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# Design thinking in early childhood education and care. A literature review and consideration from the perspective of young learners' craft, design, and technology education

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**Abstract**
Design thinking is a cognitive, iterative process that involves identifying goals, understanding users, and creating solutions. It has changed from a designers' activity to an all-around approach to the innovation process and become a pedagogical phenomenon. In this article, design thinking method is studied in an educational context among young learners (children aged 5–8) through a literature review. The aim of this review is to gain an understanding of the reasons why and the ways in which design thinking is applied as an educational method in early childhood education and care. Through the review, we aim to find new ideas for teaching craft, design, and technology education with young learners. We present the results of 20 peer-reviewed articles reporting empirical studies of applying design thinking methods in an educational context with young learners. The results show that previous research has identified three themes of reasons to apply design thinking in early childhood education and care: enhancing multidisciplinary teaching, teaching design thinking as a method and supporting children's developmental domains, and participatory learning. The ways to apply design thinking with young learners also coalesced into three themes: children acting as designers by solving real-life problems, open-ended science problems, and challenges in imaginary play. In conclusion, we consider these findings from the perspective of teaching craft, design, and technology education for young learners.

**Keywords** Design thinking · Early childhood education and care · Young learners' craft, design, and technology education · Literature review

## Introduction

Creativity is needed for innovations and problem-solving at the individual and global levels, whether in private life or business. Creativity is not only a character trait or an innate quality but also a skill that is developed by intentional learning and practicing (O'Connor, 2014; Schut et al., 2019). In the past, design thinking was a professional

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working method for designers, architects, and engineers, but it is now known as a wide-ranging method in many fields, including education (Baker & Moukhliss, 2020; Brown & Katz, 2011; Retna, 2016). Design thinking as an educational method is a way to develop and enhance creativity, collaboration, and critical thinking through iterative innovation actions. It has proven to be an effective educational method, particularly in multidisciplinary learning and teaching future skills, and it has increasingly found its place in higher, secondary, and, more recently, basic education (Ejsing-Duun et al. 2019; Panke, 2019; Rusmann & Ejsing-Duun, 2022; Wrigley et al., 2018). However, in early childhood education and care, design thinking as an educational method remains rarely used and under-researched (Carroll et al., 2010; Noel & Liub, 2017; Parlar et al., 2017).

Design thinking approaches problem-solving by using tools traditionally employed by designers of commercial products, processes, and environments. It is a versatile approach for orchestrating conflicting ideas, identifying singular needs and common goals, making productive use of diverse backgrounds, enhancing empathy, and developing a shared vision (Elsbach & Stigliani, 2018; Panke, 2019; Viilo et al., 2018). The design thinking process involves phases of empathy and user focus, problem framing and defining, creating ideas and visualization, and experimentation and iteration. It is a way to create new ideas and foster the skills required to deal with ambiguous situations and learning to empathize and cooperate with others (Grönman & Roblin, 2021). School as a learning environment for a wide range of learners of different ages can nurture critical individuals and creative collaborators for future society (Kangas et al., 2022; Matthews & Wrigley, 2017).

This review aims to provide a qualitative description of the results of existing studies applying design thinking among young learners (children aged 5–8). Early childhood education and care is a holistic and multi-theoretical foundation combining systematic, goal-oriented education and care, based on a wide selection of scientific understandings of education, developmental psychology, sociology, sustainable development, inclusion, and well-being (Harju-Luukkainen et al., 2022). In Finland, early childhood education and care is delivered mostly by municipal providers and guided by the national core curriculum for early childhood education and care, which consists of goal-oriented and systematic activities supporting children's development, learning, and well-being. The pedagogical activities involved integrate different areas of learning, enabling a broad-based examination of phenomena supporting learning transversal competencies, multiliteracy, everyday skills, cultural competence, interaction skills, and digital competence, all of which are needed in an increasingly diverse world (Finnish National Board of Education [FNBE], 2022).

Our interest in researching applying design thinking among young learners lies in adopting good practices in our expert areas of craft, design, and technology education. In the Finnish national core curriculum of early childhood education and care (FNBE, 2022), craft, design, and technology education is part of the learning units "Diverse forms of expression" and "Exploring and interacting in my environment". Craft, design, and technology education is based on the concept of learning by inquiry and experimentation and aims to develop children's participation and agency by experimenting with different materials, techniques, and tools and encouraging children to design and make craft products based on their imagination and interests (Aerila et al., 2019; FNBE, 2022; Rönkkö et al., 2016). The learning process in craft, design, and technology education has many joint confluences with the design thinking process, like developing problem-solving skills, creativity, and innovativeness (Pöllänen, 2009; Rönkkö 2011), and we believe that craft, design, and technology education can benefit from adopting the evolution of design thinking as an educational method in the context of young learners.

Due to the proven usability of design thinking in multidisciplinary learning and teaching future skills to students in primary, secondary, and higher education (Panke, 2019; Rusmann & Ejsing-Duun, 2022; Wrigley et al., 2018), we join the researchers (Fleer, 2022a; Kewalramani et al., 2020; Voigt et al., 2019; Yalcin, 2022b) who feel that the possibilities of applying design thinking methods with younger learners in early childhood education need to be investigated in greater depth, to enhance skills of creativity, critical thinking and collaboration earlier on the learning path of future citizen. As the research about design thinking method among young learners is relatively new, the concept's definition is yet ambiguous and undefined. To form an overview of existing literature and to present a summation and analysis of the available research publications, a literature review is needed. To gain an understanding of the aims and possibilities of using design thinking method among young learners, we search the knowledge of the reasons and the ways to conduct it in early childhood education and care, through the following research questions:

RQ1: What reasons do existing studies provide for applying design thinking in early childhood education and care?

RQ2: In what ways is design thinking applied in early childhood education and care in existing studies?

## Design thinking in education

In today's rapidly changing information society, individuals are constantly confronted with new, unknown problems that require innovative solutions. These problems, which are related to, for example, sustainability and social systems issues with complex and confusing information and conflicting values, require a collaboration of multidisciplinary experts and a new kind of critical and creative thinking (Kangas et al., 2022; Koh et al., 2015), while 21st-century skills are those identified as enabling people to cope with complex problems in the world of tomorrow. There are multiple ways of categorizing these skills, like Binkley et al.'s (2012) list, based on their analysis of relevant 21st-century skill frameworks in different countries and featuring 10 skills in 4 categories: 1) ways of thinking (creativity and innovation; critical thinking, problem-solving, decision making; learning to learn, metacognition); 2) ways of working (communication; collaboration); 3) tools for working (information literacy; ICT literacy); and 4) living in the world (citizenship; life and career; personal and social responsibility).

The current educational emphasis on learning 21st-century skills reflects a desire to change educational practices like learning by remembering, internalising proven facts and truths, focusing on teacher-led classroom methods, and measuring learning outcomes by tests and exams (Koh et al., 2015). Design thinking is viewed as a promising educational approach in which students learn by tackling real-life problems and interacting with the world (Panke, 2019; Rusmann & Ejsing-Duun, 2022). Exposing learners to complex design challenges helps prepare them to deal with uncertainty and requires empathy, collaboration, teamwork, and a multidisciplinary approach. In this way, design thinking can foster many of the desirable traits identified as crucial future competencies (Voogt & Roblin, 2012).

The research results of using design thinking in education as a tool for learning have been rising. However, studies of teaching experiments and interventions with design thinking have thus far focused mostly on primary, secondary, or higher education and only in recent years turned to younger learners in the context of early childhood education and care (Noel

& Liub, 2017; Parlar et al., 2017). In Rusmann and Ejsing-Duun's (2022) review of 39 articles on developing design thinking competencies in kindergarten to 12th grade (K-12) education, design thinking methods were used in multidisciplinary learning, technology, science-as-STEM or science-as-STEAM education, design and technology, engineering and architecture, arts, languages, and spiritual education or in advisory classes. Using design thinking methods was aimed at fostering students' 21st-century skill competencies, including communication, collaboration, and critical thinking, along with metacognition and personal responsibility (Binkley et al., 2012; Rusmann & Ejsing-Duun, 2022; Voogt & Roblin, 2012).

The results of Rusmann & Ejsing-Duun, (2022) review of developing design thinking competencies in K-12 education provide the basis for a hypothesis to guide our review and in defining the concepts of multidisciplinary learning and science, technology, engineering, arts, and math education in the context of early childhood education and care. Multidisciplinary learning aims to support the development of transversal competencies and provide a more realistic context for learning by combining different school subjects. Offering opportunities to identify, formulate, and investigate real-life problems from several perspectives, it strives to enhance a deeper understanding of phenomena and arouse positive attitudes and motivation towards learning. Multidisciplinary learning is also viewed as facilitating learners' involvement in self-directed group work, where the role of teachers is shifted from direct instruction to mentoring (Braskén & Pörn, 2021; Braskén et al., 2020). In early childhood education and care, a multidisciplinary approach is consistent with the aim of holistic phenomenon-based learning, where everything is possible through play and creative collaborative problem-solving in a free, child-centred setting (Lonka et. al., 2018; Ruokonen, 2022).

Science-as-STEM or science-as-STEAM education includes integrated activities of science, technology, engineering, (the arts), and mathematics. It is a multidisciplinary way to explore and learn real-world phenomena (Kewalramani et al., 2020; Yalcin, 2022a; Yalcin & Erden, 2021) and has been found to improve learning motivation and concentration by making subjects more engaging and attractive to children (Peppler & Wohlwend, 2018). The research literature highlights the key aspects in STEAM education as the engagement of students in real-world, authentic problem-solving, fostering 21st-century skills, implementing student-centred pedagogies, focusing on project-based, problem-based, hands-on, and collaborative learning, and making multidisciplinary connections across subjects (Holmlund et al., 2018; Kelley & Knowles, 2016; Reinking & Martin, 2018; Roehrig et al., 2021). In early childhood education and care, STEAM provides an environment for a child-centred approach and allows subject areas to be fluid (Hunter-Doniger, 2021). The engineering thinking process is similar to the iterative design thinking process, moving through the steps of empathizing, ideating, designing, testing, and manufacturing. Engineering thinking in early childhood education includes activities like building structure, exploring functions, devices, or organisms from the surrounding world. Children's natural abilities to ask questions, define goals, and solve problems are engaged in engineering thinking (Dorie et al., 2014; Ehsan et al., 2021; Kangas et al., 2022).

## Method

This literature review aims to provide a qualitative description of current knowledge and the results of earlier studies applying design thinking with young learners to offer an updated, more nuanced understanding of the possibilities of using the method in early childhood education and care. The qualitative literature review was chosen to

combine different findings and evidence from earlier studies to formulate a broad summary (Baumeister, 2013; Green et al., 2006). Rather than providing a critical appraisal and a meta-analysis of previous work, a qualitative literature review allows an iterative and inclusive approach to identify, describe, and summarize the relevant ways to use design thinking methods with young learners reported in earlier studies. The systematic criterion-based selection for the research articles was chosen to avoid the bias. (Gregory & Robertal 2018; Green et al., 2006; Snyder, 2019). Gathering the text corpus of the review was conducted between January and April 2023 through an electronic search of peer-reviewed research articles via Volter, the electronic library database of the University of Turku. Volter is a large electronic collection containing 1633 databases in different disciplines, including 21 full-text databases in education, such as ERIC and the ProQuest Education Database. Through a preliminary search, we familiarized ourselves with the empirical studies applying design thinking with young learners to refine the topic and obtain a sense of the number of articles available on the topic (Green et al., 2006). Research on design thinking among young learners under school age appeared to be recent and limited in terms of number of publications.

The final search was conducted by including the words "design thinking" AND "early childhood education" OR "kindergarten" OR "young learners" without any restriction on year of publication. Searches were conducted of the titles, abstracts, and keywords of the indexed articles (Green et al., 2006). Inclusion criteria were as follows: a) only peer-reviewed full-text articles, b) empirical research, c) participant age range partially in 5–8 years, and d) the critical stance of a quality research article as demonstrated by substantiating any claims made with theoretical or empirical evidence. The most prominent reasons for exclusion were participant age (children too old for our context), a lack of empirical research, and not meeting the evidence-based results criterion, like being too descriptive or hypothetical without argumentation based on empirical results or a solid theory-base. The final text corpus contains 20 peer-reviewed research articles from 10 countries, published between 2015 and 2022. The majority (16 of 20) of articles are qualitative; the other 4 use quantitative or mixed methods approaches. The articles included in the text corpus are denoted in the reference list with * before the name of the author or authors.

The data were examined using thematic content analysis, which is theory-driven but open to new aspects emerging from the data (Grant & Booth, 2009; Krippendorff, 2018). Identifying the data, creating initial codes, and searching, reviewing, and defining the themes were the steps followed in generating the themes (Fereday & Muir-Cochrane, 2006). The first author was responsible for the data search, identifying the essential data through filtration, and feeding the summarized data into a codebook in an MS Excel spreadsheet. To help answer the research questions, coding followed a three-phased methodology. First, the data were coded into multiple open codes consisting of aims, learning activities, reported benefits and challenges, and other results of the empirical studies. Second, the open-coded data were clustered by combining similar subject areas into categories. Third, the categories were generated into selective themes for answering the research questions. Open coding was carried out by the first author, and the second phase of clustering categories was undertaken jointly by the first and second authors. In the third phase, the third author joined in the analysis by ensuring the consistency of assigning the data to the final selective themes (Bowen, 2009; Fereday & Muir-Cochrane, 2006; Humble & Mozelius, 2022). In cases of ambiguity, collaborative discussions among the authors were conducted. For instance, combining the overlapping concepts of interdisciplinary, cross-curricular, and integrated learning and STEM, STEAM, science, or engineering education

required many discussions among the authors before they were combined into the theme group of multidisciplinary learning.

## Results

The articles reviewed provided diverse perspectives on applying design thinking in early childhood education and care. To shed light on the reasons for using design thinking in this context and the various ways it is employed, we present the results based on the two research questions.

RQ1: What reasons do existing studies provide for applying design thinking in early childhood education and care? Three key themes emerged:

a) Enhancing multidisciplinary teaching (7 of 20 articles)

b) Teaching design thinking as a method (7 of 20 articles)

c) Supporting children's developmental domains and participatory learning (6 of 20 articles)

RQ 2: In what ways is design thinking applied in early childhood education and care in existing studies? Three key themes emerged:

a) Real-life problems (7 of 20 articles)

b) Open-ended science problems (8 of 20 articles)

c) Challenges in imaginary play (5 of 20 articles)

### Reasons to apply design thinking in early childhood education and care

#### Enhancing multidisciplinary teaching

The first theme in the rationale for the use of design thinking methods with young learners was enhancing multidisciplinary teaching. It appeared in seven articles in which the use of design thinking methods was substantiated by the research-based benefits of multidisciplinary teaching through STEM, STEAM, or engineering education (see Table 1). The use of design thinking methods in multidisciplinary learning was viewed as beneficial for improving creativity, communication, and problem-solving skills (Kewalramani et al., 2020; Yalcin, 2022a; Yalcin & Erden, 2021), strengthening motivation (Ehsan et al., 2021; Fleer, 2022a), using different technologies (Kangas et al., 2022), and understanding complex concepts in real-world phenomena (Gross & Gross, 2016).

Using design thinking methods through STEM education was applied in three articles (Kewalramani et al., 2020; Yalcin, 2022a; Yalcin & Erden, 2021) to enhance multidisciplinary learning, the acquisition of language, collaborative creativity, and the development of cognitive capacities among young learners and foster 21st-century skills like communication, innovation skills, peer learning, self-confidence, and a sense of responsibility and empathy (Fleer, 2018; Peppler et al., 2018; Sullivan & Heffernan, 2016). In two studies (Gross & Gross, 2016; Kangas et al., 2022), STEM education was broadened to STEAM education by adding art education as a mediator for multidisciplinary learning. In these studies, the approach was chosen to promote learners' creative technological competencies and 21st-century skills (Hachey et al., 2022; Lundberg & Rasmussen, 2018). In two articles (Ehsan et al., 2021; Fleer, 2022a), multidisciplinary teaching was implemented through engineering education, because play was seen as a natural way to enhance engineering skills, and children´s innate abilities to ask questions, define goals, and solve

**Table 1** Existing studies applying design thinking with young learners to enhance multidisciplinary teaching

| Authors | Method | Participants | Reason to apply design thinking |
|---|---|---|---|
| Kewalramani et al., (2020) | Qualitative case study | 17 children (5 y.) | STEM education |
| Yalcin & Erden, (2021) | Mixed methods experimental study | 20 children (5 y.) | STEM education |
| Yalcin, (2022a) | Mixed methods case study | 23 children (5 y.) | STEM education |
| Kangas et al., (2022) | Qualitative collective case study | 647 children (6–8 y.) | STEAM education |
| Gross & Gross, (2016) | Qualitative case study | 20 children (5 y.) | STEAM education |
| Ehsan et al., (2021) | Qualitative case study | 10 children (5–7 y.) | Engineering education |
| Fleer, (2022a) | Qualitative follow-up study | 13 children (4–7 y.) | Engineering education |

problems offered a real-world design context for learning engineering (Bairaktarova et al., 2011; Dorie et al., 2014; Gold et al., 2021).

### Teaching design thinking as a method

The second theme in reasons to apply design thinking in early childhood education and care appeared in seven articles: the aim was experimentation to teach design thinking for young learners as a method (see Table 2). In four of these articles (Fleer, 2022b; Gözen, 2015; Hatzigianni et al., 2020; Johnson-Green, 2018), the way to use design thinking was defined as teaching young learners through imaginary play to amplify their development of design competence (Fleer, 2022b), via architectural design tasks to improve higher-order thinking and design skills (Gözen, 2015), in 3D maker spaces to increase creativity and imagination skills (Hatzigianni et al., 2020), and composing music by using design thinking methods for deliberating like an engineer (Johnson-Green, 2018).

In three of the articles in this theme, the reason to use design thinking with young learners was described as teaching them the design process as a method for problem-solving (Chatzigeorgiadou et al., 2022; Kodsi, 2022; Lyu et al., 2021). Solving everyday human-centred problems with design thinking methods (Lyu et al., 2021) was aimed at adapting to the outside world and choosing appropriate paths for future societal developments. Using free constructive play (Kodsi, 2022) was substantiated as encouraging children to naturally find the stages of the design process and problem-solving skills and learn to understand the water cycle by using design thinking methods (Chatzigeorgiadou et al., 2022) that aimed to promote young learners' scientific thinking and active participation.

### Supporting children's developmental domains, agency, or participatory learning

The third theme among reasons to apply design thinking with young learners was supporting their developmental domains, agency, or participatory learning. The theme contains six articles (see Table 3), in which the aim of using design thinking is described as investigating how it affects young learners' developmental domains—social, emotional, cultural, linguistic, cognitive, and so on (Hatzigianni et al., 2021; Mize et al., 2022; Paracha et al., 2019; Yalcin, 2022b) – or how it enhances children's agency (Voigt et al., 2019) or participation in learning (Brinck et al., 2022).

Design thinking methods were used in this theme's empirical studies to address complex and abstract real-life issues like war and peace (Hatzigianni et al., 2021), to support social–emotional skills in collaborative real-life problem-solving (Mize et al., 2022), and to stimulate children's ethical reasoning in game design (Paracha et al., 2019). The results of these experiments showed that design thinking methods helped to deepen young learners' understanding of abstract real-life issues and empathize with others' perspectives (Hatzigianni et al., 2021; Mize et al., 2022) and provided an effective pedagogical intervention to stimulate reflection and empathy (Paracha et al., 2019).

Design thinking activities improved children´s curiosity, questioning, activity in learning, and sense of group belonging (Yalcin, 2022b) and boosted children's motivation and agency (Brinck et al., 2022; Voigt et al., 2019). The results of a young learner's design process in digital fabrication (Voigt et al., 2019) indicated that empathy was dependent on children's ability to connect with a problem on a personal level, while creativity was enabled by sustained dialogue with peers and facilitators, and iterations were bound to different levels of personal identification with the problem. Young learners' participation

**Table 2** Existing studies applying design thinking with young learners to teaching design thinking as a method

| Authors | Method | Participants | Reason to apply design thinking |
|---|---|---|---|
| Fleer, (2022b) | Qualitative educational experiment | 13 children (3–6 y.) | Teaching design competences |
| Gözen, (2015) | Quantitative experimental design | 177 children (6–11 y.) | Teaching architectural design skills |
| Hatzigianni et al., (2020) | Qualitative collective case study | 34 children (5–8 y.) | Teaching 3D design in makerspace |
| Johnson-Green, (2018) | Qualitative educational experiment | 45 children (5 y.) | Teaching to think like an engineer |
| Lyu et al., (2021) | Qualitative case study | 22 children (6–11 y.) | Teaching everyday problem-solving |
| Kodsi, (2022) | Qualitative naturalistic observation | 16 children (5 y.) | Problem-solving in constructive play |
| Chatzigeorgiadou et al., (2022) | Qualitative teaching intervention | 61 children (5 y.) | Problem-solving in scientific thinking |

**Table 3** Existing studies applying design thinking with young learners supporting children's developmental domains, agency, or participatory learning

| Authors | Method | Participants | Reason to apply design thinking |
|---|---|---|---|
| Hatzigianni et al., (2021) | Mixed methods case study | 76 children (4–6 y.) | Exploring peace, war, and social justice |
| Mize et al., (2022) | Qualitative educational experiment | One preschool group | Social and emotional learning |
| Paracha et al., (2019) | Qualitative action research | 30 children (7 y.) | Social and emotional learning |
| Yalcin, (2022b) | Mixed methods case study | 23 children (5 y.) | Supporting developmental domains |
| Voigt et al., (2019) | Qualitative educational experiment | 18 children (6 y.) | Learning empathy, creativity, & self-efficacy |
| Brinck et al., (2022) | Qualitative educational experiment | 20 children (4–6 y.) | Supporting participation and agency |

was enhanced through participatory design practices (Brinck et al., 2022), and movement between different roles enabled creative flow and supported children's agency.

## Ways to apply design thinking in early childhood education

In all articles, design thinking was applied to young learners through the design process, where learners acted as designers and solved different design challenges by following the steps of the design process. The challenges used with young learners consisted of a wide variety of different topics that coalesced into three themes: real-life problems (7 articles), open-ended science problems (8 articles), and challenges in imaginary play (5 articles).

### Solving real-life problems

The context of *solving real-life problems* presented as design challenges concerned children's current living environments, like kindergarten and the playground (Hatzigianni et al., 2021; Mize et al., 2022), or future scenarios like smart homes (Lyu et al., 2021; Voigt et al., 2019). The design challenges in this theme also varied by target; in some cases, that was the individual level, like designing a safe home for a puppy (Ehsan et al., 2021), while in others it was the group level, like how to work together to move a fallen tree from a playground (Mize et al., 2022), and in some cases all of humanity, like creating solutions to mitigate the consequences of climate change (Voigt et al., 2019).

Design challenges concerning young learners' current living environment were most common in this theme. They comprised tasks such as designing and printing 3D items to solve a real-world problem meaningful for each learner, like building a shelter for homeless hermit crabs (Hatzigianni et al., 2021) or building a safe play space for a puppy by using big soft blocks (Ehsan et al., 2021). At a group level, real-life design challenges involved developing a digital game to prevent bullying (Paracha et al., 2019), designing and testing in a miniature world how to move a fallen tree from the playground using pulleys, Legos, and Lincoln Logs (Mize et al., 2022), and designing and manufacturing a wooden puzzle for the use of the whole preschool group (Brinck et al., 2022). Design challenges in future living environments, including tasks like designing the kindergarten of tomorrow (Brinck et al., 2022), produced a satisfying solution for future smart home users' everyday challenges (Lyu et al., 2021), while designing a smart home solution helped solve problems caused by climate change, like storms and heat waves (Voigt et al., 2019).

### Solving open-ended science problems

The second theme in ways to apply design thinking with young learners in existing studies was *open-ended science problems*. In this theme, design challenges were introduced for learners as open problems to be investigated by small-group scientific activities, starting with the teacher's presentation of the problem and continuing by following the steps of the design process: empathizing, defining the problem, ideating, prototyping, testing, and assessing the solution. The design challenges in this theme also concerned everyday problems like "How can we help turtles to move faster?", "How can we repair a broken toy?", and "How can we build a parking house for all toy cars?" (Yalçin, 2022a, b; Yalçin & Erden, 2021). However, the design challenges in this theme were note limited to specific techniques or tools; they encouraged investigation through scientific activities, including measuring, calculating, constructing prototypes, and testing solutions that could

be anything between 2 and 3D illustrations, life-sized or miniature constructions, object design, or dynamic/kinaesthetic design contexts like role-playing, dramatization, and verbal, oral, or written expressions (Gözen, 2015).

The design challenges in this theme were multidisciplinary invention projects, where young learners created individual inventions by combining, for example, craft, design, technology, science, and art and jointly designed solutions for an open-ended task in a real-life or a future scenario (Kangas et al., 2022). In Chatzigeorgiadou et al.'s (2022) study, the design thinking method was used to explore the concepts of the water cycle. By learning more about phenomena through open-ended science activities, children learned concrete ways to explore those phenomena. As an end product, children created a digital storybook, presenting their new knowledge and restructured understandings of the phenomena in their own words and illustrations. In the STEAM club's (Gross & Gross, 2016) open-ended learning task, children combined electricity, circuitry, programming, and coding to create interactive sound sculptures. Even in composing music, design thinking methods can be used to understand and innovate how to engineer music. In open-ended musical architecture tasks, children learned high-level musical thinking and created their own complex music by experimenting and improvising with electronic keyboards, describing musical structures with Lego bricks, and planning their own music through drawing and mathematical patterning (Johnson-Green, 2018).

### Solving design challenges in imaginary play

The third theme of different ways to apply design thinking with young learners was *design challenges in imaginary play*. In Fleer's (2022a, b) studies, the context of making learning engineering design meaningful for children (2022a) and supporting children's design orientation in preschool settings (2022b) was a narrative play world based on the story of Robin Hood. This imaginary world gave children the possibility to act "as if" they were engineers solving problems in the world of Robin Hood by helping to retrieve treasure and rescue the imprisoned Robin from a castle. Other play worlds for this theme's design challenges existed in an imagined future robotic city (Kewalramani et al., 2020), in an imagined world without wars and social injustices (Hatzigianni et al., 2021), and in children's free play (Kodsi, 2022).

The design challenge in a future robotic city (Kewalramani et al., 2020) was to design and build a city for robotic toys to live as a happy family and imagine and prevent possible problems from arising. The tools for this scientific design thinking process were robotic toys and electronic magnetic blocks, which provided children a way to create innovative solutions by using a source of light and sound sensors and components for creating a mobile robotic arm, hammer, electric fans, and a self-driving vehicle. In Hatzigianni et al.'s (2021) study, design thinking methods were applied to explore the concepts of peace, war, and social justice. The process moved from mapping children's existing knowledge to learning new information from museums and visitors, ideating ways to resolve conflicts in a peaceful way, and finally acting out these new imagined scenarios with puppet theatre figures. The last study in this theme considers a design challenge in children's free play, where Kodsi (2022) examined constructive play through the design thinking process. While building a playground of blocks, a robot with plastic units, a castle and a village from wooden blocks, a ship of Lego bricks, a spaceship from stools, and a house for a family from various toys, children showed in-driven design processes, naturally following the

steps of design thinking by defining a goal, crafting a work plan, assessing the outcome, and adjusting that outcome after receiving feedback.

## Discussion

This review has aimed to obtain an understanding about the reasons and ways design thinking can be applied in early childhood education and care. After reviewing the 20 selected articles, we learned that design thinking is a useful and effective method for young learners. The articles provided diverse perspectives on applying design thinking in early childhood education and care. The results for the first research question (What reasons do existing studies provide for applying design thinking in early childhood education and care?) formed three themes: enhancing multidisciplinary teaching, teaching design thinking as a method, and supporting children´s developmental domains, agency, or participatory learning.

The first two themes are aligned with the reasons to apply design thinking in K-12 education: conducting multidisciplinary learning and teaching design, engineering, and architecture methods (Rusmann & Ejsing-Duun, 2022). On the other hand, the third theme on applying design thinking for supporting children´s developmental domains, agency, or participatory learning, is not mentioned in K-12 education (Rusmann & Ejsing-Duun, 2022). However, it can be viewed as complementary to the broader K-12 education goal of nurturing 21st-century competencies, including communication, collaboration, critical thinking, metacognition, and personal responsibility (Binkley et al., 2012; Rusmann & Ejsing-Duun, 2022; Voogt & Roblin, 2012).

Regarding the second research question (In what ways is design thinking applied in early childhood education and care in existing studies?) the findings indicate that design thinking is a versatile and effective method for young learners. In all the reviewed articles, children were encouraged to act as designers by addressing various design challenges. This aligns with the core concept of design thinking, which involves defining and solving problems through all stages of the design process (Elsbach & Stigliani, 2018; Grönman & Roblin, 2021; Panke, 2019; Viilo et al., 2018). The design challenges used with young learners covered a wide range of different topics across three main themes: real-life problems, open-ended science problems, and challenges in imaginary play. The common feature of these contexts is the importance of empathy and meaningfulness from the learners' perspective, which are indeed the requirements for the continuum of motivation, participation, and agency in the process (Kewalramani et al., 2020; Lyu et al., 2021; Mize et al., 2022; Voigt et al., 2019). In Fig. 1 (next page), we have illustrated the results of both research questions in one circle graph, showing the reasons and ways to apply design thinking with young learners.

Real-life problems were a the most common way to apply design thinking with young learners when the aim was to support their developmental domains, agency, or participatory learning. This indicates that learners' own, individually meaningful living worlds and solving challenges in real-life contexts are recognized as important to developing social and emotional learning (Mize et al., 2022; Paracha et al., 2019), empathy, creativity, and self-efficacy (Voigt et al., 2019), and participatory agency (Brinck et al., 2022). This also appears to be in line with the idea of exposing learners to complex real-life design challenges when preparing them to deal with uncertainty,

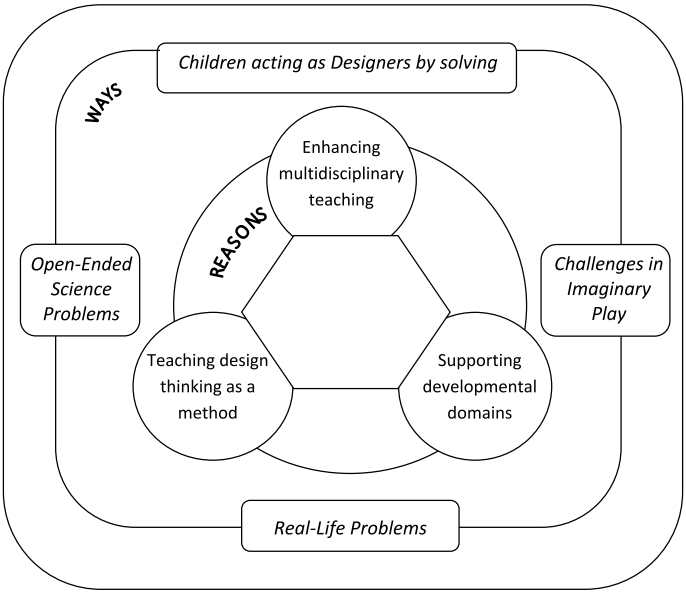


**Fig. 1** The reasons and ways to apply design thinking with young learners

develop empathy, and learn collaboration to foster future competencies (Green et al., 2006; Rusmann & Ejsing-Duun, 2022; Voogt & Roblin, 2012).

The open-ended science problems were used in half of the eight studies that aimed to apply design thinking with young learners to enhance multidisciplinary teaching (Gross & Gross, 2016; Kangas et al., 2022; Yalcin, 2022a; Yalcin & Erden, 2021). The rationale was a multidisciplinary way to learn to combine different school subjects, offer opportunities to identify, formulate, and investigate phenomena from multidisciplinary perspectives, and find connections across subjects (Braskén & Pörn, 2021; Holmlund et al., 2018; Reinking & Martin, 2018; Roehrig et al., 2021).

Design challenges in the context of imaginary play appeared to offer the most versatile possibilities for the various goals of applying design thinking with young learners. In this theme, the aims for using design thinking with young learners emerged in all areas: enhancing multidisciplinary teaching (Fleer, 2022a; Kewalramani et al., 2020), teaching design thinking as a method (Fleer, 2022b; Kodsi, 2022), and supporting children's developmental domains, agency, or participatory learning (Hatzigianni et al., 2021). This is logical when play is viewed as a natural way to enhance the development of multiple skills and children's innate abilities to ask questions, define goals, and solve problems and thus a rich context for learning (Bairaktarova et al., 2011; Dorie et al., 2014; Ehsan et al., 2021; Fleer, 2022a; Gold et al., 2021). This finding is also aligned with existing literature, which states that in early childhood education and care it is possible to teach everything through play and creative collaborative problem-solving in a free, child-centered setting (Lonka et al., 2018; Ruokonen, 2022).

## Conclusion

Proving the actual positive impact of using design thinking as an educational method is difficult without a comparative study, including experimental and control groups. In this review's text corpus, there are three experimental studies with control and experimental groups (Gözen, 2015; Yalçin & Erden, 2021; Yalçin, 2022b). In all three, the results are clear: STEM activities, taught by using design thinking methods, were effective in supporting children's learning and innovation skills; life and career skills; and information, media, and technology skills. The pre-, post-, and persistence tests showed that these skills did not increase with the children in the control group, but with the experimental group, the increase was significant and permanent.

Similarly, although without comparative studies, the rest 17 research articles of this review's text corpus reported quantities of beneficial learning outcomes of using design thinking method with young learners. The impact covered enhancing multidisciplinary learning, teaching problem-solving and supporting curiosity, questioning, and participatory learning. It improved creativity and communication, strengthened motivation, use of technologies, and understanding of complex concepts. It amplified children's design competencies, imagination, and higher-order thinking skills and helped them to adapt to the outside world, choose appropriate paths for future societal developments, and promote scientific thinking. It was also reported to support children's developmental domains in social, emotional, cultural, linguistic, and cognitive skills and stimulated ethical reasoning, understanding of abstract real-life issues, empathizing with others, and a sense of belonging in a group. Based on these descriptions of positive impact, it seems clear, that design thinking as an educational method has a great potential to be applied in early childhood education and care.

This review was motivated by our interest in studying and adopting recent developments in the use of design thinking with young learners (Carroll et al., 2010; Ejsing-Duun et al., 2019; Rusmann and Ejsing-Duun, 2022). The results of the review demonstrate that design thinking is a versatile approach offering multiple ways to teach problem-solving across a wide range of topics with young learners. We identified several areas of interest for our area of expertise. In early childhood education and care (FNBE, 2022), craft, design, and technology education promotes creative exploration, diversity, and collaborative design. It emphasizes inquiry-based learning, encouraging young learners to observe, question, and solve everyday problems. This approach aligns seamlessly with the reasons presented in this review for applying design thinking in early childhood education and care.

The three themes of reasons to apply design thinking in early childhood education and care are transferable to craft, design, and technology education, which combine elements from arts, engineering, and science, and thus fostering multidisciplinary teaching. The craft process mirrors the design process, emphasizing the importance of teaching design thinking as a problem-solving method. Moreover, the 2022 FNBE core curriculum directs us to enhance children's agency and participation throughout the craft process, making it an integral part of young learners' holistic development. The results of using design thinking with young learners in the context of real-life problems, open-ended science problems, and imaginative play are also highly applicable in craft, design, and technology education. These approaches are already familiar starting points for designing craft products.

We identified several inspiring aspects from this review that should be considered in the development of future craft, design, and technology education involving young learners. Empathy plays a crucial role in the design process, from defining the design challenge to

creating user-oriented solutions. Empathy needs to be cultivated throughout the learning process to maintain motivation and engagement. Children's ability to connect with challenges on a personal level is essential for increasing motivation (Lyu et al., 2021; Montero, 2023; Voigt et al., 2019). To achieve this, various methods can be employed to pique and sustain learners' interest in and dedication to the process. Inspiring ideas from this review include using narratives to create imaginative play worlds, involving external experts like "castle engineers" to test children's solutions (Fleer, 2022a, 2022b), collaborating with real designers to design the kindergarten of tomorrow (Brinck et al., 2022), engaging parents and grandparents to share their childhood experiences (Hatzigianni et al., 2021), and using experts from specialized fields to mentor designing and manufacturing process in a 3D maker space (Lyu et al., 2021).

Furthermore, we found adaptable ideas to make learning more fun, such as using motivating narratives instead of rigid instructions as a framework for learning tasks (Ehsan et al., 2021; Fleer, 2022a, b; Hatzigianni et al., 2020; Mize et al., 2022; Paracha et al., 2019). Additionally, incorporating diverse teaching methods alongside traditional individual-centered learning in craft, design, and technology education, such as breaking the primary challenge into smaller subtasks for small groups (Fleer, 2022a, b), switching and modifying the roles of adults and children during the learning process (Brinck et al., 2022), and using collaborative-centered problem-solving methods for various group design challenges (Mize et al., 2022; Yalcin, 2022a, b; Yalcin & Erden, 2021) can enrich, deepen, and make more interesting the learning experience for a wide range of learners.

On the other hand, we think that certain aspects of craft, design, and technology education can also contribute to learning design thinking. For example, using real, durable building materials like wood, wool, or fabric instead of disassembled elements like blocks and Legos or non-durable materials such as cardboard and modelling clay can provide children with unforgettable learning experiences and a sense of self-efficacy. Building tangible, usable craft products like cuddly toys or treehouses from authentic materials will foster a deeper understanding of sustainable development and material knowledge.

Overall, applying design thinking with young learners offers promising avenues for fostering future skills and enhancing personal growth. Children growing up in today's rapidly changing society are constantly confronted with new, unknown problems with complex information and conflicting values, making it crucial for them to learn and develop critical thinking and innovation and collaboration skills. Ideally, this kind of education can start in early childhood education and care.

## Future research

Due to the promising results and the need to prepare young learners for the complex challenges of the future, interest is growing in using design thinking in the context of early childhood education and care. Further research, especially on an empirical level, is needed, expected, and awaited. The challenges of applying design thinking with young learners, presented in the studies comprising this review's text corpus, concerned the participants' young ages, which in some cases (e.g. Yalçin, 2022b) appeared to limit the level of collaboration, and a lack of curricular support for choosing key learning concepts (Fleer, 2022a). In addition, the ways to implement key learning concepts like choosing the best teaching methods to harness children's engineering habits of mind (Hatzigianni et al., 2021; Kewalramani et al., 2020) were reported as areas needing further development. Furthermore,

from our perspective, research concerning how to support different learners in the various phases of the learning process in design thinking is needed to maximize the benefits of the method on an individual level and to find the most effective ways to refine teaching into a learner-oriented approach.

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## Declarations

**Conflict of interest** The authors have no competing interests to declare that are relevant to the content of this article.



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