Gifted students' needs in technology education

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ABSTRACT

Students who are gifted and students with high abilities can have special educational needs. Teaching should be challenging and stimulating and teachers and educators in inclusive settings have a variety of needs to consider, included the gifted students' needs. However, when it comes to technology education, little is known about gifted students' needs. The aim of this ongoing study is to describe and synthesize knowledge about gifted students' needs in technology education through a systematic research literature review and a thematic analysis. The tentative results are four themes describing gifted students' needs in technology education as *Complexity*, *Autonomy*, *Support*, and *Authenticity*. The themes can be used by teachers and guide them in their efforts to plan and implement diverse and differentiated technology teaching as a proactive response to the gifted students' needs in inclusive settings.

Key Words: gifted education, needs, literature review, differentiation, inclusion

1. INTRODUCTION

Students that learn with ease, reach learning goals with ease, and those who are ahead of their peers in their knowledge development, are differently described in different contexts by researchers. For example, these students can be referred to as gifted, talented, high achieving, students with high ability or high potential (Dai & Chen, 2013; Mellroth, 2018). These concepts, all describing the students, are complex and culturally specific in terms of where and to what extent different personal abilities and characteristics are valued, hence the variety (Al-Hroub & El Khoury, 2018; Kaufman & Sternberg, 2008; Sak, 2021). In this paper, *gifted students* will be used when describing students that learn with ease, and this term should be understood as an overlapping umbrella concept including talent, high achieving, high ability, and high potential. Giftedness should also be seen as a developable ability (Gagné, 2004; 2005). In a school context, teachers need to recognize multiple forms of giftedness and there is a call for educating teachers about the needs of gifted students (Campbell et al, 2022; Laine & Tirri, 2016; Rimm et al., 2010). If those needs are not met, there is a risk that gifted students will not reach their potential, will underachieve, or may even drop out of school (Rimm et al., 2010). There is a lack of research studying gifted students' needs from different perspectives and in relation to different subjects, and also a lack of research studying how these needs can be met in specific educational contexts, for instance technology education. Themes, describing gifted students' needs from the technology education perspective, can help develop both gifted education and technology education and guide teachers when designing differentiated technology education for inclusive settings.

2. AIM AND RESEARCH QUESTION

The aim of this systematic research literature review is to develop themes for technology education by identifying and synthesizing knowledge about technology education for gifted students. The research question is:

- What needs of gifted students in relation to technology education are pointed out in research literature?

3. EDUCATION FOR GIFTED STUDENTS

There are general approaches to teaching gifted students, but no clear recommendations are given for the subject technology. These approaches can be applicable in all school subjects. *Differentiation* is one approach to teach gifted students, and other approaches are *enrichment* and *acceleration*.

Differentiation is a pedagogical and proactive response to the needs of different students in the classroom (Tomlinson, 2016). Many school systems have an inclusive approach, meaning that students with a diversity of needs are taught jointly. Differentiation involves variations in teaching, and these variations can relate to instruction, content, methods, or assessments. The variations can be supportive, or they can be challenging. Differentiated teaching can address students' prior knowledge, interests, and motivation through four different variants: differentiating the content (where, for example, the learning material can start at an abstract and complex level and stimulate higher order thinking), differentiating the process (working in different ways with a material), differentiating the outcome (as a result of varying content or methods), and differentiating the learning environment (based on students' different needs, e.g. group work with people similar to oneself) (Mellroth, 2021; Tomlinson, 2016).

Enrichment is described by Gagné (2007) in terms of difficulty, depth, diversity and density. He describes that gifted students can work with material that is more complex and advanced (difficulty); with more detailed material (depth); with content that is not described in the curriculum (diversity); or with compressed course content to avoid repetition of what he or she already knows and masters (density). Subject-specific enrichment is the most effective in stimulating gifted students, as opposed to more general enrichment without clear objectives (Freeman, 2004).

Acceleration can be used to differentiate instruction. Since some students are quick learners, they may be allowed to progress more quickly through a subject and access more advanced content (Little, 2018), perhaps finishing courses earlier than planned. Another way to accelerate is to attend one or more grades higher than the age indicates (Sims, 2021). There are recommendations to slow down the pace for gifted students. So, while gifted students need complex and advanced content, they may also need support to deeply absorb the content and engage with the task (Little, 2018).

4. TECHNOLOGY EDUCATION

Technology education differs in aim and content between different educational systems and countries. In the UK for example, the subject *Design and Technology* emphasizes design and design processes (Department for Education, 2022). Design includes functionality, fitness for purpose, form and aesthetics. Food technology with a focus on raw material processing is also a part (Barlex, 2018; Rutland, 2018). In Finland, the technology subject includes crafts with a focus on design processes, craftsmanship with different types of materials, and problem solving (FNAE, 2022). In Sweden, technology education should provide students with abilities to reflect on and develop knowledge of technological solutions, and to solve technical problems with technological methods (SNAE, 2022). In both New Zealand and the US, technology education focuses on technological literacy (Milne, 2018; Reed, 2018). According to Rossouw et al. (2010), technological literacy can refer to what people need to know to live with and control the technological environment that surrounds us. It includes practical knowledge, the ability to reason about technology, and also attitudes towards technology. It is argued by Nordlöf et al. (2022) that even though technology education varies between different countries, it generally involves three categories in terms of content, namely technical skills, technological scientific knowledge, and socio-ethical technical understandings.

Education involving technology can be integrated with other subjects, such as science and mathematics. STEM (Science, Technology, Engineering, Mathematics) education has a focus on authentic learning and real-world problem solving (Hallström & Schönborn, 2019; Ülger & Çepni, 2020). In STEM education, teachers often apply an integrated approach to teaching and learning and the specific subjects are not separate but instead treated as one fluid unit (Ülger & Çepni, 2020). Regardless of the curriculum used, and wherever in the world technology education takes place, teachers may encounter gifted students in their teaching.

5. METHOD

A systematic research literature review (Hart, 2018) was conducted and complemented with a thematic analysis (Braun & Clark, 2006). Two databases with relevance for educational science were chosen: Educational Resources Information Center (ERIC) and SCOPUS. The search was limited to peer-reviewed articles in English published from 2010 in academic journals. Around 2010, many countries adopted new curricula (c. f. Department for education, 2022; FNAE, 2022; SNAE, 2022) and therefore searches were limited to 2010 and beyond. Five different searches were conducted (Table 1).

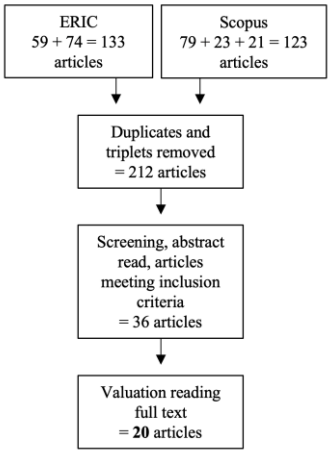
The five searches resulted in 256 articles (Figure 1), and after removing doublets and triplets, 212 articles remained. Three inclusion criteria were developed for the screening (title, abstract, and keywords), all of which had to be met: relevance for a) technology education or STEM education, b) gifted education, c) gifted students' needs.

Table 1.
Description and summary of articles

Date of search Database	Search blocks	Total
230118 ERIC	ALL (Gifted* OR Talent* OR "high achievers" OR "high* able" OR "high ability" OR "high potential") AND ("technology education" OR "STEM education" OR engineering) AND needs	59
230118 Scopus	ALL (Gifted* OR Talent* OR "high achievers" OR "high* able" OR "high ability" OR "high potential") AND ("technology education" OR "STEM education") AND "student needs"	79
230127 Scopus	TITLE-ABSTRACT-KEY (Gifted* OR Talent* OR "high achievers" OR "high* able" OR "high ability" OR "high potential") AND ("technology education" OR "STEM education" OR engineering) AND "student* need*"	23
230127 Scopus	TITLE-ABSTRACT-KEY (Gifted* OR Talent* OR "high achievers" OR "high* able" OR "high ability" OR "high potential") AND ("technology education" OR "STEM education" OR (engineering AND K-12)) AND needs	21
230204 ERIC	TITLE-ABSTRACT-KEY (Gifted* OR Talent* OR "high achievers" OR "high* able" OR "high ability" OR "high potential") AND ("technology education" OR "STEM education" OR (engineering AND K-12)) AND needs	74

This screening resulted in 36 articles chosen for a full text reading, where 16 articles were excluded since the topics of those articles (for instance policy, leadership) were not within the scope of this study.

Figure 1.
Search process



After this systematic search, the final 20 articles were coded and analyzed thematically (Braun & Clark, 2006). First, notes were added to data extracts associated with gifted students' needs in technology education. The notes then were organized into meaningful groups and coded, and 21 different codes emerged. The data were coded inductively to prevent preconceived impacting. The codes were collated into themes based on similarities and aspects of meaning related to each other. The themes of gifted students' needs in technology education were finally named (Table 2).

Table 2.
Codes and Themes

Codes	Theme
Abstraction, Complex activities and thinking, Experiments, Conceptual explorations	Complexity
Pace, Perfection, Independence, Responsibility	Autonomy
Feedback, Mentors, Ethics, Discussions, Acknowledgement, Freedom	Support
Open-ended tasks, Creativity, Holistic, Interdisciplinary, Metacognition and transfer, Real-life problems and situations, Meaningfulness	Authenticity

6. FINDINGS

Four themes of gifted students' needs in technology education emerged: *Complexity*, *Autonomy*, *Support*, and *Authenticity*. A brief description of the themes will be presented next with some examples from the final selected articles.

6.1. Complexity

Complexity advocates that gifted students in technology education need advanced work and complex activities that allow them to explore concepts on an abstract level and conduct advanced experiments with a focus on understanding (Torkar et al., 2018). Experiments can aid and support concept understanding while building models and structures for visualizing concepts. Complex content or complex systems of ideas with great depth and significance can meet high abilities and stimulate higher-order thinking, that is, analyses, syntheses, and evaluations (Taber & Cole, 2010). Higher order thinking can help develop content and concept understanding. Gifted students also need to be continuously challenged, and complex activities, advanced experiments, and conceptual explorations allow new connections to be made between the concepts in a challenging way.

6.2. Autonomy

Autonomy refers to the gifted students' needs for self-regulated learning and a sense of freedom. Gifted students often take a role as active learners and assume responsibility of learning processes and of the outcomes of current projects. They need to feel that they are in control of the depth and breadth of the content and learning processes (Morris et al., 2021). Further, they need some freedom in choosing activities that can be motivating for them, and they need to be able to adjust the pace of the learning. In other words, they need to feel that they have ownership over the activity and that they are in control of the situation, content, and pace. New and additional content introduced at a fast pace allows for making connections between concepts and thinking in an abstract manner. In addition, gifted students need to perform activities to the level of perfection that they themselves find sufficient, which affects the pace and duration of the activities. A part of autonomy is also the possibility for gifted students to express themselves in any way they choose. When given these opportunities, gifted students can work intensely to learn and to create a final product.

6.3. Support

Support describes gifted students' needs for response, feedback, discussions, and acknowledgement in relation to technology education (Tosunogly & Yildiz Durak, 2022). Even though gifted students need autonomy, they also need guidance in their choices. The guidance helps them focus and achieve what is currently beyond their reach. The response and feedback should be continuous and also adjusted and adapted to each individual student (Monteiro et al., 2012). Further, gifted students need in-depth discussions. These can be held with for instance their teachers, their peers, or mentors from outside the school. The discussions can be on different types of content and different processes or about ethical issues (Abdurrahman et al., 2019). Various competing interests can be discussed and different perspectives can be highlighted and respected. Such discussions challenge gifted students cognitively and help develop higher order thinking.

Acknowledgement is an important part of *Support*, and gifted students need to be acknowledged for their competence as well as for their abilities and potentials. This is discussed by Monteiro et al. (2012), claiming that it is not enough for the gifted students to recognize their own potential and personal abilities, they also need others to recognize them, especially their teachers.

6.4. Authenticity

Authenticity indicates that gifted students need meaningful and relevant activities based on real-life problems and situations (Morris et al., 2021). They need to get a grasp on the bigger picture, see the whole context, understand the historical perspectives of a situation, and work with learning content using an interdisciplinary approach.

When working with real-life problems, gifted students need to work with authentic methods used by professionals, and they need hands-on tools and materials to carry out physical solutions (Abdurrahman et al., 2019). The authentic activities can advantageously be open-ended, and findings and solutions can be reported to a real and interested audience (Taber & Cole, 2010;

Torkar et al., 2018). The open-ended activities create opportunities for gifted students to be creative, to find creative solutions to problems, and to present them with questions that promote creative thinking. This interdisciplinary approach and open-ended activities open up for gifted students to think of their learning and develop their metacognition (Taber & Cole, 2010). Taber & Cole (2010) argue that this is important for gifted students in technology education. Open-ended activities can in addition also satisfy gifted students' need for knowledge transfer, that is, to use knowledge from one context and apply it in novel situations (Abdurrahman et al., 2019).

7. DISCUSSION

As a complement to general approaches for teaching gifted students (differentiation, enrichment, acceleration) the resulting themes from this literature review describe needs of gifted students in technology education. Gifted students are a heterogenous group (Dai & Chen, 2013) thus they may have varying degrees of needs from the themes. However, the themes can function as a guide for teachers to ensure that gifted students' needs are taken into consideration.

The theme, *Complexity,* aligns with differentiated teaching (Tomlinson, 2016) as technological concepts and methods can be taught in various ways. For stimulating gifted students, the focus should be on understanding concepts, which is supported by Freeman (2004) suggesting subject-specific enrichment as the most effective form of stimulation. Technological concepts and methods are subject-specific even though they can be intertwined with other disciplines. Interdisciplinary content is yet another way of meeting the needs for complexity. When they encounter different perspectives and approaches in one area, gifted students can discuss dilemmas and different options that also relate to other areas, meanwhile developing higher order thinking.

Gifted students should be given opportunities to be autonomous, independent, and able to make some of their own decisions in technology education. The theme, *Autonomy,* describes this and can be understood as self-regulated or student-centered learning (Morris et al, 2021). When gifted students are autonomous, they can be creative and choose methods based on professional preferences when solving problems. Gifted student typically wants to use methods applied in real-life settings. Therefore, the freedom of choosing a method and a suitable level of creativity is important. If access to material and tools is provided, technological problems can be understood as real and meaningful (Morris et al., 2021). However, gifted students should be given a great deal of freedom under supervision, as they also need *Support* to focus and not get caught up in perfectionism when creating solutions. The pace of learning, which should be fast, is important for gifted students (Little, 2018). Thus, it is important that gifted students are given enough time to solve problems in their own ways.

When gifted students are presented with real-life technological problems, they are given opportunities to work with different perspectives. This can give the students a holistic understanding of technology, and according to the literature this is important (Morris et al., 2021; Torkar et al., 2018). Authentic problems and open-ended activities can have a positive impact on gifted students' motivation (Taber & Cole, 2010), as has the degree of choice in activities. *Authenticity* in technology education can cater to gifted students' needs for self-regulated learning since students take an active role as investigators (Taber & Cole, 2010) when solving the

problems. When students use a self-regulated approach in technological activities, they can nurture their metacognition while reflecting on and reasoning about their own abilities (Torkar et al., 2018). Further, when students are working with transfer, new situations and interdisciplinary contents, they also nurture their metacognition.

Mentoring is discussed in the research literature about gifted education. In technology education, gifted students need to discuss content and methodological issues in terms of in-depth and up to date knowledge with competent people (Abdurrahman et al., 2019; Monteiro et al., 2012) in order to construct, deepen, and widen their learning. Preferably a mentor can represent the professional community of engineers, and he or she can act as an expert in a technological field discussing concepts, understandings, and dilemmas with the gifted students. A mentor can also act as a role model for gifted students, someone who they can identify with. In this way, since the mentor has real-life experience in the area of study, authenticity is provided.

This review makes an important contribution with knowledge about gifted students' needs in technology education, and provides teachers and teacher students with themes that can be used when designing differentiated teaching activities. Teachers can take into account the four themes and use them to provide for gifted students to have their needs met. The themes can also be used when comparing different technology educational traditions and can facilitate a common understanding of gifted students' needs.

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