Designing Multi Sensory Environments for Children's Learning: An Analysis of Teachers' and Researchers' Perspectives

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ABSTRACT

Embodied learning offers new opportunities to enhance learning effectively, and engage children with stimulating educational experiences. Multi Sensory Environments (MSEs) are spaces that allow for several interaction modalities that stimulate users' senses and allow the collection of multimodal data. In educational contexts, they provide opportunities to support children's learning in a playful manner. The use of MSEs is usually carried out with the collaboration of teachers; their perspectives and responsibilities are crucial for the children's experience. The goal of our research is to uncover evidence-based challenges and opportunities, while considering teachers' experiences. We conducted fourteen semi-structured interviews with teachers ($n = 6$) and researchers ($n = 8$) experienced using MSEs', and analysed the identified challenges and considerations during a workshop with four Child-Computer Interaction (CCI) experts. We offer a series of implications for consideration when designing and/or using MSEs to support children's learning.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in interaction design**; **Empirical studies in HCI**; • **Applied computing → Interactive learning environments**.

KEYWORDS

child-computer interaction, education, multisensory environments, learning

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1 INTRODUCTION

Over the last years, researchers have leveraged sensory-based technological capabilities, such as motion-sensors and wearable devices, to explore how novel affordances (e.g., full-body interaction) affect learning in a variety of domains, such as science, mathematics, music, and language acquisition [1, 11, 27, 30, 34]. Recent advances in sensing technologies afford such systems the ability to arrange multimodal stimuli in a variety of ways in response to children's presence, gestures, emotional states, actions, and manipulations [38]. The growing literature on multisensory educational processes highlights the significant potential that sensory experiences may have in assisting children [3, 17, 45]. Contemporary studies have demonstrated that enabling young learners to interact with educational materials by moving their bodies, boosts implicit awareness and improves learning [3, 10, 22]. The majority of Multi Sensory Environments (MSEs) for learning include connected technologies centered on embodied cognition and sensory processing theories [46], and the enhancement of cognitive abilities such as, conceptual visualisation, implicit memory, logic, and problem-solving through the precept of "playful learning"[31]. Children's learning experience is affected by several variables; most importantly, the role of teachers [41]. However, despite the importance of these roles in supporting children's learning (e.g., task design, dispositions, empathy), there is a lack of research focusing on identifying the challenges faced by children's teachers as users of MSEs. This study aims to fill the gap in the literature by identifying evidence-based challenges and insights derived from their experience during all phases of MSE utilisation (from setting the learning activities to understanding the produced data). Such knowledge will help various stakeholders, for example, designers and researchers, who work at the intersection between sensory systems for learning and children. In particular, we address the following Research Question (RQ): *"What are the challenges and main considerations to account for, when teachers use MSEs to support children's learning?* To tackle the aforementioned RQ, we conducted a series of interviews with teachers ($n = 6$) and researchers ($n = 8$) with experience using MSEs. Then, we analysed the identified challenges and practices during a workshop with four Child-Computer Interaction (CCI) experts. Finally, we identified a set of key aspects to consider when designing and/or employing MSEs to support children's learning.

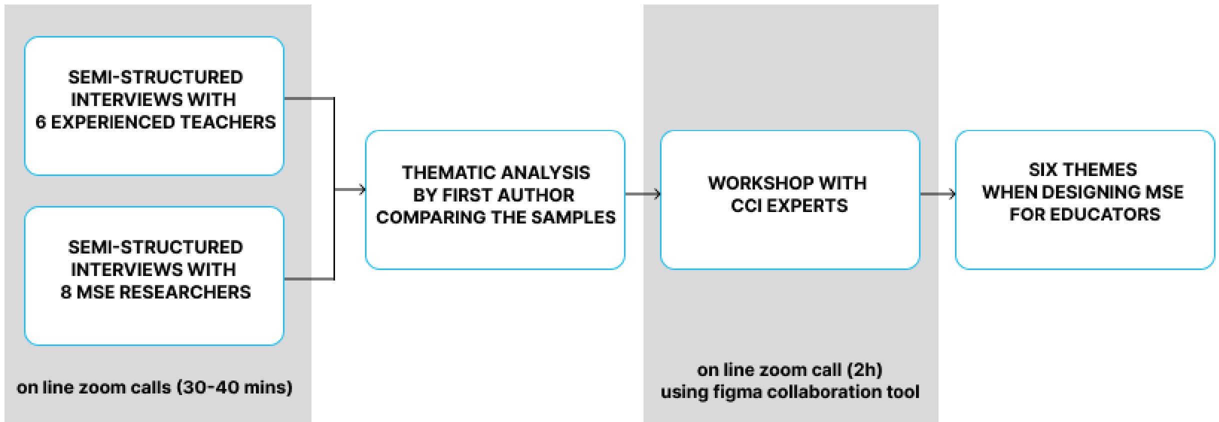


Figure 1: Methods overview

2 BACKGROUND

2.1 Multisensory learning experience for children

In last decade, we have seen enormous use of sensing technologies in CCI research [38]. These technologies have been used to support children's play, communication, and learning. Technologies such as smart displays, motion-capture systems, and smart toys enable children to perform complex interactions such as gestures, waving, handshaking, and other motion-based interactions. These advancements allow us to gather, analyse, triangulate, and present data from multiple measures of students' actions and sensations [1]. The CCI community has engaged in discussions about the promised benefits and ethical issues of sensing and logging technologies [14]. In particular, studies have demonstrated the use of motion sensors (e.g., Microsoft Kinect, Leap Motion) that are capable of detecting body movements (walking, standing, balancing) and gestures (grasping, pointing, clicking) in touchless games [19, 20, 23]. Another example by Cuturi et al. [3], illustrates how visual and haptic/proprioceptive sensory information can support children's skills acquisition (e.g., mental rotation, 2D–3D transformation, and percentages). Therefore, leveraging sensing technologies has the potential to amplify children's interaction and learning capacities, with several benefits (e.g., enhanced understanding of children's cognitive and affective processes, development of real-time artificially intelligent systems to best support the embodied grounding of curricula) [1, 23]. In order to achieve successful adoption of MSEs for use with young user groups, teachers should be considered co-users. In turn, we should look to them for direction on how to ensure easy system setup, customization of content difficulty, or even providing explanations and complementing the system's feedback and instruction capacity. Despite the importance of the teacher's role, there is a lack of knowledge regarding potential challenges (e.g., managing MSEs' advanced functionalities) and practices (e.g., how MSE's capabilities can be incorporated into contemporary curricula/instruction). The role of teachers has a considerable impact on the initiation and facilitation of children's learning experiences, resulting in concrete and successful outcomes [16, 36]. Moreover, they could help children understand the functionalities of the MSE in a simplified manner [21].

3 METHODS

The approach employed in this paper has three phases (see Figure 1). First, the data were collected using individual semi-structured interviews with teachers and MSE researchers who have more than one year experience using MSEs. Second, the interview corpus was transcribed by the first author, who identified categories to investigate based on thematic analysis comparing both teachers' and researchers' answers. Lastly, a workshop with four CCI experts led to a discussion that identified six themes to consider when designing MSEs for teachers.

3.1 Data Collection: semi-structured interviews with teachers and researchers

Semi-structured interviews represent a flexible method for small-scale research [6], and were employed to allow us to focus on themes that are relevant as well as investigate potential topics that were not included in the pre-identified questions (depending on the potential questions or issues raised by the participants). As such, the participants were able to further elaborate on subjects and add topics they believed were important.

3.1.1 Participants. We conducted 14 interviews with 6 teachers from primary schools and 8 researchers in the field of MSEs (see Appendix A for participants' profiles). Their participation was voluntary. The main aim of including teachers in the interviews was to understand their thoughts and needs related to using MSEs in their daily routines with children. On the other hand, the purpose of including researchers was to 1) investigate their perspective on how a teacher's role impacts children's learning experience, and 2) learn which stage of the design process is most appropriate for them to work with teachers. The intention of interviewing both teachers and researchers was to compare their experiences, identify where they agreed and disagreed, and see how they could work together more effectively in the design of MSEs for children.

Teachers were selected from two different learning contexts. Half of the teachers ($n = 3$) had one year experience with a system called "Magic Room" [9]. Magic Room provides students with tactile, auditory, and visual stimuli by projecting a digital world on to a classroom's walls and floor, using a gamut of "smart" physical objects. The main educational activities provided by the system were designed to improve memory, problem-solving and body control. Figure 2a presents an activity called the "association game", where a sequence of sounds is played. After each sound, images are projected on the floor, and the children are asked to identify the image associated with each sound by standing on the selected image. The remaining teachers had between 1 and 3 years experience with a MSE called "Kinems" [32]. Kinems is a motion-based educational game platform designed to help students master skills related to learning. Figure 2b shows a child playing the Kimens game, Sea Formuli, which focuses on developing algebraic thinking. To solve the presented problems, children must calculate the missing number (operand) or operator in an equation relating 3 terms, where each is represented by a basket located on the ocean floor. Three floating jellyfish, each labeled with an operand or an operator, display the potential answers to be selected. Children perform a gesture to select the jellyfish containing the correct answer, and then move the jellyfish to the empty basket.

The researchers had a minimum of 3 years experience using MSEs, primarily with motion-based technologies, Virtual Reality (VR) and Augmented Reality (AR) for children's learning. Three researchers were involved in the design and development of the two aforementioned MSEs, and two researchers had used them during experiments. Additionally, several researchers had experience with Learning Analytics (LA), specifically its use to support learning and instruction.

3.1.2 Interview protocol. Educators were interviewed using a list of 16 questions, provided in this link, which were divided into knowledge questions (demographic data and preliminary questions about academic subjects, children's age group and level of experience with MSEs), and MSE learning experience questions (with the goal of gaining a better understanding of how teachers approach such systems considering children's learning needs). Researchers were asked 14 questions, with the first four aimed at identifying their research area, level of experience, and technologies used; the remaining questions focused on understanding the researcher's perspective concerning the benefits of MSEs for learning and the teacher's role.

Due to the current COVID−19 situation, the interviews occurred online and were video recorded. Each lasted for 30 − 40 minutes. The study had previously been approved by the National Human Research Ethics Organisation, and participants gave their consent for the data collection after reading an information letter. Moreover, participants could withdraw from the interview process at any time.

3.2 Data analysis: workshop with CCI MSE experts

The first author transcribed the interviews and then used an inductive approach to identify the categories to investigate, which emerged from the questions and answers provided by both samples [28]. The categories were organized using the Figma collaboration tool, and include: advantages and challenges of using MSEs, difficulty to manage, best practices, when and why teachers' presence is crucial, possibility to design and set up the experience, possibility to supervise and change the set up in real-time, and possibility to post-analyse the data collected.

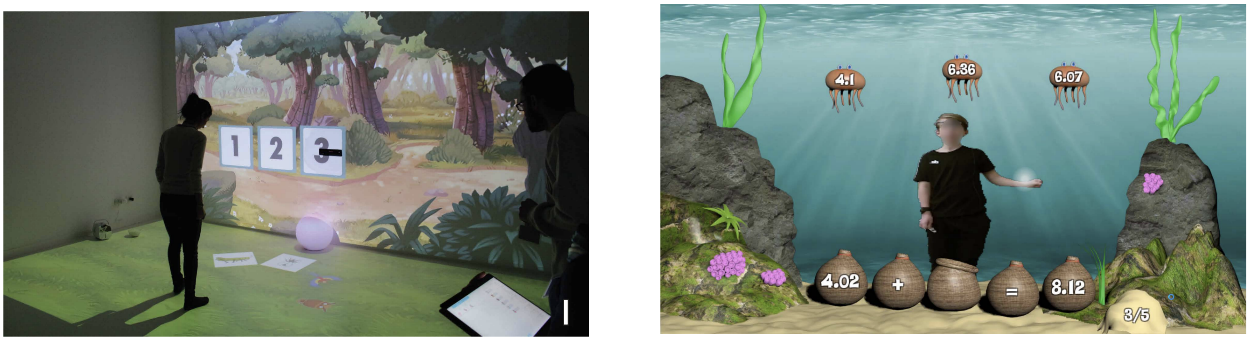
Following, we conducted a workshop with four participants (two PhD researchers and two professors), all experts in the domains of CCI and MSEs, to derive deeper insight from the analysis of the selected categories. The workshop was held via Zoom and the participants were asked to brief and arrange post-it notes on a virtual wall, analysing both teachers' and researchers' perspectives for the aforementioned categories. The post-it notes were visible to all participants. This was an iterative process that consisted of adding and discussing post-its until patterns emerged. Resultingly, we identified six themes from the encoded categories addressed during the workshop. These six themes were derived from teachers' and researchers' insights and emphasised when and why they agreed or disagreed.

4 FINDINGS

The six themes listed below come from the discussion among the CCI MSE experts, which highlighted the similarities or contrast between the teachers' and researchers' perspectives.

Theme 1 - The promise of "multisensoriality" and the capacity to foster inclusion and playfulness. Both teachers and researchers identified MSE's playfulness as an advantage to foster children's motivation, engagement, and inclusion. T1 stated, *"The main advantage of using MSEs in my classroom is that children are engaged and motivated because it is different than using paper-based material and children have different ways of learning. Moving their bodies and playing helps them concentrate more and be more creative"*. T2 and T4 agreed with T6, who reinforced this concept by adding, *"..moreover I noticed that children with Special Educational Needs (SEN) felt more included in the classroom during the multisensory experience thanks to the different stimuli provided"*. Researchers stressed the potential benefits of "multisensoriality", such as immersivity. For example, R13 stated, *"The right stimulus at the right time is crucial and could also be a sequence of distinct or simultaneous stimuli. This usually leads to a profound experience that remains with children, and educational content will be memorized even in the long term"*. Moreover, they added, *"understanding if the immersive experience can provide educational benefits for children is important, but the goal might also be to provide enjoyable experiences to improve their quality of life."*

Theme 2 - Technology management as the main challenge. The majority of teachers (n = 4) stated that controlling a new technology, while simultaneously managing and supporting children, is the biggest challenge faced when adopting MSEs. Other concerns included technical issues, for example, unstable connections with sensors or the internet, which may result in system lag or a crash. All teachers enjoyed using MSEs and reported this technology as valuable due to its low threshold for children's use. However, they also indicated that technical challenges might hinder adoption and proper use. This is illustrated by the following two quotes. T1 said, *"I think the children's activities in the Magic Room are not that difficult to manage, but I'm afraid of the technology behind it and of not being able to manage it if something goes wrong"*. T2 added, *"I can't manage it alone"* and suggested assistance from a technical



(a) Magic Room

(b) Kinems

Figure 2: Multisensory systems used by the teachers and researchers interviewed.

expert. Additionally, all teachers emphasised the need for additional technical training to become more familiar with MSEs and help address potential technical issues that may arise. In support of this, T4 explained that he was able to learn quickly by observing a technical expert use a MSE and replicating the procedures repeatedly.

The researchers agreed that the teachers' technological competence is an important challenge and stated that it may influence acceptance and motivation. In support of this, R1 argued, *"In my experience, many teachers who don't know how to use a new technology are skeptical and believe that the system will replace them. Furthermore, the age of the teacher counts: the younger ones are more enthusiastic to integrate new technologies into their curricula"*. Nevertheless, researchers also emphasised that the aforementioned concerns should not be strictly regarded as the teachers' responsibility and that the onus to mitigate potential technical challenges also belongs to other MSE stakeholders (e.g., MSE designers). This was illustrated by R11's statement, *"..some systems are not robust, they could be prototypes and it's challenging for every type of user to manage them"*. R10 and R14 added that potential lags or unexpected actions from children, may very easily lead to both teachers' and children's frustration. As R10 explained, *"When children are not able to solve a problem they could be stressed [...]. For example, if they couldn't understand how a gesture (grasping, pointing, etc.) functions when a technological latency occurs, this may cause them frustration, and they may be unable to complete a session due to a lack of motivation. Also, most of the time, teachers don ́t know how to deal with unexpected technological problems"*.

Theme 3 - Scaffold and (pre)setup MSE activities. Most teachers stated that they are willing to invest time in designing and preparing MSE-based activities for their children, but given the varying requirements of their classes, a basic pre-set of different activities would be appreciated. As T1 explained, *"I would like to have a dashboard to set up the activities before the session as with other traditional paper-based learning activities. However, it could be challenging for me to plan them from scratch, I would much rather start from a pre-set given by the experts."* T4 added: *"To me [it] is important to customise activities related to children's needs, but I would prefer to do it in a team with experts"*. The researchers also believed that defining the learning content and MSE activities should be the teachers' responsibility, given they are familiar with the children's capabilities. However, they highlighted the challenge of designing and developing an authoring tool that allows teachers to plan MSE learning activities. Moreover, R11 suggested, *"workshop sessions or participatory design with them [the teachers] could be helpful. It is beneficial to decide the setting, and the contents together with them. Researchers want to have a structured learning experience based on theories and literature knowledge, but teachers have the experience of the reality"*.

Theme 4 - Teachers as silent orchestrators of children's learning activities. The teachers' role is to facilitate learning activities. Teachers recognised the value of children's autonomy when learning and stated that during multisensory learning experiences, they prefer to observe and intervene only when needed (e.g., when there is a misconception or confusion). This is especially important for children with SEN, as they often require additional supervision and support during their learning experiences. As stated by T5, *"The closer I am to the children during the activities, the more efficient they are. But working on children's autonomy is important, and I prefer to observe them silently and intervene when I think it is appropriate during the session"*. T4 added, *"when it comes to children with SEN, I need to supervise them throughout the session, because they might need help [at any time]"*. The researchers confirmed that the teachers' presence is of paramount importance to children during their interactions with the MSE, but also acknowledged certain limitations. R11 said, *"It's important to be there when children play, and to intervene when necessary, however, a constant presence could be a problem for real interaction with the MSE to happen. I think that the instructors' presence is useful just when a problem appears"*. R13 suggested that researchers need to provide teachers with the proper tools to manage MSE learning experiences, which allow them to facilitate activities on learning goals, since teachers know the curricula and children's individual needs.

Theme 5 - Real-time supervision and automatic feedback during children's learning experiences. When asked if they would like a tool which allowed them to supervise their students learning experiences with MSEs in real-time, and which indicators would be beneficial during this process, half of the teachers did not understand the role that visual indicators (e.g. Learning Analytics (LA) derived from the MSE sensors) could play. However, after the interviewer demonstrated a practical example of a MSE's LA capabilities to capture and display critical information in real-time, teachers reacted in a proactive manner. T4 stated, *"I would like to see indicators, such as fatigue, errors, and emotions in real-time through a tablet dashboard"*. To this T5 added, *"I would like to understand both students' concentration and biological parameters. I think that it is useful to visualise the indicators on a computer or even a phone"*. Moreover, T6 highlighted the importance of timelines in the following quote, *"It would help me modify the level of difficulty. Waiting until the end [of the activity] is not always good. I would like to instantly make modifications when needed. It will help the student to complete the activities more successfully"*. However, when posed the same questions, researchers were more skeptical. Specifically, the majority of researchers agree that supervising (e.g., giving students feedback, helping students when needed) the experience is important, but they also underlined several potential challenges. For example, R8 indicated that automated feedback could be more useful by stating, *"The teacher can intervene, but this is not scalable. Indeed, the Artificial Intelligence (AI) can continuously follow the student and correct the error instantly, if the feedback occurs 2 minutes late, as could happen with teachers, it will no longer have the same effect."*. Building on this, R1 added *"These systems could offer automatic feedback to children because sensors can capture the 'hidden data' and metrics that teachers cannot see. However, when adding automatic features to a learning technology, we must consider the extent of synergy with the teacher's role"*. R14 also mentioned the difficulty in designing an accessible dashboard for teachers with the quote, *"Real-time indicator information with a dashboard is very helpful, but how do we present it to be, realistically, useful? I think they [the teachers] would need a lot of support"*.

Theme 6 - Learning Analytics (LA) to guide future steps. Teachers strongly believed that having the possibility to analyse session data (e.g., LA) after the learning experience has completed, may be the key to setting-up future meaningful learning experiences. In particular, T6 stated, *"Without the analysis of children's learning experiences, we have no guide. I would like to have a dashboard with scores, time, class level, and also sensor data of every child"*. Moreover, T5, emphasised the importance of data visualisation to also enable parents to understand the progression of their children's learning sessions: *"A dashboard to analyse the statistics would help me to give an evaluation, and charts would be helpful in explaining the children's progress to their parents"*. Researchers agreed that the most important advantage of LA in MSE use, is the affordance for teachers to analyse the learning session, and provide post-activity feedback to their students (and at times, the parents). Furthermore, researchers discussed the potential of adaptive MSEs based on (trained by) the collected LA. As stated by R13, *"[It] would be beneficial if teachers can analyse the data with a digital tool (e.g. Learning Analytics Dashboard (LAD)).[...] Probably they won't understand the raw data. We need to intermediate as researchers with simpler visualisations. I believe it would be beneficial if they could modify the indices to look at related to the child and their profile.[..] We can also think about how we could integrate adaptive and recommender systems to give them suggestions on how to set up future activities' parameters based on those data"*.

5 DISCUSSION AND CONCLUSION

The study presented in this paper aims to identify the key challenges of involving teachers in the design of MSEs for children's learning and to gain insights that lead towards design and research opportunities. To the best of our knowledge, little research has been conducted on how to incorporate new, emerging technologies into classroom settings, such as MSEs. Our work affirms that MSE's technological complexity makes them challenging for teachers to manage, and that complete delegation to teachers may result in stress and decreased motivation for their use. Our approach listened to, and triangulate, teachers' perspectives with the experience of researchers in the field. The interviews showed the importance of collaboration between these two groups in order to provide children with a fruitful learning experience with MSEs. Specifically, the researchers contributed technical and theoretical knowledge related to designing accessible MSEs, while teachers provided understanding of the students' needs and how the curricula are implemented. Therefore, our results support the notion that joined forces are critical to design appropriate mutisensory based learning experience for children [16, 36]. In our study, we distinguished three critical phases where teachers' involvement required our attention: the MSE (pre)set-up and activity design, real-time orchestrations and monitoring, and post-data analysis of the student´s learning experience in the MSE. We identified several teacher challenges to address during the aforementioned three phases, and we present the implications drawn from our findings, along with considerations for the future MSE design of children's learning experiences.

5.1 Implications for practice

Our findings revealed that initially teachers struggle to understand how to use MSEs, and that this leads to their loss of motivation, and limits adoption of the respective system. This falls in line with previous studies that investigate teachers' perspectives on the use of advanced technological features to support young learners [15, 40]. It is expected that the introduction of new technological affordances will require a significant investment of teachers' effort in order to master the required competencies for fluid use. Nevertheless, teachers' acceptance and mastery remain crucial in order for new technologies to be integrated into contemporary learning practice (e.g., tablets [29]), and avoid potential negative consequences (e.g., teachers' technological stress [42]). A lesson derived from our findings, is that as teachers' MSE related competencies increase as a result of technical training, they begin to recognise and gradually accept the potential of these systems to engage their students. This leads to positive changes in teachers' dispositions, and they begin to establish practices that help overcome practical and technological challenges. Therefore, an easy-to-use, intuitively designed system, in conjunction with appropriate system training and technical support over time, should be implemented to support the use of MSEs. Encouraging teachers' participation in the development of educational technology is fundamental to helping students achieve their learning goals [7]. The teacher's role typically involves the assessment of students' needs and experiences, aiming to adjust the learning design (e.g., plan activities). Our results show that, due to the contextualised knowledge of their own students' needs, teachers would like to design MSE learning activities in advance, as this is part of their responsibility to properly scaffold learning design (e.g., develop activities that are appropriate for the child to achieve their goals and stay engaged) [12, 24]. However, this is under-practiced in the development of today's technologies. Previous works have looked for ways to develop appropriate technology capabilities that allow teachers to create MSE activities, by including teachers in the co-design process [25]. This may provide teachers with a level of comfort and practical experience which supports their adoption and use of MSEs. However, it does not instill teachers' self-autonomy with respect to setting up MSE learning experiences. Although our findings indicate that teachers are excited about the possibility of designing and setting up MSE activities, they are also concerned with these task due to the technology's complexity and a feeling of continuous need to work with experts. The findings, based on teachers who have more than one year of experience, demonstrate a sense of non-appropriation and an inability to plan MSE activities in their curricula. Thus, researchers might involve teachers as domain experts when establishing system requirements and design specifications, so that the produced MSEs are appropriate and easy to use, and encourage teachers to become protagonists with strengthened confidence. This approach may also promote mutual learning, by enabling teachers to achieve technological autonomy, while researchers benefit from teachers' practical experience to design future MSEs.

5.2 Implications for research

In the educational context, use of extensive sensor data helps teachers monitor their students' learning progress [33, 44]. Viewing the collected data on supportive tools, such as LADs, affords teachers new insights which help them make informed data-driven learning decisions by providing formative and summative feedback, however, additional effort is needed to ensure that the produced LADs are effectively designed [5, 18, 37]. Researchers and designers must consider how to deliver post-analysis data visualisation that are clear, understandable, and accessible by teachers. Our findings fall in line with previous works on designing learning interfaces (e.g., [5, 18, 37]), which highlight challenges of achieving intuitive and useful functionalities (e.g., what data to visualise, how and when to present them to the teacher). Additionally, although teachers' expressed a strong interest in leveraging the indicators (e.g., children's fatigue and emotions), their responses informed us that the use of LA and automated feedback is a completely new domain. Thus, researchers must work in conjunction with teachers to determine the most appropriate visualisations to display and the combination level of AI feedback and teacher-facilitated feedback. Another finding from the researchers´ interviews is that teachers' presence during the learning activity should be mostly passive, and they suggest to add automated feedback to intervene when needed. However, joining the contemporary debate surrounding the use of AI (machine over human control) [13], some researchers agreed that automated systems might not yet be mature and accessible enough for integration into educational environments. On the other hand, both teachers and researchers agreed that the adaptation of content based on children's sensor data might aid in the creation of meaningful learning experiences [39]. Moreover, this raised additional discussion regarding how AI may complement teachers' roles when using MSEs (e.g., hints or feedback provision). These directions are a stepping stone for future RQs which examine the collaboration between teachers and AI features, such as "How automatic AI feedback can help teachers manage the MSE and intervene with real-time changes?". While real-time monitoring of student´s sensor data leads to skepticism and needs further investigation, post-data analysis is considered a necessary step. Our findings show that it may help teachers understand children's misconceptions and experiences, give appropriate learning feedback, and prepare future learning sessions. Additionally, making the data more accessible and readable is imperative when considering the direct communication between teachers and children's parents. This implies having clear, informative indicators, which can be achieved through the design of LADs.

5.3 Limitations

The challenges and considerations presented, were composed in accordance with teachers' and researchers' views, from a teaching and CCI design perspective. Since children are the primary users of MSEs, the absence of their voices in this conversation may be regarded as a limitation. Another limitation we draw attention to, is that although coverage was attained across all categories throughout the data coding procedure, there could exist a representation bias (e.g., teachers with technological competence). Furthermore, despite the fact that we followed a multi-step and structured process to analyse the data, our personal background knowledge with MSEs, might have influenced the results.

5.4 Conclusion and future directions

Our work identified a collection of six themes and a related discussion on challenges and considerations to help teachers overcome potential usage barriers of MSEs for learning. Moreover, we highlight the importance of integrating teachers throughout the main stages of the MSE design process and during the development of appropriate learning design in practice. Considering teachers' needs will allow researchers and designers to create MSEs, and respective learning processes that are inclusive for both children and teachers. Future work involves participatory design and training programs to actively engage teachers' collaboration to synergistically create meaningful MSE learning activities. To accomplish this, the use of tools which take into account participants' technological knowledge and complexity of MSEs, is critical. For example, previous works have developed toolkits consisting of cards to involve stakeholders and make the design process inclusive using familiar game paradigms [2, 4, 26]. Furthermore, alternate research has designed authoring tools aimed at assisting caregivers in designing and setting up activities [8, 9]. These tools include various levels of teachers' involvement, with some requiring the creation of activities from scratch, and others allowing only the change of certain features (such as the number of questions or the level of difficulty) [35, 43]. As well, future research is needed to identify the appropriate level of involvement and control teachers should receive throughout the different phases of the design. It is important to provide teachers with the flexibility needed while avoiding frustration from usage. This will result in the development of tools (e.g., teacher dashboards) that will provide critical insights to teachers (and parents, if needed), as well as enable customizing essential components of the MSE (e.g., authoring functionalities).

6 SELECTION AND PARTICIPATION OF CHILDREN

No children participated in this study.

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Appendices

A APPENDIX: PARTICIPANTS' PROFILE

Table 1: Participants' profile

ID	Age	Gender	Subject	Age group	Type of technologies	Experience	Context
T1	29	F	Music, italian language, history, arts, religion	6-7	MSE	1 year	School
T2	59	F	Music, italian language, history, arts, religion	9-10	MSE	1 year	School
T3	39	F	Tecnology, multimedia	6-10	MSE	3 years	School
T4	33	M	All the subjects	6-10	MSE	1 year	School
T5	45	F	All the subjects	6-12	MSE	1 year	School
T6	30	F	Mathematics	over 12	MSE	1 year	School
R7	29	M	Sports, training	over 6	MSE, VR, AR, LA	4 year	Research lab
R8	30	M	Sports, training	over 6	MSE, AR, LA	6 year	Medical centre
R9	41	M	Physical exercise, calligraphy, language	over 6	MSE, LA	8 year	School
R10	32	M	Coding, mathematics, language.	over 8	MSE, robot, tangible interfaces, coding tool	5 year	School
R11	35	F	Coding, mathematics, science	over 8	MSE, coding tool, computer and mobile based application	6 year	School
R12	27	F	Language	6-12	MSE, robots, intelligent assistants	3 year	Therapeutic centre
R13	32	M	Cognitive and motor skills	6-12	MSE, VR, conversational agent, smart objects	8 year	School, therapeutic centre
R14	40	F	Mathematics, language	6-12	MSE, LA	3 year	School, museum