where you received practical information about STEM careers?			
Yes, often	4%	9%	4%
Yes, once or twice	13%	36%	12%
Never	83%	52%	84%
Has an engineer/scientist/mathematician visited your class, or have you visited any workplace where they work?			
Yes, often	3%	11%	11%
Yes, once or twice	22%	41%	37%
Never	75%	48%	52%

A descriptive survey model was used as a quantitative research method. Data was analyzed on the IBM SPSS Statistics 27 package. The value of 0.05 was the significant level in interpreting the results. The data did not have a normal distribution (kurtosis and skewness values; Kolmogorov–Smirnov < 0.05); therefore, non-parametric tests were used in the analysis of data. The Kruskal–Wallis H test was used in testing STEM-CIS scores (mean rank values) between Finland, Norway, and Russia. The Mann–Whitney U test was used in analyzing the STEM-CIS scores according to gender. The original STEM-CIS [1] consists of 44 items and four subscales (science, mathematics, technology, engineering), but because science at schools in Finland and Russia is taught as separate disciplines, here the survey consisted of 77 items and 7 subscales (biology (B), chemistry (C), geography (G), physics (P), mathematics (M), technology (T), and engineering (E)). Each discipline-specific subscale contained 11 items that address 6 social cognitive career dimensions: self-efficacy (items 1–2), personal goals (items 3–4), outcome expectations (items 5–6), interests (items 7–8), contextual supports (items 9 and 11), and personal inputs (item 10). The scoring was carried out with a 5-point Likert scale, with response options ranging from "strongly disagree" (1) to "strongly agree" (5). Higher scores reflected the greater perceived value of the subject. The overall reliability value α was 0.97 (n = 77).

A series of confirmatory factor analyses (CFA) using the Lavaan [33] and SemPlot [34] packages for R [35] was conducted to assess the structural validity of the adapted STEM-CIS survey. We chose a robust maximum likelihood parameter estimation method because of the non-normally distributed dataset. There were difficulties in fitting this model, but by removing the geography items, we obtained the model that involved six dimensions, see Figure 1. There was a discussion beforehand concerning the geography subscale in the survey: In Finland and Russia, geography would self-evidently be a natural science, while in Norway, it is considered more as a social science. The fit of this model was evaluated using standard fit indices (chi-square, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR)). The non-significant chi-square test statistic, CFI of 0.90 or greater, TLI of 0.90 or greater, RMSEA of 0.08 or lower, and SRMR of 0.08 or lower each reflect an adequate model fit [36]. In our model, the chi-square statistic was significant with a value of 1939.7. However, this statistic tends to be significant with many respondents [37]. Therefore, it is not that important in this study. Furthermore, the CFI was 0.981, the TLI was 0.975, the RMSEA 0.034, and the SRMR 0.055. Thus, a rather good fit was confirmed.

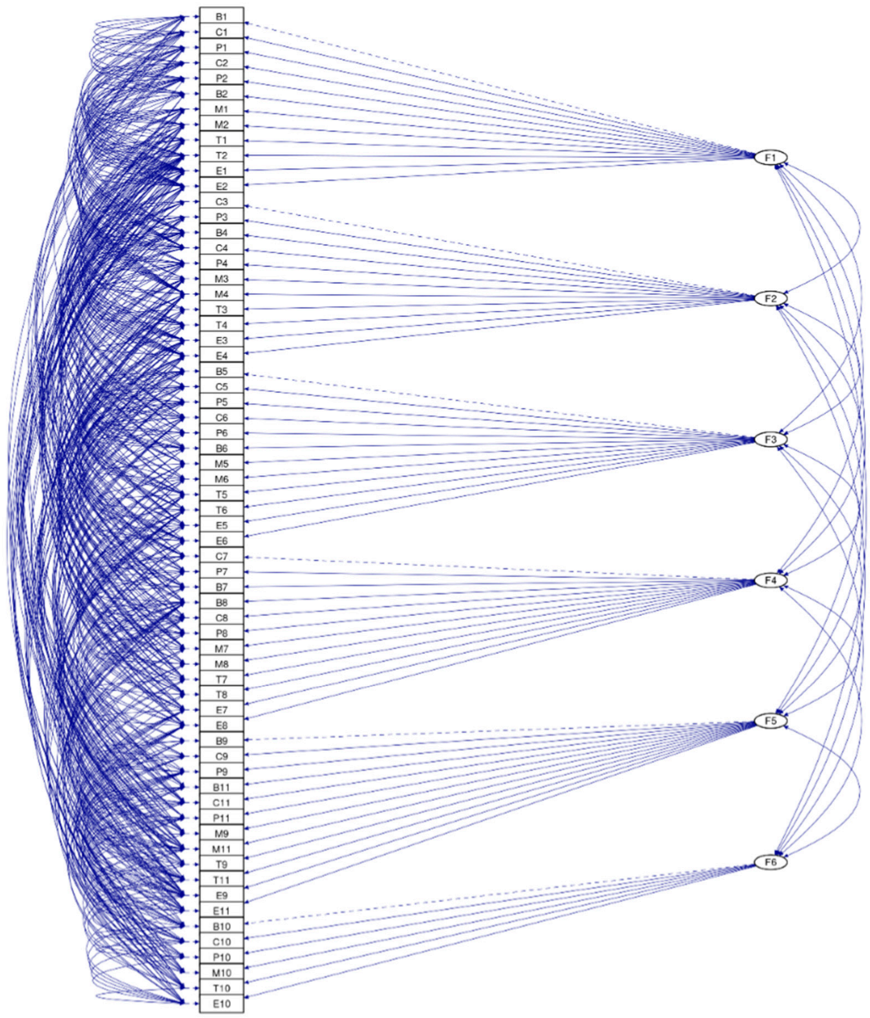

Figure 1. CFA fit of the six-dimension mode.

3. Results

The interest in STEM subjects in general was approximately at a medium level (300 < mean rank value < 400) in all 3 countries (Table 2). The interest among Norwegian students is lower than that of Finnish and Russian students, and the difference is statistically significant. Russian students showed more interest in all STEM subjects compared with Finnish and Norwegian students, except in chemistry, in which Finnish students were the most interested. Finnish students' mean rank values were located mainly between the ones of Russian and Norwegian students. Students from Finland and Russia were equally interested in physics and mathematics, and students from Norway and Finland were less interested in technology than students from Russia. Norwegian students were the most interested in engineering. Females had a higher interest in biology than males, while males had a higher interest in physics, mathematics, technology, and engineering compared with females (Table 3).

Table 2. Kruskal–Wallis test results of interest (items 7–8) by country, $n = 700$, df = 2.

Country (N)	Test Statistics	B $\alpha = 0.68$	C $\alpha = 0.67$	G $\alpha = 0.70$	P $\alpha = 0.73$	M $\alpha = 0.72$	T $\alpha = 0.79$	E $\alpha = 0.87$	Total $\alpha = 0.86$
NOR (273)	Mean rank	312.72	328.72	324.90	300.61	300.32	299.99	348.48	296.65
FIN (108)		340.95	419.93	343.31	374.54	382.06	331.31	324.80	364.61
RUS (319)		386.06	345.63	374.84	385.06	382.76	400.22	360.93	391.81
	χ^2	20.310	16.520	9.454	28.144	28.154	38.791	2.848	33.249
	p	0.000	0.000	0.009	0.000	0.000	0.000	0.241	0.000
	η^2	0.029	0.024	0.014	0.040	0.040	0.055	-	0.048
	Mean	2.910	2.882	2.813	3.099	3.036	3.347	2.921	3.001
	SD	1.013	1.041	0.987	1.079	1.085	1.018	0.997	0.698

Table 3. Mann–Whitney U test results for interest with statistically significant differences between genders.

Subject	Mean (SD) Males $n = 307$	Mean (SD) Females $n = 385$	Mann–Whitney U	$-Z$	Asymp. Sig.	Effect Size r^2
Biology	2.80 (1.03)	3.01 (0.98)	53,863.500	2.038	0.021	0.006
Physics	3.28 (1.14)	2.97 (0.98)	47,767.500	4.391	0.000	0.028
Mathematics	3.15 (1.08)	2.96 (1.07)	53,316.000	2.236	0.013	0.007
Technology	3.57 (1.06)	3.17 (0.95)	46,131.500	5.061	0.000	0.037
Engineering	3.10 (0.99)	2.79 (0.96)	48,744.500	4.136	0.000	0.025

There were statistically significant differences between Norwegian, Finnish, and Russian students in self-efficacy (Table 4). Finnish students had high self-efficacy in science and mathematics, showing the highest self-efficacy in chemistry, and they also showed high interest in chemistry, while for the other disciplines they showed only medium interest (Table 2). Russian students had high self-efficacy in geography and technology, for which they also showed interest. Norwegian students had low or medium self-efficacy in STEM subjects, and they showed low interest in them, except for engineering, where they showed medium interest. Females had higher self-efficacy in biology than males, while males had higher self-efficacies in physics, technology, and engineering compared with females (Table 5).

In the personal goals dimension, there was a statistically significant difference between Finland and the other two countries in STEM subjects overall (Table 6). Finnish students had the highest mean rank values for science and mathematics, and Russian students had the highest mean rank values for technology and engineering. Finnish students seemed to have more personal goals for chemistry compared with Norwegian and Russian students, and fewer goals for engineering; however, the difference in the latter was not statistically significant. Again, females had higher personal goals for biology, while males had higher personal goals for physics, mathematics, technology, and engineering (Table 7).

Table 4. Kruskal–Wallis test results of self-efficacy (items 1–2) by country, n = 700, df = 2.

Country (N)	Test Statistics	B α = 0.73	C α = 0.83	G α = 0.77	P α = 0.75	M α = 0.82	T α = 0.81	E α= 0.92	Total α = 0.89
NOR (273)	Meanrank	268.43	332.47	246.57	302.21	312.72	264.69	335.95	275.16
FIN (108)		474.76	513.18	456.02	469.47	447.31	326.63	366.81	470.34
RUS (319)		378.67	310.86	403.72	351.55	350.06	432.02	357.43	374.40
	χ^2	95.321	86.540	127.963	54.877	35.335	105.731	2.697	80.392
	p	0.000	0.000	0.000	0.000	0.000	0.000	0.260	0.000
	η^2	0.136	0.124	0.183	0.079	0.051	0.151	-	0.115
	Mean	3.724	3.413	3.813	3.632	3.549	3.587	3.119	3.548
	SD	0.902	1.07	0.907	0.938	1.015	1.029	0.966	0.678

Table 5. Mann–Whitney U test for self-efficacy with statistically significant differences between genders.

Subject	Mean (SD) Males n = 307	Mean (SD) Females n = 385	Mann–Whitney U	−Z	Asymp. Sig.	Effect Size r^2
Biology	3.67 (0.92)	3.78 (0.86)	54,636.000	1.739	0.041	0.004
Physics	3.74 (0.92)	3.55 (0.93)	51,831.000	2.832	0.003	0.012
Technology	3.73 (1.10)	3.48 (0.96)	49,010.500	3.921	0.000	0.022
Engineering	3.26 (0.98)	3.02 (0.93)	50,853.000	3.287	0.001	0.016

Table 6. Kruskal–Wallis test results of personal goals (items 3–4) by country, n = 700, df = 2.

Country (N)	Test Statistics	B α = 0.64	C α = 0.60	G α = 0.61	P α = 0.69	M α = 0.69	T α = 0.82	E α= 0.85	Total α = 0.86
NOR (273)	Meanrank	361.65	375.32	359.01	329.55	293.41	282.70	349.12	324.86
FIN (108)		383.62	433.47	409.91	395.38	426.42	371.90	312.09	407.19
RUS (319)		329.74	301.17	323.10	353.23	373.55	401.28	364.68	353.25
	χ^2	7.319	42.450	16.202	8.523	42.267	54.188	5.922	12.956
	p	0.026	0.000	0.000	0.014	0.000	0.000	0.052	0.002
	η^2	0.010	0.061	0.023	0.012	0.060	0.078	-	0.019
	Mean	2.863	2.819	2.845	3.115	3.461	3.393	2.971	3.067
	SD	0.966	0.973	0.923	1.01	0.977	1.01	0.971	0.654

Table 7. Mann–Whitney U test for personal goals with statistically significant differences between genders.

Subject	Mean (SD) Males n = 307	Mean (SD) Females n = 385	Mann–Whitney U	−Z	Asymp. Sig.	Effect Size r^2
Biology	2.77 (0.96)	2.95 (0.95)	53,893.000	2.025	0.022	0.006
Physics	3.31 (1.05)	2.97 (0.93)	46,823.000	4.760	0.000	0.033
Mathematics	3.55 (1.00)	3.41 (0.95)	53,691.500	2.097	0.018	0.006
Technology	3.62 (1.05)	3.22 (0.94)	45,312.000	5.386	0.000	0.042
Engineering	3.14 (0.98)	2.85 (0.94)	48,217.000	4.334	0.000	0.027

In the expectation of results dimension, Finland again had the highest mean rank values in science and mathematics and, in total, the difference was statistically significant compared with those of Norway and Russia, which were very close to one another (Table 8). Differences were statistically significant between the three countries again in chemistry. Females had higher expectations of results for biology compared with males, while males had higher expectations of results for physics, technology, and engineering than females (Table 9).

Table 8. Kruskal–Wallis test results for expectation of results (items 5–6) by country, n = 700, df = 2.

Country (N)	Test Statistics	B α = 0.73	C α = 0.76	G α = 0.72	P α = 0.76	M α = 0.73	T α = 0.80	E α = 0.82	Total α = 0.88
NOR (273)	Mean rank	371.80	366.03	387.84	344.06	334.27	277.49	330.68	341.04
FIN (108)		398.95	435.86	425.63	415.68	420.70	372.84	373.81	425.42
RUS (319)		315.87	308.32	273.11	333.94	340.63	405.42	359.57	333.23
	χ^2	19.160	35.857	51.672	14.011	15.969	63.291	5.022	17.781
	p	0.000	0.000	0.000	0.001	0.000	0.000	0.081	0.000
	η^2	0.027	0.051	0.074	0.020	0.023	0.091	-	0.025
	Mean	2.835	2.841	2.707	3.009	3.356	3.380	3.126	3.036
	SD	1.027	1.042	0.943	1.056	1.028	0.979	0.987	0.695

Table 9. Mann–Whitney U test for expectation of results with statistically significant differences between genders.

Subject	Mean (SD) Males n = 307	Mean (SD) Females n = 385	Mann–Whitney U	−Z	Asymp. Sig.	Effect Size r^2
Biology	2.68 (1.04)	2.97 (0.99)	49,887.000	3.580	0.000	0.019
Physics	3.18 (1.13)	2.89 (0.97)	48,740.000	4.019	0.000	0.023
Technology	3.52 (1.04)	3.26 (0.91)	49,481.500	3.768	0.000	0.021
Engineering	3.27 (0.98)	3.02 (0.96)	51,452.000	3.027	0.001	0.013

The fifth dimension, contextual support, showed no significant statistical differences between the countries on average (Table 10). Students showed medium contextual support, i.e., the existence of role models or family members working in the STEM field was similar in all three countries. Norway had the highest contextual support mean rank value for geography, yet students did not show any particular interest in it. Females had higher contextual support in biology and chemistry, and males had higher contextual support in technology and engineering (Table 11).

Table 10. Kruskal–Wallis test results of contextual support (items 9 and 11) by country, n = 700, df = 2.

Country (N)	Test Statistics	B α = 0.50	C α = 0.50	G α = 0.59	P α = 0.60	M α = 0.60	T α = 0.64	E α = 0.71	Total α = 0.87
NOR (273)	Mean rank	360.86	364.55	377.42	334.06	323.50	313.43	339.63	344.78
FIN (108)		356.66	367.60	343.19	346.02	359.31	340.03	340.09	350.41
RUS (319)		339.55	332.69	328.25	366.08	370.63	385.77	363.33	355.18
	$\chi2$	1.814	4.715	8.991	3.860	8.440	20.158	2.486	1.019
	p	0.404	0.095	0.011	0.0145	0.015	0.000	0.288	0.601
	$\eta2$	-	-	0.013	-	0.012	0.029	-	-
	Mean	2.529	2.493	2.442	2.752	2.914	3.006	2.878	2.716
	SD	0.994	0.989	0.984	1.084	1.097	1.033	1.041	0.751

Table 11. Mann–Whitney U test for contextual support with statistically significant differences between genders.

Subject	Mean (SD) Males n = 307	Mean (SD) Females n = 385	Mann–Whitney U	−Z	Asymp. Sig.	Effect Size r^2
Biology	2.38 (1.19)	2.65 (0.96)	49,531.500	3.725	0.000	0.020
Chemistry	2.41 (1.02)	2.57 (0.95)	53,704.000	2.098	0.018	0.006
Technology	3.15 (1.08)	2.89 (0.98)	50,679.500	3.303	0.001	0.016
Engineering	2.99 (1.05)	2.79 (1.02)	52,595.500	2.556	0.006	0.009

In the dimension of individual inputs, there were statistically significant differences between the three countries in biology, geography, and mathematics. Russian students had the highest mean rank values and Finland had the lowest (Table 12). Finnish students had particularly low mean rank values for all STEM subjects in the individual inputs dimension, except chemistry, for which they had medium values. Russian students were shown to feel the most comfortable talking to people who work in STEM fields. Again, females would have more individual inputs in biology and geography, while males would have more individual inputs in technology and engineering (Table 13).

Table 12. Kruskal–Wallis test results of individual inputs (item 10) by country, n = 700, df = 2.

Country (N)	Test Statistics	Biol	Chem	Geo	Phys	Math	Tech	Eng	Total α = 0.88
NOR (273)	Mean rank	329.53	329.50	326.94	310.09	337.56	302.90	328.75	311.86
FIN (108)		269.81	320.28	270.31	288.32	249.68	255.30	288.69	247.38
RUS (319)		395.76	378.70	397.81	406.13	395.71	423.47	390.04	418.48
	χ^2	39.293	12.681	41.674	49.058	47.200	87.855	28.182	74.611
	p	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
	η^2	0.056	0.018	0.060	0.070	0.068	0.126	0.040	0.107
	Mean	3.00	3.00	3.00	3.20	3.10	3.30	3.10	3.096
	SD	1.16	1.13	1.14	1.17	1.21	1.13	1.11	0.881

Table 13. Mann–Whitney U test for individual inputs with statistically significant differences between genders.

Subject	Mean (SD) Males n = 307	Mean (SD) Females n = 385	Mann–Whitney U	−Z	Asymp. Sig.	Effect Size r^2
Biology	2.84 (1.17)	3.19 (1.13)	49,413.500	3.867	0.000	0.022
Geography	2.90 (1.18)	3.09 (1.11)	54,212.500	1.955	0.026	0.006
Technology	3.47 (1.15)	3.10 (1.08)	47,787.000	4.521	0.000	0.030
Engineering	3.23 (1.11)	3.01 (1.09)	52,778.500	2.549	0.006	0.009

In general, Finland had high mean rank values (over 400) for self-efficacy, personal goals, and expectation of results, but the mean rank values collapse when entering the interest, contextual support, and individual inputs dimensions. Russia had a mean rank value over 400 in the individual input dimension. Norway had mean rank values below 300 in the dimensions of self-efficacy and interest, and Finland had mean rank values below 300 in the dimension of individual inputs. It is also noticeable that there were gender differences in biology, technology, and engineering in each dimension. Females and males estimated their skills in STEM subjects to be very similar; only in ICT was the difference between genders statistically significant in favor of the males (Table 14).

To determine internal consistency, Cronbach's coefficient α was calculated for the six STEM-CIS dimensions and for the subscales in each dimension, except for the individual inputs dimension, which constitutes only one item. For the dimensions, Cronbach's α varied from 0.86 to 0.89. Kier et al. [1] reported that the Cronbach's alpha of the STEM-CIS ranged from 0.77 to 0.89 for the subscales. In this study, Cronbach's α ranged from 0.50 to 0.92. The dimensions self-efficacy (Table 4) and expectation of results (Table 8) yielded acceptable reliability coefficients for all 7 subscales, but in the personal goals dimension, the subscales α varied from 0.60 to 0.85 (Table 6), and in the dimension of contextual support, both biology and chemistry yielded the least satisfactory Cronbach' coefficient value of 0.50 (Table 10).

Table 14. Self-evaluation of skills in school subjects in the range 1–6 (1 = the highest level of skills and 6 = the lowest level of skills) between males and females.

Subject	Sex	Mean	SD	SE	Kruskal–Wallis H Test
Biology	Males Females	3.22 3.33	1.22 1.20	0.07 0.06	$\chi^2 = 1.039$ $p = 0.595$
Chemistry	Males Females	3.44 3.50	1.50 1.51	0.09 0.08	$\chi^2 = 0.631$ $p = 0.730$
Geography	Males Females	3.21 3.20	1.35 1.37	0.08 0.07	$\chi^2 = 0.643$ $p = 0.725$
Physics	Males Females	3.25 3.35	1.48 1.39	0.08 0.07	$\chi^2 = 1.327$ $p = 0.515$
Mathematics	Males Females	3.25 3.19	1.49 1.42	0.09 0.07	$\chi^2 = 0.409$ $p = 0.815$
ICT	Males Females	2.97 3.47	1.57 1.39	0.09 0.07	$\chi^2 = 20.645$ $p = 0.000$ $\eta^2 = 0.030$

4. Discussion

According to SCCT, self-efficacy affects outcome expectations, and together they influence interests. Students are likely to develop interest, choose to pursue subjects of interest, and—as a result—perform better in activities in subjects in which they have a stronger self-efficacy [8,9]. According to Table 2, interest in STEM subjects in the three countries was very similar despite different self-efficacies: Among Norwegian students, the interest was at a medium level in all seven STEM subjects, even though students reported low self-efficacies in biology, geography, and technology; Finnish students showed medium-level interest in all subjects except chemistry, even though they had high self-efficacies in all four science disciplines and mathematics; finally, Russian students showed medium-level interest in all STEM subjects except technology, for which they had a high self-efficacy, together with geography.

Self-efficacy is seen as an important source of outcome expectations, because students are more likely to expect favourable outcomes when performing activities at which they feel strong. By calculation of the correlations, we found that all the dimensions were almost evenly correlated. However, high self-efficacy and outcome expectations in chemistry, geography, and mathematics among Finnish students seemed to motivate personal goals as well. Additionally, the high self-efficacy among Russian students in technology relates to high outcome expectations and personal goals in that subject; however, on the other hand, for some reason they believe that engagement in geography will not lead to a valued outcome, because high self-efficacy in geography is connected to low outcome expectations and medium personal goals.

Individual inputs were mainly at a medium level among Russian and Norwegian students; additionally, Russian students showed high individual inputs values in physics and technology. Finnish students showed low individual input values in all STEM subjects except chemistry, in which they showed medium values. This could be explained by the finding that 83% of Finnish students had not participated in any event where they received practical information about STEM careers, and 75% of them had not had an engineer, scientist, or mathematician visit their class, and they had not visited any workplace where STEM experts work (Table 1). It seems that Finnish students are much less exposed to experts working in the STEM fields outside school in informal settings. These percentages also include those students who had participated in the then ongoing BeTech! project activities. When students have little knowledge regarding STEM professionals, they are more inclined to hold stereotypes that have a negative influence on their STEM career interest [4,36]. According to Luo et al. [16], elementary students' stereotypical beliefs regarding STEM careers negatively predicted their self-efficacy in STEM activities and career aspirations. Perceptions of people in science careers as "clever", "geeky", or "not nurturing" prevented females at upper elementary school from aspiring to science careers [4]. DeWitt and Archer [38] argue that elementary students enjoy science classes, but they do not aspire to become scientists. Children maintaining science aspirations over time can be mediated by their parents' science capital (parents with science degrees and/or working in science jobs) because, in such families, science aspirations are expressed more strongly [38]. According to Table 10, contextual support, referring to role models or family members in STEM field, was not experienced significantly by students in any of the three countries.

In each dimension, there is a persistent traditional gender gap in biology, technology, and engineering. When students estimated their skills in science and ICT (information communication technology), there was a statistically significant difference between sexes only in ICT in favour of males (Table 14). Many programs have sought to promote females' engagement in STEM fields but, so far, their effects have remained low. STEM fields are not identical; in science and mathematics, there is near equality in gender representation, but in computer science and engineering, women's representation is significantly lower. According to Master and Meltzoff [39], STEM gender stereotypes contribute to the underrepresentation of women in STEM fields, such that women worry that they do not fit the image of a STEM person, and they believe that they do not have the ability to succeed in STEM. They suggest that social factors, such as stereotypes and self-representations surrounding "belonging", are powerful contributors to the observed gender differences in STEM interest [39]. To overcome this, we must increase informal learning opportunities outside school for students so that they can explore the fascinating—for them unknown—world of STEM professions, and personally meet people having chosen careers in those professions.

A limitation of the STEM-CIS instrument is that it is designed with only one or two items per construct, which is detrimental to the instrument's reliability. While the instrument could be improved at the item and subscale levels, the Cronbach's alpha values were at 0.86 or above for all six constructs. The reliability coefficients of the geography (G) subscales were in line with the other science subscales, yet its items had to be removed in the CFA. This needs to be studied in more detail. Additionally, the sample size of students in Finland was lower than that in other countries.

In the future, the large number of subscales could be reduced by combining the four science subscales into two. In Finland, for example, science teachers usually teach two subjects, either the combination of biology and geography or the combination of chemistry and physics. These two combinations could form the two subscales of science. It is justified to assume that there are differences in skills, beliefs, and attitudes toward biology and physics among students in general—not only between genders. For this purpose, using only one science subscale would be confusing in Finland and Russia, where students are used to studying four different science disciplines. Additionally, the subscales of technology and engineering could form one subscale together, as they already do in the SIC-STEM instrument [32].

5. Conclusions

The adapted STEM-CIS demonstrated satisfactory levels of reliability and validity in the dimensions and in the most subscales. Poor fit was expected in this pilot study using combined data, so it needs further study in each individual country with its own sample of students as the next phase of research. After all, the instrument is promising and can provide schools with data that can help in understanding their students' interests and choices surrounding STEM.

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