Existing Literature on Child-Centered Design and the Ways Children Have Been Involved in AI Research and Development

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Introduction

Children and youth live in a world of increasingly ubiquitous artificial intelligence (AI) technologies in daily applications. As such, there is a need to support children and young people in making informed decisions about the role of technology in their lives. Academic literature and political recommendations both seek to empower children in relation to AI-powered technologies. Less attention has been paid, however, to how this is actually achieved in practice. Often, technological skills are emphasized over the societal and ethical implications of these technologies. However, scholars point out the importance of teaching children how to reflect on intelligent technologies that go beyond just technical features. Dindler et al. (2020) argue for *Computational Empowerment* by providing children and young people with the means necessary to take part in technological development.

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We reviewed the existing literature to evaluate the ways in which youth have contributed to and had their voices heard in the development and research of emerging AI technologies. The review includes papers from the last 10 years and follows a rapid review methodology. We searched five databases: the ACM Digital Library, IEEExplore, Scopus, and two EBSCO databases (ERIC and PsycINFO). These databases include work from a diverse set of fields including but not limited to: learning sciences, child-computer interaction, healthcare, and psychology. We searched titles, abstracts, and author keywords using a search string combining multiple terms related to study population characteristics, AI technologies, and involvement methods. The search was concluded on June 8th, 2023 and yielded 844 unique records, which were imported into the Covidence systematic review management application.
Additionally, we included results from manual and snowball searches that met our inclusion criteria (n = 35). A list of the inclusion and exclusion criteria is described in **Table 1** below, and an overview of the search is shown in **Figure 1**.

	Inclusion	**Exclusion**
Population	The record involves children, aged 5 to 18, including neurodiverse, differently abled or other minority groups.	The record does not involve any children in the age-range of 5 to 18.
Research aspect	The record revolves around children's opinions on or children discussing the responsible development of AI or AI literacy.	The record does not involve these children's involvement and/or dialogue on AI literacy and/or the responsible development of AI.
Study design	The record involves empirical research.	The record does not involve empirical research.
Quality	The record is a full paper and is peer reviewed.	The record is not a full paper (e.g., abstracts, works-in-progress) or is not peer-reviewed (e.g., theses).
Publication Date & Language	The record was published in the last 10 years (>2012) and is written in English.	The record was not published in the last 10 years (<2013) and is not written in English.

Table 1. List of inclusion and exclusion criteria for literature search

A total of 49 studies qualified for data extraction after completing the title, abstract and full text screening. We used topology from Druin et al. (2002) to identify which role the children played within the reported study as well as which design phase the children were involved in. We used the three phases (requirements, design, and evaluation) as described by Barendregt et al. (2016), to identify which design phase the children were involved in. We extracted the type of contribution that the child made to the study results through a list of codes that were iteratively generated by the researchers and the findings (i.e., the children's identified design opportunities for AI implementations and their ethical concerns regarding AI's influence in society). Lastly, we extracted the ways in which the researchers ensured the validity of the data and gained insights from the children's perspectives (e.g., positionality statements).

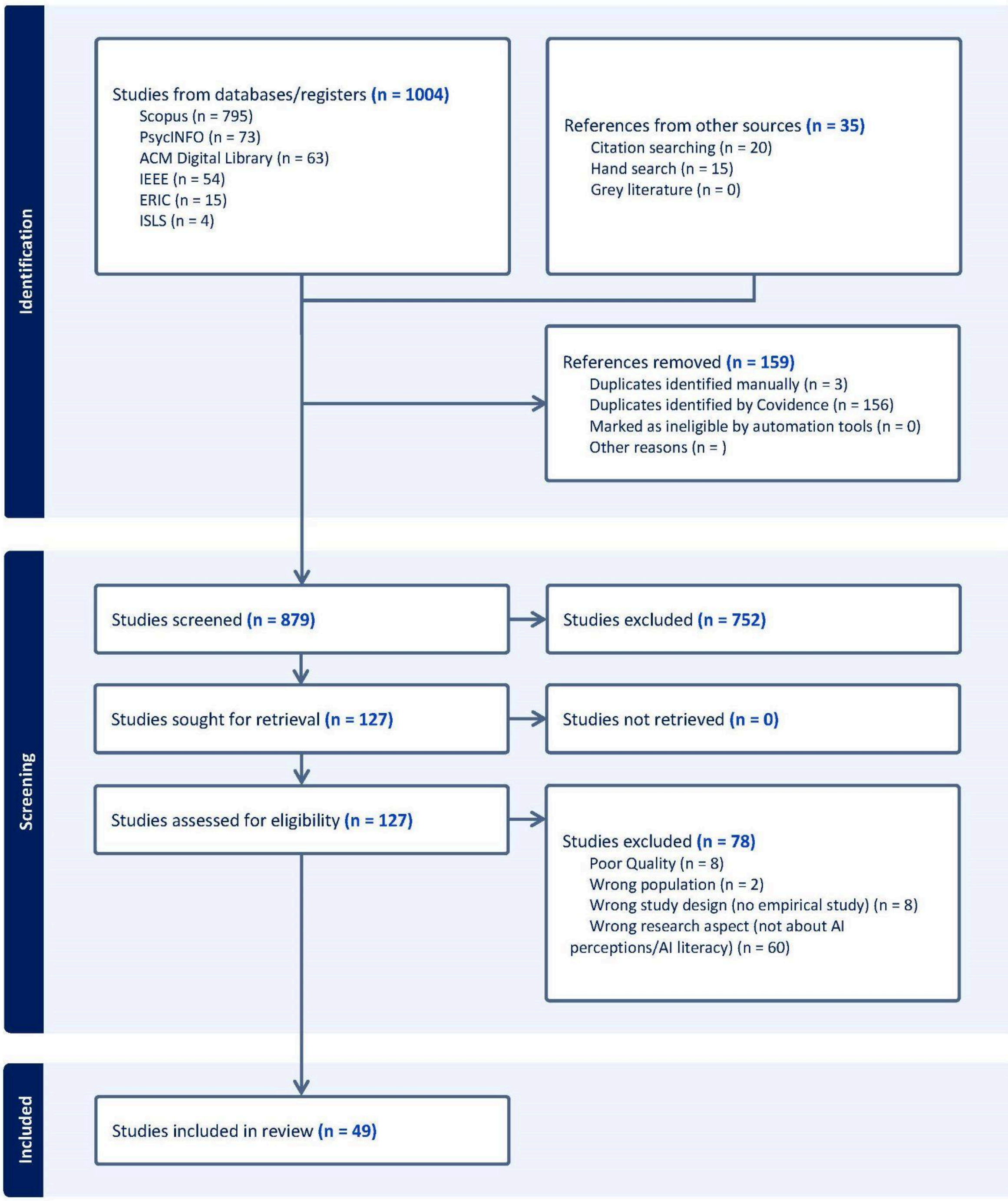

Figure 1. Overview of literature search

We found that the degree of authenticity and personal engagement varies depending on the methodology and its implementation. Accordingly, we selected and ranked a series of key activities that can promote computational empowerment in practice and support child engagement in both the reflection upon and the creation of alternatives for AI technologies. Through these activities, we observed children making contributions, including designs, requirements, recommendations, opportunities for AI implementation, and both concerns and aspirations for future applications of AI.

Activities

Scholars have designed and implemented a diverse range of activities that foster children's critical attitudes surrounding both new design opportunities and the ethical and societal implications of AI-powered technologies. While many of the activities focus on the implications of AI in general, some highlight specific implementations of AI, such as voice assistants, social robots, chatbots, or recommender systems for internet content. We divide the selected activities, taken from the literature, into different stages of the design process: 1) **sensitizing** activities on the workings and ethics of AI technologies; 2) reflections on **requirements** for AI technologies; 3) **design**-oriented activities; and 4) **evaluations** of self-created designs and designs by others (see **Table 2** in the Appendix for an overview). As we discuss several of these activities, it is advisable to structure and combine them in a manner that allows children to engage with the same topic in different ways. For example, a workshop can first include various activities to build children's understanding and elicit critical discussions about AI before kickstarting creative processes.

Sensitizing activities

Sensitizing activities typically aim to provoke critical reflection on existing technologies by engaging children with the ethical implications or workings of the technology. In most cases, stories are used to elicit reflection on the ethical implications of AI. While there exist many videos about algorithmic bias and the potential harms of AI, children can learn more through personal, hands-on exploration of the technological implications. This can be accomplished with group discussions or mapping assignments. In sensemaking discussions, for example, facilitators can alternate scenario details with reflection questions to encourage children to explore their preconceptions of harmful ramifications caused by technology. Socratic seminars can leverage the varied perspectives of peers for further ethical reflection. Children may categorize several examples of artificial intelligence-powered technology as useful or harmful in order to determine what they consider to be harmful. They can reflect on data privacy by mapping their willingness to share different types of data with various stakeholders.

Through activities without or involving technology, we can encourage children to reflect on how artificial intelligence works. For instance, children may be shown multiple everyday technologies and asked to consider whether these incorporate AI algorithms; asked to play a card game designed to teach about bias in training data; or asked to draw or construct an algorithm with sticky notes. Everyday technology can also be leveraged to inspire critical reflection in youth. The creation of an auto-generated poem on a mobile phone can inspire youth’s reflections on data privacy or interactions with web-based tools that allow children to experience machine learning (ML) models, such as Google Quick Draw or Google Teachable Machine, which allows them to understand how data is used to make decisions in ML-powered technology. Furthermore, children's long-term interaction with technology could provide them with a greater understanding of its workings and ethical implications. It is advisable to use sensitizing activities to gauge children's knowledge levels and deploy some of them in order to ensure that their level of understanding is roughly the same so they have equal opportunities to participate in further activities.

Reflection on requirements

Insights from sensitizing activities can help children reflect on requirements for AI technologies in their personal world. This includes requirements for what the technology should be able to do, situations in which the technology might be helpful or harmful, reflection on the values of stakeholders, and preferred and harmful ways of interacting. The latter has particular implications for AI technologies, since some of them might be perceived by children as having personalities, for example, voice assistants, chatbots, or social robots. Children can be asked to create vision boards or scripts to think about the identity and language used by these tools. In group discussions, different design opportunities can be evoked as the children consider different situations in which AI-enabled technologies may be useful. They can also be prompted to reflect on how the technology might impact others. Value-sensitive design methods, such as the identification of stakeholders, the differing values of these stakeholders, and potential tensions between these values through an ethical matrix, can be used to provide rich, contextual implications of AI technologies for society at large. In particular, we recommend that children be encouraged to investigate the groups that benefit from AI technologies as well as the groups that may be adversely affected by them in order to make informed conclusions on the requirements for AI technologies.

Design

Children can reflect on the real-world implementation of these requirements and their ethical and societal impacts through design-oriented activities. The main characteristic of such activities is that they allow children to create alternative scenarios. Graphical story-writing activities, such as creating storyboards, can be used to support reflection on what interactions with AI technology might look like in practice. To take this a step further, bodystorming, a technique in which the physical body is used to ideate through a combination of role-play and brainstorming, allows youth to experience the potential interaction with new technologies. However, brainstorming, a method of generating ideas, is challenging. Ideation cards or elaborations on ideas from peers can help children overcome mental blocks by providing inspiration. Moreover, constructive design activities, such as prototyping with or without technical materials, can provide children with an opportunity to reflect on how to interact with the technologies they have designed. As part of the design process, it is recommended that children are guided to reflect critically on prior established requirements by, for instance, mapping ideas according to the degree to which each one meets those requirements. To maintain the focus on the possibilities of AI technology, children should also be encouraged to define their own design opportunities instead of attempting to solve a problem for which AI might not even be a viable solution.

Evaluation

Children can reflect on the related problems in their newly created scenarios through evaluation activities. This can be accomplished by acting out the scenario or interacting with the prototype. By presenting the design, children can also solicit feedback from others. Children can then use their new insights to iterate on their design and update their scenario. It would be beneficial to implement reflection activities to help children distill how they might apply the insights they have gained to their futures. For instance, they may write a letter to their future selves advising how to interact with AI technologies, or they may create a video in which they appear as experts on the technology.

Best Practices for Implementation

We just discussed methods for supporting children's ways of expression through convergent and divergent thinking and the creation of artifacts, i.e., a design process. Involving children in these design activities that allow them to voice their opinions has certain implications. Not only do we need to think about the activities but also about the didactic and pedagogical aspects of involving children in such a process. The appropriateness of the content of the activities, the atmosphere, and the demographics and abilities of the children should all be considered.

Content

To effectively engage children in the considerations, designs, and development of AI systems or their implementation, it is essential to take the children’s interests, skill-levels, prior experience, and what they will take away from the activities into account. The activities should resonate with their interests and lived experiences. This can be done, for example, by incorporating the children’s own data or having the children choose their own topic of interest for which to develop AI implementations. This works to enhance their investment, motivation, and emotional engagement throughout the activities. Additionally, popular culture and media shape children’s and youth’s understandings of AI and smart technologies. As such, Hollywood portrayals of robots and voice assistants may lead to distorted conceptions of the capabilities and functions of these technologies. Sensitizing activities can be incorporated to support children's reflections on what their preconceived notions of AI are and how they differ from real-world applications. Lastly, activities should encompass holistic perspectives that help children consider both the ethical consequences and possibilities of AI systems. By doing so, we minimize the chances of causing anxiety in children and increase their understanding of a changing world.

Atmosphere

Being creative and sharing ideas brings about vulnerability. Creating a safe and supportive environment is crucial for enabling children to have authentic expressions of both concerns and ideas. This includes dedicating time to developing rapport and long-term relationships with children to reduce power dynamics and encourage authentic discussions of AI. For example, a youth advisory board with familiar spaces and long-term engagement may make teens more willing to share or decrease their feelings of being judged during an open discussion. Additionally, children should not feel that they will be assessed based on their contributions. This might be particularly pertinent if activities take place in formal educational environments.

Involvement of marginalized groups

The development of AI implementations should involve a wide range of voices to create inclusive technologies. Despite half of the reviewed literature involving children from non-white racial groups in their work, only a few make deliberate considerations to highlight minority voices that have been historically marginalized in the field of AI. With the primary objective of maintaining cultural relevance and expression, some scholars have used tailored approaches designed to situate activities in children's unique lived experiences and challenge the status quo. For example, when exploring the design opportunities of conversational agents, consider employing activities like vision boards and written scripts to reflect pieces of children's identity and language in the design ideas. Use materials, tools, and examples that incorporate their culture to increase authenticity and relevance. Moreover, opportunities can be provided for racialized groups to consider the limitations of specific AI technologies in relation to their identities. These forms of activity allow minority groups to inscribe their diverse lived experiences into their discussions and artifacts. Activities should harness the opportunity of working with marginalized groups to not only learn from them but also empower them to resist normative technological design assumptions (i.e., white-able-bodied and cis-heteronormative).

Roughly 18% of the articles we reviewed included children with disabilities, but only 8% showcased methods that support the inclusion of diverse bodies and abilities. These studies specifically include children with low vision or children with autism spectrum disorder, which leaves room for further inclusion of a wider range of individuals. Embodied interactions such as bodystorming or prototyping with tangible materials can facilitate more inclusive participation for children who are blind or have low vision. Moreover, avoid technoableist approaches to designing activities that have the goal of fixing differences; instead, take a holistic lens and design activities that embrace and celebrate differences in abilities and perspectives. Overall, an intersectional approach that considers and encourages diversity will help children contribute more meaningfully and authentically.

Summary of Insights

Determine existing AI literacy levels:

- Gauge the current AI literacy level of children using short provocations (e.g., quizzes and interactive games) to create a baseline proficiency for subsequent activities.
- Break down common and naive notions of AI technologies from popular culture to provide realistic understandings of AI functionalities and limitations.

Active engagement through design processes:

- Alternate activities in which children use divergent thinking abilities in which children engage in the ideation on, design, and construction of artifacts, with critical convergent thinking abilities in which they analyze, evaluate, and reflect on the technologies they designed.
- Provide students with information on the design process itself and the need for iteration, research, and continuous reflection.

Multiple and interrelated sensemaking activities:

- Have a series of diverse and interrelated activities that improve children's sensemaking and reinforce AI concepts from different angles. (e.g., games, storytelling, hands-on experiments, and group discussions)
- Provide experiences and tools to support comprehensive understanding and elicit meaningful contributions from children.

Reflection on broader contextual implications:

- Strengthen the meaning and authenticity of children's voices through fostering their critical thinking about AI's impact on society and their understandings of broader socio-political contexts
- Help children identify and voice ethical concerns about AI implementation through deconstruction exercises and Value Sensitive Design (VSD) methods.

Holistic and multifaceted perspectives:

- Encompass holistic perspectives by helping children consider ethical consequences as well as the possibilities of AI systems.
- Encourage a diverse range of perspectives (interdisciplinary and intersectional) to develop well-rounded thinking about both the social harms and social benefits of AI.

Motivation and tailored implementation:

- Motivate children to participate by tailoring and implementing activities with topics or goals that are relevant or interesting to the group at hand
- Center activities around personal and emotional engagement
- Give children the ability to actualize/physicalize design ideas into high fidelity prototypes
- Mold activities to fit the interests of the children involved will help foster their intrinsic drive and care.

Foster community and reduce power imbalances:

- Dedicate time to developing rapport and long-term relationships with children to reduce power dynamics and encourage authentic discussions of AI
- Community and safe spaces are particularly important when working with marginalized/minority groups or when dealing with sensitive topics (e.g systems of oppression).

Appendix

Table 2: Overview of activities for different stages of the design process

Age	Sensitizing	Requirements	Design	Evaluation
< 8	Discussion on scenarios involving child-robot ethics (Mott et al., 2022)	Stakeholder analysis (Vallès-Peris et al., 2018) Define design opportunity (Vallès-Peris et al., 2018)	Sketching (Mott et al., 2022) Low-fidelity prototyping (Mott et al., 2022) Include interactions by prototyping with electronics (Vallès-Peris et al., 2018)	Enacting interactions with prototype (Vallès-Peris et al., 2018) Presenting (Vallès-Peris et al., 2018) Video interview (Mott et al., 2022)
8 - 10	Sensemaking discussion (Salac et al., 2023) Sticky-notes evaluation of existing technologies (Garg & Sengupta, 2020) Drawing understanding of ML algorithms (Irgens et al., 2022) Harmful/helpful technologies(Irgens et al., 2022) Google search bias (Irgens et al., 2022) Google quick draw (Irgens et al., 2022) Google Teachable Machine (Irgens et al., 2022)	Group discussion (Garg & Sengupta, 2020) Interest board (Garg & Sengupta, 2020)	Layered elaboration (Salac et al., 2023) (Garg & Sengupta, 2020) Low-fidelity prototyping (Garg & Sengupta, 2020) Prototype ML algorithm (Neto et al., 2021) Storyboarding (Irgens et al., 2022)	Enacting interactions with prototype(Garg & Sengupta, 2020) Presenting (Neto et al., 2021) Peer feedback (Neto et al., 2021)
11 - 12	Socratic seminar (DiPaola et al., 2020) Make algorithm with sticky notes (Solyst et al., 2022) Google quick draw (Solyst et al., 2022) AI stories (Solyst et al., 2023)	Stakeholder identification (DiPaola et al., 2020) Stakeholder-value pair (DiPaola et al., 2020) Ethical matrix (DiPaola et al., 2020)(Williams et al.,2023) Ideation on requirements (Piccolo	Sketching: YouTube interface redesign (DiPaola et al., 2020) AI for social good ideation and ML model creation (Solyst et al., 2022) (Williams et al.,2023) Storyboarding (Buddemeyer et al., 2022) Scenario writing, critiquing,	

	Card game (Solyst et al., 2023)	et al., 2021) Digital assistant help/harm (Solyst et al., 2022)	ranking, and selection (Cagiltay et al., 2020) Roleplay with props (Piccolo et al., 2021)(Cagiltay et al., 2020)	
13 - 14	AI bingo (Schaper et al., 2023) Ranking technologies (Schaper et al., 2023) Google Teachable Machine (Schaper et al., 2023) Diary reflections on in situ interaction with technology (Garg, 2021) Embodied data modeling (Schaper et al., 2022) Data compass (Schaper et al., 2022)	Group discussion (Han et al.,2023)(Lopatovska & Davis, 2023) Bodystorming (Metatla et al., 2019) Script writing (Garg, 2021) Robot language, personality and interactions (Li et al., 2023) Stakeholder mapping (Schaper et al., 2022) Design goal definition (Schaper et al., 2022)	Storyboarding (Schaper et al., 2023)(Schaper et al., 2022)(Alves-Oliveira et al., 2022) Sketching (Alves-Oliveira et al., 2022) Low fidelity prototyping (Schaper et al., 2023)(Li et al., 2023)	Peer feedback (Garg, 2021) Presentation (Schaper et al., 2022) Researchers create high-fidelity prototypes of children's ideas and evaluate them with children (Metatla et al., 2019) Letter to future self (Garg, 2021)
15 +	Diary reflections on in situ interaction with technology (Cha et al., 2021) Auto generated poem (Lee et al., 2022) Interaction with Replika (Lee et al., 2022)	Group discussions (Rankin & Henderson, 2021) Vision boarding (Rankin & Henderson, 2021) Script writing (Rankin & Henderson, 2021)(Fitton et al.,2018) Ideation on design requirements (Rankin & Henderson, 2021) Goal setting (Cha et al., 2021) Self-define projects based on interest (Cha et al., 2021)	Low-fidelity prototyping (Rankin & Henderson, 2021) Minimum Viable Product (Lee et al., 2022) Storyboarding (Rankin & Henderson, 2021)	Enacting interactions with prototype (Fitton et al.,2018)

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