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Intrinsic Motivation in Child-Computer Interaction: A Scoping Review

Çocuk-Bilgisayar Etkileşiminde İç Motivasyon: Bir Kapsam İncelemesi

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Abstract

Child-computer interaction research focuses on the design of technologies that support the learning processes of children. Intrinsic motivation is an important factor that influences children's interactions with technology and their learning processes. However, the relationship between technology and children's intrinsic motivation in learning processes has not yet been sufficiently examined. In this review, we examine how intrinsic motivation is defined and measured in relation to learning and technology design in the child-computer interaction (CCI) research field. For this purpose, we conducted a scoping review in the leading venues of CCI research: the International Journal of Child-Computer Interaction and the ACM Digital Library. This eventually resulted in 27 publications that used the word stem 'intrinsic motiv*' in the title, abstract, and keywords. Our analysis revealed that intrinsic motivation is commonly defined as an inherent characteristic of the learner and is associated with the characteristics outlined in Self-Determination Theory in the field of psychology. Approximately half of these studies (15 studies) used experimental methodology and a quantitative research approach. The remaining studies were highly varied and included case studies, observations, interviews and surveys, user studies, field trials, and secondary data analysis using qualitative, quantitative, or mixed-method research approaches. Although most of the experimental studies highlighted the link between intrinsic motivation and learning, only six studies measured whether there is an increase in children's learning outcomes, constituting only 20% of the entire corpus. We discuss the implications of these findings for technology design, CCI research, and finding ways to improve children's learning in different contexts. The main contribution of this scoping review is to provide suggestions for future research about methods of assessing intrinsic motivation in children's learning. Accordingly, future directions that will shed light on the research on technology designs developed to support children's intrinsic motivation in the learning process are discussed.

Öz

Çocuk-bilgisayar etkileşimi araştırma alanında çocukların öğrenme süreçlerini destekleyen tasarımlara yer verilmektedir. İç motivasyon, çocukların teknoloji ile etkileşimlerini ve öğrenme süreçlerini etkileyebilecek önemli bir unsurdur. Ancak, teknolojinin çocukların öğrenme süreçlerindeki iç motivasyonu ile olan ilişkisi henüz yeterince irdelenmemiştir. Bu makalede, çocuk-bilgisayar etkileşimi araştırmalarında iç motivasyonun nasıl tanımlandığı, ölçüldüğü ve değerlendirildiği araştırılmaktadır. Bu amaçla çocuk-bilgisayar etkileşimi alanında önde gelen yayın mecraları olan ACM Digital Library ve the International Journal of Child-Computer Interaction'da kapsam incelemesi gerçekleştirilmiştir. Sonuç olarak başlık, özet ve anahtar kelimeleri içinde "iç motivasyon" kelime kökü yer alan 27 yayın derlememize dahil edilmiştir. Bu yayınları incelememiz sonucunda iç motivasyonun öğrenene özgü/ öğrenenin doğasında olan bir özellik olarak tanımlandığı ve psikoloji alanındaki Öz-belirleme kuramındaki özelliklerle ilişkilendirildiği görülmüştür. Derlemede yer alan çalışmaların yaklaşık yarısının (15 çalışma) deneysel bir yöntem ve nicel bir araştırma yaklaşımı kullandığı bulunmuştur. Kalan çalışmalar çok çeşitlidir; vaka çalışmaları, gözlem,

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derinlemesine mülakatlar, anket araştırmaları, kullanıcı deneyimi araştırmaları, saha çalışmaları ve ikincil veri analizi gibi yöntemler kullanıldığı görülmüştür. Bu yöntemlerle birlikte nitel, nicel ve karmaşık-yöntemler olmak üzere farklı araştırma yaklaşımları kullanılmıştır. Deneysel araştırmaların büyük çoğunluğu iç motivasyon ile öğrenme arasındaki ilişkiyi vurgulasa da sadece altı araştırma çocukların öğrenme ve bilgi edinmesinde iç motivasyonun doğrudan bir etkisi olup olmadığını ölçmüştür, bu da tüm derlemin sadece %20'sini oluşturmaktadır. Makalede, bu bulguların etkileri, teknoloji tasarımı, çocuk-bilgisayar etkileşimi araştırmaları ve farklı ortamlarda çocukların öğrenmelerini destekleyici yöntemler bulma konuları kapsamında tartışılmaktadır. Bu incelemenin temel katkısı, iç motivasyonun değerlendirmesinde gelecekte kullanılabilecek yöntemler ile ilgili öneriler sunmasıdır. Buna bağlı olarak, çocukların öğrenme sürecinde iç motivasyonlarını destekleme amacıyla geliştirilen teknoloji tasarımlarına yönelik araştırmalara ışık tutacak çözüm yolları tartışılmaktadır.

Keywords Child-computer interaction · intrinsic motivation · technology design · learning

Anahtar Kelimeler Çocuk-bilgisayar etkileşimi · iç motivasyon · teknoloji tasarımı · öğrenme

Intrinsic Motivation in Child-Computer Interaction: A Scoping Review

Today, technology has become an integral part of children's learning in everyday life. Thus, the implementation and development of technology design play an important role in fostering children's engagement and interest in learning. The Child-Computer Interaction (CCI) research field is highly active in the areas of learning and educational technologies (Giannakos et al., 2020; Hourcade, 2015). In recent years, several researchers in CCI have brought up the need for a shared understanding of which learning theories are used (Eriksson et al., 2022) and what role they play in CCI research (Antle & Hourcade, 2022) and pointed out the importance of improving knowledge and theory development for learning within CCI (Barendregt et al., 2018; McDermott et al., 2022; McKenney, 2016). In this paper, we build on and extend the abovementioned findings by mapping out how intrinsic motivation as an underlying factor of learning is assessed in CCI research.

Since the formal beginnings of education (Dewey, 1913), motivation has been viewed as the primary determinant of student learning and school success. Research has shown that motivation is the driving force behind students' interest and engagement with the learning materials and their persistence in learning activities (e.g., Lepper et al., 1997; Lepper et al., 1973; Mueller & Dweck, 1998). Based on the literature, motivation can be categorized into two types: extrinsic motivation and intrinsic motivation (Ryan & Deci, 2000a). Broadly, intrinsic motivation refers to the drive/urge to engage in an action out of genuine curiosity or interest. On the other hand, extrinsic motivation refers to engaging in an action to attain a goal or benefit. Intrinsic motivation is mainly concerned with the inner desire or interest of the individual rather than outside influences (Atkinson, 1958; Hennessey et al., 2015). Thus, educators consider intrinsic motivation to be more desirable and to result in better learning outcomes than extrinsic motivation (Deci et al., 1999; Lepper et al., 1997).

In the context of CCI, motivation can play an important role as children's interest in technological tools is mainly driven by their novelty, attractiveness/beauty, and difficulty level. However, the impact of intrinsic motivation on learning outcomes in CCI is yet to be explored. While investigating child factors in CCI is gaining interest in research, and the term "intrinsic motivation" is commonly used in the field, it is largely unknown how it is defined by designers and researchers and how it is measured in studies using different methodologies. Furthermore, considering its complexity and multifaceted nature, intrinsic motivation can be an important underlying factor in technology-driven educational contexts. Thus, it is important to understand how it is studied in relation to children's learning through technology design. Learning is generally assessed by examining the outcomes, such as verbal, written, or behavioral outcomes. However, learning is not just limited to the outcomes; it is also a process of change in behavior, capacity, or competence. Therefore, the change in people's attitudes toward learning, including their intrinsic motivation to learn, should be

examined, although not immediately visible in their knowledge or behaviors at the time of learning (Schunk, 2012).

To address these questions, in this scoping review, we specifically examine how the term intrinsic motivation is referred to in CCI, methods of measurement, and their advantages and disadvantages based on the specific research context. Moreover, we discuss whether and how intrinsic motivation may contribute to learning in CCI, as evidenced by the findings from these studies. The specific research questions (RQ) we address are as follows:

RQ1. How is intrinsic motivation defined in CCI research?

RQ2. How is intrinsic motivation evaluated or assessed in the studies using different research methods?

RQ3. How is intrinsic motivation associated with the learning process and outcomes in the CCI field?

Contemporary Perspectives on Motivation

In the context of understanding motivation, several theoretical perspectives offer insightful explanatory frameworks. Some of these perspectives commonly referred to within the context of CCI and learning include self-determination theory (SDT) by Ryan and Deci, flow theory by Csikszentmihalyi (1990), and the theory of intrinsically motivating instruction by Malone (1981). Below, we briefly mention each theory and discuss their approach to intrinsic motivation.

According to SDT, individuals have needs for autonomy, competence, and relatedness to maintain their psychological well-being (Ryan & Deci, 2000a). As mentioned above, in this theory, motivation is described as intrinsic and extrinsic. Intrinsic motivation can be seen as the natural inclination of a learner to engage in fun activities, new, meaningful, and optimally difficult. Extrinsic motivation can be seen as a learner's inclination to engage in activities that include external incentives. Over time, extrinsic motivation can turn into an internal process as well, and its degree of internalization varies along a continuum/scale, which makes it a complex phenomenon (Ryan & Deci, 2000a, 2000b).

Although providing an exact definition of the term "intrinsic motivation" is challenging, intrinsic motivation signifies finding a motivating force inside to engage in an activity, regardless of any external factors. In the psychology literature, it is commonly referred to as a contrast to extrinsic motivation, which is directly related to external rewards and reinforcement (Lepper et al., 1973; Lepper & Greene, 2015; Mueller & Dweck, 1998; Ryan & Deci, 2000a). Intrinsic motivation is essential to exploring the world, learning new information, and building and maintaining long-term habits (Ryan & Deci, 2000a).

One primary way of evaluating intrinsic motivation is using the Intrinsic Motivation Inventory (IMI) (Ryan & Deci, 2000a). This inventory was developed and used by Ryan and Deci in several studies evaluating participants' intrinsic motivation and self-regulation when completing tasks in the experimental studies. The standard version of the inventory (22 items) has six subscales focusing on self-reports of 1) interest and enjoyment, 2) competence, 3) effort and importance, 4) choice, 5) pressure and tension, and 6) value and usefulness (See Table 1 for definitions of subscales). Among these subscales, the subscale that is most widely used for intrinsic motivation is perceived interest/enjoyment (Deci & Ryan, 2013; Ryan & Deci, 2000a). Moreover, when children's need for autonomy, relatedness, and competence are met, their well-being increases, and they can be intrinsically motivated to actively engage in learning materials and activities (Niemiec & Ryan, 2009).

Table 1

Identifying Factors for Assessing Intrinsic Motivation Derived from the Intrinsic Motivation Inventory by Deci and Ryan

Subscale	Definition
Interest and enjoyment	Innate curiosity and wonder about the world or a phenomenon that keeps one to explore, investigate, engage, and feel passionate
Perceived competence	Feeling of accomplishment that comes from completing a difficult task or mastering a new skill.
Effort and importance	Commitment and self-significance that keeps to stay on-task
Perceived choice	A sense of control and autonomy that allows one to have a say.
Pressure and tension	Challenges that are appropriate for the skill level that allows a room for growth
Value and usefulness	Meaningful purpose or goal that drives one to connect his/her actions

Flow theory is more concerned with the feeling of time flying by when people engage in an activity that is interesting and challenging enough for them (Csikszentmihalyi, 1990). They call this state "flow," and individuals forget about passing time when they are in this state, which is certainly related to deep focus and intrinsic motivation. In learning environments, the goal is to experience "flow" so that students can be immersed in the learning activity and benefit from it to the fullest extent by building skills.

In close relation to flow theory, Malone (1981) proposed the theory of intrinsically motivating instruction, and Malone and Lepper (2021) developed a taxonomy to identify key elements to measure intrinsic motivation in learning contexts. These key elements include challenges, curiosity, control or the possibility of control, and imagination/fiction. When these elements are incorporated into learning contexts, they increase the focus and intrinsic motivation of the learners and subsequently lead to better learning outcomes.

Considering these theoretical perspectives and elements identified as closely linked with intrinsic motivation, it is important to examine how these elements/factors are viewed in applied CCI settings and how they are used and evaluated in technology-based learning contexts. By understanding the existing research on intrinsic motivation, researchers and designers can delineate the relationship between specific technological features that foster children's intrinsic motivation, leading to the development of effective instruction technologies.

Intrinsic Motivation and Children's Learning

Children's intrinsic motivation is crucial for nurturing their natural curiosity from an early age and for enabling them to engage effectively with their environments and acquire knowledge. In the developmental psychology literature, young children are commonly viewed as "active learners" or "little scientists" who are intrinsically motivated to learn about the world around them (e.g., Gopnik & Wellman, 2012; Piaget, 1970). Similar to scientists, children actively explore their surroundings, gather information via their experiences and social interaction, and construct knowledge based on these experiences (Harris, 2012; Wellman, 2002; Wellman & Gelman, 1998). This understanding highlights the central role of intrinsic motivation in guiding children's exploratory behaviors and learning processes.

Building on this understanding, researchers (e.g., Benware & Deci, 1984; Deci & Ryan, 2005) expanded the concept of intrinsically motivated learning with SDT and showed that the interplay of autonomy, competence and relatedness are essential elements for building engagement and motivation in the learning process. Within the context of learning, their findings showed that individuals who find joy, interest, and intrinsic motivation in the learning process and elaborate on the information are more likely to deeply engage with the learning material and achieve better learning outcomes (e.g., Benware & Deci, 1984; Deci & Ryan, 2005). Similarly, Berlyne's (1978) research identified curiosity as an internal process and an important mechanism

for motivation. Bruner (1977) further extended these ideas by emphasizing the need for a balance between short-term and long-term learning objectives, arguing that intrinsic rewards, such as the joy of learning and discovery, are more beneficial than extrinsic ones, like grades.

Intrinsic motivation is particularly evident in children as they naturally play and search for information for the enjoyment of learning (e.g., Gottfried, 1983). This type of motivation has been shown to play a more significant role in fostering children's learning and achievement rather than extrinsic rewards (e.g., Carruthers, 2018, 2020; Mueller & Dweck, 1998; Lepper et al., 1997). Furthermore, children's intrinsic motivation, including autonomy, competence and relatedness, can be cultivated by parents and teachers through supportive environments and scaffolding suited to the child's developmental needs (Carlton & Winsler, 1998; Niemiec & Ryan, 2009). For instance, research shows that young children benefit from play-based or discovery-based learning environments where they can actively engage with the learning material (e.g., Blinkoff et al., 2023; Callanan et al., 2020; Zosh et al., 2022). Such approaches not only nurture children's natural curiosity but also lead to meaningful and lasting learning experiences.

Taken together, these theoretical insights and research findings indicate that intrinsic motivation is the fundamental force behind deep engagement, allowing children to go beyond surface-level comprehension and achieve conceptual understanding. In addition, intrinsic motivation can be enhanced through supportive environments and opportunities for autonomy and exploration.

Child-Computer Interaction and Intrinsic Motivation

CCI is a multidisciplinary research area that studies the interaction between children and computational information and communication technologies (Hourcade, 2015; Read et al., 2013) and is highly informed by the theories and techniques of learning and education (Giannakos, Horn et al., 2020; Giannakos, Papamitsiou et al., 2020). Starting as a subfield of human-computer interaction (HCI) in the 1960s (e.g., Ackermann, 1991; Papert, 1980), CCI lies at the intersection of several research areas, such as psychology, learning sciences, design, engineering, computer science, and media studies. An area of future development of research in CCI is with regard to adopting and adapting research methods (Giannakos, Horn et al., 2020). This research field has led to the development of guidelines for designing learning technologies and using particular types of user interfaces (e.g., tangibles, programmable toolkits, social robots, etc.) in educational applications for children (Hourcade, 2015).

Since CCI is a multidisciplinary field, it is important to understand how intrinsic motivation is viewed in CCI research and how it influences children's interactions with technology. The application of the term intrinsic motivation is multifaceted; it can range from learning new skills to becoming an expert on a topic. Consequently, researchers and practitioners engage in different strategies and use different tools or techniques to boost intrinsic motivation. Due to their motivational potential as well as educational and pedagogical role, many learning environments equipped with technology have been integrating tasks for children to engage, use, and enjoy.

In technology design, the most common elements used for motivation depend on reward systems or external factors such as badges, numeric scores, or likes. However, Ryan and Deci's (2000a) work describes intrinsic motivation as an inherent way of skill-building and long-term learning that is triggered by curiosity and independent of any external reward systems or validations. Thus, it remains challenging for technology design to offer and cultivate key elements that aid intrinsic motivation in children while employing those tasks.

In the current research, there are insightful literature reviews that examine the topic from a broader perspective (e.g., Lai, 2011; Oginsky, 2003; Sekhar et al., 2013). There are also literature reviews either focusing

on one of the subscales of intrinsic motivation in the literature such as autonomy and intrinsic motivation (Dickinson, 1995) or focusing specifically on one type of technology's relation with children's intrinsic motivation such as video games (Reid, 2012) or game-based learning (Parthasarathy, et al., 2023), online learning (Kawachi, 2003) or augmented reality (Saadon et al., 2020). However, to the best of our knowledge, there is no review of the literature that examines how recent studies assess intrinsic motivation in relation to learning in the CCI.

A limited number of studies have examined how intrinsic motivation is directly linked with learning and its implications for the design of technology for children's games, learning environments, and everyday tasks. For instance, Alvarado (2012) focused on how intrinsic motivation is associated with children's engagement in social games. Likewise, Bellotti et al. (2013) focused on how enjoyment and curiosity are connected to learning in serious games. There were also studies emphasizing how to increase intrinsic motivation via physical activity programs (Yansun et al., 2022) and by designing a toolkit (Mavroudi et al., 2018). These studies provide insight into possible methods and research directions for examining the association between children's intrinsic motivation and learning and how to design tools to cultivate intrinsic motivation.

Method

The goal of our scoping review is to shed light on the adoption of intrinsic motivation in the CCI research landscape (Arksey & O'Malley, 2005; Levac et al., 2010; Snyder, 2019). This means that we aim to provide a starting point that supports researchers in building an understanding of the ways that intrinsic motivation in CCI is incorporated and examined and how it is measured in relation to children's learning in technology interaction. By focusing particularly on the CCI venues in our analysis, we provide a meaningful way of understanding the intrinsic motivation in CCI. This section describes the methodology we followed in our scoping review, including how records were identified, screened, and assessed to make up our final corpus. Following the increasing trend of using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statements (Moher et al., 2009) for conducting reviews in human-computer interaction (Stefanidi et al., 2023), we applied an adapted PRISMA statement for scoping reviews (Tricco et al., 2018), depicted in Figure 1. We also describe how we conducted our analysis on the final corpus. In this paper, we provide a snapshot of the research landscape in the field, which we conceived as a scoping review (Arksey & O'Malley, 2005; Levac et al., 2010; Tricco et al., 2018). As such, the paper maps a certain area of academic interest to "clarify a complex concept and refine subsequent research inquiries" (Levac et al., 2010). This review's goal is not a comprehensive overview; instead, it showcases a focused, specific snapshot of the current landscape of intrinsic motivation incorporated in CCI to make sense of how it is examined.

Identification

To investigate how intrinsic motivation is examined in CCI research, we conducted a scoping review for this study as CCI is a multidisciplinary field that bridges learning and education knowledge and interaction design practices (Giannakos, Horn et al., 2020). To ensure a representative sample, the search was deliberately limited to two of the CCI community's leading venues and publications: the International Journal of Child-Computer Interaction (IJCCI) and the ACM Digital Library, which contains pioneering venues pertaining to child-computer interaction research (e.g., Proceedings of the Interaction Design and Children and the Human Factors in Computing Systems conferences).

We used the search term "intrinsic motiv*" in their metadata (i.e., title, abstract, and keywords). This means that the review cannot claim to cover all aspects of CCI research, but the papers reviewed were systematically coded to identify and provide an overview of possible research approaches to evaluate

intrinsic motivation in CCI. The search was performed in July 2024. We used the following search query in the ACM Digital Library: [Abstract: "intrinsic motivation"] AND [Full Text: child*], which resulted in 96 papers. For IJCCI, we used the following search query in Scopus: [ISSN (22128689) AND ABS ("intrinsic motivation")], which resulted in only one paper. Our review followed an adaptation of the PRISMA statement (Moher et al., 2009; Tricco et al., 2018), structured in four main phases (see Figure 1).

Screening and Eligibility

Both the authors screened the initial set of 97 papers. In this first screening, we decided to exclude papers that had not undergone peer review or were not classified as research articles in the ACM or IJCCI. We decided to include only full papers in our analysis because our primary concern was to elaborate on the methodological details of the measurement of intrinsic motivation and its link to learning and technology design. Consequently, the set of inclusion criteria was as follows:

1) The publication was a full research paper. Based on this criterion, we excluded 16 ACM Digital Library publications involving Late-Breaking Works (also known as Work-in-Progress Papers), doctoral consortium, keynote, demo, and literature review papers. The rationale behind this is that such paper formats (e.g., work-in-progress or doctoral consortium) are often part of a much larger project and tend to make unclear descriptions about what is planned, what is being done, and what is done. In these types of papers, it is clear that the methodological details and practices are not yet explicit and have not been under peer review, which is why we chose to exclude them. Thus, we excluded 17 papers that did not fall into the full or short paper format; two literature review papers (Poon, 2020; Tyack & Mekler, 2020), one keynote (Oudeyer, 2019), one demo paper (Harrell & Abrahamson, 2007), one doctoral consortium paper (Alvarado, 2012), 11 work-in-progress papers among which only three were conducted with children (Li et al., 2024; Tachihara et al., 2015; Tan et al., 2014) and one was about children's intrinsic motivation (Çelik et al., 2023), but none of them involved assessment of children's intrinsic motivation, and one paper of which the full text is not accessible online (Bellemare et al., 2013).

2) Our second criterion was to include only studies done with children (individuals up to the end of high school, typically aged 17 and below) and studies related to our concern of evaluating how intrinsic motivation has been measured with children. Thus, we further excluded the studies that were not conducted with children (which excluded 53 more papers), all from the ACM Digital Library. We had no further limitations in terms of the years or ages of the children. Thus, our corpus resulted in 27 publications: 26 from ACM DL and one from IJCCI.

Figure 1

Flow Diagram of Scoping Review

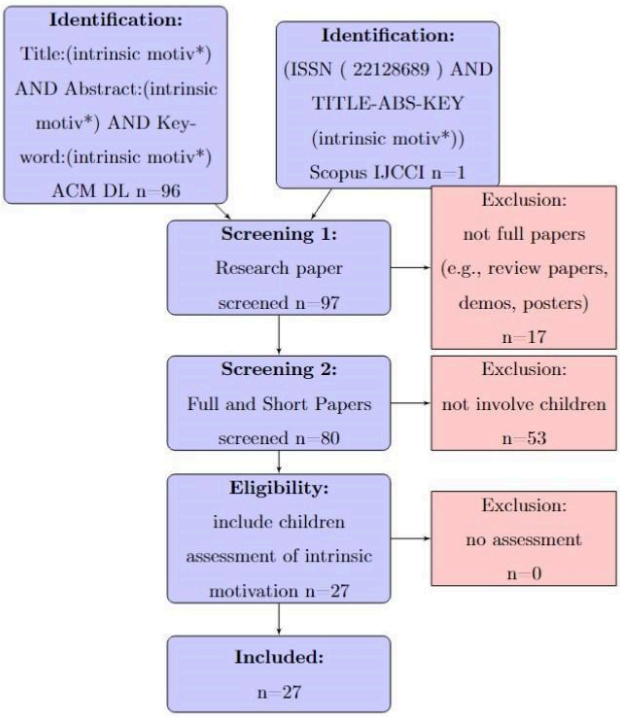

Table 2

Final Corpus Overview with 27 Publications - 26 from ACM DL and 1 from IJCCI

Year	Author name	Database	Target age group	Context	Tool
2009	Jaques et al.	ACM DL	12-19	school	animation
2012	Van Dijk et al.	ACM DL	10-12	museum	interactive table
2013	Lin & Farnham	ACM DL	13-17	internet	social media
2014	Ruf et al.	ACM DL	12-13≈	classroom lab	programming
	Belim et al.	ACM DL	7		mobile game
2017	Remmer et al.	ACM DL	6-7	school	AR
	Lomas et al.	ACM DL	4-5 graders	N/A	game
	Ioannou & Kyza	ACM DL	10-11	museum	digital media
2018	Przybylla & Romeike	ACM DL	15	school	physical computing
	Dönmez et al.				robotic toy
	Tomokiyo	ACM DL	4-5 and 8-9	school	computing
	Alekh et al.	ACM DL	5-14	school	DIY
		ACM DL	13-14	school	
2019	Stone et al.	ACM DL	N/A	school	extracurricular
	De'Aira et al.	ACM DL	4-8	therapy cent.	social robot
	Lehtonen et al.	ACM DL	6-42	activity park	MR exergame
	Peters et al.	ACM DL	8-10	N/A	personal assist.
	Quinlan et al.	ACM DL	6-11	prog. club	programming
	Mariescu-Istodor & Jormanainen	ACM DL	13-19	school	machine learning
2020	Jormanainen & Tukiainen	ACM DL	11-12	school	robotic programming
	Nofal et al.	ACM DL	10-14	museum	tangibles
2021	Yuan	ACM DL	≈4	kindergarten	AR

Year	Author name	Database	Target age group	Context	Tool
2022	Cahyono	ACM DL	6-12	therapy center	software
	Matthews et al.	IJCCI	7-12	after school club	
					tangibles
2023	Yang et al.	ACM DL	highschool	blended	IT class
	Lang et al.	ACM DL	N/A	Braille club	tangibles
	Fairlie	ACM DL	7-9	dance	computing
2023	Marchy et al.	ACM DL	highschool	online	N/A

Data Analysis

The authors independently coded all the publications individually, manually, and completely. In our analysis, a consensus-based approach was applied (Blandford et al., 2016), meaning that if there was a disagreement in the code, the authors discussed and resolved the disagreements. The authors coded all 27 papers twice to achieve consistency and to ensure that all categories were finalized, meaning that disagreements were only minor and did not require any new categories.

Results

In this section, we present the results of our scoping review. We first provide descriptive information about the paper included in the review. Next, we provide our findings in response to our research questions investigating 1) the definition of intrinsic motivation in CCI research, 2) the assessment of intrinsic motivation in CCI research, and the association between intrinsic motivation and the learning process and outcomes in the CCI field.

Descriptive Information

Year, Age Interval, Context that the Studies Occurred

Detailed information regarding the year, age, context, and types of technology used in the studies can be found in Table 2. Based on this information, we observed that the years that the papers were published were scattered between 2009 and 2023; we can say that, on average, two papers were published every year since 2009. There was an increase in the number of papers after 2017 and a slight accumulation in the years 2018 and 2019. Of all 27 papers, four (15%) were published in 2018 and six (22%) were published in 2019.

The papers were also varied based on the country where the data collection happened; the USA was in first place with five papers (19%). There was one paper from Brazil and one paper from Australia. There were three papers from Asia: one from China and two from Indonesia. The rest of the papers were from different countries in Europe. This distribution shows that there is an increasing trend in examining intrinsic motivation in the CCI context, not only in the US and Europe but also in other countries across the world.

The target age group varied in the papers, starting from four years of age and extending to high school years. The most common age group was the elementary school age group (6-10 years), with eight studies including participants of this age group. Ten studies included the middle school age group (11-14 years). Some of the studies with the middle school age group covered a wide age range between 11-19, which we can call as targeting both middle school and high school children. There were fewer studies (five studies only) with the preschool age group. There were only four studies with only high school students (See Table 2). As for the context of the papers, the majority occurred in the school context, including classrooms and school clubs. The other contexts included museums, laboratories, activity parks, therapy centers, and online studies.

Types of Technology Used

The types of technology used in the studies are coded to understand how specific types of technological tools are associated with increasing intrinsic motivation. Overall, we found 17 types of technology used in the studies. Digital games were the most common type of technology (used in four studies) being studied for investigating intrinsic motivation that involved gamification of education content such as blended learning of IT education (Cahyono, 2022; Ioannou & Kyza, 2017; Lomas et al., 2017; Yang et al., 2023). Gamification was a technique used to examine intrinsic motivation in interacting with mixed reality technologies such as virtual reality or gamified embodied interaction in an activity park (Lehtonen et al., 2019), augmented Reality in kindergarten (Yuan, 2021), and elementary school (Remmer et al., 2017).

The next most common technology that appeared in our corpus was programming. Tools, including web-based programming tools such as Scratch and Karel (i.e., Quinlan et al., 2019; Ruf et al., 2014; Tomokiyo, 2018), and physical computing (i.e., Przybylla & Romeike, 2018). Moreover, the integration of machine learning (ML) in IT classes is gaining importance in the field of CCI, and intrinsic motivation can be investigated as an important factor in classrooms where ML is implemented. For instance, one study (Mariescu-Istodor & Jormanainen, 2019) examined children's intrinsic motivation in response to an ML-related curriculum development for high school students.

The remaining papers examined children's intrinsic motivation in using other types of emerging technologies such as tangible user interfaces (Lang et al., 2023; Matthews et al., 2022; Nofal et al., 2020), interactive tabletops in a museum context (Van Dijk et al., 2012), animated pedagogical agents (Jaques et al., 2009), do-it-yourself tools (Alekh et al., 2018), smart personal assistants in health support systems, e.g., for children with diabetes (Peters et al., 2019), playful interactions with robotic toys (Dönmez et al., 2018), and social robots used in rehabilitative therapy exercises (De'Aira et al., 2019).

RQ1: Definition and Theoretical Framework of Intrinsic Motivation

In response to our first research question, we examined whether the papers included in this scoping review provided a clear definition of intrinsic motivation, including its components/elements, and whether they referred to any theoretical frameworks in relation to their definitions. Although intrinsic motivation is mentioned in all papers, only 12 of the 27 papers presented a clear definition of "intrinsic motivation" that grounds the study. Seven of these papers (Ioannou & Kyza, 2017; Jormanainen & Tukiainen, 2020; Lin & Farnham, 2013; Mariescu-Istodor & Jormanainen, 2019; Peters et al., 2019; Quinlan et al., 2019; Remmer et al., 2017) directly referred to SDT by Ryan and Deci (Deci & Ryan, 1987, 2000; Ryan, 1982; Ryan & Deci, 2000a, 2000b). In these studies, the intrinsic definition is generally defined via the factors included in the IMI. These factors that identify and measure intrinsic motivation in IMI are (1) interest and enjoyment—explore, investigate, willing to continue, and persist; (2) perceived competence—positively challenging; (3) perceived choice; (4) pressure and tension. This definition by Ryan was found to be the most common one, which was also indirectly referenced in (Alekh et al., 2018; Cahyono, 2022; Dönmez et al., 2018).

Albeit less common in the corpus, another theoretical framework that laid the basis for three of the papers (Cahyono, 2022; Lomas et al., 2017; Remmer et al., 2017) was a taxonomy for intrinsic motivation, which was developed by Malone (Malone, 1981; Malone & Lepper, 2021), who presented 30 theoretically grounded principles for designing intrinsically motivated instruction. The taxonomy was derived from the flow theory and highlights that an optimal difficulty level is constantly needed to keep the learner engaged in the activity (Csikszentmihalyi & Csikszentmihalyi, 1992, as cited in Lomas et al., 2017). The elements in the taxonomy include (1) challenges; (2) curiosity, or surprise and novelty; (3) control, or opportunity of the learner to shape

the learning object; (4) the imaginary or fictional world for emotional needs and experiences (Remmer et al., 2017).

Furthermore, some papers focused on the gamification of educational tools to investigate their motivational aspects. While doing so, Cahyono (2022) identifies the characteristics of intrinsic and extrinsic motivation provided in gamification elements by combining Malone's (1981), Malone and Lepper's (2021) and Dominguez et al.'s (2013) theoretical groundings. Accordingly, intrinsic motivation involves curiosity and challenge (triggered by game elements such as leveling and progress bar), competitions (triggered by ranking on a leaderboard, ranking), an epistemic attitude provided by the learning process, and cognitive interest (triggered by animation, audio, etc.). In contrast, extrinsic motivation is defined as pertaining to the element of fantasy (e.g., avatar or character), concrete reinforcement/reward and punishment (e.g., badge, stars, points, money), praise or appreciation, and the necessity to attain a higher status such as levels (Cahyono, 2022).

In sum, we can deduce that intrinsic motivation is commonly defined by factors that emphasize engagement and interest, as outlined by SDT, along with challenge and novelty, as highlighted in the taxonomy of Malone. These theoretical perspectives and definitions highlight the importance of autonomy and perceived choice, competence and skill, interest and enjoyment, and novelty and curiosity as factors underlying intrinsic motivation.

RQ2: Methods and Inventories Used to Evaluate Intrinsic Motivation

As discussed in the previous section, the IMI is the most widely used measure of intrinsic motivation across various contexts. Although IMI is applicable in many settings, it is not the sole method for measuring intrinsic motivation. Other measures have been developed to target specific contexts and capture the unique aspects of intrinsic motivation in CCI (see Table 3). In this review, we first categorized the methodology of the studies as experimental vs. non-experimental (i.e., observation, interview, survey, case study, and field trial). This categorization allowed us to capture both controlled experimental findings and insights from naturalistic settings. For the experimental studies, our primary criteria were the inclusion of experimental and control groups and the random assignment of participants to these groups, as this type of design provides stronger cause-and-effect relations on intrinsic motivation than other designs. However, because some of these studies took place in naturalistic settings such as museums and classrooms, they used a quasi-experimental design method with no random assignment. We included these studies under the experimental category as well. These quasi-experimental studies provide valuable and ecologically valid insights into intrinsic motivation. Overall, we found 14 experimental studies, including mixed methods studies, followed by four case studies, four surveys, four observations, two user studies, one field trial, and one secondary data analysis. This number exceeds 27 because some studies used more than one method.

In addition to the research methodology, we categorized the research approach used in the studies to understand how intrinsic motivation has been examined from different theoretical perspectives. Almost all experimental studies used IMI (see Table 3). However, when other research methodologies are employed, such as survey/interview, observation, case studies, user studies, and field trials, researchers also opt to construct custom surveys or observation checklists, including close-ended and open-ended questions to evaluate intrinsic motivation (Jaques et al., 2009). Considering that intrinsic motivation is an inherently complex concept and one methodology alone may not always suffice, about one-third of the studies used mixed methods integrating quantitative and qualitative approaches. The mixed method approach provides a more detailed understanding of individuals' intrinsic motivation for engaging in a certain task to understand the phenomenon of interest more fully (APA Dictionary of Psychology, n. d.).

In addition to the widely used IMI, the Intrinsic Motivation Questionnaire (IMQ) used by Martens et al. (2007) is another tool developed for and used in online education or e-learning environments. This scale emphasizes students' perception of their learning experience and self-regulated motivation, which leads to deep engagement and processing of the given task. Thus, this scale provides an alternative view to some primary subscales of IMI. For instance, Yang et al. (2023) utilized this scale in their study and found that students with higher intrinsic motivation do not increase their study time or effort quantitatively; rather, they improve their study strategies qualitatively. Specifically, students with higher intrinsic motivation explore more, have better regulation, and show a deeper level of engagement and understanding of the material.

Similarly, another scale mentioned in our corpus is the Motivation Strategies for Learning Questionnaire (MSLQ) proposed by Garcia and Pintrich (1996) and used by Yuan (2021) in a second language learning context and Jacques et al. (2009) in a STEM learning context. The IMQ mentioned above and the MSLQ mainly focused on students' perception of their learning strategies and how to improve them in specific learning contexts.

While these scales provide a simple and standardized way of measuring intrinsic motivation, some studies also employ behavioral observation as it provides a direct and real-world observation of intrinsic motivation (see Table 3). The main rationale for using this method is to identify the naturalistic behavioral indicators of intrinsic motivation that may not be evident in self-report scales. This method has been mainly used in game design and involves using video recordings and coding them for certain behaviors that signal interest and enjoyment, such as persistence, duration, and effort (Ioannou & Kyza, 2017; Lomas et al., 2013).

Last but not least, a study in our corpus utilized a large textual/language dataset (i.e., college application essays) in combination with Natural Language Processing (NLP) tools to develop metrics of intrinsic motivation (Stone et al., 2019). In this innovative approach, each sentence in a college application essay was coded to extract the components of intrinsic motivation.

Table 3

The Description of The Methodology and Research Approaches Used in Studies

METHOD	RESEARCH APPROACH
Survey/ Interview	DBR: (Tomokiyo, 2018) QT: Ratings of Confidence and Early Exposure (Tomokiyo, 2018) MM: with interviews (Lin & Franham, 2013) QT: an online questionnaire on interest in studying mathematics (Marchy et al., 2023)
Observational	QL: Thematic video content analysis (Dönmez et al., 2018), self-report (Tomokiyo, 2018) MM: Questionnaires (Remmer et al., 2017), and verbal reports (Nofal et al., 2020)
Experimental	QT: Intrinsic Motivation Inventory (a Likert scale questionnaire) or Motivated Strategies for Learning Questionnaire (Alekh et al., 2018; Bryant et al., 2019; Fairlie, 2023; Jaques et al., 2009; Jormanainen & Tukiainen, 2020; Mariescu-Istodor et al., 2019; Ruf et al., 2014; Van Dijk et al., 2012; Yang et al., 2023; Yuan, 2021), task performance (Quinlan et al., 2019), persistence ratings (Lomas et al., 2017) MM: with interviews (Quinlan et al., 2019), interest and engagement observations (Lomas et al., 2017; Ioannou & Kyza, 2017), open-ended questions (Ioannou & Kyza, 2017), student views (Przybylla et al., 2018)
Case Study	DBR: (Matthews et al., 2022; Lang et al., 2023) QT: Likert scale questionnaires (Cahyono, 2022) MM: with teacher interviews (Cahyono, 2022)

METHOD	RESEARCH APPROACH
User Study	MM: with questionnaires and semi-structured interviews (Lehtonen et al., 2019), task performance (Peters et al., 2019)
Field Trial	MM: observations and pre-post feedback (Belim, 2014)
Second Data Analysis	QT: Natural Language Processing (NLP) Tools (Stone et al., 2019)

Note. DBR = Design-Based Research, QT = Quantitative, QL = Qualitative, MM = Mixed Methods

Overall, our findings suggest that while IMI emerges to be the most prevalent way of measuring intrinsic motivation, depending on the context and goals of the study, researchers employ different methodologies, including surveys, observation, and even AI and NLP tools, to capture the multifaceted nature of intrinsic motivation.

RQ3: Intrinsic Motivation in Relation to Learning in CCI

Our third question in this review addressed how intrinsic motivation is associated with the learning process and outcomes in the CCI. To answer this question, we examined whether experimental studies measuring intrinsic motivation, including factors like engagement, persistence, and perceived choice, also linked them to the learning process and measured learning outcomes. Table 4 provides a summary of the experimental studies in our corpus, whether they connected intrinsic motivation to learning and measured learning outcomes, and whether they specifically mention the subscales of intrinsic motivation in relation to learning outcomes.

As mentioned above, there were 14 experimental studies in our corpus, and we observed that 11 of them explicitly mentioned learning in relation to intrinsic motivation (i.e., Alekh et al., 2018; Fairlie, 2023; Ioannou & Kyza, 2017; Jaques et al., 2009; Jormanainen & Tukiainen, 2020; Mariescu-Istodor & Jormanainen, 2019; Przybylla & Romeike, 2018; Remmer et al., 2017; Ruf et al., 2014; Yang et al., 2023; Yuan, 2021). These experimental studies included a variety of learning domains, such as computer programming (Jormanainen & Tukiainen, 2020; Mariescu-Istodor & Jormanainen, 2019; Przybylla & Romeike, 2018; Ruf et al., 2014; Yang et al., 2023), second language learning (Yuan, 2021), STEM-based learning (Alekh et al., 2018; Jaques et al., 2009; Remmer et al., 2017), historical and archeological learning in museum contexts (Ioannou & Kyza, 2017; Van Dijk et al., 2012) and learning dance and choreography that requires computational reasoning (Fairlie, 2023). While all of these studies mentioned a specific learning domain in their methodology, it is important to note that not all of these studies directly measured the learning outcomes (i.e., increase in children's knowledge or skills). Based on our coding, we found that only six studies (Fairlie, 2023; Ioannou & Kyza, 2017; Jaques et al., 2009; Mariescu-Istodor & Jormanainen, 2019; Ruf et al., 2014; Yuan, 2021) measured whether there is an increase in children's knowledge or skills as a result of the manipulation or training included in the study. The remaining studies simply assumed the relationship between an increase in intrinsic motivation and learning outcomes, and they only measured how their manipulation of intrinsic motivation was received by children in a specific learning context.

Five experimental studies did not mention any specific subscales when they discussed intrinsic motivation (Jaques et al., 2009; Remmer et al., 2017; Yang et al., 2023; Yuan, 2021). The most common subscale associated with learning was interest/enjoyment. Almost all experimental studies using IMI included this subscale in their methodology. As for other subscales, perceived competence was referred by six studies (Alekh et al., 2018; Ioannou & Kyza, 2017; Jormanainen & Tukiainen, 2020; Mariescu-Istodor & Jormanainen, 2019; Przybylla & Romeike, 2018; Ruf et al., 2014) effort and importance was mentioned in three studies (Ioannou & Kyza, 2017; Mariescu-Istodor & Jormanainen, 2019; Przybylla & Romeike, 2018); perceived choice

was referred by two studies (Lomas et al., 2017; Ruf et al., 2014), pressure and tension was referred by three studies (Alekh et al., 2018; Ruf et al., 2014; Przybylla & Romeike, 2018), and value and usefulness was mentioned in five studies (Alekh et al., 2018; Jormanainen & Tukiainen, 2020; Ioannou & Kyza, 2017; Mariescu-Istodor & Jormanainen, 2019; Przybylla & Romeike, 2018).

Overall, the experimental work mostly emphasized the importance of interest, enjoyment, value, and usefulness for engagement in a given task and for enhancing learning outcomes. It is also noteworthy that the study by Ruf et al. (2014) also examined the role of self-regulation and intrinsic motivation in children's learning of computer programming. Intrinsic motivation and self-regulation were differently related to children's learning outcomes with different learning tools (i.e., Scratch vs. Karel). This study opens the way for questioning the associations with other psychological factors like self-regulation.

Table 4

Experimental Studies about Learning and Intrinsic Motivation

Authors	Title	Learning Domain	Link to Learning	Increase in Knowledge/Skills?	Subscale of IM (if any)
Lomas et al. (2017)	Is difficulty overrated?: The effects of choice, novelty and suspense on intrinsic motivation in educational games	Difficulty Level in Educational Games	No	No measure of an increase in knowledge/ skills.	Interest and Enjoyment, Perceived Choice
Ruf et al. (2014)	Scratch vs. Karel: impact on learning outcomes and motivation	Computer Programming	Yes	Measure of Exam Performance	Interest and Enjoyment, Perceived Competence, Perceived Choice, Pressure and Tension. Addition of Self-Regulation Scale
Jaques et al. (2009)	Evaluating the affective tactics of an emotional pedagogical agent	Earth Time Zones	Yes	Measure of Student Performance	MSLQ (Motivation Strategies for Learning Questionnaire) is used. No specific mention of a subscale
Alekh et al. (2018)	Aim for the sky: Fostering a constructionist learning environment for teaching maker skills to children in India	STEM-based Learning	Yes	No measure of an increase in knowledge/skills. Measure of IM from pre- to post-test.	Interest/Enjoyment, Perceived Competence, Pressure/ tension and Value/Usefulness
Mariescu-Istador et al. (2019)	Machine learning for high school students	Machine Learning/ Computer Programming	Yes	Measure of students' perceived learning experience	Interest/Enjoyment, Perceived Competence, Effort/ Importance and Value/ Usefulness
Yang et al. (2023)	Gamification teaching design and application in the context of blended learning: Taking a middle school IT class as an example	Blended Learning of an IT Class	Yes	No measure of an increase in knowledge/skills. Measure of IM from pre- to post-test.	They used Martens, R., Bastiaens, T., & Kirschner, P. A. (2007) Intrinsic Motivation Scale No mention of subscales
Przybylla et al. (2018)	Impact of physical computing on learner motivation	Physical Computing	Yes	No measure of an increase in knowledge/skills. Measure of IM from pre- to post-test.	Interest/Enjoyment, Perceived Competence, Effort/ Importance and Value/ Usefulness
Bryant at al. (2019)	The effect of robot vs. human corrective feedback on children's intrinsic motivation	Therapeutic Rehabilitation	No	No measure of an increase in knowledge/skills.	Interest and Enjoyment, Pressure/Tension
Yuan et al. (2021)	An experimental study of the efficacy of augmented reality in Chinese kindergarten-level students' learning of English vocabulary	Second Language (English Vocabulary)	Yes	Measure of students' vocabulary learning Measure of IM	MSLQ (Motivation Strategies for Learning Questionnaire) is used. No specific mention of a subscale
Jormanainen et al. (2020)	Attractive educational robotics motivates younger students to learn programming and computational thinking	Computer Programming	Yes	No measure of an increase in knowledge/skills.	Interest/Enjoyment, Value/ Usefulness, Perceived Competence.

Authors	Title	Learning Domain	Link to Learning	Increase in Knowledge/Skills?	Subscale of IM (if any)
Remmer et al. (2017)	Why Pokémon GO is the future of school education: Effects of AR on intrinsic motivation of children at elementary school	STEM (Geometry at elementary school level)	Yes	No measure of an increase in knowledge/skills. Measure of Global satisfaction, Immersion and Desire to Repeat	No mention of subscales
Ioannou et al. (2017)	The role of gamification in activating primary school students' intrinsic and extrinsic motivation at a museum	Mobile learning at a local archeological museum	Yes	Measure of an increase in students' historical knowledge	Interest and Enjoyment, Effort/Importance, Value/ Usefulness Perceived Competence
Van Dijk et al. (2012)	Measuring enjoyment of an interactive museum experience	Museum experience	No	No measure of an increase in knowledge/skills.	Interest and Enjoyment
Fairlie (2023)	Encouraging the development of computational thinking skills through structured dance activities	Computational thinking	Yes	Measure of computational thinking- Beginners Computational Thinking Test (BCTt) Measure of IM	Interest and Enjoyment Perceived Competence

In summary, our findings showed that almost half of the studies in our corpus examined whether intrinsic motivation is related to improvement in learning outcomes. However, only a few studies included explicit measures of learning.

Discussion

In this scoping review, we found 27 studies examining intrinsic motivation in the child-computer interaction research field across various technology designs that aim to serve for children's learning. Based on the results above, we discuss the current state-of-the-art of assessing children's intrinsic motivation in child-computer interaction research and the implications for future work in this field. Given that intrinsic motivation is one of the key factors influencing the learning process, it is highly important to find ways to incorporate appropriate tasks that would internally motivate children into the design of educational technologies. However, despite gaining attention in the field, intrinsic motivation has yet to be assessed in very few studies. Among the papers that are included, two-thirds of them were published within the last five years. Thus, only a very small number of papers resulted in our corpus, and these papers show that research examining the factors associated with children's intrinsic motivation is just starting to gain attention in CCI. Thus, one of the issues that emerge from this study is that there is an opportunity for more research in studying intrinsic motivation in CCI as part of evaluating technologies. Below, we consider and discuss some aspects of enhancement in CCI studies to provide evidence-based research on intrinsic motivation in relation to children's interaction with technologies.

Definition and Theoretical Framework of the Intrinsic Motivation for Framing the Study

Our results showed that only half of the studies in our corpus provided a clear definition for the theoretical grounding of intrinsic motivation and framing the work. The rest of the papers briefly mentioned the concept as a term in a more generic fashion. Moreover, most of the studies that provided a clear definition rely on the IMI developed by Ryan and Deci (2000a). This aligns with the fact that IMI is an established tool to measure intrinsic motivation on an analytical level. However, there are also a few more resources that could be noticed, such as the taxonomy developed by Malone and Lepper (2021), which was useful to expand the empirical investigations on intrinsic motivation. The taxonomy was used in three papers in our corpus (Cahyono, 2022; Lomas et al., 2017; Remmer et al., 2017). For instance, as used in Lomas et al. (2017), the taxonomy combined with the flow theory (Abuhamdeh & Csikszentmihalyi, 2012; Csikszentmihalyi, 1990), which describes the relationship between difficulty and enjoyment to analyze and explain the motivational aspect of gamified experiences in education.

The lack of a clear definition or a solid theoretical grounding for intrinsic motivation in CCI research found in our results supports the point that a shared understanding of which learning theories are used and what role they play in CCI research is needed for this topic as well. Furthermore, Barendregt et al. (2019) emphasized that the creation of intermediate-level knowledge as a kind of design knowledge that resides in the realm between the design of particular artifacts and theories should be promoted in the CCI field. Thus, the CCI field may benefit from further studies that incorporate and synthesize different approaches or theories to understand and contribute to the intermediate-level knowledge about intrinsic motivation to address queries specific to the learning environment.

As also pointed out by Eriksson et al. (2022), the role of learning theory in CCI is mainly application, meaning that the theory is used 'as is.' Moving toward a more generative perspective, using learning theory as analysis or synthesis could be a way forward. When addressing intrinsic motivation, CCI research should provide explicit theoretical grounding for aspects of technology design that support motivation in learning. The current use of intrinsic motivation theories in the reviewed corpus is scattered, but due to its multidisciplinary nature, CCI has the potential to build novel associations between children's intrinsic motivation and thereby further develop technology design in service of children's learning.

Methods and Inventories Used to Evaluate Intrinsic Motivation in CCI

The findings showed that the research methodology (experimental vs. non-experimental) and the context of the research (i.e., online learning contexts or naturalistic settings such as museums) were influential in the choice of research approaches. Overall, Ryan and Deci's SDT was the most commonly referred theoretical perspective, and IMI was the most commonly used and standardized way of assessing intrinsic motivation by tapping into its main components, such as interest and enjoyment, effort, choice, and competence. It is also important to note that the majority of the studies included a short version of IMI consisting of the subscales of interest/enjoyment and perceived competence (e.g., Alekh et al., 2018; Bryant et al., 2019; Fairlie, 2023; Jormanainen & Tukiainen, 2020; Mariescu-Istodor et al., 2019; Ruf et al., 2014; Van Dijk et al., 2012).

Surprisingly, the subscale effort/importance, which is related to perseverance in a given task, was not mentioned in any study. It was also surprising to see that none of the studies measured how the novelty aspect of the technology studied was related to children's engagement. In the CCI field, the studies often test a prototype of a new technology or interaction modality, which may have a novelty effect that might mainly influence the motivation for using and enjoying the technology. Thus, the CCI field needs more studies that investigate and perhaps compare the novelty aspect with other subscales on children's intrinsic motivation for enjoying the design. This is also important to maintain a sustainable and/or durable use for the technology being developed.

In addition to IMI, studies examining student motivation in learning contexts referred to flow theory by Csikszentmihalyi (1990) and used MSLQ by Garcia and Pintrich (1996) or IMQ by Martens et al. (2007), particularly when the learning setting was online. These scales have overlapping components with IMI about interest, perceived choice, and engagement, but they are specifically developed for learning contexts to understand students' levels of regulating their learning and motivation. Since these scales were tailored for specific learning environments such as second language (Yuan, 2021), STEM (Jacques et al., 2009), and computer (Yang et al., 2023), their focus was mainly on self-regulated/directed learning where learners are more autonomous and strategic to achieve learning outcomes. These differences indicate that while IMI provides a foundational measure, context-specific measures in different learning contexts can provide insights into how aspects of intrinsic motivation are particularly related to learning in digital environments.

Furthermore, several studies went beyond the limitations of self-report measures of intrinsic motivation and conducted observational studies (e.g., Dönmez et al., 2018) and secondary data analysis (Stone et al., 2019) to gather rich, detailed data on intrinsic motivation-related behaviors. These studies provide the basis for outlining the core components of intrinsic motivation in different contexts, with the advancement of AI tools and technologies, measuring intrinsic motivation via observational studies such as video analysis examination of verbal and nonverbal behaviors related to intrinsic motivation. Moreover, there are no studies examining participants' physiological responses when interacting with technological tools. In the future, studies can include measures of excitement or tension in relation to intrinsic motivation via variability in heart rate, skin response, and facial expressions.

Intrinsic Motivation in Relation to Learning Outcomes in the CCI

Children's motivation to use technology can lead to desired learning gains. There is an increased research focus on the assessment of learning as part of evaluating technology in educational settings to make research-based informed choices (Giannakos et al., 2020). However, we have observed from the experimental studies that only a few of them explicitly measured learning outcomes/increases in knowledge and skills. Below, we address and discuss some aspects for improvement in CCI research to generate evidence on learning outcomes and explore the direct associations between intrinsic motivation in CCI and learning outcomes.

Many of these studies manifest that the goal is to facilitate, support, and scaffold learning, but the methodology rather shows mediation of a learning situation, which leads to unclear assessment criteria for the intrinsic motivation that leads to learning. Thus, inspired by Eriksson et al. (2022) and Barendregt et al. (2019), we suggest explicitly communicating the research goal and the interplay between the related construct of intrinsic motivation and outcomes in children.

It is also important to note that the experimental studies were mostly conducted in real-life settings and used quasi-experimental rather than true experimental methodology. While this situation increases the ecological validity of the studies, it leads to less controlled studies with a decreased possibility of inferring causal connections among variables. It is also important to note that the studies reviewed in this paper mainly focused on how to cultivate intrinsic motivation to learn rather than trying to have a direct impact on learning. However, intrinsic motivation and learning are hard-to-quantify concepts influenced by many individual and environmental/social factors. These factors may include cognitive factors such as attention, memory, executive function, and self-regulation. In addition, contextual factors such as opportunities for learning and exploration and high regard for curiosity could influence the level of intrinsic motivation, ways of increasing intrinsic motivation, and how to foster it to improve learning outcomes in CCI contexts. Thus, this area of research deserves further attention from developmental scientists, learning theorists, and CCI researchers and designers.

Limitations

As with all literature reviews, this review also has several limitations, particularly due to the title-abstract-keyword search strategy, the use of the stem "intrinsic motiv*," and the two venues, which may have resulted in missing studies highly relevant to the topic. Furthermore, the selection bias in terms of publication venues as well as full and short paper formats may also cause a similar impediment. It is important to note that a scoping review aims to provide a current, concise overview of a research area or field (Arksey & O'Malley, 2005; Levac et al., 2010). Thus, this review showcases a limited number of papers that does not represent the entire research in the child-computer interaction field. It is possible that we may have overlooked some other relevant papers due to our search query and chosen database in formulating the search protocol.

We acknowledge that the two databases, ACM Digital Library and IJCCI, do not justify all relevant work that is published in this area. Relevant research may be found in other fields of research and venues such as education technology, learning sciences, and developmental research. We further acknowledge that the ACM Digital Library is not the only database relevant for design-based research practices in CCI as a subfield of human-computer interaction. Due to these limitations, we provide a situated overview of the leading venues of the field and the current landscape of research in CCI without making any claims to cover all intrinsic motivation studies in CCI.

Conclusions and Future Directions

We have presented a scoping review regarding the assessment of intrinsic motivation to develop and report on research in CCI. It is our hope that the main take-aways of this paper for future research directions listed below can inspire CCI researchers to examine the factors that influence intrinsic motivation in children and that it can contribute to an increased awareness of intrinsic motivation in CCI. Future directions for studying intrinsic motivation in CCI research are as follows:

- Improving methodological precision and standards with clear theoretical and conceptual framing of the term and primary features of the research design in identifying and operationalizing the assessment of the underlying components of intrinsic motivation.
- Expanding the target age groups to include high school and preschool children.
- Establishing cause-effect relations and addressing the link between the effect of technology interaction on children's intrinsic motivation through true experiments also aligns with the need for increased methodological precision.
- Conducting design-based research to measure and evaluate intrinsic motivation by conducting both quantitative and qualitative methods is an opportunity to bridge the gap between educational practice and theory to advance domain-specific theories about learning and develop the tools used to leverage intrinsic motivation.
- Evaluating the relation between the novelty aspect and the intrinsic motivation for engaging with the technology being developed.
- Exploring the social and cognitive factors associated with intrinsic motivation in CCI through experimental and observational studies.
- Doing research with children having developmental delays/difficulties in different domains (e.g., children with learning difficulties) to help inform us on different aspects of intrinsic motivation pertaining to learning and possible technologies and tools for support.

In sum, this review's conclusions could be helpful in organizing and describing research with a strong design component, particularly related to children's intrinsic motivation in learning interventions and the educational use of technology. Furthermore, the strong focus on knowledge development in the literature describing and arguing for the description and assessment of intrinsic motivation is something that the CCI field could benefit from and be inspired by.

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