Computational thinking by means of digital technology-enhanced learning environments to foster psychological and socio-pedagogical development pertaining to children in special education

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Abstract

Many children in special education experience psychological and socio-pedagogical developmental challenges or experience difficulties with problem solving or communicating. Such challenges underscore the need for targeted teaching methods that support adaptive developmental needs of children in special education. In this regard, digital, technology-driven learning environments to create problem-solving tasks can serve as a non-obvious and yet underexploited method for promoting psychological and socio-pedagogical development. Previous research findings have indicated that digital technology-supported learning environments can contribute to computational thinking (CT), while a limited number of recent studies suggest that learning environments enriched with digital technology that stimulate CT can also promote competencies related to psychological and socio-pedagogical development. But it still remains unclear how such environments contribute to these desired competencies in children in special education and what role teachers play in this regard. To address this knowledge gap, a research agenda has been established that proposes an exploratory study to provide directions and guidance for development opportunities to determine a) which competencies can be enhanced through digital, technology-supported learning environments for special educational needs, b) how these competencies can be facilitated, and c) which educational practices can promote CT and improve competencies related to psychological and socio-pedagogical development. Based on insights yet to be uncovered, it is to be tentatively expected that CT offered through digital technology-enhanced learning environments can contribute to various competencies related to psychological and socio-pedagogical development in special education children with ID, ASD and ADHD.

Keywords

Computational Thinking, Psychological and Socio-Pedagogical Development, Special Educational Needs, Digital Technology-Enhanced Learning Environments, Problem-Solving Approach

1. Introduction

Children are at school to learn, but that does not always happen automatically. In addition to learning school subjects being less straightforward, for example because a child has difficulty processing information or suffers from fear of failure, there are many other causes that can play a disruptive role [1]. Conditions such as intellectual disability (ID), autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD) can have a huge impact and limitation on children's learning abilities [2]. ID refers to neurological developmental disorders that affect functioning in two areas: cognitive functioning, such as learning, problem solving, and judgment; and adaptive functioning, daily activities such as communication skills and social participation [3]. ASD encompasses behavioral characteristics that indicate vulnerability in the areas of social interaction, communication, flexibility in thinking, movement, and action, sensory stimulus

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processing, and filtering and integrating information [4]. ADHD is characterized by impulsive behavior, concentration problems, restlessness, emotional dysregulation, and learning difficulties [5]. Computational thinking (CT) can be beneficial for children with such learning difficulties, as it develops problem-solving, logical structuring, and pattern recognition skills [6]. However, traditional teaching methods may not be effective. Instead, approaches such as the use of concrete objects, real-life connections, and accessible tools such as educational games, robots and social robotics have shown promise in making CT more manageable and effective for this target group [7]. Adapting teaching materials is crucial to meet the specific needs of students with the aforementioned learning difficulties.

Today CT plays an important role in human development in everyday life [8, 9] and can be described as a process in human thinking that involves reformulating problems and their solutions in a way that can be effectively carried out by an information-processing agent, such as a computer, or by a human himself [9]. CT involves a set of problem-solving skills derived from computer science concepts, such as decomposing problems, recognizing patterns abstracting information and algorithmic thinking [9]. Furthermore, CT can contribute to a deeper understanding of social phenomena in the world including human social interaction which is necessary in order to solve complex problems in interaction with other people [8]. In this research agenda, we will refer to this as social-problem-solving [10]. In summary, it can be stated that CT can support people with a wide range of problems and encourage them to interact with others for the purpose of problem-solving, which can influence how people organize and manage their daily lives [8, 11]. Emphasized in this way, CT may foster psychological and socio-pedagogical development. Psychological development refers to the personal and behavioral growth of intellectual, emotional and social capacities and functioning of people throughout their lives [12]. Socio-pedagogical development refers to overarching themes, such as learning, social integration and well-being [13].

However, generally considered, few studies have been conducted to date on the beneficial influence of CT fostering psychological and socio-pedagogical development of children in special education. Although much research has been published on the application and acquisition of CT skills in children, little research has been conducted in the psychological and socio-pedagogical domain. In this research agenda, we therefore assume that CT might foster psychological and socio-pedagogical development by offering a structured approach to organizing problem-solving processes and that this is valuable to investigate (further).

1.1. CT and psychological and socio-pedagogical development in children from special education

The research agenda underlying the planned doctoral research will constitute a theoretical foundation with the expectation that CT, offered via digitally supported learning environments, can contribute to various competencies related to psychological and socio-pedagogical development, aimed at children aged 4 to 12 in special education with a learning disorder related to (ID), (ASD) or (ADHD) [14]. The rationale for selecting this young age group as the subject of study is motivated by the fact that CT may provide beneficial developmental opportunities for children in special education from early childhood onwards [15]. Previous research indicates that CT might contribute to social-problem-solving skills in children from special education [15]. Therefore, the planned doctoral research will explore whether CT can contribute to social-problem-solving in children from special education. Also, children from special education appear to have individual educational needs in one or more domains, besides the social domain, which may be related to (mal)adaptive development [16]. To this end, special education emphasizes more individual teacher practices and adaptation to children's special educational needs [17]. In order to reflect authentic learning situations as accurately as possible, the research will therefore be conducted in regular practice of physical classrooms within special education.

1.2. Digital technology-enhanced learning environments

From previous research it is already known that children apply CT-skills to use digital technologies to solve problems within educational contexts [15]. The use of digital technologies to solve problems within educational contexts is also known and described as digital technology-enhanced learning environments [18]. The use of digital technologies challenges children to translate problems and their solutions into an instruction that can be executed by a computer as an information-processing agent [19]. One example of an activity is guiding a robot to be programmed through a maze [18]. In order to program the robot, children can break down the problem into smaller parts and analyze the maze while determining the robot's steps to be programmed, which results in children acquiring further proficiency in CT-skills [19]. Another example can be social robotics in which children can interact in a social manner through speech, gestures, and facial expressions [20].

Furthermore, previous research indicates that, if digital technology-enhanced learning environments require social interaction, the problem-solving process might contribute to social-problem-solving skills in children [15]. Communication about the problem-solving process among children, in turn, might contribute to a deeper understanding of social-problem-solving [19]. But for children to successfully perform in learning environments supported by digital technology, they may need help from teachers [16].

1.3. Teacher practices in digital technology-enhanced learning environments

In digital technology-enhanced learning environments, teachers can provide closed or open problems, to support children's application and acquisition of CT-skills [21]. On the one hand, for closed problems, only one solution is possible, and it is clear in advance which learning objectives need to be reached. On the other hand, regarding open problems, multiple solutions are possible and different learning objectives can be addressed during the problem-solving process [22]. For both closed and open problems, teachers can adapt their teaching approach and guidance style. Teachers can demonstrate how CT-skills are applied to use digital technologies, also known as direct instruction [23], or provide feedback and direction on CT-skills to be applied, also called scaffolding [24]. In addition, teachers can align the learning environment to children's special educational needs [16].

Previous research suggests that the extent to which learning environments are aligned, besides an adapted approach, are a relevant factor for the level of task engagement among children [25] (Moreira et al., 2015). Task engagement can be described as a quality of human activity that can be recognized by a concentrated activity in which the person opens up, feels motivated and experiences a sense of accomplishment [26] (Laevers, 1997). However, to date, little is known about which educational practices and teacher guidance are related to promoting CT and for fostering psychological and socio-pedagogical development in children from special education in the context of digital technology-enhanced learning environments. In addition, not much is known about children's task engagement within this context.

1.4. Transfer of CT-skills

Ultimately, it is relevant to explore whether CT-skills acquired within digital technology-enhanced learning environments can be applied in unplugged learning environments and vice versa, which can cause transfer to occur [27, 28]. In unplugged learning environments, problems are solved without the use of digital technologies [29]. Previous research suggests that children can acquire CT-skills in unplugged learning environments, for example in unplugged smart or board games [30, 31]. However, only a limited number of studies have examined transfer of skills in children [27]. A distinction can be made between near transfer, where prior knowledge is used to improve performance on a new but related task, unlike far transfer, which applies skills to a very different situation [32-34]. It is precisely this area of interest to find out how the approach to

learning can be influenced via a focus on CT to support the needs of children in special education in a more easy-accessible and hands-on way.

The planned doctoral research will explore whether CT can foster psychological and socio-pedagogical development of children in special education through learning environments supported by digital technology. Specifically, the research will explore whether CT can contribute to social-problem-solving skills in children from special education within the context of digital technology-enhanced learning environments. In addition, teacher practices and the role of children's task engagement will be investigated. The intended outcome of the planned doctoral research is to develop and evaluate a framework to help teachers implementing CT in the educational curriculum to foster children's psychological and socio-pedagogical development. Moreover, the output of both the research agenda and the planned doctoral research can make a valuable contribution to non-digital approaches and support opportunities in various contexts.

2. Methodology

Based on the literature reviewed and the research agenda established, the main research question that emerges is: 'Can CT by means of digital technology-enhanced learning environments foster psychological and socio-pedagogical development of children in special education'? In the sub-questions formulated, we will refer to these environments as CT-related digital technology-enhanced learning environments. Furthermore, skills and knowledge associated with psychological and socio-pedagogical development, such as (social-)problem-solving, will be called dimensions of psychological and socio-pedagogical development. To answer the overarching main question, the following sub-questions will be investigated within the planned doctoral research:

1. What evidence can be attributed to CT-related digital technology-enhanced learning environments in fostering psychological and socio-pedagogical development of children in special education?

2. Which dimensions of psychological and socio-pedagogical development in children in special education can be fostered by CT-related digital technology-enhanced learning environments?

3. Which teacher's practices are related to promoting CT and fostering psychological and socio-pedagogical development for children in special education in the context of digital technology-enhanced learning environments?

4. Does task engagement moderate the association between CT-related digital technology-enhanced learning environments and the psychological and socio-pedagogical development of children in special education?

5. Which dimensions of psychological and socio-pedagogical development of children in special education provide a useful framework to help teachers implement CT in the educational curriculum?

2.1. Operationalization of Research

Our approach will draw up a research agenda and map out the existing literature on whether CT, through digitally supported learning environments, can promote the psychological and socio-pedagogical development of children in special education. The exploratory research will focus on specific groups, such as children with ID, ASD, and ADHD, which have been selected because of their prevalence in the research context. To guide and direct the research, a focus group will be established with experts in the field of CT and psychological and socio-pedagogical development, including both researchers and teachers. The aim is to identify the most important developmental needs of children in special education, in terms of CT and competencies in both psychological and socio-pedagogical development, and to substantiate the selection of a specific research group for the subsequent studies. This decision will be based on various criteria, such as the areas where experts see the most pressing need for research and the areas in which teachers are most enthusiastic and willing to participate.

The research agenda will also guide the practical direction of the study. A mixed-methods research design will be adopted to investigate all variables and interconnections being able to answer the research question and sub-questions. Both quantitative data, through the use of validated questionnaires, and qualitative data, through the use of observations and interviews, will be collected. In data analysis, children with similar educational needs will be clustered. This way, both cognitive and behavioral processes and children's developmental outcomes can be mapped in a specific and generic way, as well as teacher evaluations of the usefulness of the CT framework to be developed. The research will be conducted within the educational context of De Berkenschutse, a specialized school in the Netherlands among children aged 4 to 20 diagnosed with ID, ASD and ADHD.

3. Potential contribution of research for science and society

As can be inferred from the introduction and theoretical exploration, there are challenging opportunities for new research, but there are also a number of existing gaps that have not yet been identified. The planned doctoral research will explore and bridge these gaps. From a scientific perspective, it is relevant to explore these research opportunities with the goal of generating new knowledge and putting existing knowledge into a broader perspective. From a societal perspective, it is relevant to explore these research gaps, because CT may help children from special education with a broad range of problems and interact with others for the purpose of problem-solving which may affect how they manage their daily lives. This way, CT may provide beneficial developmental possibilities for children in special education from early childhood onwards.

4. Discussion & limitations

Our proposed research is intended to shed light on the extent to which technology-enhanced learning environments not only can contribute to a development of CT-skills, but also can facilitate acquiring competencies related to psychological and socio-pedagogical development in children from special education. To this end, many children in special education show impairments in their psychological and socio-pedagogical development. However, not much is known about which competencies related to psychological and socio-pedagogical development can be fostered through digital technology-enhanced learning environments, and how these environments contribute to such competencies in children from special education. The planned doctoral research will address this gap by focusing on both multi-step problem solving and for improving social-emotional

competencies. Furthermore, to investigate which teacher practices can support CT and competencies related to psychological and socio-pedagogical development in children from special education within this context to which teacher practices will be operationalized by providing open or closed problem activities. Finally, our research will unravel whether competencies acquired within digital technology-enhanced learning environments can be applied to other learning environments by children from special education. Understanding whether transfer can occur, and if so under what conditions, is essential to developing inclusive and sustainable educational settings.

5. Future work

It is expected that our proposed research direction and scientific results will contribute to the development of interventions that can improve the learning and development opportunities of children in special education through the impact of CT and digital technology-enhanced learning environments. The results obtained underscore the importance for targeted educational approaches of integrating CT to facilitate special educational needs, whereby psychological and socio-pedagogical development in children can be partially overcome. However, to make more specific statements about the potential that applications of digital technology-enhanced learning environments and other facilitating materials by impact of CT in special education can provide, more research is needed, in which the professionalization of teachers and childcare workers is essential.

6. Conclusion

The underlying research direction hypothesizes that CT can support children with learning and developmental impairments by providing structured, step-by-step methods for problem solving, leading to greater clarity and less social reluctance. However, this approach is still relatively unexplored territory, with only marginal knowledge available regarding whether, how, and to what extent computational thinking (CT) can have a positive influence on the socio-pedagogical and psychological development of individuals, particularly children and young people, through the teaching of crucial thinking and problem-solving skills, and what added value digital technology-enhanced learning environments can represent in this. The role of the teacher in special education is also crucial in creating the most stimulating learning environment for the special needs child. The findings of our study contribute to the development of tailored interventions that can enhance reading ability and reading motivation in dyslexic children. The results not only reveal implications for further research but also underscore the importance of integrating CT into current school curricula, thereby partially overcoming the impact of learning disorders.

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Compliance with ethical standards

The Ethical Research Board (cETO) of the Open University of the Netherlands has assessed the proposed research and concluded that this research is in line with the rules and regulations and the ethical codes for research in human subjects (reference: Ceto_ U202404611). Informed consent was obtained.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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