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Reoccurring science identities:

Swedish secondary students' interest in science and technology compared 2003 and 2020

Abstract

This paper examines Swedish secondary students' interest in science and technology from a gender perspective in a comparative research design using quantitative data collected 2003 and 2020. National data has been collected from 610 15-year-old students in 2020 as part of a large-scale comparative research project, the Relevance of Science Education - Second (ROSES) and compared with data from the Relevance of Science Education (ROSE) study from 2003. The results empirically update the research field and show a reoccurring interest pattern with minor changes. Content related to space and unexplained phenomena are still ranked as interesting to learn about. Girls are interested in health issues and the human body, space, dreams and the human soul. Boys favour items about space, inventions and discoveries together with ABC weapons. Minor developments are that interest in learning about diets and exercise as well as technology has declined. The least interesting things to learn are almost the same as in 2003, with

several topics connected to the national science curriculum. The character of students' interest in S&T is framed and discussed using the theoretical approach of science identity. The stable character with minor changes is discussed as reoccurring science identities interpreted by the differentiation hypothesis of the "person-object theory of interest". Gender differences are interpreted as collective identities shown to be 'domain specific' not 'subject specific' and the content level of analysis provide specificity to 'interest patterns' which has not been well described earlier in the research literature. Research consequences of this conceptualization and implications for school practice is critically discussed. A research implication from this conceptualization is the importance for future studies to investigate varieties of collective identities.

INTRODUCTION

There is a long-standing internationally reported body of literature concerning students' low interest in and perceived lack of relevance of school science and technology (S&T) education (Anderhag et al., 2016; Jenkins, 2006; Oskarsson, 2012; Stuckey et al., 2013). Many students' reluctance to study S&T is important because it negatively influences their learning and thereby the possibility of reaching educational goals (Bruun Nicolaisen et al., 2023; Drymiotou et al., 2021; Gubo & Schiffl, 2022; Potvin & Hasni, 2014; Sjøberg & Schreiner, 2019; Sokolowska et al., 2014). It is therefore important to follow and empirically investigate possible developments. In an early review of students' interest in S&T, Gardner (1975) presented significant differences between boys' and girls' interest. Dawson (2000) concluded that there seems to be a stability in students' interest since not much had changed between 1980 and 2000. During this period, Ramsden (1998) delivered a similar message, associating the slogan "mission impossible" with attempts around the world to change the situation. This intriguing state of affairs can be followed in early 2000 both in policy and research (European Commission 2004, 2007; Hill et al., 2010; OECD, 2008; Osborne & Dillon, 2008; Tytler, 2007). In the Swedish context, the problem has been informed by several reports with a wish to change the situation (Nordic Council of Ministers 2021; Royal Swedish Academy of Engineering Sciences, 2023a; b). The fact that there seems to be stability in students' relationships with S&T is an empirically grounded finding. This has inspired research to search for explanations by looking at the situation through the lens of identity. This theoretical development is followed in the study presented here and is the main reason why the field today is concerned with gaining a deeper understanding of students' science identities.

Although students' lack of interest in S&T seems to be reproduced over time, minor changes have been identified. Secondary analyses of PISA data (Oskarsson et al., 2018) show an increase in students' enjoyment in learning S&T among the Nordic countries between 2006 and 2015. Given the numerous societal developments related to S&T, such as climate change, smart phones, and the exploration of the universe, one could expect such circumstances to cause significant transformation of experiences (see for example Jenkins & Nelson, 2005) which subsequently would change students' relationships with S&T, e.g., their science identities. Bellová et al., (2021) point in the same direction by showing that such developments would also influence science teaching and learning. Earlier Swedish reports by Jidesjö et al. (2009) showed students to be interested in certain S&T topics, e.g., body and health issues, diseases, space, new inventions, and things that we cannot explain. The least popular things to learn about were shown to be about S&T in everyday life, for example, how musical instruments produce sounds or how different foods are produced, conserved, and stored, in addition to traditional science facts such as atoms or optics. In some areas, interest is shared by both boys and girls, e.g., body and health together with space exploration, but significant differences are also described: "Girls are oriented towards health issues and the body, why we dream, diseases, drugs, abortion, eating disorders, and occultism. Boys are oriented towards space, bombs, explosive chemicals, weapons, and new technology. (Jidesjö et al., 2009, p. 223)"

In the search for explanations, another study by Oscarsson et al. (2009) explored the possibility of a correlation between the instruction provided by S&T teachers in school and the students' level of interest. The study showed both students and their teachers to be positive about S&T in general, but that many of the things commonly taught by teachers were ranked low by their students while items ranked high by the students were not taught much. These results indicated a clash between S&T in and outside school which is also pointed out by Jenkins & Nelson (2005) as important to understand the situation.

The purpose of this paper is to empirically investigate and report Swedish secondary students' interest in S&T education. A comparative and detailed content level of analysis is performed from a gender perspective and framed by the theoretical approach of science identity to interpret the results. The work is guided by the following research question: From a gender perspective, what similarities and differences can be identified based on analysis of what S&T content students want to learn about in comparison between 2003 and 2020?

Students' interest in S&T seen through the lens of identity

The many comparative studies of students' interest in S&T (see for example Dawson, 2000; Jidesjö et al., 2009; Prieto-Rodriguez et al., 2020; Schreiner & Sjøberg, 2019) have made gender comparison between boys and girls almost standard when reporting results which is therefore used in present study. In the review by Osborne et al. (2003) it was pointed out that deeper and more detailed studies of students' interest in S&T are needed to take the research field further. Consequently, several studies contributed to the field in early 2000 (Jidesjö et al., 2009; Schreiner, 2005). In parallel, the science identity literature grew. Potvin & Hasni (2014) show identity to be more commonly used in attitudinal studies and Krapp & Prenzel (2011) point out that large scale quantitative research studies can investigate weather students' interest in S&T is "subject specific" (i.e. biology but not physics) or "domain specific" (i.e. various themes and content from different subjects). To investigate "interest patterns" created by people's identity development a detailed content level of analysis is needed to characterize possible domain specificity which is accomplished in present study from a gender perspective.

The concept "students' interest" has been viewed from several different angles. Krapp and Prenzel (2011) found the "person-object theory of interest" to be commonly used. In this approach, interest is seen as having an intrinsic character, i.e. its "self-intentionality", which means that a person has his or her own, internal motivation to gain increased knowledge of something. This "something" has another character and relationship with the individual, it is content or domain specific. A person critically evaluates activities to construct "interest patterns". An individual is not generally interested but the interest is: "directed towards an object, activity, field of knowledge, or goal" (Krapp & Prenzel, 2011, p. 30).

In this view, the internal dimension of interest is not only about what one would like to learn, but also about who I am and who I want to be. Students' interest in S&T is seen as developmental, i.e. identity based and evolves out of relationships between persons and objects where gender have been shown to be one important marker. In addition, a person's interest depends on previous experiences and which group of people an individual identifies with (Oskarsson, 2012; Schreiner, 2005). This implies that students' interest and commitment to learn has an interconnected character and is influenced by both internal and external dimensions. It is something that is developed in dialectical interplay in a social and cultural environment where different identities of young people are formed. Krapp & Prenzel (2011) describes this as the differentiation hypothesis of students' interest in S&T. When people grow up and search for identity, they cannot be interested in everything. They become selective and critically evaluate if abilities and interests are compatible with their self-concept. Hence, content will become included or excluded to create interest patterns which are perceived as personally important and relevant. The authors point out such patterns in S&T to be poorly described in the research literature.

Interest in this sense is seen as something individual but can group together to form collective identities. Gender, social class, and ethnicity are markers in the creation of collective identities. Students' interest in S&T can be investigated to identify such groupings, as was done by Oskarsson (2012) and

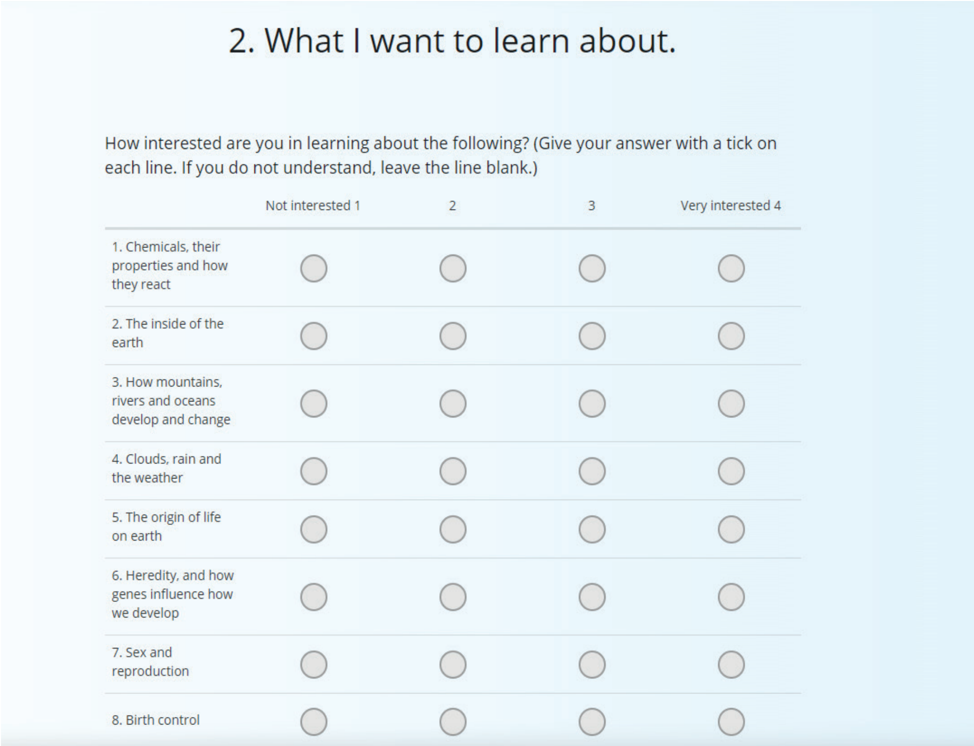
Schreiner (2005). Interest *is seen as* an identity. Yep (2016) explains it further as something that should be conceived as a social construction whose meanings are derived from cultural, historical, and geopolitical contexts. They give people a sense of "being", a lens through which they relate to a social world, which also creates a set of guidelines for ways of acting. Thus, both individual and collective identities are central to human interaction and as Hosek and Soliz (2016) point out, if we are to understand them more fully it is necessary to incorporate them in research, which is done in present study.

MATERIAL AND METHODS

The material reported in this study is part of a large-scale international research project coordinated in Sweden, called the Relevance of Science Education Second (ROSES) which builds on The Relevance of Science Education (ROSE) project. The ROSE study was developed collaboratively at the beginning of 2000 by researchers in several countries under the leadership of professor Svein Sjøberg at Oslo University in Norway. All the Nordic countries, along with over 40 nations from different continents, participated. Hence, there is a Nordic tradition of active participation in this research field. The background of the ROSE project and the key findings are well described in Schreiner & Sjøberg (2019) and Sjøberg & Schreiner (2019). Their work indicates that modernity has a substantial influence on students' interest in and attitudes towards S&T, suggesting that larger cultural traditions are a significant component of causal connections.

The development of ROSES has been reported in the ROSES handbook (Jidesjö et al., 2020). The handbook describes the background, rationale, methods, sampling, translation procedures and questionnaire development. As ROSES builds on ROSE, the rationale and research design are the same. The project's aim is to gather data on secondary students' voice in S&T in an international setting to make empirically based contributions to discussions about young people's relationships with S&T in various cultural contexts. The data is diverse. The results reported here are part of the first analysis of Swedish results and present new findings on what students' want to learn, e.g. their interest in S&T.

Data was gathered using a questionnaire developed from a previous questionnaire used in ROSE. The questionnaire has been updated in an international collaboration, mainly by researchers from the advisory group with input from colleagues in the international network and piloted in five countries before being finalised. The ROSES master questionnaire is the same for all participating countries. The questionnaire contains new items concerning sustainability perspectives, social media, and informal science learning. The number of items has been reduced by developing constructs which make it possible to measure the same aspects with fewer questions. In addition, experiences, and cognitive labs with students in the pilot studies indicated a need for adjustments. As an example, from the *What I want to learn about category*, the item "*The first landing on the moon and the history of space exploration*" was replaced with the shorter and more current "*Human exploration of Mars*". From such work the master questionnaire was established. For a full description see Jidesjö et al. (2020). The findings presented here measure students' interest in S&T on 78 items, with content from the different science subjects in various contexts. Data was collected digitally using a web-survey. In 2003 data was collected using printed questionnaires. Below, in Figure 1, an excerpt screen shot shows a respondent view of the questionnaire.


2. What I want to learn about.

How interested are you in learning about the following? (Give your answer with a tick on each line. If you do not understand, leave the line blank.)

	Not interested 1	2	3	Very interested 4
1. Chemicals, their properties and how they react				
2. The inside of the earth				
3. How mountains, rivers and oceans develop and change				
4. Clouds, rain and the weather				
5. The origin of life on earth				
6. Heredity, and how genes influence how we develop				
7. Sex and reproduction				
8. Birth control				

Figure 1 A screen shot of the ROSES questionnaire as it is presented for secondary students.

A four-grade Likert scale was used ranging from Not interested (value 1) to Very Interested (value 4) and is coded according to the ROSES code book. In the data collection format, only the endpoints were labelled 1 and 4 since respondents are more likely to interpret a scale as continuous if inner alternatives simply divide the scale into three intervals with equal size. Students are presented with short statements with four alternatives throughout and from a methodical viewpoint negative phrasing is avoided. In the introduction students are informed that they can refrain from answering if they do not know or do not understand a question, they can end whenever they like, and their answers will be kept anonymous and only used by researchers for research purposes.

Data was collected from secondary students at the end of compulsory schooling since at this stage they can look back on the S&T education they have experienced. In Sweden this implies 15-16 years of age. In Sweden science is taught separate from technology and science is treated as integrated at the first three years of compulsory schooling. In the next three years the schools can choose to treat science as integrated or divided in the school subjects biology, chemistry and physics. In the last three years of compulsory education science is divided and taught as separate school subjects. Despite the Covid-19 pandemic, data was successfully collected in Sweden during spring 2020. Sampling was carried out from a national database of all schools with ninth grade students, where one class each was selected from 33 randomly selected schools using implicit stratification. The list of schools was sorted according to the average student merit**.** The schools together with one class in each school were randomly selected from this list. The chosen class in each school was invited to participate by means of an email sanctioned by the school principal. The principal forwarded the email to teachers who taught science in the selected class. The email included a description of the ROSES project with a specific link to the questionnaire. The size of the classes varied from 9 to 27 students. The teacher chose an occasion when it was convenient for the students to take the survey, which took on average

20 minutes to complete. After data cleaning, a sample of 610 responses was established. Data from these 610 students in 2020 is compared with data from 2003. The procedure of random sampling was similarly done in 2003 with a sample of 751 students from 29 schools Jidesjö et al. (2009).

In this paper the analysis of data was carried out using descriptive statistics of mean values to investigate boys' and girls' interest in S&T with a setup of rankings to compare possible developments between two data sets. Data gathered on the ordinal scale were analysed with parametric tests as interval data and presented with mean values and standard deviation, which is a suitable procedure in this study and well described in the literature (Rattray & Jones, 2007). This methodical approach is due to the research design and the purpose of the study since it makes it possible to compare results between ROSE and ROSES to check for developments and trends. We do not compare specific mean values between the different years, as it could be a methodologically biased procedure caused by the different methods of collecting data. Students answered the questionnaire with paper & pen in 2003 and in digital mode in 2020. Therefore, a non-parametric methods approach is used to compare results between 2003 and 2020, and the mean values are only used to create and establish a ranking of the items for each data set respectively. The items are listed from the most popular to the least for each survey and then analysed by a comparative approach.

RESULTS

In the first part there is a presentation of students' interest which is used later to make a comparison of interest between 2003 and 2020. The results presented in Table 1 consist of the 15 most popular items students are interested in, with a comparison of mean differences between boys and girls.

Table 1 The 15 most popular items that students want to learn about. The table is sorted by mean values (1 equals low and 4 high) for all students together with standard deviation (SD). Mean values for girls and boys are presented with mean differences (Diff), girls' mean minus boys' mean. Statistically significant differences between girls and boys are presented with a 95% confidence interval and marked with an asterisk.

	All	SD.	Girl	Boy	Diff
1. The possibility of life outside earth	2.96	1.06	2.90	3.03	-0.13
2. Why we dream while we are sleeping, and what the dreams may mean	2.90	1.04	3.14	2.71	0.43*
3. Human exploration of Mars	2.79	1.07	2.69	2.94	-0.25*
4. How it feels to be weightless in space	2.76	1.13	2.62	2.92	-0.30*
5. Black holes, supernovas and other spectacular objects in outer space	2.75	1.11	2.62	2.89	-0.27*
6. Phenomena that scientists still cannot explain	2.75	1.14	2.70	2.81	-0.11
7. How alcohol and tobacco might affect the body	2.69	1.03	2.82	2.58	0.24*
8. How to exercise to keep the body fit and strong	2.68	1.04	2.73	2.67	0.06
9. How different narcotics might affect the body	2.65	1.05	2.77	2.56	0.21*
10. Life and death and the human soul	2.61	1.07	2.79	2.45	0.34*
11. How to control epidemics and diseases	2.60	1.03	2.75	2.49	0.26
12. How meteors, comets or asteroids may cause disasters on earth	2.57	1.04	2.43	2.71	-0.28*
13. How the atom bomb functions	2.57	1.08	2.18	2.93	-0.75*
14. Inventions and discoveries that have changed the world	2.56	1.14	2.56	2.61	-0.05
15. Biological and chemical weapons and what they do to the human body	2.55	1.10	2.27	2.80	-0.53*

The results in Table 1 show in brief that students are interested in learning about space exploration, health issues, things that scientists still cannot explain and important inventions and discoveries. The mean values of these items are on average high for all students, although there are variations between girls and boys. Girls are more interested in health issues and the human body, dreams, and the human soul while boys favour items about space, inventions and discoveries together with ABC weapons.

In the next step, girls' interest in S&T is compared between 2003 and 2020, presented below in Table 2.

Table 2 A comparison of girls' interest between 2003 and 2020. Presented as mean values of items for each year ranked respectively.

Girls 2003		**Girls 2020**	
Why we dream while we are sleeping, and what the dreams may mean	3.35	Why we dream while we are sleeping, and what the dreams may mean	3.14
How to exercise to keep the body fit and strong	3.21	The possibility of life outside earth	2.90
What we know about HIV/AIDS and how to control it	3.20	How alcohol and tobacco might affect the body	2.82
How different narcotics might affect the body	3.14	Life and death and the human soul	2.79
What to eat to keep healthy and fit	3.13	How different narcotics might affect the body	2.77
How alcohol and tobacco might affect the body	3.12	How to control epidemics and diseases	2.75
How to perform first-aid and use basic medical equipment	3.12	How to exercise to keep the body fit and strong	2.73
Cancer, what we know and how we can treat it	3.11	Thought transference, mind-reading, sixth sense, intuition, etc.	2.72
Sexually transmitted diseases and how to be protected against them	3.11	Phenomena that scientists still cannot explain	2.70
Thought transference, mind-reading, sixth sense, intuition, etc.	3.10	Human exploration of Mars	2.69
Eating disorders like anorexia or bulimia	3.09	How my body grows and matures	2.69
Biological and human aspects of abortion	3.02	Biological and human aspects of abor-tion	2.68
The possibility of life outside earth	2.96	Heredity, and how genes influence how we develop	2.66
How my body grows and matures	2.95	Eating disorders like anorexia or bulimia	2.63
Life and death and the human soul	2.94	How it feels to be weightless in space	2.62

Comparison of the two rankings shows that they are largely similar. Girls' interest is oriented towards body and health together with exploration of the Universe. In the comparison between the two rankings, HIV/AIDS is at the top 2003 but has been replaced in 2020 by epidemics and diseases in the corresponding position. Another observation is that items concerned with technology have been replaced by items about space. There is only one space item ranked highly 2003 but four in 2020. This alteration also has the effect of demoting the item about what to eat to keep to healthy and fit.

In Table 3, presented below, the same analysis is done for boys.

Table 3 A comparison of boys' interest in S&T between 2003 and 2020. Presented as mean values of items for each year ranked respectively.

Boys 2003		Boys 2020	
How it feels to be weightless in space	3.10	The possibility of life outside earth	3.03
How the atom bomb functions	3.03	Human exploration of Mars	2.94
Explosive chemicals	3.01	How the atom bomb functions	2.93
How computers work	2.98	How it feels to be weightless in space	2.92
The possibility of life outside earth	2.91	Black holes, supernovas and other spectacular objects in outer space	2.89
Biological and chemical weapons and what they do to the human body	2.88	Explosive Chemicals	2.88
How to exercise to keep the body fit and strong	2.87	Phenomena that scientists still cannot explain	2.81
Phenomena that scientists still cannot explain	2.84	Biological and chemical weapons and what they do to the human body	2.80
How meteors, comets or asteroids may cause disasters on earth	2.81	Rockets, satellites and space travel	2.77
Black holes, supernovas and other spectacular objects in outer space	2.76	Why we dream while we are sleeping, and what the dreams may mean	2.71
How cassette tapes, CDs and DVDs store and play sound and music	2.76	How meteors, comets or asteroids may cause disasters on earth	2.71
The effect of strong electric shocks and lightning on the human body	2.74	How to exercise to keep the body fit and strong	2.67
Rockets, satellites and space travel	2.74	Very recent inventions and discoveries in science and technology	2.63
Brutal, dangerous and threatening animals	2.70	Inventions and discoveries that have changed the world	2.61
The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	2.67	How a nuclear power plant function	2.59

Similarly, as for girls' interest, a first impression of the results is that boys' interest seems to have changed only marginally between 2003 and 2020. Although the two rankings are mainly similar there are minor changes consisting of items shifting position. Another observation is that the item about dreaming and what dreams may mean has been included in the top 15 items to learn more about among boys in 2020. As for the girls, items about technology seem to have been replaced. Five space items in 2003 have increased to six in 2020 and there are two new items in 2020 about important and recent inventions and discoveries which replace items about technology from 2003.

In the final analysis presented in Table 4 below, the 15 items with lowest mean values are presented, discussed as content with low interest among boys and girls.

Table 4 The 15 least popular items that students want to learn about. Mean values for girls and boys are presented with mean differences (Diff). The table is sorted by mean values from all students. Statistically significant differences between boys and girls are presented with a 95% confidence interval and marked with an asterisk.

	All	Girl	Boy	Diff
How different sorts of food are produced, conserved and stored	2.07	2.08	2.07	0.01
Why we can see the rainbow	2.05	2.06	2.05	0.01
How to improve the harvest in gardens and farms	2.04	2.00	2.10	-0.10
Plastic surgery and cosmetic surgery	2.04	2.32	1.77	0.55*
Atoms and molecules	2.03	1.87	2.18	-0.32*
How the ear can hear different sounds	2.03	1.94	2.12	-0.18*
Plants in my area	2.01	1.99	2.04	-0.05
Light around us that we cannot see (infrared, ultraviolet)	2.00	1.85	2.14	-0.29*
How technology helps us to handle waste, garbage and sewage	2.00	1.85	2.15	-0.31*
Properties of gems and crystals and how these are used for beauty	1.98	1.92	2.05	-0.13
Clouds, rain and the weather	1.94	1.97	1.91	0.06
Organic and ecological farming without use of pesticides and artificial fertilizers	1.91	1.90	1.92	-0.02
Famous scientists and their lives	1.90	1.87	1.94	-0.07
How mountains, rivers and oceans develop and change	1.89	1.79	1.97	-0.18
How different musical instruments produce different sounds	1.86	1.73	1.98	-0.26
Detergents, soaps and how they work	1.83	1.90	1.78	0.12

There are small gender differences among the least popular items to learn more about, which is why the analysis is taken for all students together and not divided into girls and boys as in Tables 2 and 3. The results show that among the least interesting things to learn about there are topics related to everyday life, such as how food is produced and stored, how to improve the harvest, weather phenomena together with detergents, soaps and how they work. Several of the items in Table 4 are typically part of the school science curriculum, for example how the ear can hear different sounds, how different musical instruments produce different sounds and famous scientists and their lives.

DISCUSSION

This paper investigates Swedish students' interest in S&T using a comparative design by making use of two large data sets, from ROSE in 2003 and ROSES in 2020. Research into students' interest in S&T has a long tradition (Anderhag et al., 2016; Dawson, 2000; Gardner, 1975; Jenkins, 2006) and is a worldwide concern (Potvin & Hasni, 2014) and the nature of the problem often conceptualises interest as a function of experience. Therefore, interest is understood to be related to how students experience S&T and expected to change due to societal development. A research problem in this developmental and identity-based approach, i.e. the "person-object theory of interest" (Krapp & Prenzel, 2011) is that it would be expected that transformation of interest would be identified, since S&T in society have an obvious property of development. Accordingly, empirical investigation of this phenomenon needs to be recurrently examined to identify possible developments. The main results of this paper conclude that students' interest in S&T seems to have a reoccurring pattern with only minor developments. Since there are many developments of S&T in society with a capacity to create consequences for experience, it could be expected that the situation would have changed. Hence, the result is somewhat daunting. We therefor make use of the theoretical approach of science identity as described by Krapp & Prenzel (2011) drawing on the level of differentiation to investigate what this framing imply for how the situation can be conceptualized and understood.

The students who are the respondents in the work reported here grew up during the first part of the 21st century and have experienced many different developments compared with the students who responded to the ROSE study in 2003. As an example, the latter grew up in the 1990s, probably almost without computers and surely without smart phones and social media. To follow the conceptualization of interest as having a transformative function in relation with experience, the development of internet, smart phones, and social media, would imply a change in students' experience of S&T and subsequently it could be expected that their interest would have been affected. In contrast, the results reported here do not confirm this interpretation. Instead, the main result is that students' interest in S&T has a persistent and recurrent character. The science identity approach (Hosek and Soliz, 2016; Potvin & Hasni, 2014; Yep, 2016) can take this further because large-scale quantitative data on students' interest makes it possible to examine ways that students' interest differentiates to create interest patterns where specific topics is a distinctive feature. The approach to critically address the concept of science identity to interpret students' interest in S&T is supported by several observations.

Results shows that *explorations of space*, *health issues*, *things that cannot be explained* together with *important inventions and discoveries* are ranked highly in lists of all students' interests. The items are either about themselves or about something exciting or unknown. This is in similarity with previously reported results from the ROSE studies in Sweden (Jidesjö et al., 2009). Furthermore, we know from other studies around the world (see for example Baram-Tsabari & Yarden, 2005) that similar content has been identified using other instruments in another cultural context (see also Sjøberg & Schreiner, 2019). Despite this methodological and cultural pluralism, the students' interest in S&T manifests a character of conformity. This notion validates the claim that a large part of students' interest in S&T has a persistent character; it seems to be stable. A main message from a first review of students' interest in S&T summing up research from the first part of the 20th century (Gardner, 1975), was that girls are more oriented towards body and health issues and the biological sciences, while boys to a larger extent favour content from the physical sciences. There are close points of similarity between what Gardner (1975) reported and the character of the results reported here almost 50 years later. The evidence in the literature is like a reoccurring pattern. Inspired by Krapp and Prenzel (2011) this observation calls for us to carefully and critically consider how students' interest has been conceptualized in the S&T education research literature. Viewing students' interest through the lens of identity (Yep, 2016), interest may be regarded as a disposition, incorporated into a more stable sense of identity, rather than solely shaped by experiences (see also Carlone & Johnson, 2007). Consequently, this way of approaching the situation is suggested by us as appropriate to understand the stable character of students' interest.

This theoretical framing has additional consequences. A common way to present results in studies of students' interest in S&T is to compare boys and girls. Schreiner (2005) scrutinised large scale international data to search for other underlying variables or factors but concluded that gender difference is the strongest. In alignment with this statement, it would be expected that the results presented here would show such differences, with specific content being associated with boys and girls respectively. This is precisely what has been identified. Following the differentiation hypothesis as reported by Krapp & Prenzel (2011) this show that students' interest is domain specific, not subject specific. Interest differentiates and cluster as collective identities with gender as a strong marker. With this, we are not saying that all girls favour the same interest, nor the boys. Therefore, investigations of variation in collective identities are suggested as an important research continuation.

Another implication from conceptualizing students' interest in S&T as science identities has to do with the desire to change the situation where students are reluctant to study S&T in school (European Commission, 2004, 2007; Hill et al., 2010; OECD, 2008). This disengagement has consequences both for the recruitment of workforce in S&T as well as for educating all citizens in S&T, which is as relevant today as reported earlier (Bruun Nicolaisen et al., 2023; Drymiotou et al., 2021). Much money has been spent with a desire to change students' interest in S&T, especially as it is believed to relate to educational choices (Nordic Council of Ministers 2021; Royal Swedish Academy of Engineering Sciences, 2023a; b). Since there is an experienced lack of students in the Science, Technology, Engineering and Mathematics (STEM) area in many countries (Osborne & Dillon, 2008; Tytler, 2007) this situation has been used as a driving force to justify development programs as well as further research. In this respect, a critical question to ask is why not much seems to change. Perhaps this seemingly static situation is partly caused by a bias in how students' interest in S&T is conceptualised. Implications for practice vary depending on the theoretical approach taken to the problem. In present study, we find the identity approach as appropriate to interpret large-scale quantitative data on students' interest in S&T. The differentiation hypothesis conceptualizes students' interest and measure the domain specificity as "interest patterns" which is an important contribution because such content structures are not well described in the science education research literature (Krapp & Prenzel, 2011). An important continuation is to have them more clearly defined before recommended and practically applied in S&T education. Such work could also impact recruitment efforts and contribute to the goal of providing high-quality STEM education to all people.

Even if the overall impression of the results is that it shows a reoccurring pattern, there are some minor changes. The analysis of girls' interest revealed that an interest in learning about HIV/AIDS has been replaced by an expressed wish to learn about epidemics and diseases. Likewise, items concerned with technology have been replaced by items about space. Items about space and the universe have replaced items about what to eat to keep healthy and fit. It is tempting to say that this is caused by societal development. We do not have the data to conclude causality but following the identity approach by Krapp and Prenzel (2011) the results present changes of interest patterns and how interest is directed to specific domains of knowledge where the concrete topics creates the character. When looking into the details and at the same time at the broader picture, it seems to us as if there are major areas of students' interest that show a reoccurring character while others show development which is in line with the concept of "interest pattern" belonging to the differentiation hypothesis. The same argument can be empirically justified in a more detailed content analysis of boys' interest. There is a core interest for content belonging to physical sciences as a reoccurring science identity. Minor developments are for example that the item about dreams has become part of boys' favoured interest. Items about technology seem to have been replaced and in similarity with girls' development, the interest to learn about space has increased. Important and recent inventions have also become part of boys' favoured interest. This content level of analysis reveals an underlying character of domain specificity with certain topics creating an interest patten. The persistence and at the same time minor developments observed in the results is understood as caused by mechanisms of the differentiation hypothesis belonging to the "person-object theory of interest" which warrant further research attention as there can be intra-individual as well as inter-individual distinctions (Krapp & Prenzel, 2011).

From a methods point of view there are some things to be concerned about. Overall, the items with highest mean values in ROSES 2020 are lower when compared with the highest mean values in ROSE in 2003 (Table 2 and Table 3). Similarly, the items with lowest mean values in ROSES 2020 are higher when compared with the lowest mean values in ROSE 2003. ROSE data was collected in paper format and ROSES data in digital format. If this change in collection method of data caused this variation cannot be concluded, neither have we found this aspect discussed in methods literature. Nonetheless, it does not change the consistency of the rankings. Hence, it does not influence reliability dimensions of the instrument. However, the pattern identified of what seems to be systematic alterations of mean values warrants further attention. Additionally, in connection with the content level of analysis, the meaning of the non-parametric approach is important. As an example of girls' interest, the item *Why we dream while we are sleeping, and what the dreams may mean,* show that mean values have fallen from 3.35 in year 2003 to 3.14 in year 2020 (Table 2). Such alterations can be observed but are not meaningful in the research design used in this paper. In present paper, the mean values are used to construct the individual rankings for each year respectively. Hence, the correct observation in this design is that the item about dreams is the most popular item both years. In this interpretation it is reoccurring, not in development.

The final result in this paper presents items with lowest mean values. This is interpreted as S&T content which students have a low interest in learning about. There are two things to point out. Firstly, several of the items are typically part of what can be called traditional S&T school content. To justify this claim we refer to the Swedish national science curriculum (Swedish National Agency for Education, 2022). As for the items with high interest there seems to be a characteristic of stasis for items where students express low interest when compared with earlier studies (Jidesjö et al., 2009). Due to the resemblance with the curriculum, an argument to explain the situation could be that there is a teaching effect behind the result. We do not have the data to investigate whether this is an important part of causality but if so, it would be a somewhat serious condition for S&T education if more education serves to decrease student interest. To follow the perspective of curriculum, it would be important to illustrate ways of presenting the content to students that would enable them to see the true relevance of S&T from different aspects, e.g., cultural, economic, personal use and democratic (see also Bruun Nicolaisen et al., 2023; Drymiotou et al., 2021; Gubo & Schiffl, 2022; Sjøberg & Schreiner, 2019). Independent of curriculum there can still be a teaching dimension in action which we propose as important for future research studies.

Secondly, several items are included in the questionnaire to investigate the importance of whether content or context is important for students' interest. There are many studies that recommend S&T education to be more context-based, for example using socio-scientific issues as sources of inspiration to increase students' involvement with S&T. The evidence in this study does not confirm this direction as several of the items that are contextual are at the bottom of the list. From a learner perspective, it appears that a context-based approach does not necessarily result in a heightened level of interest. This interpretation of the results is supported by Oskarsson et al. (2018) who showed that students performed well in PISA on context-based items only if the question itself was interesting, which is in line with the differentiation hypothesis to conceptualize interest.

In conclusion, the research contribution of the work presented in this paper is twofold. By a comparative design, it updates the research field on students' interest in S&T by measuring gender differences in a differentiated way between 2003 and 2020 and it proposes that students' interest in S&T can be seen as an expression of a more fundamental phenomenon, namely identity. We argue that this approach makes up a reasonable account of the results and empirically point out an important research continuation, namely varieties of collective identities. We suggest the reoccurring character of students' interest to be interpreted as being part of young people's identity formation and call this phenomenon reoccurring science identities. However, identities are not developed in a vacuum. They depend on experience and social context (Hosek and Soliz, 2016; Krapp and Prenzel, 2011). In this connection we concretely show the "domain specificity" and minor temporal changes of "interest patterns". It is important to identify mechanisms behind these observations to understand causality. Utilising the differentiation hypothesis of the "person-object theory of interest" to explore students' interest in S&T represents a promising advancement for the research field as it shows interest in S&T to be domain specific with certain topics belonging to interest patterns of boys and girls respectively. However, it is important to empirically validate this conceptualization and describe consequences before coming up with recommendations for practice, which is yet another important message of this paper. We are cautious about this since the results are not easy to interpret. Students' personal interest is always involved in teaching S&T (Bellová et al., 2021) but with that we are not saying that students are in a position to decide what should be taught. The purpose of this paper is to empirically update the research field of students' interest in S&T and theorizing the results to take the research further. The design of the Swedish national curriculum leaves space for teachers to choose content outside what is stipulated as core content. This logic makes it possible for teachers to involve what is locally important and needed for students' learning. Further, in relation with societal development there could be important content needed as part of compulsory S&T education not on top of students' interest in this paper, e.g., geoscience content to learn about climate changes or consequences from use of natural resources. Such implications for practice at different levels of the educational system should be carefully considered by a more complete exposition of research.

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