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Use of a robot in an imaginary space. Robot-assisted language learning with a friendship booklet (*carnet d'amitié*)

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Abstract: The integration of technology, including social robots, into classrooms has paved the way for new opportunities in second-language (L2) learning. This emphasises the importance of understanding child–robot interaction (CRI) and its impact on comprehensive language development. This study investigated CRI in a French L2 setting through young learners' L2 written productions and visual expressions, adopting an embodied digital interaction perspective. It explored the intersection of pedagogy and technology in education, aligned with digital language practices and robot literacy. Over four months, young learners engaged with a social robot in French language learning, using a friendship booklet (*carnet d'amitié*) task to establish rapport and encourage free interaction. We observed a transition from scripted interactions to a dynamic "imaginary space" within the CRI and the extended interaction that positively influenced engagement and language exploration. The learners exhibited diverse language strategies to convey meaning, reflecting metalinguistic awareness and adaptability within the French language framework. This study provided insights into the integration of social robots in L2 education, highlighting the transformative potential of CRI and the imperative for critical robot literacy.

Keywords: social robots; child–robot interaction; second-language learning; robot-assisted language learning; imaginary space

1 Introduction

Technological advancements are increasing the presence of technology in classrooms. For example, social robots have been introduced in curricula worldwide as

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tools for enhancing 21st-century skills (Bocconi et al. 2016). This approach resonates with the multimodal perspective highlighted by Mondada (2019), which emphasises the significance of materiality, embodiment and sensorial practices in comprehending social interactions. Leeuwen's (2005) perspective on multimodality, encompassing diverse semiotic modes, further enriches the learning environment. Simultaneously, the Douglas Fir Group (2016) perceives language use as a dynamic, socially situated practice that generates meaning through active engagement in multilingual and multicultural contexts. Consequently, it is interesting to investigate how child–robot interaction (CRI) shapes meaning making in second-language (L2) learning and how social robots contribute to holistic development in language education (Westlund and Cynthia 2015).

Social robots are designed for human interaction and adhere to interactional practices and expectations that are specific to social interactions (Randall 2019). Thus, they offer a novel affordance in creating CRI practices and opportunities for play in the L2 classroom. A playful design for robot-assisted language learning (RALL) encourages learners to engage with the target language, fostering a supportive yet challenging learning atmosphere (Peura et al. 2023). This combination of guided play and the robot's persuasive design techniques in RALL includes structured activities that encourage exploration and learning, ultimately fostering growth within the zone of proximal development (Vygotsky 1978).

Although research indicates the efficacy of social robots in teaching various language skills, including vocabulary and spoken interaction (Berghe et al. 2019; Huang and Moore 2023; Lee and Lee 2022), their effectiveness in classroom settings requires further exploration (Woo et al. 2021). Moreover, the influence of these robots on creative and playful production in informal contexts alongside formal instruction remains relatively unexplored.

To address these gaps, this study explored the extended interaction between young learners and social robots in a French L2 setting, using a friendship booklet (*carnet d'amitié*) as an instructional material. We investigated the linguistic elements and strategies that young learners employ in L2 narrative writing in an informal setting within the space created by CRI. Additionally, we explored visual expressions associated with CRI, thus contributing to the existing literature (Secim et al. 2021). Ultimately, we aimed to provide insights into the role of social robots in language education, particularly in young learners' language acquisition, thus enhancing our comprehension of how young learners construct meaning in their L2.

2 Theoretical framework

2.1 Guided play in CRI

Engaging in guided play with robots enriches children's learning experiences. Interactions such as dialogues and role-playing facilitate language acquisition by mirroring the natural process of L1 learning (Ipek 2009; Lee and Lee 2022). Children's tendency to engage in pretend play with robots transforms learning into game-like activities (Mubin et al. 2013). Incorporating real-life stories into robot interactions enhances contextual understanding, thereby supporting children's comprehension and production of speech acts (Alemi and Haeri 2020).

Language play fosters creative engagement for children with limited L2 proficiency, allowing learners to explore target language features within a social context, in line with Vygotsky's (1978) zone of proximal development. Swain's (2009) concept of languaging further illustrates how playful learning facilitates the active creation and use of language as a cognitive tool.

Adopting an ecological perspective, our study aligns with van Lier's (2004) emphasis on engagement, meaningful interaction and critical thinking over standardised testing. This approach acknowledges the dynamic nature of language learning, extending beyond traditional methods to incorporate experiential learning alongside formal instruction.

Sylvén and Sundqvist's (2017) survey highlighted the positive impact of informal extracurricular language activities, demonstrating that autonomous language use, often facilitated by technology, benefits learners regardless of context. Benson (2017) emphasised the importance of the individual learner's L2 environment, which is influenced by available resources. Recognising these resources is essential for their effective integration into learning contexts.

2.2 Persuasive design techniques

The effectiveness of robots in learning is enhanced by persuasive design techniques such as iconic gestures and feedback mechanisms that facilitate emotional engagement and motivation among learners (Berghe et al. 2019). Well-designed social robots foster feelings of closeness and enjoyment, distinguishing these interactions from those with inanimate objects (van Straten et al. 2020). This distinction highlights that robots occupy a distinct ontological space, blurring the lines between the animate and the inanimate (Kahn et al. 2013; Peura and Johansson 2023), suggesting that children perceive robots as social entities and form emotional bonds with them (van Straten et al. 2020).

Comprehensive reviews of RALL (Berghe et al. 2019; Lee and Lee 2022; Randall 2019) emphasise the role of persuasive design in effectively introducing vocabulary through interactive platforms and learning games on tablets. For example, the L2TOR project (Vogt et al. 2019) demonstrated that children acquired vocabulary through interactions with a robot, although similar results were obtained with a conventional tablet. This suggests that while persuasive design enhances engagement, context and the nature of the interaction play critical roles in learning.

Few studies have focused on speaking skills with robots, partly due to the challenges in engaging non-native speakers in conversations where errors are common (Engwall et al. 2021). However, Alemi and Haeri (2020) demonstrated that children learnt interlanguage pragmatics, such as speech acts, with the help of a robot, highlighting the motivational potential of robots.

Robots can take on diverse roles in educational settings, functioning as teacher assistants (Alemi and Haeri 2020), peers or tutors (Kennedy et al. 2016) or even learners (Tanaka and Matsuzoe 2012). Kanda et al. (2007) noted that the peer role can also manifest as a social companion, with the primary incentive for engaging with robots being the opportunity to establish friendships.

2.3 Robot literacy

The concept of robot literacy enhances the zone of proximal development by enabling learners to engage naturally and critically with robots in educational contexts. Introduced by Suto (2013), robot literacy emphasises an understanding of robots that goes beyond digital literacy to include an embodied dimension.

Boraita et al. (2020) noted that robot literacy relies on metaphors, which play a crucial role in shaping technological comprehension. These metaphors evolve with increased knowledge and experience with technology (Peura and Johansson 2023). In CRI, robot literacy encompasses understanding the complexities of human–robot interactions while recognising the metaphorical or imagined characteristics attributed to robots. This understanding enables learners to use robots effectively as educational tools by acknowledging their dual nature as both machines and symbolic social entities.

2.4 Agency and the robot as “the other”

Exploring robot literacy introduces the concept of agency. Agency, integral to all learning, empowers learners to navigate their educational journeys and engage meaningfully (Douglas Fir Group 2016; Lantolf and Thorne 2006; van Lier 2010). This positions learners as active participants in social contexts, fostering an appreciation

for "otherness" (Kramsch 2011). Through their interactions and discourse, learners construct their own and others' subject positions, contributing to their understanding of language, culture and the "other".

In CRI, the robot functions as "the other", serving as a metaphorical friend that shapes intercultural dynamics for young learners. Through interactions with both the robot and their human peers, learners navigate the complexities that arise from the robot's simulation of native-like speakers. Although robots lack the nuanced cultural understanding of native speakers, they introduce a new dynamic to the learning process; as they are seen as "the other", they too take on agency. In essence, CRI introduces a complex interplay between the learners' technological emulation of the robot's target language competence (such as native-like French with no understanding of Finnish) and the nuanced cultural aspects of human communication.

2.5 "Third space"

As Kramsch (2009) argued, culture is intricately linked to language and constructed through shared meaning-making processes embedded in interpersonal interactions. She also emphasised that different discourses, ranging from media to everyday conversations, are crucial for constructing social reality. This insight contributes to the concepts, which have evolved from "third place" to "third space," highlighting the importance of diverse discursive environments in shaping social and cultural understanding (Kramsch 1995, 2011; Kramsch and Uryu 2020). In this intermediary space, learners shape their perceptions and synthesise perspectives.

Our study investigates the way these dynamics unfold through learners' interactions with the robot within this potential third space in CRI, enriching our understanding of the role of technology in synthesising language, culture and meaning-making in L2 contexts. Additionally, we incorporate Kramsch's insights on visual communication and multimodal semiotic systems, recognising the embodied nature of visual semiotics and the influence of digital media on children's representations of their L2 experiences with robots.

3 Study overview

This study forms part of a larger empirical research project exploring the pedagogical advantages of RALL in L2 classrooms, aligning with the emphasis in the Finnish curriculum on digital skills, interdisciplinary learning and early language acquisition (Finnish National Agency for Education 2016). In line with Mondada (2019), our approach adopts an embodied digital interaction perspective, integrating

multimodal resources such as bodily gestures, sound, and color to foster shared interaction spaces between young learners and robots. The robot is conceptualised as a French-speaking peer figure, embodying "the other" for the young learners and facilitating CRI.

The learners engaged with French as their L2, interacting with the social robot in an informal setting within the formal classroom environment. This setup encouraged free interaction, free from traditional schooling constraints such as textbooks, grading and time limits. We examined this new learning environment, which bridges formal educational settings and voluntary L2 interactions occurring outside the classroom, categorising it as an extracurricular informal learning setting taking place on school premises on an optional basis, without grading. In this context, the teacher partially structures activities, giving young learners the option to engage in them outside lessons as well.

In addition, to allow for young learners' voices and perspectives in this study (cf. Cekaite 2018), we applied a social semiotic approach that emphasises understanding the various modes of communication contributing to meaning making, aligning with Mavers' (2009) perspective on narrative representations in visual analysis.

3.1 Research questions

Using qualitative content analysis based on Kuckartz's (2014) guidelines, we explored the linguistic competencies that the young learners developed in relation to meaning making, taking into account the informal context of their task. Additionally, we examined the effects of imaginative play as part of CRI on the young learners' written L2 expression and how it shaped the space between the learners and the robot.

Our research questions were as follows:

1. How did the young learners construct meaning with the robot in their L2 in an informal learning context?
2. What kind of space was formed between the learners and the robot?

3.2 Materials and methods

This study was carried out as a pedagogical experiment in the L2 classroom of a Finnish primary school, involving 27 ten-year-old learners, 10 of whom were male and 17 female. Twenty-two of the learners spoke Finnish as their L1, while five had other home languages. All the learners were learning French as their first L2, which was the focus of the experiment.

Figure 1: Aldebaran robotics' NAO6 robot, called *Dominique* or *Domi* for short.

The social robot used in this study was NAO6, developed by Aldebaran Robotics (see Figure 1). The robot was introduced to the participants as *Dominique* or *Domi* for short, as this is a gender-neutral name in French.

Domi was present in the French language classroom the entire semester, alongside other pedagogical materials and approaches. The robot interacted exclusively in French, although both Finnish and French were used as the languages of instruction throughout this study.

Domi's dialogues were created and programmed using the Choregraphe programming tool (Aldebaran Robotics, Paris, France). All the necessary hardware and software, including the language models, were built into the robot. For data protection, NAO6 did not store any information during teaching sessions, and the only information it sent to the outside world was its place of use. However, NAO6's lack of algorithmic complexity produced speech recognition problems. When learners addressed the robot outside the expected parameters (pre-scripted codes), the robot's responses and reactions could be irrelevant or non-existent.

This study adhered to ethical standards by following the guidelines of the Finnish Advisory Board on Research Integrity. Given that the participants were children, additional measures were taken to ensure their well-being and uphold

their rights throughout the research process, including attending to their needs and actively listening to them during data collection.

3.3 Data collection and the *carnet d'amitié*

In this study, we focused on the final outputs – the learners' *carnets d'amitié* – resulting from their interactions with the robot. To achieve these outputs, the learning task involved creating a *carnet d'amitié* (see Figure 2) with Domi, aimed at developing the learners' ability to inquire about a friend's family, hobbies and preferences, as well as to comprehend their responses, thus promoting dialogue, speech practice and experimentation with new expressions. The structure of the *carnet d'amitié* was merely suggested; it could be filled in thematically, but the structure also left room for flexibility.

The task progressed through several stages. First, the learners were asked to compose their own questions about what they wanted to know about Domi. The questions were collected on a shared online platform and translated into French. Next, the researcher scripted the questions using the Choregraphe tool. On the online platform, the learners were able to visualise some of the codes through which Domi received the questions, which was significant in developing the learners' robot literacy (Peura and Johansson 2023) and helping them understand technology. Based on the learners' questions, the researcher devised the structure and content of the *carnet d'amitié*.

Once the questions and answers were coded into Domi, the young learners were able to converse with the robot alone or in pairs. They engaged with Domi by asking the questions that they had practised in previous lessons (see Figure 3). The nature of the task allowed the learners to stay within their zone of proximal development, as

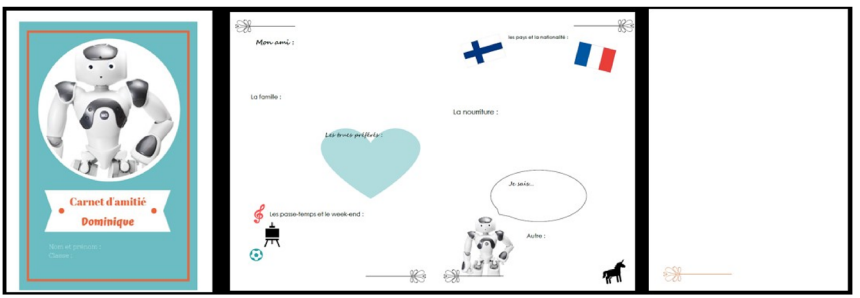

Figure 2: The *carnet d'amitié*. This figure displays the cover page on the left, pages with prompts in the middle, and the back page on the right, reserved for personal expression.

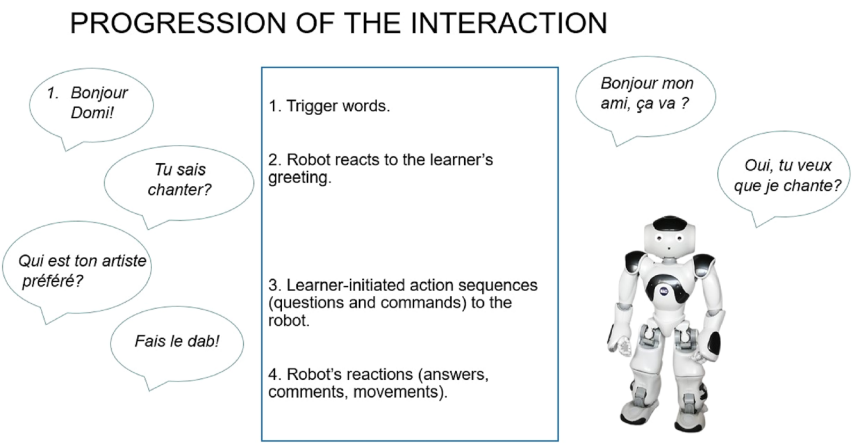

Figure 3: Interaction progression: The sessions began with the trigger phrase "Bonjour Domi!" to initiate interaction. The robot responded when the learners' verbal inputs matched its expectations.

the difficulty levels of the questions and responses varied. The learners were able to autonomously decide which questions to ask and to set the level of complexity of the questions as desired. Domi's responses varied, as it was programmed with multiple alternative answers to the same question, ranging from simple to more elaborate responses. It also used gestures and, in some cases, responded by dancing, singing or telling jokes. As Domi responded to the children's queries on the *carnet d'amitié* pertaining to itself, its personal pre-scripted history unfolded. The children subsequently translated their experiences into written L2 form on the *carnet d'amitié* if they wished to do so.

Domi's presence in the French language classroom throughout the semester allowed the learners to practise their learning over an extended period. During the sessions and outside of the French lessons, Domi operated independently, emphasising its role as a peer and a conversation partner. The learners also interacted with it during breaks without their teacher's guidance. Although the *carnet d'amitié* was structured according to themes suggested by the learners themselves, it was not designed or taught as a formal written task with explicit instructions on topic selection, sentence construction, or language features like pronoun and verb usage.

The dataset comprised 108 pages of transcribed and anonymised texts and illustrations from the learners' *carnet d'amitié*.

3.4 Data analysis

We explored the meaning making and interactions of the young learners with Domi using qualitative methods. This approach revealed the unique insights and expressions of the young learners.

To structure our analysis, we initially coded the data by examining the words and images within the themes outlined in the *carnet d'amitié*, as well as those that fell outside the structured framework. Descriptive statistics helped to identify the focus: freeform production outside the structured themes. Given the unique nature of each learner's *carnet d'amitié*, we began our data analysis approach by deconstructing the freeform written and visual outputs into analytical units, exploring the interplay of visual and written narratives in relation to the learners' insights into Domi's portrayal. We explored the narrative elements that set the stage and context for the learners' productions in the *carnet d'amitié* (chosen framing), the perceived agency of the robot and Domi's character (i.e. abilities and emotions), action sequences, and cultural elements and places. Furthermore, we explored the linguistic elements and strategies that the learners employed and that demonstrate creative language use, the adaptation of language resources and emotional expressions.

Subsequently, within the dataset, we performed extreme case sampling; that is, we identified the most exceptional cases, as Dörnyei (2007) outlined, characterised by unique attributes and patterns but still capturing prevalent characteristics.

4 Results

4.1 Linguistic challenges prompt language play and language strategies

Throughout the process of creating written content, the young learners encountered linguistic challenges that prompted them to employ creative language strategies to overcome these obstacles.

Our analysis revealed strategic language use, highlighting creativity and the expression of emotions even in the absence of words. We suggest that the informal learning environment with a robot provided a space for experimenting with language, fostering familiarity with language patterns and linguistic structures, and encouraging playful word manipulation reflecting actual language use.

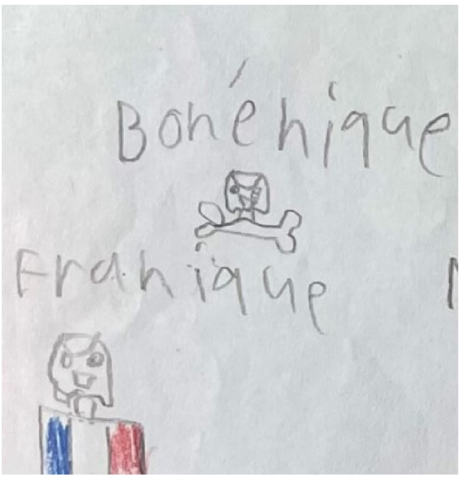

Figure 4: Linguistic creativity: English words with the French suffix – *nique*.

4.1.1 Creative expressions

Figures 4 and 5 showcase the young learners' linguistic creativity as they used suffixes to transform words and to play with words, resulting in the creation of French-sounding terminology.

Figure 4 shows how the learner creatively addressed a vocabulary gap in French by describing the robot using invented words. The learner combined an English word ("bone") with the French suffix – *nique*. Similarly, the learner played with the words "Dominique" and "France" to create the word "Franique" (in contrast to "Français").

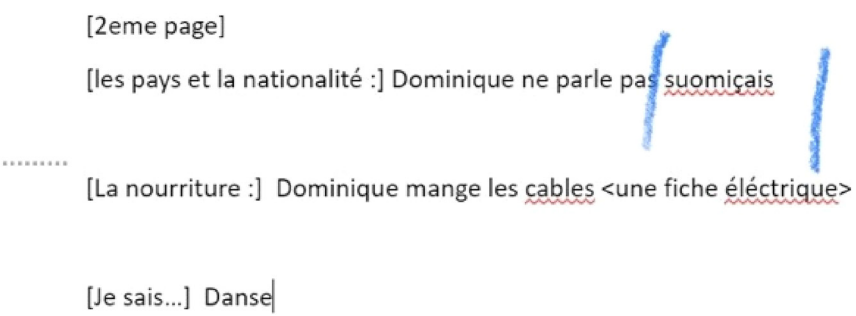

Figure 5: Linguistic creativity: Finnish word with the French suffix – *çais*.

A similar linguistic phenomenon is depicted in Figure 5, where the learner resorts to the Finnish term *suomi* ("Finnish as a language") and appends the typical French suffix – *çais* (as in "Français") to it. This strategic use of language resources reflects the learner's metalinguistic awareness and ability to adapt linguistic elements, the characteristic features of the French language, to fit the framework of the French language. This phenomenon of developing the L2 (Ipek 2009) can be regarded as an example of written languaging, shedding light on the metalinguistic competencies of young learners.

4.1.2 Expression of emotions (when there are no words)

Within the learners' written expressions in their L2, we observed a range of affective expressions that depicted Domi as a machine capable of eliciting emotions, in line with previous studies (Peura and Johansson 2023; van Straten et al. 2020). This suggests that the learners were building a unique relationship with the robot, expressing both attachment and irritation through these affective expressions. Here, too, learners often encountered vocabulary gaps. Figure 6 shows a learner's expression of their emotions when they lacked appropriate words, using their strategic competencies – that is, Domi's monologue.

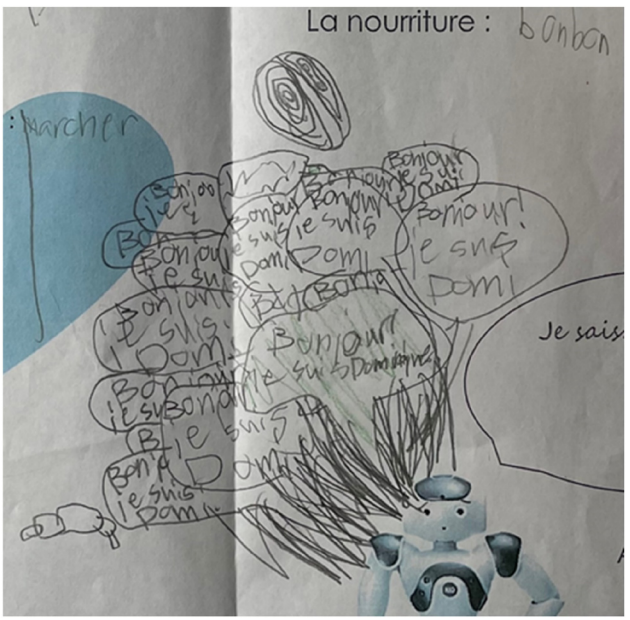

Figure 6: Expression of frustration.

Specifically, the figure expresses the learner's vexation with a technical bug in Domi. This frustration is strategically conveyed through the use of repetition ("*Bonjour! Je suis Domi*" ["Hello! I'm Domi"]), combined with visually expressive elements. This example highlights the learners' ability to adapt and creatively employ language resources to navigate complex emotional expressions.

4.2 Framing and the agency of the robot

In this study, our theoretical understanding of robots' roles in CRI influenced the way Domi was portrayed in the study setting – as a peer and a friend to the young learners. However, our examination of narrative elements and agency in the young learners' drawings revealed that Domi was not prominently represented as a friend. In the context of this study, framing refers to the visual contexts that the children created in their robot drawings. To analyse this framing in detail, we selected typical outputs. Figure 7 offers insights into the learner's language acquisition and associations. The image depicts a playful realm containing three characters inside a bubble, which are recognisable avatars from the popular online game *Among Us*.

Figure 7 suggests that the learner engages with online gaming as a means of language exposure and learning (see Sylvén and Sundqvist 2017). In this context, the question "*Domi aime* Among Us*?*" ("Does Domi like *Among Us*?") reflects the learner's interest in online gaming and indicates engagement with English-language content. However, the presence of a third character, portrayed as larger and making a *non-Français* gesture, has significant implications (i.e. exclusion). It can be inferred that the learner perceived this character as a representation of a French-speaking entity in the

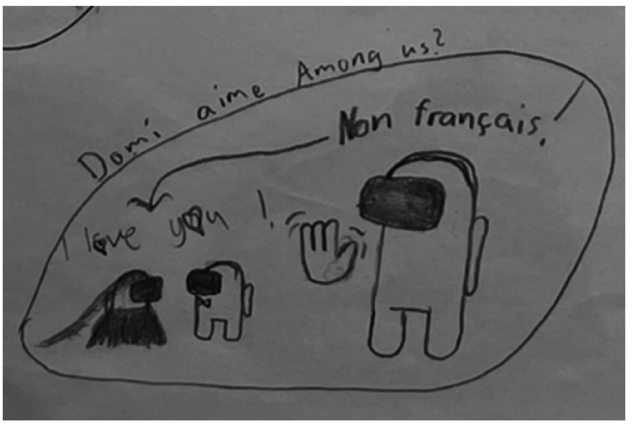

Figure 7: Playful world of the robots (exclusion).

game. The strong link between the robot and the French language is evident in the character's prominent role in interrupting the interaction between the other characters, suggesting a desire to exclude non-French speakers from the interaction. This connection underscores the learner's perception of the robot's strong association with the French language, which was significant enough for the learner to portray it visually.

The drawing in Figure 8 presents a scene rich in narrative elements.

The depiction of the "*SuperDomi*" robot as a heroic figure responding to a distress call not only displays the young learner's strong language skills and creative imagination but also reveals an understanding of interactions. Using speech bubbles and dialogue, the learner demonstrates the ability to verbalise actions and emotions in the written L2, using vocabulary beyond that contained in the school material. Moreover, phrases such as "*Il y a un vol dans la Paris*" ("There is a robbery in Paris")

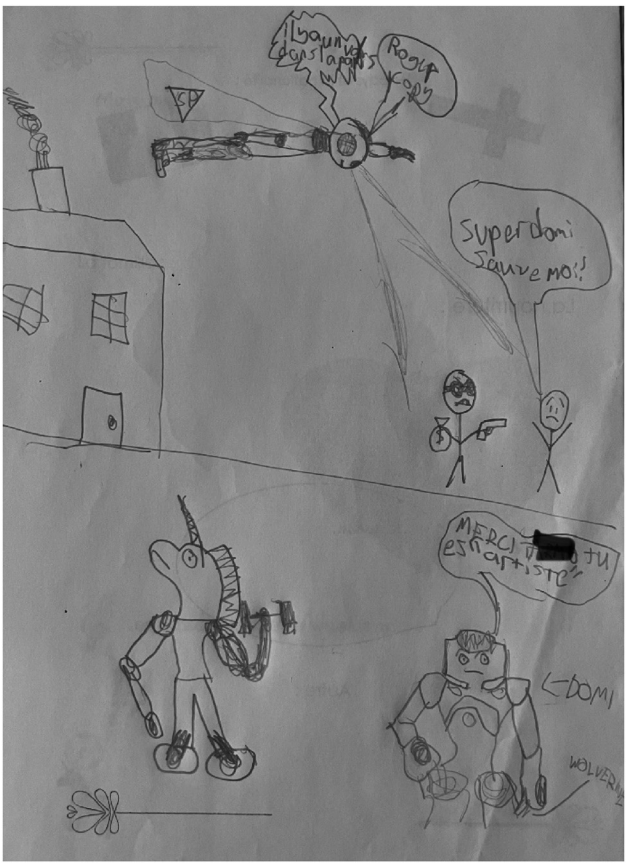

Figure 8: The robot's superhero persona.

indicate a clear link in how the learner constructs a representation between Domi and France, situating the robot in the French context. The self-praise expressed through NAO6's text, "*Merci –, tu es artiste*" ("Thank you –, you are an artist"), reflects the learner's metacognitive awareness. It implies the learner's capacity for self-reflection and appreciation of their creative and linguistic skills. This portrayal suggests the learner's recognition of Domi's agency.

4.3 Stereotypical places and characters

The association of Domi with French culture is further highlighted in the drawings found in the *carnet d'amitiés*. The various depictions of iconic landmarks, such as the Eiffel Tower, along with references to French cuisine, music and football, contribute to a culturally enriched narrative. Additionally, many of the *carnet d'amitiés* featured France's national colours (blue, white and red) and stereotypical French imagery in Domi's attire. In particular, symbols such as the beret and the baguette are well-known representations of French culture and evoke a clear association with France. Moreover, in certain *carnet d'amitiés* Domi resembled a character from the animated series *Miraculous*, adding a layer of familiarity to the robot. This connection to a popular children's series suggests the learners' exposure to media related to French culture (see Kramsch 2014; Sylvén and Sundqvist 2017). Overall, the portrayals combined attributes to imply that the robot, as perceived by the learners, was a friendly entity with an affinity for French culture.

Secim et al.'s (2021) findings on children's evolving perceptions of robots in drawings are pertinent here. In their study, the children's initial drawings focused on the robots' mechanical features, but their later drawings incorporated more intricate elements of the robots, such as their batteries, wheels, buttons and antenna. In this study, the learners' portrayal of Domi with stereotypical French attire and cultural references signifies their perception of the robot as not only a mechanical entity but also a character with cultural interests and emotional expressions, as well as their ability to playfully infuse cultural elements and emotions into their depictions of Domi. Thus, their portrayal of Domi demonstrates their perception of the robot's agency as a language speaker, highlighting its role as more than a machine.

4.4 Navigating linguistic and cultural hybrids within an imaginary space

Our findings suggest that regular interactions with a social robot over an extended period of time foster a dynamic space where scripted interactions between the robot

and the children's elementary language skills are transformed into a context that empowers learners to experiment with the language. Within this dynamic "imaginary space", learners engage in activities that encourage creative thinking and expression in French, transcending conventional boundaries between humans and machines. This space is intrinsically tied to the French lesson context and the robot's inherent capabilities, but it is gradually transformed into a realm where both the robot and the young learners have agency. The use of stereotypes in the drawings suggested that the learners had gained an understanding of French culture as distinct from their own, yet there was a sense of familiarity and comfort. The otherness of the robot, as the learners experienced, was not perceived as threatening in this context.

We perceive the imaginary space in CRI as analogous to Kramsch's (1995, 2011) and Kramsch and Uryu's (2020) broader concept of the third place or third space. This space is intricately tied to the symbolic dimension that Kramsch (2011, 2014) underscored as having a role in shaping cultural understanding. Within this imaginary space in CRI, the learners in this study actively explored, adapted and transformed symbolic representations. Thus, the concept of the imaginary space in CRI adds a layer to the third place, suggesting that while CRI tends to be one-sided, lacking the dialogue of shared meaning making, it can still create a space for learners to express linguistic and cultural hybridity. This imaginary space in CRI merges elements from fantasy fiction, robotics and French culture, aligning with Vygotsky's (1978) zone of proximal development. It helps learners enhance their language skills and cognitive growth by immersing them in imaginative settings, allowing experiences in another language. This resonates with Peura et al.'s (2023) findings from their study that the participants found their robot interaction rewarding because of the absence of judgement. These interactive environments, such as pair work with a robot, enable learners to actively shape the meaning of L2 activity in specific contexts. Consequently, young L2 learners not only acquire language but also associated problem-solving skills in language learning and ways of thinking.

5 Discussion

In this study, we explored the way young language learners interacted with a robot in a creative learning environment forged by the *carnet d'amitié* task. The absence of traditional constraints, such as grading and time limits, allowed for informal and imaginative language learning. The structure of the *carnet d'amitié* was derived from the questions that the learners themselves raised, emphasising their agency in the learning process. Paradoxically, even in this learner-driven framework, the learners' written contributions predominantly leaned towards free expression, further

highlighting their sense of agency and engagement in self-directed paths. Thus, this study indicates that learners' engagement and willingness to experiment with language were positively influenced in CRI, consistent with Randall (2019). However, in contrast to Randall (2019), this improvement was not attributed to a novelty effect, as the learners interacted with the robot over an extended period of time, indicating the need to recognise the new affordances available, as Benson (2017) proposed. Our findings further support observations in previous studies, as in Berghe et al. (2019), regarding the affective outcomes of such interactions. Our study suggests that CRI has the potential to foster both cognitive and emotional development in language learners.

The unique context of this study, in which the robot exclusively used the French language, played an important role in its outcomes. In traditional classroom settings, learners often switch between languages. However, our participants consistently communicated in French during their interactions with the robot. Their exclusive use of the target language shed light on the intricacies of their written production in French, demonstrating their exploration of various linguistic features, as observed in the study of Cekaite and Aronsson (2005) on language play. In this study, the learners not only explored different features of the French language but also employed diverse language strategies to construct meaning. They creatively used language resources to overcome vocabulary gaps and to convey complex emotions. This demonstrates their metalinguistic awareness and their ability to adapt linguistic elements within the framework of the French language. This had a positive impact on their vocabulary development (see Sylvén and Sundqvist 2017) and ultimately contributed to their overall linguistic and cognitive growth, as they recognised that French was the primary means of communication with the robot. This offers valuable insights for educators.

However, the framing of the *carnet d'amitié* raises intriguing questions about the extent to which language learners can immerse themselves in the culture of native speakers when interacting with robots. The rapid advancement of artificial intelligence (AI) and robotics makes it crucial to investigate the way these interactions influence the L2 experiences of young learners in this unique imaginary space.

5.1 Limitations of the current study

This research was conducted in a real-world school environment with themes arising from the learners' experiences with the robot during the school term. Consequently, the qualitative content analysis and findings are closely tied to this specific research context, which may have introduced subjectivity. The challenge of expanding the sample size stemmed from resource limitations, particularly the availability of only one robot and the restricted number of young learners learning French as their L2.

This focused approach was intentional, as it represents a pioneering effort in this field. Future research could complement these findings with larger quantitative studies.

The primary aim was to describe the impact of interactions between the young learners and the robot on informal learning. The *carnet d'amitié*, lacking a textbook-like structure, was not pre-constructed with specific completion instructions. Future studies should explore the way the material produced in the *carnet d'amitié* evolves when guided by specific instructions, evaluating their impact on L2 learning outcomes through thoughtful assessments. In this study, the focus was on the final outputs of the *carnet d'amitié* and their detailed analysis. Future research could document the stages of the process and analyse learning progress during the planning of questions, the interactions with the robot, and the final product. Moreover, pre-tests and post-tests could assist in measuring the effectiveness of the *carnet d'amitié* as a language learning tool. However, it is essential to note that such assessments may not comprehensively capture the diverse range of learning experiences and outcomes associated with informal learning contexts.

Additionally, this study did not make a strict distinction between formal and informal learning environments in the classroom setting. The influence of the learners' relationship with their robotic friend, Domi, and their informal learning experiences could also have affected their experience of the formal learning in the classroom. This, as noted by the teacher, warrants further investigation.

Importantly, the robot's algorithmic limitations, which restrict its interaction capabilities and learning adaptability, should be considered when interpreting the results. The robot operated using preprogrammed conversation scripts, resulting in inflexible interaction and limited AI capabilities. While this design ensured participant privacy, the lack of advanced algorithms posed challenges for speech recognition. Since this study focused on written and visual production, these limitations are not directly reflected in the results. However, the errors arising from these limitations offered valuable insights into language learning and human interaction. Notably, the robot's computational clumsiness appeared to encourage participants' creative language use as they filled in the gaps.

5.2 Future implications and challenges

Investigating CRI and robot literacy in informal contexts offers insights into language learning and human interaction. Engaging with a robot requires cognitive effort, embracing human imperfection through trial and error, which enhances linguistic awareness and critical thinking. This process also raises questions about the role of robots in shaping learners' experiences in a digital educational landscape. While

robots serve as pedagogical tools, their effectiveness relies on users' perceptions, making it essential to understand these tools to maximise their potential.

Prolonged CRI established a dynamic and informal imaginary space (cf. third space) that encouraged free interaction, playful engagement with a foreign language, and the exploration of linguistic concepts. The study emphasised the socially situated nature of language use, as well as the significance of robot literacy.

While the imaginary space is promising, the future use of AI-powered social robots raises ethical concerns regarding privacy, data security, and their impact on child development. As learners interact with the robot, it is essential to consider how recording and processing may affect their privacy and security. This study demonstrated how readily children form emotional bonds with an artificial agent, highlighting the need for caution in implementation. A comprehensive understanding of CRI is essential for maximising its benefits while protecting learners. Future discussions should focus on establishing clear ethical guidelines to ensure that children's engagement with the technology is enriching and safe for their overall development.

Despite these challenges, this study provides valuable insights that pave the way for future research. It lays the groundwork for understanding how CRI can shape language acquisition and offers perspectives on the unique imaginary space it creates. In this context, the imaginary space fosters creativity, self-expression and cultural understanding, while robot literacy enhances learners' ability to engage effectively with the social robot. Together, these elements ultimately contribute to transformative L2 education experiences.

6 Conclusions

In summary, the *carnet d'amitié* task illustrates a process in which multimodal interactions combined linguistic, strategic and pragmatic competencies. This study underscores the significance of informal contexts in CRI and introduces a framework for future investigation. In this study, the interaction between young L2 learners and a robot during the *carnet d'amitié* task revealed a distinctive space, indicating a transition from scripted interactions to a dynamic imaginary space in the CRI. In this setting, this space served as a platform for creative written L2 expression in French, transcending conventional learning boundaries. Prolonged interaction had a positive impact on engagement and language exploration, highlighting the learners' creativity and self-expression and revealing diverse competencies that are not always evident in traditional settings. These findings align with Vygotsky's theory (19781978), highlighting the role of this imaginative space in fostering cognitive and linguistic development. Furthermore, the robot's exclusive use of French not only facilitated the development of language strategies but also showcased the learners'

cultural hybridity and awareness. This unique setting mirrors Kramsch's "third space" (1995, 2011), emphasising the importance of language in shaping cultural understanding.

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