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Reapproaching human-chatbot interaction for early literacy development: A learner-centered review of literature and technology prior to ChatGPT 3.0

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Abstract

Artificial intelligence, or AI, has presented tremendous potential in reshaping early childhood education, particularly in literacy development. Extending this concern, recent investigations have been marching along with the wide application of LLM (Large Language Model) and contributing to the on-going discourse on various roles assumed by this increasingly prominent form of human-computer interaction (HCI) for human development. However, multiple challenges associated with AI deployment at the early stage of life remain underexplored, most of which can date back as early as before the game-changing debut of ChatGPT 3.0. Taking a learner-centered approach to such long-standing issues, this paper addresses the implications of chatbots as educational tools for enhancing early literacy in an increasingly diverse socio-cultural landscape. First, through a media archeological lens, the literature review reapproaches certain early chatbot features, discerning the instructional designs and implications for early literacy development, while considering the potential overlaps among chatbot, videogame, and virtual pet as three practically related technologies. The following discussion on a chatbot prototype is grounded in the insights drawn from a case study on the Talking Tom Cat application, as an example of combining chatbot, videogame, and virtual pet features and presenting opportunities for early literacy development even without the use of AI. The "AI-less" case study focuses on the foundational designs and analyzes 14 curated user comments to understand user experiences, highlighting the advantages of a chatbot-like videogame slash

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virtual pet, and foregrounding its limitations as caveats for future chatbot designs. Hopefully, this paper could contribute to the agenda of AI evolutions in early personalized education, offering practical implications and theoretical insights into how AI-driven learning tools could be devised and implemented in rapidly changing socio-cultural systems.

Keywords: HCI, chatbot, early literacy development, learner-centered approach.

1. Introduction

The communicative and educative functionalities of Artificial Intelligence (AI), among all the AI-related topics for human development, have manifested their own values and potentials, appealing for continual discussions about the existing practices and the unfolding future. AI chatbots, specifically, are expected to serve as a conversational partner, designed to simulate the way a real human partner talks to the user. This kind of AI application has been proved impactful in foreign language learning (Belda-Medina & Calvo-Ferrer, 2022; Adamopoulou & Moussiades, 2020), far beyond traditional classroom settings. However, when it comes to preschool users and their early literacy development, or native language learning (for a multifaceted discussion, see Morrow & Dougherty, 2011), more need to be considered in terms of cognitive development, especially the cognitive mechanisms involved in the literacy developing process of young chatbot users. Meanwhile, it is noteworthy that a body of research has reported digital media use as the culprit of expressive language delay (e.g., van den Heuvel, et al., 2019). In this concern, explanatory clues for the language lag and impairment among children, supposedly related to the use of digital media including chatbot, could be identified in a technology review guided by cognitive science.

Moreover, although the industry continues to extend the application of chatbot by combining it with other media forms (Reiser & Dempsey, 2012), academic caution should be encouraged in the face of the blurred and intermingled categories of technologies with reference to chatbot, empowered by concurrent growth of AI across multiple fields. In distinct research streams under Human-Computer Interaction (HCI), not only do the underlying mechanisms of chatbot-user interactions need additional inspections, but it is alarmingly possible to confuse chatbot characteristics with other media features in specific cases, which can result in a confounding explanation or misunderstanding of certain media effects - be it good or bad. Therefore, the relationship between chatbots and similar technologies, though commonly juxtaposed in

previous literature, should also be re-examined and clarified. To this end, the current study has been narrowed down to the so-called pre-ChatGPT age, or before the watershed-like arrival of ChatGPT 3.0 in November 2022, to re-approach the former human-chatbot interactions from the perspective of media archaeology with learner-focused concerns. Advancing this agenda, a chatbot prototype is then proposed to facilitate early literacy development, following a technology review on a thought-provoking case of earlier human-chatbot interaction. Figure 1 presents a visualization of the workflow, reflecting our dual focus on past and future technologies of chatbots as early literacy tools.

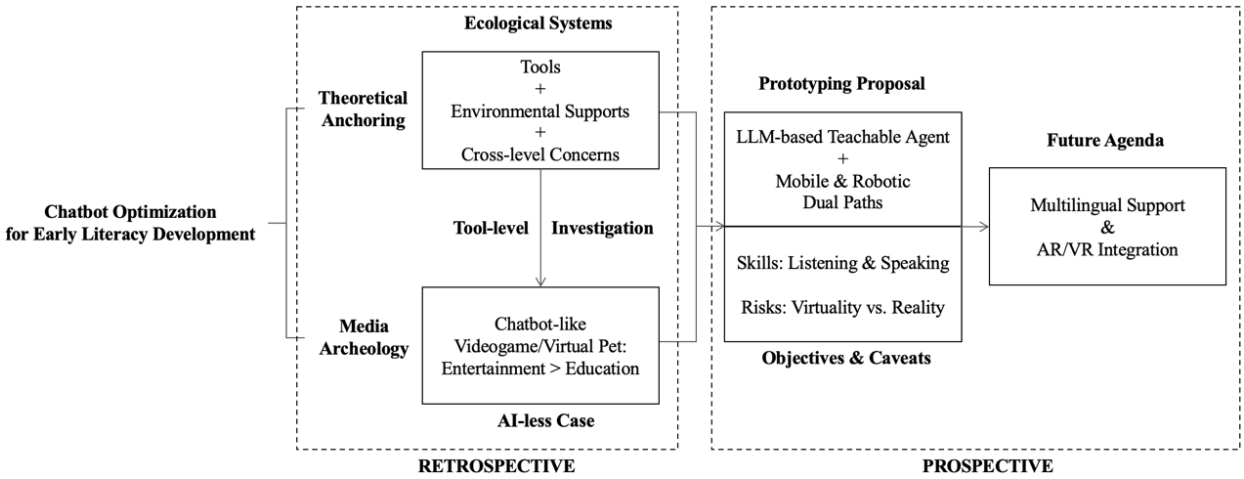


Figure 1. *Conceptual research model*

2. Framework for Theoretical Synthesis

Despite years of research and attempted summaries (e.g., Pérez et al., 2020; Kuhail et al., 2023), here remains a notable absence of systematic analysis of accumulated knowledge in terms of human-chatbot interactions for specific educative purposes. Addressing this gap, our research aims to first organize the literature, identify trends and gaps in previous technologies, and shed light on future directions for chatbot-based literacy development of children, or preschool users. To this end, multiple analytical tools and conceptual components are required, calling for an umbrella framework to guide the integration of relevant perspectives.

Recognizing chatbot as an umbrella concept, chatbot researchers may begin with a typology to better delineate the scope of their investigation. One approach is to classify chatbots based on their target users. In the present study, the target users are preschool learners who engage with chatbots - whether intentionally or incidentally - for native language development. Accordingly, a learner-centered approach is adopted to synthesize interdisciplinary theories, findings, and

methodologies to address the diverse learning issues that may arise during human-chatbot interactions.

This learner-centered approach is first anchored in Bronfenbrenner's Ecological Systems Theory (EST), which positions the child within a nested network of interdependent environmental systems (Bronfenbrenner, 1977). These systems - ranging from the immediate settings of the child (microsystem) to broader sociocultural forces (macrosystem) - interact dynamically to shape development. Within this ecological framework, the proposed research agenda spans at least three analytical levels: tool-level, environment-level, and cross-level concerns.

- At the tool level, research can focus on the design and adaptation of AI-powered chatbots to support early language development.
- At the environment level, studies can investigate the microsystems and mesosystems of the child. For instance, inclusive AI platforms could be designed to align with cultural norms and family communication patterns by understanding how different environments interact (e.g., home and preschool).
- From the cross-level perspective, systemic issues such as privacy, bias, and digital equity should be addressed by examining how interactions among various ecological systems shape both opportunities and risks for child development.

While EST offers a valuable ecological framework, helpful in identifying multilevel learning contexts and developmental supports (e.g., Rojas-Drummond, 2016; El Zaatari & Maalouf, 2022), we acknowledge its limitation in capturing moment-to-moment learning processes within an interaction unit. To address this, our approach is enriched by integrating Vygotsky's (1978) Zone of Proximal Development (ZPD), widely used in formal education research (e.g., Rahman, 2024), which emphasizes how learning occurs through social mediation and scaffolding within a learner's potential development range. Conceptually, the ZPD refers to the gap between what a learner can do independently and what they can achieve with appropriate guidance (Vygotsky, 1978). In the context of AI chatbots for early literacy development, this translates into designing adaptive conversational agents that can scaffold language learning by responding contingently to the learner's current linguistic capacity - prompting, modeling, and reinforcing language use in a developmentally sensitive manner. As such, ideal human-chatbot interactions for early literacy development should be dynamic, supportive, and learner-

contingent, approximating the guidance of a more capable peer or adult. Future design considerations may include customizing chatbots to offer graduated support and feedback based on a learner's evolving input, thus functioning as a digital scaffold within the child's ZPD. When situated within the broader ecological systems, this also suggests that chatbot design and deployment must consider contextual alignment, ensuring that the cognitive and social scaffolding provided by the chatbot is compatible with the learner's microsystem (e.g., family, classroom) and mesosystem (e.g., interaction between school and home).

In sum, while the current study focuses on the tool level, including a case study and a prototype proposal, the integration of EST and ZPD provides a more holistic understanding of how chatbots can scaffold literacy development. With environment-level and cross-level issues addressed in later sections, the application of these two foundational developmental theories could lay the groundwork for future multi-layered and context-sensitive explorations into AI-assisted language learning during early childhood.

3. AI-Less Case Study and Technology Review

Instead of general learning settings, a common situation of a chatbot used for early literacy development is that, as can be imagined, a child, aged from several months to 13 years or beyond (before entering adolescence), interacts with a virtual image on a smart device by tapping and speaking, or play with a little speaking toy robot. Yet, before the broad application of large language model (LLM), the limited functionalities of a typical, commercialized, and widely available chatbot are worth further considerations in retrospect, as the features of such AI-less chatbots would determine the chatbot-based environmental supports for the early literacy development. Besides, even without being powered by AI, an AI-less chatbot may seem AI-like or even human-like to children as users, because of the stage features of children's cognitive development. In this sense, it is necessary to get back to where chatbot started with no AI applied, namely the AI-less stage of chatbot, to review the influences of basic chatbot designs on early literacy development, as well as the possible impact of chatbot use on early life stages.

Talking Tom Cat (TTC below), known as a videogame slash virtual pet, was first released in 2010, followed by sequels like My Talking Tom and My Talking Tom 2 (both will be put under TTC for the rest of this study), which has gained over millions of users around the world. The target user group, as officially denoted, is children above 4 years. When approaching TTC as a

potential AI-less chatbot, we could expect it to have various implications, as argued by chatbot literature, in terms of language learning (Huang et al., 2022), identity construction (Schlesinger, O'Hara, & Taylor, 2018), and babysitting or companionship (Shum et al., 2018). In what follows, a technology review touches upon all these aspects, as they may exert educational or socio-cultural influences on early literacy development.

3.1. Unwinding Analogous Concepts: Chatbot, Virtual Pet, and Videogame

Instead of a potentially problematic integration in conceptualizations, we propose to first discern distinct technologies and then create linkages among them to better facilitate theoretical development and substantive application. In this regard, to what extent TTC possesses the features of a) chatbot, b) virtual pet, and c) videogame will be inspected respectively.

Arguably, the notion of chatbot, either with a physical form (a toy robot, for example) or not (usually referring to the software type), could be interchangeable with the concept of electronic or virtual pet to a large extent, particularly considering their capabilities of interacting with the users and thereby developing a virtual relationship (yet to varying degrees). In this view, playing a videogame, usually in a one-direction manner as a player controlling a game character, can be easily differentiated from playing with a chatbot or virtual pet, as there is no relationship intended by this experience. Then it is natural to ask if there is any similarity between a typical chatbot and TTC - the latter is selected as an AI-less case of chatbot here, though widely branded as a videogame. Furthermore, how do such similarities, if any, and the differences serve to form environmental supports for children developing their language skills? Taking these questions into account, the following review based on the case of TTC could help understand the distinct roles and the commonalities of these highly related technologies, applied in an individual's early life.

Considering the significant proportion of gaming, we first approach the interactions between TTC and its users as playing, which can arguably apply to all the interactions between other potential chatbots and children. It is widely accepted that TTC falls into the category of mobile videogame, while sharing similarities with a virtual pet, since the main game character is designed as a pet cat. In this sense, as TTC is also considered to be a potential chatbot, while not AI-powered, it constitutes a combination of the three concepts noted before. Previous literature has reached a wealth of conclusions about the implications of videogame and virtual pet on the identity construction, literacy development, and so forth. In this view, a systematic

understanding of how a specific aspect of early personhood is influenced by a chatbot can be partly drawn from extant research in videogame and virtual pet.

As argued by Bergen and colleagues (2016), videogame assumes an important part in children's cognitive development. Kids today have innovative and tech-based play materials. These tech-based materials serve to enhance their sensory and motor skill development, implicating that we are supposedly able to manipulate play environments through the design of play materials. Notably, when children reach a certain age, they stop playing with certain materials; and choosing a play material highly depends on age, sex, ability to handle the material, cultural differences, social status, and economic status (Bergen et al., 2016). In this concern, as a videogame for children, TTC is supposed to be designed in a way that specific demands of target children are fully considered.

From the perspective of cognitive science, Jean Piaget divided the cognitive development into four main stages, each of which builds on the preceding one: the sensorimotor, preoperational, concrete-operational, and formal-operational stages, following the fixed order (as summarized in Webb, 2008). It is the preoperational and concrete-operational stages that cover the main target age group of TTC, as mentioned earlier. When turning 2 years old, children start to show signs of representational thought, which indicates the end of the sensorimotor stage; subsequently, during the preoperational stage, children begin to actively develop internal representations, paving the way for the subsequent development of logical thoughts while exhibiting a tendency of centration. In the stage of concrete operations, from roughly ages 7 or 8 until 11 or 12 years, children become able to manipulate mentally the internal representations that they formed during the preoperational stage. Hereafter, not only do they have thoughts and memories of objects, but they can perform mental operations on these thoughts and memories regarding concrete objects, such as cars, food, toys, and other tangible things (Webb, 2008), yet it is still hard for abstract, intangible things to enter their memories. In this view, TTC, as a videogame slash virtual pet, while being not so tangible, shall be designed in a way that simulates what would really happen to a "talking cat" facing certain interactions. Only in this way can TTC and its young users develop a maintainable relationship. The more TTC seems like an actual pet to target children, instead of a virtual, nonlife thing, the easier it is for TTC to enter a child's thoughts and memories. As for memories, or internal representations, Dual-code theory could be applied to the integration of mental imagery (namely, pictorial and analog codes) and mental narrative (i.e., verbal and symbolic codes), processed differently via two

distinct systems (Sternberg & Stemberg, 2012). In this regard, since the available responses from TTC incorporate audios, texts, and images (static or animated), the later design analysis should investigate the codes beneath specific interactions, processed differently in mind when a child plays with TTC.

Moreover, Cole (2014) discussed the construction of gender identity based on experiences of digital media and interactive play. In line with Cole (2014), digital literacy expresses, shares, and reaffirms gendered self-identification through experiences of videogame play with narratives that either confirm or deny stereotypical biases. In a previous study, as note by Cole (2014), in-depth interviews were conducted to explore the effects of play practices on conceptions of masculinity and personal identity in males who grew up in the 1980s by focusing on a linguistic analysis of the pragmatics of their shared thoughts on play, fantasy, use of digital media, and violence. The same purpose of such interviews could be achieved by analyzing online ratings and comments on TTC, in that the ratings and comments constitute the first-hand self-reported data that directly reflect the shared or exceptional thoughts of users. Moreover, Cole (2014) also offered evidence for the influences of fantasy and play on future perceptions of reality, as well as cultural identification and group formation. We are well informed that childhood experiences of interactive digital entertainment media could extend the cultural influences on a person's adulthood and on the social level.

Besides, when TTC is treated as a virtual pet, more features need to be considered. Virtual characters have been widely appreciated as a significant application in the field of technology-enhanced learning. In a study by Chen and colleagues (2011), the concept of animal companions, or 'non-smart' virtual characters, is proposed to encourage students' effort-making learning behaviors. The results of their preliminary experiment reveal that participants in the group with a complete version of animal companion displayed better quality of effort-making learning behavior (Chen et al., 2011). The same pattern could apply to early literacy development, implying the potentials of the applications of virtual pets or other characters in the early development of individuals. Yet, the test of relevant hypotheses is beyond the reach of a retrospective study, requiring future research to follow up on this inquiry.

In general, the current technology review adopts McLuhan's tenet that media themselves constitute the messages, believing that media are associated with controls and forms of human alliance and action (McLuhan, 2017). We place the focus on media effects – namely the effects of TTC's overall design - rather than message effects, or the possible influences that can be

brought by specific contents of the TTC-player interactions. Also, Perkins's theory of fingertip effects (1985) is introduced to address what environmental supports or systems, aside from TTC per se as a learning tool, are needed to embrace the positive impact of TTC on children. Hinging on the affordance of different versions, the effects of TTC on children could vary a lot. Accordingly, it should be the priority of game designers to consider any possible opportunities for effective interactions; on the other hand, when accompanying their children to play with TTC, parents are highly suggested to take advantage of such opportunities to reach, hopefully, the educational goals by providing necessary guidance or assistance. Bearing these in mind, we could then discern abundant educational and socio-cultural implications - not limited in early literacy development - from certain details of TTC's design.

3.2. Design Analysis: Interface and Experience

Even without a step-by-step instruction, most first-time players are presumably able to play with TTC through its supposedly foolproof interface. From the perspective of UI (User Interface) and UX (User Experience) design, an examination on the interface, incorporating its main functions and structure, and on how user experience would be in a dynamic view, is supposed to lay the foundation for further investigations. What follows is the UI and UX design analysis of the earliest version of TTC. Notably, a remake of TTC was released in 2016, with some features removed and some altered. This study sticks to the earliest version (Figure 2), rather than the remake, in that the main features shared in the whole TTC series derive from this old version. More functionalities were added later in the updates, while the layout of them, as well as the image design, also experienced many alterations. The old version serves as the most essential prototype of TTC and assumes a major part of the gaming experience. Instead of elaborating on every specific function, we only note some details necessary for delineating the whole user experience.

Upon launching the 2010 version of Talking Tom Cat, as shown in Figure 2, users are met with a home screen dominated by Tom, the animated cat. The core interaction is simple: users speak, and Tom mimics their voice in a comical tone - no actual dialogue or conversation occurs. The UI features five primary buttons and an "i" icon for help. These buttons surrounding Tom allow users to:

- Record short videos (30 seconds) for social sharing (YouTube, Facebook).
- Trigger character reactions by touching Tom (e.g., poking, pillow smashing).
- Interact with Tom playfully by using buttons (e.g., drinking milk).

- Refresh the set of actions available.

Figure 2. *Interface of TTC, 2010*

Notably, the refreshing button on the right bottom is designed to bring the player more interactive options to replace the existing ones. While most of the interactions could be completed by tapping on these buttons, Tom also responds to every touch directly on him - Tom is identified as male in the whole series. When left alone, Tom also takes actions himself, keeping the UI animated. Other features include Tom scratches the screen; Tom drinks a glass of milk; Tom throws a pie on the screen; Tom tries to eat Talking Larry, a bird, but fails to do so; Tom makes a noise with a pair of cymbals. In the remake and sequels, Tom can be fed with food, which has become another core user experience. Playing with TTC has thereafter come closer to raising a pet in real life, supposedly having more significant implications on the relationship between TTC and players, and in turn on the formation of babysitting culture and companionship.

3.3. Rating and Comment Analysis: User Opinions

Turning to ratings and comments on App Store, for iOS users, we thereby approach the user feedback on TTC, withstanding that the validity and reliability of such online contents could constitute another issue, which, however, will not be addressed here, but left for follow-up studies with more scientific sampling or procedures for verification. Conducting a content

analysis, we determined the categories and units for analysis in a relatively objective and reasonable manner and then analyzed the noteworthy characteristics lying behind the user messages (N=14) to draw the educational and socio-cultural implications of TTC. As part of our sampling strategy, comments were handpicked based on relevance to not only literacy but socioemotional outcomes.

In App Store, as of June 2022, within the United States (which means the region setting of App Store, not necessarily the exact region), there were about 89,000 ratings on TTC, the remake of the earliest version (the 2010 version has been replaced, not available anymore), more than 284,000 ratings on My Talking Tom and more than 507,000 ratings on My Talking Tom 2. On average, TTC scores 4.2 out of 5, reaching a 4-star game (5-star games are the best but rarely can be found). The sequels have made even more outstanding achievements, both maintaining four and a half stars. Given that the UI and UX design analysis goes with the 2010 version of TTC, supposedly closest to its remake, the content analysis of ratings and comments will go with the remake version. It merits notice that the data collection was completed before the launch of ChatGPT 3.0 - the prestigious conversational AI service by OpenAI, announced at the end of November 2022. Since then, the situation and the discourse surrounding AI and chatbot have encountered dramatic changes. In this sense, the time point of this data collection allows us to gain an overview of the user feedback in retrospect, right before ChatGPT alters, perhaps permanently, their opinions about chatbots and the like.

Sorted by “Most Critical”, “Most Helpful”, “Most Recent”, “Most Favorable” - four categories based on which the Apple Store sorts the ratings and comments for people to access - the contents of user feedback for analysis could be selected by drawing on these categories (Figure 3). However, as the four “Most-” categories all tend to merely focus on one certain polar, the rest of the contents somewhere in between these extremes could be missed out. In this regard, for primary analysis following thematic saturation, we screen and select 8 quality comments with a 5-star rating (the most favorable feedback, also the most in numbers), 4 with a 4-star/3-star rating (as the middle group), and 2 with a 2-star/1-star rating (the most critical feedback, also the least in numbers), all of which were present on the “See All” page by default, while possible biases on the part of Apple Store are not excluded. They were written in the years 2020-2022. By “quality comment” noted here, as criteria for inclusion, it refers to the comment that matches the rating and gives relevant reasons and substantial reviews, instead of contradicting its rating or simply writing for catharsis. An overview of the results is presented below.

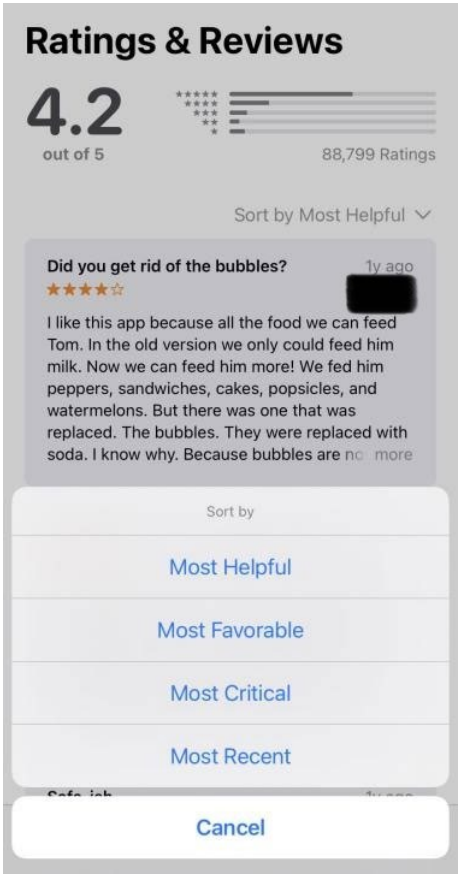


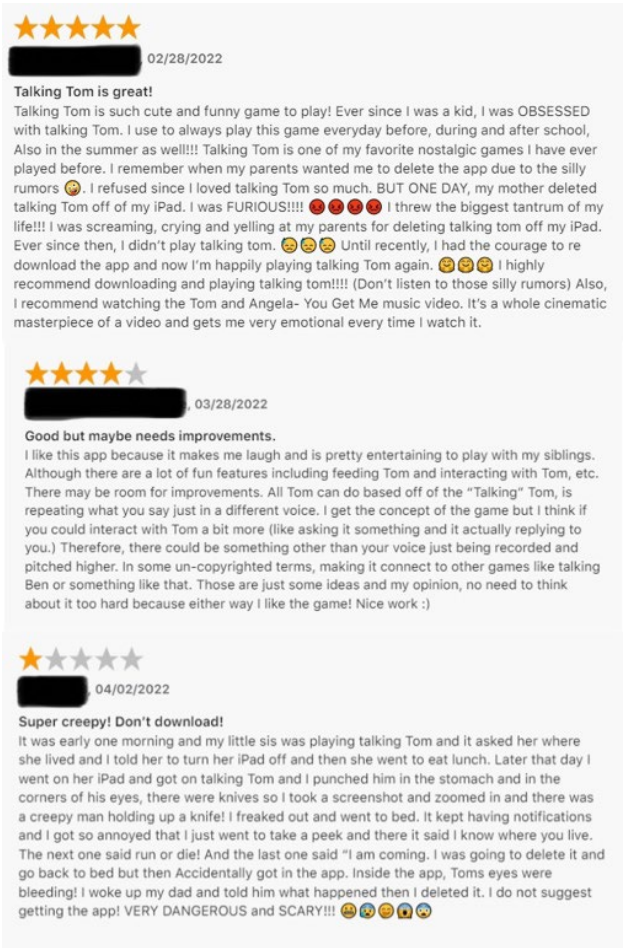
Figure 3. *"Ratings & Reviews" of TTC with four sorts available, 2022; the username is shaded in black*

As shown at the top of Figure 4, among the most favorable reviews, users praised TTC as "cute," "funny," and deeply nostalgic. Many commented that they had been obsessed with this app as a kid and referred to Tom as an "old friend," suggesting a sentimental attachment that extended into adulthood. Notably, it is reported by some self-claimed adult players that they "re-download" this app and play with this "old friend" again. Time for playing TTC during childhood could be "everyday", "before, during and after school", as well as "in the summer". Some considered TTC as one of their "favorite nostalgic games," implying the app's strong emotional and temporal resonance in users' lives.

In the moderate category, reviews were generally positive but also suggested functional improvements (e.g., "good but required improvements"). Several users called it "entertaining" and said that they enjoyed playing it with their siblings, highlighting its familial bonding potential. Still, a recurring critique focused on the limited interactivity, especially the "talking" aspect of Tom. As stated in a representative comment, TTC just repeats what the user says in a funny voice. Users would like to interact with Tom in a way more like real-life communication – for example, "ask it something and it actually replies to you" - which is exactly a major

function of a typical AI-powered chatbot, represented by ChatGPT. These remarks reveal early user interest in more natural, conversational interactions, years before ChatGPT's arrival, and underscore an unmet need for authentic dialogue with artificial characters, which could to some extend explain the later popularity of generative AI.

The most critical reviews labeled TTC as "creepy," "scary," and even "dangerous." Several reported frightening episodes or cited unsettling rumors, like weird reflections in the cat's eyes. And some reported that they got scared and deleted the app. There were also voices accusing TTC of tracking their location. Some even said that kids went missing because of it. While such claims may lack verification, they point to pervasive user anxieties around safety and surveillance. One especially alarmed reviewer declared that apps like this should not be for children, and that there needs to be a clean version with a proper age limit. These intense reviews suggest that user concerns about trust, privacy, and age-appropriateness may significantly shape public perceptions and acceptance of virtual companions.


★★★★★
[redacted] 02/28/2022
Talking Tom is great!
Talking Tom is such cute and funny game to play! Ever since I was a kid, I was OBSESSED with talking Tom. I use to always play this game everyday before, during and after school, Also in the summer as well!!! Talking Tom is one of my favorite nostalgic games I have ever played before. I remember when my parents wanted me to delete the app due to the silly rumors 😳. I refused since I loved talking Tom so much. BUT ONE DAY, my mother deleted talking Tom off of my iPad. I was FURIOUS!!!! 😡😡😡😡 I threw the biggest tantrum of my life!!! I was screaming, crying and yelling at my parents for deleting talking tom off my iPad. Ever since then, I didn't play talking tom. 😔😔😔 Until recently, I had the courage to re download the app and now I'm happily playing talking Tom again. 🥲🥲🥲 I highly recommend downloading and playing talking tom!!!! (Don't listen to those silly rumors) Also, I recommend watching the Tom and Angela- You Get Me music video. It's a whole cinematic masterpiece of a video and gets me very emotional every time I watch it.

★★★★☆
[redacted], 03/28/2022
Good but maybe needs improvements.
I like this app because it makes me laugh and is pretty entertaining to play with my siblings. Although there are a lot of fun features including feeding Tom and interacting with Tom, etc. There may be room for improvements. All Tom can do based off of the "Talking" Tom, is repeating what you say just in a different voice. I get the concept of the game but I think if you could interact with Tom a bit more (like asking it something and it actually replying to you.) Therefore, there could be something other than your voice just being recorded and pitched higher. In some un-copyrighted terms, making it connect to other games like talking Ben or something like that. Those are just some ideas and my opinion, no need to think about it too hard because either way I like the game! Nice work :)

★☆☆☆☆
[redacted], 04/02/2022
Super creepy! Don't download!
It was early one morning and my little sis was playing talking Tom and it asked her where she lived and I told her to turn her iPad off and then she went to eat lunch. Later that day I went on her iPad and got on talking Tom and I punched him in the stomach and in the corners of his eyes, there were knives so I took a screenshot and zoomed in and there was a creepy man holding up a knife! I freaked out and went to bed. It kept having notifications and I got so annoyed that I just went to take a peek and there it said I know where you live. The next one said run or die! And the last one said "I am coming. I was going to delete it and go back to bed but then Accidentally got in the app. Inside the app, Toms eyes were bleeding! I woke up my dad and told him what happened then I deleted it. I do not suggest getting the app! VERY DANGEROUS and SCARY!!! 😬😰😳😱😨

Figure 4. *Rating-and-comment samples from the three groups; the usernames are shaded in black*

Taken together, these user reviews highlight multiple themes, including a) nostalgia and emotional bonding, b) desired interactivity, and c) fear-based resistance, which influence the perceived value and limitations of TTC. Table 1 offers an overview of the evaluative dimensions in TTC user feedback. While some positive narratives point to TTC's benefits for companionship or family bonding, little direct evidence emerged regarding early literacy development or identity formation. Therefore, both follow-up studies and improvements on the basic designs are needed, which will be further addressed in the remainder of this paper.

Table 1. *Thematic Summary of User Reviews on TTC*

Theme	Sentiment Category	User Sentiment Summary
Nostalgia & Emotional Bonding	Favorable	Strong sentimental attachment from childhood; emotional re-engagement in adulthood
Entertainment Value	Favorable/Moderate	Viewed as cute and funny; good for light fun and bonding with siblings
Limited Interactivity	Moderate	Users want real conversations, not just voice repetition; desire more chatbot-like features
Creepy/Aesthetic Concerns	Critical	App appearance or behaviors are unsettling for young users
Privacy & Safety Concerns	Critical	Suspicions around data tracking and child safety; some cite rumors of danger
Moral & Age-Appropriateness	Critical	App considered unfit for children; calls for regulated, cleaner versions

Meanwhile, the current content analysis, limited by the lack of user demographic information such as age, remains exploratory in nature, which could be methodologically unsolid or problematic with the possibility of imperiling the validity of some preliminary conclusions reached above. Although such user-generated data could provide first-hand materials for analysis, from which various perspectives of user experience have been drawn for grasping the implications of TTC, additional refinement is needed to strengthen methodological rigor and thereby land on more reliable conclusions. Nonetheless, the insights drawn from this technology review shed light on evolving user expectations of virtual agents and set the stage for further empirical inquiry into the educational and developmental impacts of TTC or similar technologies.

3.4. Technology Comparison: TTC vs. Virtual AI Chatbots

Although both chatbots and virtual pets can involve human-machine interaction, not all virtual pets or game-based interfaces qualify as chatbots in a technical sense. TTC, while interactive

and responsive, lacks core features of AI-powered chatbots, such as conversational understanding and generative capability, and instead functions primarily as a sound mimicry tool. Table 2 summarizes the differences, showing how TTC contrasts with AI-enabled chatbots across features like interactivity, responsiveness, and user learning potential.

Table 2. *Comparison between AI-powered Chatbot and TTC*

Feature	Chatbot (e.g., Siri)	TTC (Talking Tom Cat)
Conversational Ability	Yes (natural language)	No (voice repetition only)
Purpose	Task-solving, conversation	Entertainment, companionship
Responsiveness	Textual & vocal output	Voice mimicry & character reactions
Adaptive Learning	Often present	Absent
Personalization	As user assistant	As user-driven play material
Emotional Simulation	Empathetic dialogue possible	Expressive animations
Caretaking/Feeding Mechanic	No	Yes (enriched in sequels)

TTC's early interface allowed users to record short videos of Tom repeating their speech in a humorous tone. Despite the notion of "talking" in its name, TTC does not support real conversations and lacks dialogic responsiveness. As user feedback has noted, TTC could be more than a simple voice mimic if enhanced with real conversational AI. In this light, LLM-based chatbots in the post-ChatGPT era significantly surpass TTC in conversational ability and personalization. The evolution of chatbots has been catalyzed by the emergence of LLMs, which can generate coherent, context-sensitive conversations (Kandpal et al., 2022). Companies like Microsoft and Google are now competing intensely in the generative AI space, broadening its applications across sectors (Cottier et al., 2023). As of late 2023, most advanced AI services prioritize conversation-based interfaces, moving beyond keyword-triggered responses, typical of earlier-generation chatbots (Reshmi & Balakrishnan, 2016). Contemporary LLM-powered chatbots differ fundamentally from rule-based predecessors by simulating natural, human-like language through complex training on large corpora (King, 2015). This offers transformative potential, especially in education, including early literacy development. Unlike TTC, which merely repeats spoken input without contextual understanding, modern chatbots can model coherent grammar, vocabulary, and pragmatic use, potentially supporting language acquisition in young users.

Yet, these advancements come with caution. LLMs' ability to mimic human speech raises issues of authenticity and cognitive impact. Research shows that exposure to low-quality or artificial language patterns may hinder children's language development (van den Heuvel et al., 2019). Even when AI-generated responses are grammatically sound, their indistinguishability from human inputs may confuse young learners, blurring lines between real and simulated interaction. Moreover, the emergence of hyper-realistic chatbot responses raises epistemological and ethical concerns. For example, design researchers have used alternative realities to explore how speculative digital entities reshape perceptions and social relations (Duggan et al., 2017). Applying this lens to LLMs suggests the need for cross-disciplinary scrutiny of how chatbot-mediated environments may affect identity formation and cognitive development in children. In this concern, embodiment is another critical variable. While TTC's avatar is a virtual screen-based character, other chatbots may take physical robotic forms. Such embodiment influences user engagement and the social presence of the chatbot. A physically embodied TTC could offer a richer, more tangible experience akin to real pet ownership, amplifying its educational and cultural impact. Therefore, both virtual and embodied forms should be considered in design and research.

In sum, this comparison reveals that TTC operates more like a virtual pet than a true chatbot - designed to simulate playful, care-based relationships rather than information exchange. The tactile interactions, humor, and growing caretaking features mimic real-life pet ownership, contributing to feelings of companionship and emotional bonding. As sequels evolved, feeding and nurturing mechanics became central, reinforcing TTC's alignment with digital babysitting experiences, which may take a considerable part in early literacy development, if utilized as a context for informal learning (Tessmer & Richey, 1997).

3.5. Summary and Limitations

While labeled as a "talking" character, Tom does not engage in dialogue or adapt responses based on input, distinguishing him from typical chatbots. However, TTC blurs lines by simulating companionship through responsive actions, visual attention, and caring features like feeding (added in later versions). As mentioned previously, TTC, in a broad sense, is referring to a series of games that incorporates the earliest and most classic version and its sequels, as well as a high volume of derivative games. Reflecting on the evolution of the TTC series from the year 2010 to the current days, we can gain some insights into how Outfit7, the game company, has been building on this virtual pet.

TTC is the first app under the brand of Talking Tom & Friends, managing to forge the flagship character, Talking Tom. Besides, an array of talking friends can be found with their own apps, such as Talking Ben the Dog, Talking Ginger, My Talking Angela, and so forth. The content matrix, with TTC as the nexus, expands beyond games or virtual pets, and includes animations, movies, and music videos - to name but a few. For instance, the "Tom and Angela - You Get Me music video" is highly recommended in some comments under TTC. Similarly, arrays of derivative works have managed to establish a supposedly quite mature world view that could be named after TTC.

It is expected that TTC, along with his talking friends, will exert more impacts on the social cognition and identity construction of their young users, as these talking friends will present how friendship and communities are formed through their interactions with one another and the young users. Boundaries between the virtual identities and the real identities, arguably, will be further blurred on the cognitive level. Facing the fact that social media are opening to virtual characters, some insights, as from Shirky (2008) and Stahl and Literat (2023), into collective identities formed on social media, could provide useful suggestions for the branding and development of TTC targeting the future generations. As for the academic sphere, the following sections proceed to establish a prototype based on this technology review, hopefully initiating reflections on this exemplification of using chatbots for educational purposes at the early stage of individual development.

Before moving on to the next stage of work, considering the methodological limitations noted before, we encourage follow-up studies to incorporate longitudinal data or experimental comparisons between AI-less and AI-driven chatbots. In this case study, the analysis of only 14 user reviews lacks accuracy, thus requiring future works to address potential bias in relying on app store reviews, as well as the small sample size used here only for initial analysis. For instance, Liu et al. (2022) employed dialog analysis with 68 students to measure engagement in a 6-week intervention, offering a model for robust qualitative methods. Moreover, instead of a singular focus on young users, it is advisable to include interviews with educators or parents, providing valuable insights into how gamified human-chatbot interactions could influence satisfaction, engagement, and trust in early educational settings.

4. Stakeholder Analysis of Chatbot-based Early Literacy Development

Building off the insights from the AI-less case study, a learner-centered prototype could standardize chatbot designing practices and indicate the directions in which future

improvements can be made on the chatbots targeting young users and serving educational purposes. Before the prototyping process, a closer inspection on the stakeholders of chatbot-based early literacy development is warranted, as the stakeholder analysis can produce useful insights for specific design strategies.

4.1. Target Users and Possible Assistants

When it comes to early development, stakeholders of an instructional technology should not be limited to the learners, or preschool children, but also include possible learning assistants, like parents, who could monitor and facilitate the use of the technology. The present project spotlights the use of chatbot for early literacy development, or the language learning of preschool children, aged 3-5 years (Centers for Disease Control and Prevention, 2021), which may happen when they play with a chatbot. In this regard, there are at least two fundamental questions: a) how children at different age groups develop literacy; b) what types of environmental supports are helpful to the target age group.

For the first question, Piaget's theory about early cognitive development, as introduced earlier, could be helpful; for the second question, guided by EST and ZPD, we turn to a Social-Emotional Learning (SEL) model, proposed by Denham and Brown (2010) for instructors to navigate children to play with others productively, which can be largely facilitated by parental roles and educator input in accordance with children's exhibited skills. As proposed in their proposal, "children who exhibit a profile of age-appropriate SEL skills are theoretically likely to be able to succeed in school" (for more details, see Denham & Brown, 2010; p.657). Although their work was based on the classroom setting and aimed for academic success, we attempt to utilize their model, as grounded in EST and ZPD, to scaffold the chatbot prototyping for early literacy development. In the design document, it will be clarified that how the two questions above should be addressed with relevant SEL rationale.

4.2. Learning Objectives

The chatbot prototype should mainly aim to support two early language skills as widely acknowledged: listening and speaking. To be specific, listening here refers to the discriminative and comprehensive listening competencies, which could be achieved in early years and lay the foundation of critical listening skills (Bourdeaud'hui et al., 2021). Considering that critical listening requires multiple higher-order cognitive abilities and a relatively high level of metacognitive awareness as well as listening motivation (Bourdeaud'hui et al., 2021), the

listening skills that preschool children could learn from the interactions with a chatbot should not stretch beyond the discriminative and comprehensive stage. In short, children are not required to determine or evaluate the quality, value, significance, accuracy, and truthfulness of the message, just learning to receive, process and understand the basic information conveyed in a conversation.

As for speaking, from an interactive perspective, it should comprise the abilities to produce, receive and process information, in the presence of at least one speaker and one listener to convey feelings, thoughts, and opinions (Wong & Yunus, 2021). In practice, preschoolers do not need to engage in intense speaking tasks like group discussions or class presentations, which may be too intense or overwhelming if considering the ZPD of this age group. Thus, the ultimate learning goal should be to speak the native language fluently and accurately in their daily communication. Accordingly, the chatbot should chiefly serve to encourage the development of speaking skills in terms of fluency and accuracy. Besides, the most salient constraint faced by the preschoolers would be the lack of sophisticated prior knowledge regarding the target language. In this regard, it is not suitable for preschool children to learn reading and writing - supposedly more demanding than listening and speaking - from a chatbot. Thus, reading and writing are excluded from the list of learning objectives in the present prototyping project.

5. Chatbot Prototyping for Early Literacy Development

In this section, a chatbot prototype for early literacy development will be proposed. This prototype, as a benchmark delineating guidelines for future designs of both embodied and virtual chatbots, is constructed to not only emphasize the educative use of AI chatbot in empowering literacy development but also support children's overall cognitive development.

To begin with, interacting with a chatbot to learn a language is supposed to fall into the category of informal and personalized education, which may take place in absence of normal social contexts (imagine a child playing alone with TTC). In this concern, although the learning relies on a chatbot for the most part, it is advisable to let the users learn with the chatbot in a setting close to a real social context. Talking with a chatbot for early literacy development should be as close to a real-world conversation as possible; the learning outcomes could be enhanced by chatbot responses that exhibit verisimilitude with the equivalent real-world situations. Moreover, language is a social communicative tool, while bodily embodiment is believed to have considerable implications on the social cognition (Goldman & de Vignemont, 2009).

Hence, it is necessary to distinguish physically embodied chatbots from their virtual, nonembodied counterparts. However, regardless of being physically embodied or not, the common principles and elements of the prototype need to be introduced first.

5.1. Selective Themes

Stories are believed to be part of our cognitive repertoire for thinking, explaining, understanding, and remembering, which can also be used as the authentic exploration of experience (Jonassen & Hernandez-Serrano, 2002). Further, as part of the SEL mechanism, emotion and social influence may have an impact on behavioral intention – in this project, to listen and speak actively; and narratives are more likely to convey emotions and social contexts than other kind of information (Hamby et al., 2016). Therefore, a built-in pool of story themes should be available, providing specific contexts for the interactions. For example, a preschool user could choose to play the role of a prince or princess, immersing themselves in relevant stories, while talking and playing with the chatbot that assumes a minister or court lady, accordingly. By doing so, identification with the story character could be initiated, which refers to "a process that culminates in a cognitive and emotional state in which the audience member is aware not of him- or herself as an audience member but rather imagines being one of the characters in the text" (Cohen, 2001; p. 252). This could expedite the development of self-awareness, social awareness, and relationship skill, as included in the SEL skillset proposed by Denham and Brown (2010). As for the connections between learning units, following the completion of each story under one theme, the recommendation of the next content items or themes, enabled by machine learning techniques, should challenge the user but not be overwhelming to keep children in their ZPD, which can reduce the time required to reach certain skill mastery, as shown in the ZPD-grounded content sequencing project by Vainas et al. (2019).

5.2. LLM-Based Teachable Agent

Teachable Agent, or TA, as discussed by Biswas and colleagues (2005), can empower self-regulation mentoring and learning by teaching (LBT) to promote effective learning and understanding. For encouraging preschoolers to make strong, active, and productive cognitive connections between learning and teaching, LLM-based TA should be the core of the prototype.

The user will attempt to teach the chatbot, by talking about some basic facts in the narrative world conveyed beforehand, like the color of sky - depending on the selected theme - and

interact with the chatbot that asks follow-up questions, answers the user's questions, and conducts assessments on what has been taught by the user in line with a predetermined rubric. With the help of LLM, characterized by pre-training, post-training (including instruction fine-tuning and Reinforcement learning from human feedback, or RLHF), and evaluation (for more details, see Sun et al., 2023), such interactions would require minimal human supervision. During this process, the children could learn about what parts of their teaching are incorrect, imprecise, or incomplete, by checking on whether the chatbot understands them; and the subsequent teaching could be improved accordingly. If with a human mentor on site (e.g., a parent), the learning would see even more prominent progress, as such an assistant could help the learner better locate problems in teaching and offer suggestions for improvements. Motivation for continual listening and speaking could be enhanced by placing preschoolers on the position of teachers, which also contributes to the training of self-management and responsible decision-making, the other two packages of the SEL skill set (Denham & Brown, 2010). The motivation to engage in the story, also enhanced by teaching, may even prompt reflection and positive personal change (Hamby et al., 2016).

5.3. Rationale for Physically Embodied Versions vs. Nonembodied Versions

As noted earlier, the external form of a chatbot could be, typically, a screen displaying a virtual image or a mini robot who can talk and act. No matter which form is taken by a chatbot, merits and drawbacks coexist in each version. The prototyping process moves on with both forms, physically embodied and non-embodied, as two distinct versions serving the same purpose and sharing certain elements.

One shared attribute is the learning experience emphasizing gameplay. Game-based learning is believed to be an important instruction method to boost learning performance (Laffey et al., 2003; Dickey, 2005). The gameplay experience is built on two parts in this prototype. In the first part, after selecting the theme, the preschool user will listen to the chatbot telling a story, in which the user will be assuming the protagonist - the user's name will be asked at the beginning. The story will be told in an interactive style, as the user, the main character of the story, is able to decide the proceeding direction of the plot, which renders the storytelling process close to an RPG (Role-playing Game) experience. What differs the virtual version from the physically embodied version is, the former plays an animation on the screen, maybe even by initiating the AR mode to help the user better understand and engage in the story, whereas

the latter draws on the gestures and motions of its body parts, which simulates the behaviors of a real-world storyteller in many ways.

Upon entering the second part, after the whole story is told, the chatbot will invite the user to talk about some basic facts related to the story. In this part, the user will assume the teacher that also matches the role in the story. For example, the context of the teaching could be that the princess is trying to address a question proposed by his minister. Depending on the teaching, follow-up interactions, including new stories and questions, will play out differently. During this process, the user can see the gradual growth of the role he or she plays, like the smart little prince gradually growing up to be a sagacious king, which is supposed to motivate the preschool user to actively engage in this gameplay slash learning experience. For achieving the two parts above, excellent story writers are needed in the development team, along with programmers, toy engineers, and art designers, to name but a few. The expertise of story writer should be placed at the core of the content design, since the construction of narratives encompasses daunting communication efforts that vary across facets such as modality, format, length, emotional depth, and plotline complexity, as argued by narrative scholars (e.g., Hamby et al., 2016). Thus, the development of child-friendly stories, as the learning materials for early literacy development, should be entrusted with story experts who are familiar with child narrative features.

5.4. AR-Enhanced Learning for Non-embodied Versions

In accordance with cognitive constructivism, a learning context that supports the learning in constructing experience-based knowledge is necessary (Tessmer & Richey, 1997; Dennen & Hao, 2014). Evidence indicates that Augmented Reality (AR) - referring to any technology that blends real and virtual information in a meaningful way (Klopfer, 2008) - could enhance the effectiveness of learning, based on its construction on the foundation of the surrounding reality. For example, Li and colleagues (2013) divided 72 students into 36 dyad AR groups and non-AR groups to play a game; then the students were asked to complete a questionnaire to recall certain information and knowledge embedded in the game. The results showed that the use of AR boosted the participants' engagement, as well as information extraction ability. Likewise, to provide an engaging experience for active language learning, we strongly suggest applying AR to the physically non-embodied chatbot (TTC is a case in point). In the absence of physical embodiment, AR can instead present reality-based realism that is required to simulate a social

context. As for if AR could be replaced with Virtual Reality (VR) here, we return to this concern in the later discussion.

6. Discussion

Being more than a retrospective study, the combination of a review and a prototyping proposal in this paper could add to the chatbot literature by reapproaching the trends and gaps in earlier research and technology before ChatGPT 3.0. Delving into a representative chatbot-like mobile application, we contrast chatbots with videogames and virtual pets; and we also analyze the underrepresented sociocultural and educational implications of chatbots in early literacy development, via a learner-centered approach, which then guides us for the prototype design. In the following discussion, we will address some issues encountered during the prototyping process and provide caveats and suggestions for future academic and industrial endeavors.

6.1. Assessment of Prior Knowledge

It has been repeatedly stressed that the prior knowledge of a preschool user in terms of the target language for learning constitutes the clincher to the contents of the learning experience. The conversations and interactions between the chatbot and the children should be somehow reduced to a degree that the children could effortlessly understand the former. However, considering individual differences, like linguistic talent, or variety in environmental conditions for early development, preschoolers vary a lot in prior knowledge of the same language, as can be observed among them. In this view, how to incorporate a pre-assessment on the preschool users' language skills, without making this seem to be a bar set between the children and the chatbots, suggests a future avenue to work on.

6.2. AR, VR or Physical Embodiment

Combining AR with the virtual, non-embodied chatbot could have the benefit of novelty, making up for the absence of physical embodiment to some extent. It seems that existing studies have yet to pay enough attention to the combination of these technologies. While the introduction of animation to the virtual version for storytelling could add fun to the learning experience, the user's listening skills may be better trained with the physically embodied version, as the latter is designed to bodily simulate a human talker in the real world. In this concern, the lack of physical embodiment constitutes a common limitation among all virtual instructional technologies for young learners who might, as discussed previously, have difficulty distinguishing virtuality from reality or memorizing abstract, intangible things due to

their unmature cognitive state. This limitation, once again, emphasizes the need for environmental support or cross-level collaboration in chatbot-based early literacy development, especially from parental companion.

As for whether AR is interchangeable with VR – defined as "an interactive, participatory environment that could sustain many remote users sharing a virtual place" (Gigante, 1993; p.3) - in the prototype, we could first question about if they can perform part of each other's functions in certain respects. In the current study, such questions remain unaddressed, waiting for empirical studies to produce concrete findings on this topic. Yet, taking a stance against full digitalization or cyberization, we advocate for the development of one's early literacy and identity based on the singular reality, while the unfolding age of Metaverse and mixed realities has given rise to legal, ethical, and humanitarian issues, being inspected from the perspectives of sociology, media culture, cultural criticism and so on (e.g., for the impacts of mixed reality on cultural heritage, see Bekele et al., 2018; for how identity should be learned in physical environments like museums, see Lei, 2023a & 2023b). As AR refers to "a situation in which a real-world context is dynamically overlaid with coherent location or context sensitive virtual information" (Klopfer & Squire, 2008; p. 205), it can be said that AR sticks to the real world with meaningful modifications, instead of presenting a purely artificial or alternative world, thus presenting a better reality-consistent technological solution than VR does in this concern. Researchers are invited to continue with this discourse, taking additional features of both technologies into consideration.

6.3. Native Language Learning or Multilingual Development

One assumption being made in the present study is that chatbot will be mostly utilized for the early development of a child's native language. Nonetheless, if the target language is a second language for children from multilingual families - to name but one possibility - problems unsolved in the present project could manifest themselves. Therefore, the possible existence of language and cultural barriers should have been considered. In this concern, Belda-Medina and Kokošková (2022) compare several linguistic and technological aspects of four App-Integrated Chatbots (AICs), examining the perceptions of users who use English as a foreign language. Likewise, to better adapt to learner needs in this age of diversity and global citizenship, it is imperative that specialized chatbots, especially for second-language learners and young multilinguists, build off the prototype designed in the current project. Meanwhile, ethical concerns on the use of AI-powered chatbot in language learning cannot be excluded from the

design process, since LLMs per se reflect, and can potentially perpetuate, social biases in language use (Rudolph et al., 2025), which could have far-reaching and long-lasting sociocultural implications (via identity formation and so forth, as discussed before) beyond the educational context of learning a language.

7. Conclusion

As AI is increasingly applied for educational purposes like early literacy development, the designs and implications of AI chatbot have become a subject of growing concern beyond educational settings. In this paper, we explicitly encourage the utilization of chatbots in designing effective early literacy programs. Moreover, endeavors are suggested to connect the application of chatbot to other cognitive outcomes, like identity formation, which may affect the later development of one's personhood.

Currently, the digital transformation in the realm of early development, as in most other industries, is largely characterized by AI-based applications, with millions of monthly active users and billion-level solution data. We merely look back at the beginning, where the scholar ship shares a vision to provide effective education for all by tapping into the digital transformation. Future discussions could look at the process of building an AI-driven education ecosystem and its global expansion. For a starter, this paper has unveiled a partly digitalized future of early development and the role of AI in shaping it. Taking both chatbot attributes and early cognitive features into account, we highlight the importance of chatbot-related technologies in empowering personalized learning and creating equitable educational opportunities from the primary stage of one's life.

However, AI systems may unintentionally introduce biases, exacerbate inequalities, and raise concerns about data privacy and security. Therefore, merely making efforts on the level of AI learning tool would not be enough. Aside from the creation of ethical AI products, cross-sector and cross-level collaboration should be promoted to develop guidelines and practices for AI integration in early development. For a starter, to improve equitable access to AI-powered educational tools, NGOs could partner with local school districts for distributing digital devices in underserved areas and leverage existing community centers for training workshops. On the international level, cross-border pilot programs can be launched to test chatbot-based early literacy curricula, especially in multilingual, low-resource settings. By prioritizing a learner-centered approach and addressing ethical concerns in such actionable steps, all stakeholders can

thereby ensure that chatbots serve as tools for empowerment rather than exclusion. In doing so, we can hopefully help foster a generation of learners who are not only more literate but also more ethically aware of the technologies shaping our world.

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