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Girls' engagement with technology education: A scoping review of the literature

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Abstract

The aim of this study is to review internationally published scientific literature on the subject of girls' engagement in technology education, in order to identify the most common descriptions of girls' engagement with technology education, girls' technological activities, and the relationship between girls and technology. After a scoping review of the literature, 20 relevant articles were identified and included in the study; they were analysed using content analysis. The results show that, according to the reviewed studies, girls are less interested in and have less positive attitudes towards technology (education) than boys. They are also less likely to choose a technology- or STEM-oriented occupation. Several of the included studies venture possible explanations as to why this is and refer mainly to cultural factors. Those studies that do define the type of technology used in girls' activities mostly describe a neutral, or male kind of "nuts and bolts" technology. As regards girls' relationship to technology, there is potential for improving female engagement using apparently simple means; for example, making sure the social context of teaching is adapted to girls. The results of the literature review are discussed in terms of their implications for future research and can be used as a guide for educators and researchers in the area. In particular, the reasons for girls' lower interest in technology education compared to boys need to be further researched, and it may be that researchers need to study girls in their own right, not in perpetual comparison with boys, in order to come closer to an answer.

Keywords

girls' engagement, gender, technology, technology education, scoping review

Introduction

That there is a relationship between gender and technology, manifesting in structures, symbols and identities, has long been acknowledged by feminist scholars. However, the feminine connection with technology has been downplayed in public discourse, in favour of the male connection. Feminist scholars of technology (e.g. Harding, 1986; Cockburn & Ormrod, 1993) argue that everyday discourses of technology constitute a prominent factor causing negative stereotyping and gender norms. These norms fuel ideas of what technological agency is, as well as whose interest in technology and what kind of technology are regarded as legitimate (Wajcman, 1991). There are therefore structures in society that influence girls' engagement with technology and technology education from an early age. Indeed, the fundamental concept of technology, which is generally coded as a male construct, may be problematic; technology is often constructed as a male domain composed of male attributes such as logic, structure and technical knowledge (Sanders, 2005).

Why so few girls pursue a career in technology can be explained by such factors as lack of confidence, lack of support at home, in the classroom or from other authority figures, and lack of peer support, according to Cheryan, Ziegler, Montoya and Jiang (2017). Turja, Endepohls-Ulpe, and Chatoney (2009) argue that specific attitudes and roles hinder girls from engaging in technology education because technology is presented as an exclusively male domain. Cheryan et al. (2017) consequently claim that:

> even if the culture of a STEM field is not overtly hostile to women, women will be less likely to enter, persist, and be successful in a field when there is a mismatch between the way that they wish to be seen and are expected to behave and the norms of that culture. (Cheryan et al., 2017, p. 2)

Faulkner (2000) argues that stereotypes often relate to masculine instrumentalism and feminine expressiveness, with females being drawn into occupations that revolve around social interaction, and even, as Bredlöv (2017) points out, caring and "emotional labour". De Vries (2006) concludes that girls are less confident than boys when handling so-called hard technology; computers, electronics and similar artefacts. This lack of confidence even extends to encounters with and use of what is identified as hard technology in schools (Kimbell, Stables, & Green, 1996). For example, girls are more likely than boys to feel confident about, and to succeed in, working with tables of data concerning health, reproduction, or domestic situations, but anticipate failure – "I don't know anything about that" – when faced with tables of data on machinery, building sites, or cars (Murphy, 1990). Sadker and Sadker (1994) elaborate upon teaching methods by showing that teachers may inadvertently favour boys, especially in areas that society considers to be in the male domain, by providing them with more and better instruction.

This is problematic – the construal of technology and technology education as predominantly male domains – and highly relevant to the research field of technology education and needs to be addressed. There has been some research on gender and technology education from various perspectives; for example, in relation to early childhood education (e.g. Hallström, Elvstrand & Hellberg, 2015; Turja et al., 2009), Pupils' Attitudes Towards Technology (PATT) studies (e.g. Ankiewicz, Van Rensburg, & Myburgh, 2001; Svenningsson, Hultén, & Hallström, 2018) and gender specifically (e.g. Klapwijk & Rommes, 2009; Virtanen, Räikkönen, & Ikonen, 2015). However, there is still a lack of research concerning girls' engagement with technology and technology education. The aim of this study is therefore to review internationally published scientific literature about girls' engagement with technology education in order to identify the most common descriptions of girls' engagement with technology education, girls' technological activities, and the relationship between girls and technology. Doing a scoping literature review of just these three elements is important given the still rudimentary scientific knowledge about how girls actually engage with technology in educational activities.

Methods for collecting and analysing data

A scoping literature review is a "type of review [that] provides a preliminary assessment of the potential size and scope of available research literature. It aims to identify the nature and extent of research evidence" (Grant & Booth, 2009, p. 101). This kind of review has similarities with a systematic review in attempting to be systematic and transparent, but is less systematised and rigorous because it aims to establish the extent of existing evidence and the requirements for further research (Grant & Booth, 2009). We therefore adhere to the step-by-step review scheme for systematic reviews devised by Kitchenham (2004), although we do not make the claims of a systematic review (Kitchenham, 2004). This scoping literature review focuses on international studies researching girls' engagement with technology education, and the method of data analysis employed is content analysis. Conventional content analysis is an inductive method, which means that it is probing and open-ended in relation to the aim and research questions and the scoping review format, exposing descriptions of girls' engagement with technology education, technological activities, and the relationship between girls and technology in the reviewed previous studies (Hsieh & Shannon, 2005). This also means that the results of the review are presented in quite a "raw" format in Table 1, and the analysis is presented under Summary of Results and Discussion.

To conduct this review, we followed a step-by-step guide for conducting reviews based on Kitchenham (2004), covering the following stages and activities:

Stage 1: Planning the review

Activity 1.1: Identification of the need for a review

Activity 1.2: Development of a review protocol

Stage 2: Conducting the review

Activity 2.1: Identification of research

Activity 2.2: Selection of primary studies

Activity 2.3: Study quality assessment

Stage 3: Reporting the review

Activity 3.1: Communicating the results

Planning and conducting the review (Stages 1 and 2)

Activities 1.1 and 1.2: Identification of the need for a review, and development of a review protocol

The identification of the need for a review (1.1) was accomplished in the introduction. The review protocol (1.2) is inductive and open-ended, as described above under method of data analysis. Thus, it basically follows the aim of the study and the broad areas related to girls' engagement including their; descriptions of girls' engagement with technology education, technological activities, and the relationship between girls and technology.

Activity 2.1: Identification of research

For the purposes of this study, data was collected in January 2018, in the prominent international online bibliographic database for educational research, ERIC (Education Resources Information Centre). Searches were limited to full texts in high-quality, international, peer-reviewed journals, written in English, and published between 1 January 2000 and 31 December 2017 (research over the last 18 years). The specific protocol executed in the ERIC database was: "Find all my search terms": girl AND interest AND technology AND education. The results of this data collection initially consisted of 117 articles.

Initially, the limitation "elementary" was included in the research. Applying this limitation resulted in only three articles. By excluding the word "elementary" from the search, we gained a wider scope of included articles and this resulted in a broader variety of technology education studies from several countries. Furthermore, elementary does not entirely match the ages 10–17 because they also overlap with secondary education. To be able to include the age span we wanted to examine, we therefore manually excluded all articles dealing with ages lying outside 10–17-year-olds. We wanted to look specifically at ages 10–17 because this is a stage of life that research (e.g. Sinnes & Løken, 2014) has identified as particularly formative for girls' engagement with technology education.

Activity 2.2: Selection of primary studies

The following inclusion criteria (IC) were used to determine which papers would be included in the review:

IC1: The article reports on research about girls' engagement with technology education; descriptions of girls' engagement with technology education, technological activities, and the relationship between girls and technology.

IC2: The article presents a discussion of girls' engagement with technology education; descriptions of girls' engagement with technology education, technological activities, and the relationship between girls and technology.

Articles were included only if both these criteria were met.

Five criteria for excluding (EC) articles were identified:

EC1: Afterschool activities. We wanted to examine technology education during the school day, in formal school technology education.

EC2: Science education. We wanted to look specifically at technology education studies, although studies on both areas were included as well as STEM (science, technology, engineering, mathematics) studies in cases where they came through in the search. The keywords "science" and "STEM" were thus not included in the searches, but might appear in the results if they turned up in the search and were found to be relevant in relation to the aim.

EC3: ICT Education or use of ICT tools and educational technology. This was excluded for being a tool for learning technology rather than the subject of technology specifically.

EC4: Computer science. This was excluded when handling the computer was the focus, and not technology *per se*.

EC5: Age span outside 10–17-year-olds.

The search thus generated 117 international peer-reviewed research papers. We analysed titles and abstracts regarding the inclusion (IC1–2) and exclusion (EC1–5) criteria, and 20 studies finally matched our full search criteria (IC1–2 and EC1–5) based on the research aim. These 20 studies were subsequently studied in full.

Activity 2.3: Study quality assessment

As observed in Table 1, 83% of the total number of research articles was excluded based on IC1–2 and EC1–5, finally resulting in 20 included studies. The quality of the studies was ensured by including only those published in international high-quality journals.

Results: Reporting the review (stage 3)

Activity 3.1: Communicating the results

Table 1 displays the results of the final sampling of the scoping review, in the order the studies came out in the search.

Table 1. Results of the final sampling

Article	Aim and/or research question(s)	Age span	Research design and main findings	Description of: 1. girls' engagement with technology education, and 2. girls' technological activities and the relationship between girls and technology.
Ardies, J., De Maeyer, S., & Gijbels, D. (2015).	Exploring the evolution of pupils' interest during the year(s) they attend mandatory technology classes, and determining the characteristics of differences between boys' and girls' attitude changes over time.	First and second grade of general secondary education	A longitudinal study with eight measurement occasions spread over the course of two years presented to capture the evolution of students' attitudes, making use of a multilevel growth model analysis. Findings show that students' interests and aspirations in the field of technology are not stable and do change during the first cycle of secondary education. The conclusion are if the goal of technology education at school is to promote 'a larger number of students in technological oriented studies and professions', there is still much to do.	1. When describing gender with regard to technology, girls are seen as being less interested, female students tend to have less ambition in technology and are underrepresented in the field. The researchers conclude in the literature review that, at age 10, interest in STEM does not differ between boys and girls and is rather high. From that age on, interest starts to decline, especially among girls. 2. "Females do not see themselves (yet) as technicians, as we found that in their perception about technology as a subject for both genders is rather low, which means that they think it is more something for male students only" (p. 381).
Ardies, J., De Maeyer, S., Gijbels, D., & van Keulen, H. (2015).	Research questions: What is the predictive power of students' characteristics regarding aspects of their attitudes towards technology? Is there a difference between boys and girls in first and second grade with respect to the evolution in attitudes towards technology?	Age 12–14	Questionnaire with multivariate multilevel analyses. "The results of the study showed a decline in interest in technology from the first to the second grade of secondary education. This finding appears to be stronger for girls. Interest in technology is significantly positively related to the amount of time that technology is taught for, as well as to the teacher. Parents have a positive influence on several aspects of attitude to technology when mothers and/or fathers have a profession related to technology." (pp. 43–44). The study does not confirm all stereotypical ideas concerning gender differences. Female students believe that they can study technology and have a technological career.	1. Girls are generally more negative towards technology as boys are found to be more positive than girls and with a less negative trend in the development of their attitudes. However, it is claimed that "these findings cannot be generalized without caution, since results differ from country to country" (p. 48). 2. Gender differences may correlate with the presence and the amount of actual play with construction toys.

Mammes, I. (2004).	The aim was to determine differences in the interests of girls and boys in technology and to support interest in technology more widely by technology education (p. 89).	Third grade	A quasi-experimental pre- and post-test design. The results showed that girls' and boys' interest in technological subjects can be developed. Furthermore, gender differences were reduced significantly by the teaching. Findings show that early exposure to technology education at school leads to a higher level of technological interest in both girls and boys (p. 98). Researcher concluded that "the low level of interest of girls is traceable to their socialisation, and more particularly to the fact that girls are not exposed as much as boys to technology" (p. 91).	1. "Women are clearly reluctant to participate in courses of studies for technology" (p. 89). A lack of interest results in a refusal to deal with technology and this leads to technological incompetence. 2. Activities that the girls took part in were a technology programme that consisted of a Christmas tree and components of the electrical circuit, and designing and making a nesting-box.
Autio, O., & Soobik, M. (2017).	Determine whether there is a relationship between students' undertakings within Craft and Technology education and their ability to understand technological concepts by asking three different research questions.	Ages 11 and 13	Quantitative survey. To evaluate students' technical understanding and reasoning, a questionnaire was devised, concerning mechanical systems based on physical principles. Then a numerical analysis was performed. One of the results is that the students did not perform as well as expected in the measurement of technical understanding and reasoning. Authors argue that practical skills can improve both technological knowledge and reasoning.	1. It is "not a surprise that boys and girls differ in their interests, the difference is usually emotionally charged" (p. 200) and a "possible reason for this might be the different social expectations for boys and girls" (p. 201). "Boys' and girls' different interests and earlier experiences obviously have an impact on motivation for learning about technology" (p. 193). "It is obvious that technological knowledge is important, especially in spatial reasoning; this has an impact on girls' motivation for learning about technology" (p. 201). 2. "Although, it was not the main goal of this research, we can't pass the differences between boys and girls. There were statistically significant differences between boys and girls" (p. 200). The girls were getting fewer correct answers in the questionnaire.

Andreucci, C. & Chatoney, M. (2017).	The aim is to shed light on the artefacts that are used to illustrate technology education textbooks. Study also provides answers to other questions: what are the technical artefacts in textbooks? How are these objects representative of girls' and boys' technology interests?	Ages 12–14	Conducted in two stages. Firstly, an inventory of artefacts presented in four technology education textbooks for the sixth grade was carried out. Secondly, this inventory was submitted to a population of 98 girls and boys to have them make a categorisation of these artefacts. The results indicated that "a majority of artefacts implicated are neutral, but those that are gendered are more masculine than feminine marked. This factor is likely to strengthen the girls' feeling that teaching of technology is more adapted for boys than for girls. It is therefore one of the possible barriers that contribute to the disaffection of the technology courses by girls" (p. 15).	1. Girls' lack of interest is seen as a social construction: "Furthermore, the social and cultural distribution of activities between men and women can also lead to a gendered vision of technical objects according to their predominant users" (p. 5). 2. The majority of gendered artefacts in the studied schoolbooks are stereotypically male, a factor likely to strengthen the girls' feeling that teaching of technology is more adapted for boys than for girls. "However, technological areas of women's interest are numerous: technologies related to health and its prevention, to meatpacking, to cosmetology, to dressmaking and accessories, etc." (p. 16). And these could be added to the curriculum.
Osagie, R. O., & Alutu, A. N. (2016).	The study investigated the factors affecting gender equity in science and technology among senior secondary school students. Research questions: What is the choice of subjects of senior secondary school students? What percentage of females/males choose science careers? What are the major factors that affect gender inequity in the choice of science and technology careers?	Average age 15	A case study survey administered to 150 students. Analysis revealed that sex, parental and peer influences, and social and cultural stereotyping were the major factors affecting gender inequity in the choice of careers in science and technology. The results showed that less than 40% of the girls indicated interest in science and technology subjects even though they had the ability. In comparison, more than 65% percent of the boys indicated interest in science and technology subjects, even though they were not academically prepared for them. It is concluded that girls should be introduced to science and technology subjects in a way that makes it clear that they could be successful studying them. There should be an improvement in student-teacher interactions to counter the stereotypical images of science that are still prevalent. Parents, teachers and other persons in touch with girls should be made aware of the important role they can play in girls' identity work and educational choice process with regards to science and technology careers (p. 235).	1. "People treat girls and boys differently from an early age, giving them different feedback and expectations. This study shows that there is strong evidence that the culture discourages girls from being interested in technology even when they demonstrate exceptional talent from pursuing science and technology careers" (p. 234). This has affected the type of education girls and women receive, even up to tertiary institutions. 2. 88.7% of female students indicated a lack of interest in science and technology. This might have its root in "self-doubt, stereotypes, discouragement, economics and sometimes just wrong perception of what math and science are all about" (p. 234).

Stevanovic, B. (2014).	The aim is to study the changes and constants in girls' choices in science and technology education.	Ages 11–18	Data based on surveys by the INSEE, France's National Institute of Statistics and Economic Studies, and DEPP, Directorate of Evaluation, Forecasting and Performance (p. 544) Results show that female enrolment numbers in scientific courses of study is positive at the secondary level, where it has increased, but progress has been more ambiguous at the post-secondary level.	1. An insufficient representation of girls and women in STEM fields because of educational policy and information campaigns on parents, teachers, guidance staff and girls. Personal, contextual and social cognitive factors have an impact on the formation of interest (p. 553). Educational policy should be used to diversify girls' educational pathways and direct them towards scientific courses and jobs. 2. Girls are more likely to choose subjects where their gender is well represented. Classroom interactions between teachers and students, assessment styles and curriculum content result in the lower self-esteem of girls and gender-different attitudes within various areas of knowledge.
Chatoney, M., & Andreucci, C. (2009).	The study attempts to discover what impact can be produced by a study support object which is socially associated with one gender or the other in middle school technology teaching.	Ages 13 and 14	Two empirical studies. The first is a pre-investigation of the feminine, masculine or neutral gender attributed by pupils to study support tools. Results confirmed whether teachers consider the effects their choices have on the gender of the group they are teaching. The second is an experimental study of pupils' attitudes in an artefact design situation, the usage of which is primarily socially defined, and in which girls and boys may proceed differently. It is more specifically a matter of highlighting the effects produced by feminine and masculine artefacts upon girls' and boys' learning. Feminising technology does not take anything away from learning for boys.	1. "Certain contents, certain types of activities, certain forms of studies, certain gestures of education and scholastic shapes are better adapted to the girls than to the boys and conversely" (p. 393). Girls often seek help in technology from boys: "Girls, who are more inclined to totally re-invent the product (goal) and move away from the prescribed task, strictly speaking, or simply develop solutions which do not exist elsewhere (jewellery box)" (p. 401). 2. Girls prove to be more sensitive to the study aids they are working with. They show greater imagination and inventiveness and take more risks than boys on the feminine supports that they are familiar with. They act in a similar way to boys, however, when working with masculine supports. The concept of technology is not defined but the task performed in the study was a product improvement of a Mini football cage and a jewellery box.

Rasinen, A., Virtanen, S., Endepohls-Ulpe, M., Ikonen, P., Ebach, J., & Stahl-von Zabern, J. (2009).	The aim was to discover the strengths and weaknesses of Finnish and German curricula and systems of organizing technology education. Another objective was to identify gender-related reasons why girls drop out of technology and lose interest in technological careers.	Ages 7–12	Questionnaire study and curriculum analysis. Questionnaire study results on the attitudes and self-efficacy of boys and girls indicate that, already at this young age, girls are less interested and do not feel as competent as boys. "Results of the studies conducted in the UPDATE project showed that influences on interest in technological themes take place already in early childhood. Therefore, efforts should be made in developing early childhood education and elementary school education, to raise girls' interests and motivation towards technology" (p. 367).	1. An insufficient representation of girls and women in the field: "There are still remarkable gender differences in the number of males and females studying and working in the technological fields" (p. 368). The process of females drifting away from the field of technology starts at an early age. If children at this age, especially girls, think that activities in the field of technology are not suitable for girls, this will naturally be a barrier to making these topics appear interesting or relevant (p. 375). 2. "Girls in particular need to experience appreciation of their technical competences by their teachers. Technical activities conducted in class should be presented in a way that enhances girls' self-confidence in technology. Female teachers especially (and this is the majority of primary school teachers in all European countries) should act as positive role models for girls by demonstrating their own technological competence" (p. 378).
Sheffield, R., Koul, R., Blackley, S., & Maynard, N. (2017).	Examines how a Makerspace approach can capture the imagination and creativity of female primary school students, and engage them in integrated STEM-based projects.	Years 5 and 6	An exploratory case study to examine participant engagement with and reflections on a Makerspace in a STEM project. The authors do not claim that the Makerspace in a STEM project is by itself the best way to engage girls in STEM. However, they do suggest that there is much more to gain from treating STEM learning in this space as more than a purely cognitive matter, and stress that including affect and motivation is intrinsic to STEM spaces (p. 162).	1. Women hold a disproportionately low share of STEM undergraduate degrees, particularly in engineering, and those with a STEM degree are less likely than their male counterparts to work in a STEM occupation (p. 151). There should be a greater inclusion of women in STEM fields. Girls' engagement is described as though they are not interested, or that they do not have knowledge of technology. Girls will, for instance, be more motivated and engaged when empowered to participate on their own terms and when they receive positive feedback. 2. The technological activity that the girls were in-

				volved in included electric circuits that were used in a performed task, which was to create a bag.
Master, A., & Meltzoff, A. N. (2016).	The aim is to show that it is possible to increase equity and enhance outcomes for a broader number of children around the world by integrating psychological and educational science.	4 and 6 year-olds	Investigated two ways to encourage young children's interest and motivation in STEM. Designed interventions were based on: (1) increasing experience and (2) providing social information about what other "in-group" members do. First interventions: Programming a robot using a smartphone was one described task. Another task was constructing a Lego robot. Second intervention: boost children's motivation for performing a STEM task by having them complete this task as part of a group versus as an individual. In the findings, authors argued that girls' underrepresentation is not due to an intractable, immutable lack of interest or ability. Instead, girls' choices are driven by sociocultural factors; for example, stereotypes about who typically does STEM and who has ability in STEM.	1. Girls report lower interest and self-confidence than boys in STEM in most countries and perform worse on standardised STEM tests in some countries. Women are less likely than men to earn STEM degrees and work in STEM careers. Cultural stereotypes are present in children's minds and begin to shape their beliefs about what field is for them and where they belong. 2. Girls' non-engagement is not due to an intractable lack of interest or ability.
Shoffner, M. F., Newsome, D., Barrio Minton, C. A., & Wachter Morris, C. A. (2015).	The purpose was to increase our understanding of one aspect of the early career development of young people, as they form opinions and develop perceptions about career options in STEM.	Ages 10 –14	Qualitative study using focus group data to examine the outcome expectations, what young people believe will happen if they pursue certain interests, tasks, or goals. Study indicates that female students often experience a decline in self-esteem in the transition to middle school and during the subsequent middle-school years. When spoken to about future careers, girls were more likely than boys to focus on proximal outcomes, such as doing well in school, failing, or needing to spend a lot of time on homework. Result - "be aware of the negative outcome expectations that may be driving students' choices, because many of these expectations may be irrational or misinformed" (p. 113).	1. "The importance of relationships and connectedness to identity development in girls and young women" (p. 111). Outcome expectations are described as important factors in the development of young people's interest in future careers and their goals for careers. 2. Whereas both boys and girls talked about internal motivation and intellectual stimulation, girls were more likely to discuss psychological effects. (p. 111)

Chang, S., Yeung, Y., & Cheng, M. H. (2009).	The purpose is to investigate students' learning interests and life experiences involving science and technology, and also their attitudes towards technology.	Ninth graders	Likert-scale questionnaire, developed from the ROSE project. Results indicated that boys showed higher learning interests in sustainability issues and scientific topics than girls. However, girls recalled more life experiences about science and technology than boys. "One surprising finding was revealed in this study, that is girls' life experiences about S&T were higher than boys, like the sustainability issues of environment, earth science, biology and information technology, and only earth science was no significant difference." (p. 454)	1. Girls need to be promoted in science and technology. Even though immersed in the subject matter of science from an early age, female students "all described later feelings of alienation, of being 'cut off' from the possibility of developing a deeper, more 'adult' relationship with science" (p.449). Girls have more experience relating to S&T than boys, but do not feel interested in learning S&T (p. 454). 2.Only girls' relationship to technology is discussed as being in need of support.
Voyles, M. M., Fossum, T., & Haller, S. (2008).	The study addresses: "(1) Do teachers differ in the way they interact with fourth- through sixth-grade boys and girls who are working in same-gender triads to learn engineering and computer programming in a robotics course? (2) Do boys and girls in a technology course differ with respect to interest, prior experience, achievement and self-confidence, cooperation, and requesting help?" (p. 323).	Grades 4, 5, and 6.	Study perspective is "gender difference, where the goal is to identify the ways in which male and female students differ or are treated differently, and to suggest ways to address these differences" (p. 327). Analysed transcripts of videotapes of instruction; teacher, parent, and student interviews; student questionnaires; and final programmes. The results showed that girls and boys differed in several ways, and teachers explained their differing interactions with boys and girls as functional responses to those differences. At the end of the course, volunteer boys and recruited girls did not differ in achievement or interest in the course.	1. Women not pursuing careers in technology is seen as a problem. Factors other than personal preference discourage women from entering STEM fields. 2. Girls were more likely than boys to initiate interaction with teachers. Findings could be interpreted to mean that the girls were less able and needed more assistance than boys. However, it is also possible that more able or conscientious students have the confidence and good judgment to ask critical questions (p. 340). The task performed in the study was building and programming a Lego Mindstorms robot.
Villas-Boas, V. (2010).	The aims were to improve the	High	This project was planned to provide a foundation for	1. "Unfortunately, most girls do not consider a career

	quality of the teaching and to increase the interest of students in technological areas, leading to a future career in engineering.	school level students.	the teaching–learning process of science and for the application of theory in the solution of real problems. Activities based on “new educational methodologies, workshops in different areas of science and technology, a programme entitled ‘Encouraging girls in technology, science and engineering’” (p. 289). “For the moment, there are no quantitative results on the increase of students choosing engineering courses at UCS nor on the increase in women choosing engineering as a career since activities of this project only started at the beginning of 2009. However, the enthusiasm shown by participants in the programme suggests that measurable results will soon be forthcoming” (p. 295).	in these fields, in which females are underrepresented. The problem starts early, with society stimulating girls to take an interest in subjects said to be ‘feminine’ rather than ‘masculine’” (p. 294). 2. Girls could become included if they were subjected to tasks “addressing problems at school and in the neighbourhood, working with tools, building robots, taking field trips, etc. (p. 294).
Fensham, P. J. (2009).	Discusses issues arising from the use of S&T contexts in PISA and the implications they have for the current renewed interest in context-based science education	15-year-olds	Analyses of the students’ responses using the contextual sets of items as the unit of analysis provides new information about the levels of performance in PISA 2006 Science. Embedding affective items in the achievement test did not lead to gender/context interactions of significance, and context interactions were less than competency ones. (p. 884)	1. Girls are not engaging with technology education. A suitably chosen real-world context can engage both boys and girls. (p. 884) 2. The written PISA test was perceived to be of great advantage to girls because of their known better performance in reading in most of the participating countries.
Virtanen, S., Räikkönen, E., & Ikonen, P. (2015).	Explore differences between girls’ and boys’ motivation in relation to technology education in primary school.	Ages 11–13 years	A questionnaire was administered to pupils in grades five and six. Factor analyses showed that pupils’ motivation structure consisted of nine factors. The results also showed gender differences in most factors.	1. Girls were seen to be lacking in the field of technology. Girls were significantly more interested in studying environment-related issues. Interest in this context refers to choosing something among alternatives or favouring something over its alternatives. (p. 200) 2. The girls felt that it was fundamental to obtain support and encouragement from teachers. Additionally, girls enjoyed making useful and decorative artefacts for their homes more than boys.

Jennings, S., McIntyre, J. G., & Butler, S. E. (2015).	Exploring young adolescents' interest in engineering as a future career by examining the influence of gender and grade level on participants.	Ages 10–13	Video intervention, questionnaire and qualitative analyses. Qualitative analyses comparing the responses of participants who had seen a video, with those who had not, revealed that the video dispelled some stereotyped beliefs, but not others, with grade-level and gender effects. Results highlight the importance of listening to adolescents' views about engineering as a field and as a future career.	1. Girls appear to be less interested in STEM than boys: "Interactions between gender and age influence the consideration of engineering as a possible career" (p. 15). Programmes to promote girls' interest in technology are failing. 2. Girls, more than boys, were hypothesised to report feeling differently about engineering after seeing the video. Girls, more than boys, exposed to the video were hypothesised to comment positively on engineers as "helpers".
Autio, O., Olafsson, B. & Thorsteinsson, G. (2016).	Explore students' technological knowledge and reasoning.	Ages 11 and 13.	A questionnaire regarding mechanical systems connected to simple physical phenomena. Results highlighted that students should have been more familiar with the content of the survey as a result of their Design and Craft studies and the use of textbooks in other subjects, such as physics. Differences between boys and girls are explained by their different interests and this has an impact on girls' motivation for learning about technology.	1. The insufficient representation of girls and women in STEM fields might be because of the different social expectations for boys and girls. Furthermore, it is not a surprise that boys and girls differ in their interests (p. 65). 2. Icelandic girls who scored better than their peers are thought to have a better setup for scoring higher due to the curriculum.

Dakers, J. R., Dow, W. & McNamee, L. (2009).	Explore perceptions that are held by school students about technology and technology education when they enter secondary school.	Ages 12–13	Case study undertaken in the UPDATE project. No gender difference emerged, either from the questionnaires or from observation in the amount of enjoyment or engagement displayed by pupils. Both boys and girls were highly motivated and engaged throughout. It is argued that technology education is perceived to be masculine in nature, procedural in delivery and lacking in the conceptual dimension. "The findings suggest that where technology is not perceived of as masculine in these respects, and where new forms of pedagogy that integrate or fuse conceptual issues relating to technology into the learning space are employed, then girls and boys seem to develop more interest in the subject matter" (p. 390).	1. "Girls and boys are no longer streamed into either domestic science or technology subjects on the basis of gender. These boundaries, it would appear, have been dismantled. The fact remains, however, that despite these progressive shifts in policy, girls, in general, still orientate towards food or textile technology areas" (p. 385). "More girls achieve higher grades in virtually all technology subject domains. It is therefore clearly not a question of lack of ability on the part of girls" (p. 386). 2. "No gender difference emerged, either from the questionnaires or from observation in the amount of enjoyment or engagement displayed by pupils. Both boys and girls were highly motivated and engaged throughout. Boys and girls collaborated very well, both within and across groups in their attempts to find a fragrance which would meet the approval of the opposite sex" (p. 390).

Summary of the results

Girls' engagement with technology education

When describing gender and technology, most studies report that girls are less interested than boys, and that female students tend to have less ambition in technology and are underrepresented in the field (Jennings, McIntyre, & Butler, 2015; Chang et al., 2009; Ardies, De Maeyer, & Gijbels, 2015; Ardies, De Maeyer, Gijbels, & van Keulen, 2015; Villas-Boas, 2010). Some studies (Ardies, De Maeyer, Gijbels, & van Keulen, 2015; Master & Meltzoff, 2016; Rasinen et al., 2009) also report that girls are interested at the age of around 10, but from that point onwards their interest starts to decline. Girls also tend to be more negative towards technology, according to some studies (Ardies, De Maeyer, & Gijbels, 2015; Shoffner et al., 2015). Girls are thus generally more negative towards technology, whereas boys are found to be more positive than girls and with a less negative trend in the development of their attitudes.

Some studies (Mammes, 2004; Autio & Soobik, 2017; Andreucci & Chatoney, 2017; Chatoney & Andreucci, 2009; Autio et al., 2016) conclude that the low level of interest among girls is traceable to their socialisation, the different social expectations for boys and girls, and to the fact that girls are not exposed to technology as much as boys. Girls' lack of interest is thus seen as a social construction. People treat girls and boys differently from an early age, giving them different feedback and expectations, and culture discourages girls from being interested in technology even when they demonstrate talent for pursuing science and technology careers.

According to many of these studies (e.g Ardies, De Maeyer, & Gijbels, 2015; Stevanovic, 2014; Rasinen et al., 2009; Autio et al., 2016; Virtanen et al., 2015), there is also an insufficient representation of girls and women in the STEM field. Women hold a disproportionately low share of STEM undergraduate degrees, particularly in engineering, and those with a STEM degree are less likely than their male counterparts to work in a STEM occupation. The process of females drifting away from the field of technology starts at an early age, around 10. If children at this age, especially girls, think that activities from the field of technology are not suitable for girls, this will naturally be a barrier to making these topics appear interesting and relevant.

Girls will also be more motivated and engaged when empowered to participate on their own terms and when they receive positive feedback (Chatoney & Andreucci, 2009; Virtanen et al., 2015). Girls report lower interest and self-confidence than boys in STEM in most countries and perform worse on standardised STEM tests in some countries (e.g. Fensham, 2009; Chang et al., 2009; Osagie & Alutu, 2016; Dakers et al., 2009). Women are less likely than men to earn STEM degrees or to work in STEM careers. But, as argued by Master and Meltzoff (2016), girls' underrepresentation is not due to an intractable, immutable lack of interest or ability.

Chang, Yeung, and Cheng (2009) conclude that girls have more experience related to science and technology than boys, but still they do not feel interested in learning about the area. Another study (Virtanen et al., 2015) claims that girls were significantly more interested than boys in studying, for example, environment-related issues, whereas a couple of studies find that girls are just as interested in or engaged with technology as boys (Dakers et al., 2009; Voyles et al., 2008).

Girls' technological activities and the relationship between girls and technology

This second part of our aim was more difficult to trace in the selected studies. The technological activities in which the girls were involved in the various studies include electric circuits that were used in a pre-set task to create a bag (Sheffield et al., 2017); a Christmas tree and components of the electrical circuit, and designing and making a nesting-box (Mammes, 2004); a product improvement of a Mini football cage and a jewellery box (Chatoney & Andreucci, 2009); and building and programming a Lego Mindstorms robot (Master & Meltzoff, 2016).

According to Ardies, De Maeyer, & Gijbels (2015), gender differences in technology may correlate with the presence of technological toys and the amount of actual play with such toys. Autio and Soobik (2017) claim that technological knowledge is important, especially in spatial reasoning, and that this has an impact on girls' motivation for learning about technology. Girls prove to be more sensitive to the study aids they are working with. They show greater imagination and inventiveness and take more risks than boys on the feminine supports that they are familiar with (Mammes, 2004). They act in a similar way to boys, however, when working with masculine supports. Girls were much more likely than boys to initiate interaction with teachers (Voyles et al., 2008; Virtanen et al., 2015). This finding could be interpreted to mean that the girls were less able and needed more assistance than the boys. However, it is also possible that more able or conscientious students have the confidence and good judgement to ask critical questions. Mammes (2004) also found that teachers can encourage girls to be interested in science and technology through how they teach.

Discussion

In this section, we discuss the results of our scoping literature review in response to our research aim. When analysing girls' engagement, activities and relationship with technology (education) – as presented in Table 1 and in the summary of the results above – there are some important points to make. First of all, in the great majority of studies, girls come out as insufficiently represented or reluctant to participate in technology, science and/or STEM fields, or they are less interested or more negative towards technology (education) than boys. A very important point to make here is that there is ample evidence supporting these claims (see Table 1); for example, from studies of students' attitudes towards technology, which have a long tradition in technology education (Ankiewicz, 2019; Ardies, De Maeyer, Gijbels, & van Keulen, 2015; Svenningsson et al., 2018).

Secondly, however, many of the studied articles venture explanations for why girls' engagement, interest and attitudes differ from those of boys, and those that do so offer two opposing explanations; either it is the girls themselves who are responsible for this, or it is societal prerequisites or expectations of various kinds that are to blame. In the former case, there are no further elaborations other than claiming that girls are less interested in and more negative towards technology than boys (Ardies, De Maeyer, Gijbels, & van Keulen, 2015), or that "girls, in general, still orientate towards food or textile technology areas" (Dakers et al., 2009, p. 385). In the latter case, which actually accounts for a majority of the 20 articles, there are attempts to explain, with reference to cultural and societal norms and expectations, why girls are less likely to choose technology or STEM fields, or just generally have a less positive attitude towards technology. The following are some examples: socialisation, that is, girls have not been exposed to as much technology as boys (Mammes, 2004, p. 91), or have been exposed to different social expectations than boys (Autio et al., 2017, p. 201); "social and cultural distribution of activities between men and women" (Andreucci & Chatoney, 2017, p. 5); "that the culture discourages girls" (Osagie & Alutu, 2016, p. 234); because of educational policy and information campaigns influencing parents, teachers, guidance staff and girls (Stevanovic, 2014); "certain contents, certain types of activities, certain forms of studies, certain gestures of education and scholastic shapes are better adapted to the girls than to the boys and conversely" (Chatoney & Andreucci, 2009, p. 393); "sociocultural stereotypes associating STEM with males act as barriers that prevent girls from developing interests in STEM" (Master & Meltzoff, 2016, p. 215); "the importance of relationships and connectedness to identity development in girls and young women" (Shoffner et al., 2015, p. 111); "girls do not consider a career in these fields, in which females are under-represented. The problem starts early, with society stimulating girls to take an interest in subjects said to be 'feminine' rather than 'masculine'" (Villas-Boas, 2010, p. 294); and girls also feeling that it is fundamental to obtain support and encouragement from teachers (Virtanen et al., 2015).

There are, of course, exceptions here. For example, Ardies et al. found that girls are more positive towards STEM than technology, which was the same as boys (Ardies, De Maeyer, & Gijbels, 2015); teachers can encourage girls to be interested in science and technology through how they teach (Mammes, 2004); and a couple of studies also found that girls are just as interested in or engaged with technology as boys (Dakers et al., 2009; Voyles et al., 2008).

Regarding girls' technological activities, few articles define the concept or type of technology (activity), although those studies that do define a type of technology that is put forward as either neutral, or a "male" kind of technology (e.g. electrical gadgets, electronics or Lego Mindstorms). Exceptions are Chatoney and Andreucci (2009), who refer to a jewellery box, and Andreucci and Chatoney (2017), who take up examples of activities involving artefacts that can be considered as both male and female. The last part of our aim, the relationship between girls and technology, is scarcely described at all in the included studies. However, girls indeed do have a relationship with technology, and it seems that, although girls' engagement with technology and STEM fields is lower than boys', there is potential for improving this engagement using apparently simple means. For example, girls are more sensitive than boys to the "gender" of study aids/support objects that they are working with in a design project, as shown by Chatoney and Andreucci (2009). Girls also show greater imagination and inventiveness, and take more risks than boys, with a feminine study aid (jewellery box). Mammes (2004) also concludes that teachers can encourage girls to be interested in science and technology through how they teach, and that this is easier the earlier technology education is introduced in school. The existence of female teachers and female classmates is also important for improving girls' engagement, and could thus lead to a positive "snowball effect" (Stevanovic, 2014; Rasinen et al., 2009).

Our analysis of the data about girls' engagement with technology education was made difficult by the scarcity of information in the reviewed articles (see Table 1). However, by performing a content analysis, we have nevertheless unearthed some structures, symbols, and identities as being prevalent in the research on gender and technology. To some extent, the research reveals a traditional view of what technology is – a concept of technology and empirical examples of types of technology with a typical male, "nuts-and-bolts" code. Questionnaires, for example, could contain questions that prompted the following remark: "Spends a lot of time with engineering-related hobby activities" (Autio et al., 2016, p. 98), which can be seen as a male-coded form of technology. This might generate misleading answers from girls who do not identify their engagement in technology as engineering. When revisiting the PATT questionnaire, Svenningsson et al. (2018) also discovered that the gender category cannot be used as intended since it might be gender-biased; in the gender items, boys were consistently placed before girls; for example, "Boys are able to do practical things better than girls". There thus seems to be a mismatch between the image of girls as not engaged in technology and that of expecting them to be so engaged, although most of the studies in the sample acknowledge that the reasons for this disengagement are beyond girls' and women's control. However, the gendering that takes place within a research discourse seems to be complex as well as conflicting, which invites further detailed empirical research.

In conclusion, according to the reviewed studies, girls are less interested and have less positive attitudes towards technology (education) than boys. They are also less likely to choose a technology or STEM-oriented occupation. Several of the included studies venture possible explanations as to why this is the case, and refer mainly to cultural factors. Those studies that do define the type of technology used in girls' activities mostly describe a neutral, or male kind of "nuts and bolts" technology. As regards girls' relationship with technology, there is potential for improving female engagement using apparently simple means; for example, making sure that the social context of teaching is adapted to girls.

Limitations and further research

The potential limitations of this study were the manner and timing of the ERIC search, which can generate varying results despite applying the same search variables. As Hussénius, Andersson, Gullberg, and Scantlebury (2013) argue, too many studies are restricted to comparing female and male students and it could also be valuable to perform studies focusing only on girls in order to change the perspective. Techno-feminist theory highlights the co-construction of technology *and* gender. Gender relations are materialised in technology, which in turn gives meaning not only to gender relations (Wajcman, 2010), but also to girls' and boys' engagement with technology separately. Therefore, focusing future research on girls and technology could provide important insights that go beyond a comparison with boys and men. Furthermore, the studies reviewed were mainly conducted in a Western context and by Western researchers. Key results from the Rose project (Sjøberg & Schreiner, 2010) highlight girls in countries like Uganda, Ghana, Lesotho, Swaziland, Zimbabwe and Botswana as having the most positive attitudes to technology and technology-oriented occupations. This positive attitude could be of interest to explore. Data and analysis from a cross-cultural perspective as grounds for discussions and conclusions concerning gender structures and gender symbols and identities could be very illuminating.

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