Transitioning Towards a Smart Learning Ecosystem: Designing for Intersubjective Interactions between Cognitively Impaired Adolescents

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Abstract. People with cognitive impairments have limited social abilities, and their social relations often rely on other people people taking initiative. Therefore, they need social learning to be able to socially engage with others. This project accommodates this need by promoting social interactions in a smart learning ecosystem for cognitively impaired adolescents at a rehabilitation centre in Denmark. In collaboration with the staff and residents at the facility, we developed together with staff and residents a music game prototype. The basic functionality includes two users playing virtual music instruments by using gestures and body movement. To support criteria established from the users, the game is designed to induce physical, cognitive and social learning in a diffused learning space. The study measured the intersubjective interactions between the residents when playing the game and found that verbal encouragements from the system affected their interactions. The staff members reported that the game has strong motivational properties for the residents in doing physical movements and interacting with each other.

Keywords: People with cognitive impairments, Rehabilitation centre, Smart learning ecosystem, Intersubjectivity, Joint activity, Social learning, Participatory design, Kinect V2, Multi-users.

1 Introduction

People with cognitive impairments have various learning difficulties, and one involves creating social relations. The problem is reflected in their behaviour and mindset, e.g. they rarely take the initiative to contact an unfamiliar person and can have anxiety issues when meeting strangers [1]. Their social skill deficits tend to be correlated with the ability to communicate and the development of meaningful relationships [1, 2]. This tendency suggests that without social relations in the first place, the problem becomes a vicious circle of social needs with limited abilities to meet them. While social deficit issues are less consequential in institutional environments with caretakers and support workers, it becomes an issue when creating and maintaining relationships with others who do not immediately understand the highly adapted and contextualised communication processes. Hence, social relations and confidence are essential to be integrated in the community and when living independently [1, 3, 4, 5, 6]. In reaching this independence, training programs have previously corrected the inappropriate behaviour of people [1, 7]. However, these controlled situations do not translate well into real-life contexts, and instead, a person can learn social interactions and skills by engaging with other people [1]. Through social encounters we learn how to connect with people. The earliest type of social learning occurs between a mother and her infant, who learn to adapt and attune to the other. The literature refers to this phenomenon as intersubjectivity or shared experience [8]. It is currently used in music therapy to evaluate the music therapeutic process by identifying intersubjective interactions of cognitively impaired people [9, 10].

A Danish rehabilitation centre for people with severe cognitive impairments (both congenital and acquired) has expressed a need for increased social learning among their residents. They requested a study on how their institution prohibits and/or could foster improved social learning. The findings were reported in an ethnographic study by Krummheuer et al. [11]. The authors observed that the residents primarily interact with the support staff rather than each other. In particular, the residents roam the corridors when they have no other activities planned (e.g. training with the physiotherapist), or when the support staff is unavailable. Although other residents wander the corridors, they rarely take initiative to interact with each other. Thus, the residents need for an activity in this recess period to stimulate them and increase their life quality through developing more social connections.

The residents and the staff requested for a joint activity that can be provided by technological means acting as a component for enabling the institution to become a smart learning ecosystem (SLE) [11]. An SLE comprises new methods and techniques to build or remodel environments where the "smartness" of technology can activate different types of learning [12]. It should include user preferences and needs when providing the optimal services that help enhancing the user's learning experiences and to make the learning efficient [13]. In context of the rehabilitation centre, an SLE can contribute to a motivating learning environment that engages the residents in ways different from therapy. For this purpose, Krummheuer et al. defined SLE design principles through a dialogue with the administration, staff, and residents [11]. This study applies these principles to explore how the residents at the rehabilitation centre can be encouraged to interact with each other through technology. To accommodate the social need, a music game was co-created with four residents and two staff members, resulting in an interactive tool to enhance communication channels between the residents through music and dance. We promote social learning through a voiceover encouraging the users to perform intersubjective interactions, e.g. by adapting to each other's movement. To this end, we investigate their interactions while using the game, and if voiceover encouragements influenced on their behaviour.

2 Shared Experiences as Social Learning

Human behaviour is generally affected by environmental influences, and the learning process is therefore considered unidirectional. Social learning, on the other hand, occurs in a reciprocal causation of behavioural, environmental, and personal determinants [14]. These determinants can be explained by learning processes in cognitive psychology and behaviourism. Cognitive learning is a change in knowledge attributed in the learner's experience and inferred from the learner's behaviour [15]. Behavioural learning is a change in behaviour, as an example physical learning is a change in motor skills that is practised through observations and using the body, e.g. when following a dance tutorial [16]. Social learning converges the environmental influences with the learner's cognitive capabilities [17], and therefore when practising social learning it involves other types of the learning in the process.

In a previous approach to developing social skills, training programs have corrected the inappropriate behaviour of people with learning disabilities [1, 7]. Although such training can improve social skills, as in [18], the skills become worthless when the trained situations are different from real-life experiences [1]. In other words, the training programmes lack the determinants for the real-life situations that usually are uncontrolled. Instead of training skills in controlled scenarios, a person can learn social interactions by connecting with other people in the real-world, e.g. in joint activities. Two individuals can achieve a shared experience when adapting and attuning to each other, also referred to as intersubjectivity in the literature [8]. They can share control in an experience if they can anticipate what the other individual will perceive and do, see the definitions of these terminologies in Table 1. Hence, the shared experience indicates a high level of communication and understanding between two individuals, and these experiences can contribute to meaningful social interactions and social learning [8].

Table 1. Definitions of joint activity, shared experience, and intersubjectivity.

Terminology	Definition
Joint activity	Any activity experienced with one or more persons.
Shared experience	Two individuals can share control in an experience if they can anticipate what the other individual will perceive and do [8].
Intersubjectivity	When an individual is able to adapt to the consciousness and intentions of the other. Intersubjectivity is a construction of relationships through shared consciousness [8].

People with cognitive impairments are less inclined to achieve a shared experience. Their lack of cognitive processing influences problems with social cues, including perceiving facial expression, vocal cues/monitoring, language, social conversations, and body/personal space awareness [1, 19]. This communication problem extends for those with no spoken language, and they use alternatives, such as communication boards [20]. Although people with cognitive impairments find it difficult forming new relationships, they can make new friends, with time. Some can communicate with peers in a unique way, e.g. through body language [11]. Previous study showed that people with severe learning disabilities and complex social skill difficulties can interact with each other, without being taught complex social skills beforehand [1]. This, however, only worked when the participants were offered an adequate level of organisational support, for instance in the form of support workers who know the person well and can facilitate social contact [1]. However, to set up joint activities and activate people with cognitive impairments takes time and effort which the staff might not have available. Instead, they can benefit from technological solutions for activating the residents, as these activities can be made available outside scheduled activities.

3 Social Learning in Smart Learning Ecosystems

An SLE use new methods and techniques to build or model environments where different types of learning can be developed through the smartness of technology. The smartness refers to the use of digital technologies, in which the physical and virtual environment is interlinked [12, 21]. An SLE should include user preferences and needs when providing the optimal services that help enhancing the user's' learning experiences and to make learning efficient [13]. It should also be strongly motivating by adapting continuous and adequate challenges. Thus, an SLE is a space centred around its users with the technology acting as enablers of learning [12, 21]. The definition of an SLE differs from the smart (learning) environments, in terms of the space that the smart learning operates in. A smart learning environment has boundaries in which learning takes place, such as a classroom [22]; whereas a smart learning ecosystem extends the learning environment to an institution or community. An ecosystem must consider the characteristics, expectations, quality of experiences and well-being of its users, including their working and living conditions. To sustain the ecosystem, the users should be involved to define shared meanings and goals that are beyond their basic needs and can promote social capital [21]. Enabling such ecosystems can contribute to learning environments, such as rehabilitation centres for cognitively impaired people. This section analyses previous studies on how well components of SLE have been integrated in of social learning for cognitively impaired people. These studies were scoped in because they specifically report on research based on the design and development of technical solutions for people with autism [23], learning disabilities [24, 25, 26, 27], and special needs [28]. Here we continue to present these studies viewed through a technical lens as we do not differentiate between their diagnoses or other conditions.

3.1 Communication Through Mobile Calendar App

Communication tools have previously enabled new relationships or maintained previous ones. Brereton et al. [23] developed a mobile calendar app that facilitated communication and activated children with autism. With the app, they took pictures every day to capture progress and their interests. The authors had anticipated interaction from child to teacher and child to parent, but the app promoted additional interaction patterns between children and parents. The app showed to be useful when presenting and sharing these photo in classes, as it led to a second kind of interaction of children talking in simple language to other children and to their parents about the content they had seen in the calendar app. The app also facilitated interactions between parents to help them reduce anxiety for their children in activities. The app provided many social interactions, but also friendships according to a teacher. The children started becoming friends, as they got insight of the life and special interests of each other, resulting in them initiating contact to each other [23]. Thus, the app facilitated conversational aspects in the form of a network of group dialogues, which is a "likely" characteristic of a smart learning environment [22]. This is an indicator of that technology facilitated the required knowledge and actions for them to engage and initiate social interactions. As a component of an SLE the app not only satisfied its users, but also provided growth and development in social learning by enabling communication and motivating social interactions.

3.2 Shared Experience with Motion Sensors

Using motion sensors have proven to activate cognitively impaired people and support them to have playful experiences [24, 28]. Brooks et al. [24] captured movement from children with learning disabilities to activate immediate multimedia feedback, including a drum or piano sound and an intelligent robotic light. One observation indicated a level of shared experience among the children and the facilitators when they negotiated in the sessions, concerning the flexibility in modes of gestures, sounds, and language. The observation suggests that the semiotic mediation created a space for the children to engage in social interactions that otherwise were unusual in their everyday life according to the personnel [24]. Although the authors provided a space for learning, the social interactions between children and the facilitators could have originated from other factors than the technological contribution. In a similar setup with a Kinect for adults and children with special needs [28], a shared experience occurred. The users moved their body to activate three differently coloured boxes on a projected screen, while watching a projection of themselves moving on the screen. In one case, a caregiver played the game with a child and directed his behaviours. When a second child approached them, the caregiver invited the children to play with each other, resulting in expressions of joy from the first child. Although both children were motorically limited, the first child guided their interactions. Furthermore, the first child expressed a feeling of empowerment, as he was able to support the other [28]. This is an example of how the three types of learning are experienced in the activity: Physical learning occurred when they use their body to explore and play with the system; Cognitive learning occurred when the first child got instructions from the caretaker which he applied in teaching the same knowledge to another; And social learning occurred in the combination of cognitive and physical learning, e.g. when observing and mirroring each other. Therefore, this joint activity has great potential as a component of an SLE.

3.3 Social Learning with Dance and Music

Another shared experience or intersubjective interaction is related to imitation behaviours. The mirror neuron system is activated when imitating another person, as one recognises the self and others [25, 29]. Researchers suggest that the mirror neuron system is less active for people with autism, and they often lack social skills and have poorer imitation behaviour compared to people at their own age [26]. Bugnariu et al. showed this when measuring how well the autistic children imitated the gestures of a robot, such as “waving hello/goodbye” and “good job fist bump”. Although the autistic children performed the movements similar to the robot, they had motor imitation delays in comparison with other children [26]. Previous research has also investigated dance therapy as an imitation activity. Although dance therapy is seldom used, the physical activity provides skill development, social opportunities, and can be made accessible for various people [25]. Reinders [25] found that children with learning disabilities developed physical skills by mimicking the dance movement of professional trainers through video modelling, and they were highly engaged in the process. Similar benefits exist when playing music. This activity activates the mirror neuron system, as the brain codes a relationship between gestures and the produced sounds [29]. Playing music is used in rehabilitation as a media of communication and creative expression. Music therapy transcends the barriers of spoken language and aid patients in communicating when they are verbally challenged [10, 30]. Luhtala et al. [27] designed a music space for people with intellectual learning disabilities, in which the users played bass and guitar with Guitar Hero controllers. They created a prototype that had no disharmonic notes but at the same time allowed them to be creative, based on their abilities. Interviews and observations of the participants showed a feeling of accomplishment and joy when creating music which was uncommon for the participants who lacked the skills to play musical instruments [27]. Thus, dancing and playing music can provide motivation and build confidence if the activity is designed for its users. Dance and music stimulates the mirroring system and hence activates social learning, but it also triggers physical learning in exploring new types of motions and cognitive learning in understanding what a gesture means, e.g. when learning to play new melodies on a music instrument.

The analysis of related work has shown components of SLE in the joint activities for cognitively impaired people. In particular about the convergence of the physical and virtual world to facilitate physical, cognitive, and social learning. The next section provides a brief description of the Danish rehabilitation centre and the design criteria for modeling the centre into an SLE [11].

4 A Collaboration with a Danish Rehabilitation Centre

In this study, we collaborate with a centre that offers rehabilitation for people with cognitive and physical impairments. This centre inhabits 22 people with moderate and severe cognitive impairments who either were born with brain damage (i.e. congenital impairment) or acquired it later. All current residents with congenital impairments use wheelchairs, and they need support from staff members to get activated - both physically and socially. The residents are between 16 and 40 years old, and most of them are around their twenties. They have interests similar to any other adolescents, of which music and games are common interests among the residents. The rehabilitation centre offers a variety of different therapies, such as physiotherapy, ergotherapy, music therapy, speech therapy, swimming therapy, and ridingphysiotherapy. The main purpose of the centre is to prepare the residents for living alone outside the facility without or with few support workers. The prerequisites for the residents to stay at the centre are: They must be motivated for the stay; They must be able to meet intensive rehabilitation; They must be able to benefit from training based on daily activities and chores; They must be able to demonstrate the ability of learning and development; And they must be part of a group and contribute to the social community. These goals and the attributes of an SLE [12] overlap in terms of learning, personal growth, social integration, and motivation. The staff keeps track of how a resident progress within these points, as these qualities are important for their life quality in the community. These rehabilitation goals indicate that the residents should achieve maturity and a sense of responsibility, in relation to their living environment. They need to recognize their potential and learn to utilise their resources, both physically and intellectually.

The administration at the centre seek an SLE solution for transforming the main corridor. Currently, the residents use the corridors to look for social contact, in particular the support staff. They look for other people, observe what is going on, visit employees' offices, and move physically close to support staff having a conversation, possibly to feel part of the social engagement [11]. In other words, they seek social contact, but without getting meaningful social interactions, such as the intersubjective kind. Additionally, people with cognitive impairments do not easily develop such networks, and their closest relationships are typically formed with direct support staff [1, 6]. Therefore, social learning is important for meeting this goal. The staff arranges joint activities for the adolescents where they play and interact with each other in new ways. However, the weekly schedule usually includes no such activities. In collaboration with the rehabilitation centre, we address these needs and focus on social learning as a building block of the SLE at the facility (see Fig. 1). More specifically, the study investigates how a joint activity can facilitate social learning by promoting intersubjective interactions between the adolescents.

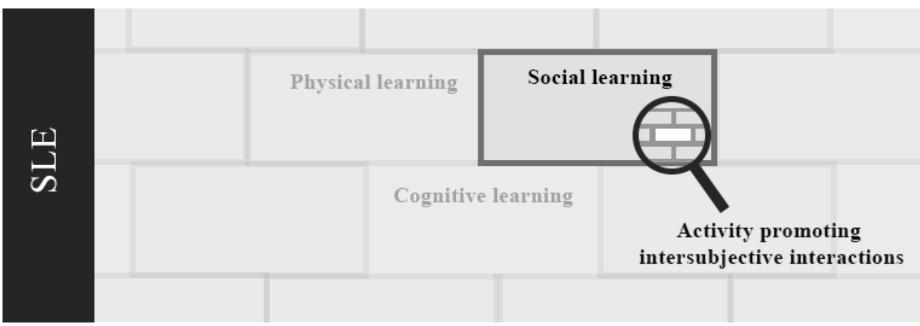


Fig. 1. Illustrating that the activity facilitating social learning is a building block of the SLE at the rehabilitation centre.

5 Establishing Criteria for the Joint Activity

The design of the joint activity must meet the needs from the administration, support staff, and residents at the rehabilitation centre. The stakeholders established SLE design principles in workshops by Krummheuer et al. [11]. We extend this work by extracting information from those workshops by co-creating with the staff and residents through new workshops, focusing on designing and prototyping the medium for the joint activity. Here it is important to mention that we have not sought to replace existing and useful activities, rather the focus is to complement an existing institution for learning to over time become an SLE.

5.1 Smart Learning Ecosystem Design Principles

Learning within an SLE can be designed with the users to preserve their needs, learning methods and environment. Krummheuer et al. employed a Participatory Design (PD) methodology through workshops to investigate and establish design principles for remodelling the rehabilitation centre into becoming an SLE [11]. It is important to mention that the design object at hand was not the de facto SLE, it is better understood as a component in the transformation of the centre to become an SLE. In summary, a bottom-up process through dialogue with the stakeholders resulted in the following five design principles:

1. The users can have **different levels of participation**, such as a passive bystander observing the activity, or an active user engaged in using the system. Thus, the activity must be accessible and spacious for the different participants, and the user interactions must be visible for bystanders.
2. The environment should maintain the **marketplace atmosphere** experienced in the main corridor of the facility. The users should have the possibility of seeing, meeting, and approaching people and activities. In gathering people around the activity, the system should provide information, translation, proximity, and contact.
3. The interactions with the system should include **multimodal ways of communication**, e.g. by using touch, motions, speech and so forth. Moreover, the variance in user needs can addressed with an adjustable activity as in [28] that designs around the various impairments to make the activity accessible for everyone.
4. The environment should take different types of learning into account, i.e. the **physical**, **cognitive** and **social learning**.
5. The activity should be considered as **one building block in the SLE**. It must be integrated at the facility, e.g. in the daily routines of the adolescents.

In addition to the established design principles, the system should be maintained and continuously increase the level of attractiveness as formulated in [12]. In this regard, the system should be valuable (and continue to be valuable) for current residents as well as new residents coming to the facility. The system should induce motivation by appealing to personal interest of the users. Secondly, to create a continuous appeal, the users should experience a state of flow which is achieved by balancing skills and challenges provided for the users of the system [31]. In our context the system should be useful regardless of the skills when playing. Game-based learning combines entertainment with a student-centred approach of achieving learning goals in an effective and interesting way [32]. In a rehabilitation centre, a game can therefore engage the residents in ways that otherwise is difficult in therapy sessions. Within this genre, situated learning presents the learning space is more diffused in comparison to traditional class teachings. It also creates continuity between the physical and virtual learning place [33] which fits with the foundations of an SLE [12].

These design principles were recommended to be implemented in a system to meet the needs of the various stakeholders [21]. It is firmly rooted in our design methodology to approach design challenges on the ground. Designing systems for a highly unique group of people intertwined with situated activities and various degrees of capabilities and contextual factors can, in our design belief-system, not be done from afar.

5.2 Designing for Diversity: Situating the Design of the Joint Activity with Staff and Residents

PD lets the end users of a product be a part of the design process. In this approach, the developers design <u>with</u> the users and relevant stakeholders, instead of designing <u>for</u> them in a user-centred design approach that is based on the data collection of the target group [34]. PD is firmly rooted in the belief that co-ownership and shared decision-making with end users is vital for useful design to emerge. PD has roots in Action Research, thus bringing about change is the objective, but unlike other approaches (such as user-centred design) this change is created in close partnership with the end users. It is a core tenet that the end users themselves are in the best position to determine in which way they need to improve their own situation [35]. It is not our ambition to unpack the full PD story for this article, as the focus is placed on system development and evaluation of it in the scope of an SLE. For readers unfamiliar with PD, consider reading the following seminal works [35, 36]. But to provide a short summary, we carried out a series of design, development and evaluation activities on the ground (see Table 2). We refer to this approach as ‘situating design’ (see for example chapter 2 in [37]). It basically means, that a <u>current</u> improvable situation is reflected with technological possibilities in a design process taking place in the de facto context of the situation, with the ambition to create an improved situation for the future.

Holone and Herstad [38] have noted that expectations and roles are best defined in the beginning of a project when working with impaired people and this phase might be more time consuming than in other projects. Reported studies of co-designing with cognitively impaired people have first used proxies, such as family and support staff, to identify the problems and the possible activities. Following this phase activities of co-design are carried out with the end users and relevant stakeholders through a series of design workshops [23]. Because of the open nature of such design projects, who are relevant stakeholders or becomes relevant might change over time as design ideas and prototypes emerge. Throughout this project we have been in close partnership with a range of stakeholders and future users of our system. In total we conducted eleven sessions with adolescents and staff members, approximately one workshop a week. The aim was to voice the users' opinions about early stages of the prototype and include them throughout the development meanwhile reflecting outcomes with professional support staff (e.g. a music therapist). An overview of our in-situ activities is found in Table 2. After each session (all situated at the centre), we had a dialogue with one or more staff members about ideas, user needs, and the observations from the interactions with the prototype. All sessions were documented with notes and audio/video recordings for further analysis.

Table 2. Overview of the collaboration with the rehabilitation centre, including meetings with the staff members, workshops, and evaluation of the prototype.

Session	Participants	Workshop focus	Methods
1	2 administrators	Pitching ideas.	Presentation
2	The whole centre	Presenting project ideas.	Low-fi demo
3	2 staff members	Further conceptualisation of the project	Sketching
4	2 adolescents 2 staff members	Evaluating how adolescents can move any of their body parts to play a sound as well gauge if they understand the interplay between body and sound.	Usability and functionality reflections
5	1 adolescent 1 staff member	Evaluation of mapping body movement to sounds (e.g. fixed positions, motion speed, and dynamic range).	Usability and functionality reflections
6	2 adolescents 1 staff member	Evaluation of which type of of music is suitable (e.g. music tones, music clips and music progression).	Usability and functionality reflections
7	3 adolescents 2 staff members	Evaluating how the system can reward social interactions (e.g. voiceovers, graphical overlay).	Usability and functionality reflections
8	3 adolescents 2 staff members	Evaluating how the system can teach the users in using the game (e.g. complete tasks, video modelling, and follow video)	Usability and functionality reflections
9	2 adolescents 1 staff member	Evaluating if the users can start the game without help (e.g. press a virtual button enter the room).	Usability and functionality reflections
10	11 adolescents 5 staff members	Deployed the prototype at the centre, available for all residents and staff.	Four days of field testing
11	3 staff members	Reflections on the prototype in use and as a concept.	Focus group interview

For each of these sessions, we conducted a workshop with specific tasks that showed how well an implementation worked. Thus, the purpose of the workshops was to develop, change and converge ideas based on the residents' preferences. We provided concrete examples for the residents to explore and evaluate primarily through yes/no questions from the facilitators or the staff members. Asking them abstract questions can result in a cognitive overload, as many people with cognitive impairments find abstract thinking difficult [39]. Therefore, they are better at refusing or accepting the ideas that are proposed to them, e.g. we asked in the workshops: "How do you move when dancing to music?", "Did you feel like you had control over the music?", "Would you like to be able to skip watching the video if you already know what to do?", "If you were to use this system on your own in your spare time, at what time of the day would you use it?". At the end of each workshop, we conducted an interview with the music therapist to analyse the observations made during the sessions.

In addition to the points listed above, the dialogue with the music therapist included for instance ideas on how to stimulate the residents by controlling the intensity of system sounds. Furthermore, being proxy to the residents, the music therapist provided knowledge about how they behaved with the system in comparison to how they normally behave in terms of their physical and cognitive limitations. Thus, the music therapist contributed largely to the design of the joint activity, and she filled the knowledge gaps of the residents and us when seeking to understand the complexity surrounding our design task. The results from the workshops are reflected in the prototype, as its development has been the main purpose of the activities.

6 Design and Implementation of the Joint Activity

This section refers to the SLE design principles (see Section 5.1) when describing the developed joint activity. To maintain readability these principles are emphasised in bold. In line with these principles, the system can provide physical, cognitive, and social learning. To address the need of social contact, the system promotes interactions between the residents through play with music. The activity is designed for two users, each playing a music instrument. Instead of using physical instruments, the residents can move their body to play music. The physical and virtual world are intertwined on a large screen, showing a projected self-image with a virtual overlay of the game interactions. The users can therefore always see themselves and others on the screen. In exploring and playing with different motions, the users can experience **physical learning** by discovering limitations of the system as well as their own. The rules of the game frame how the residents interact with each other, and in understanding and following them, they can practise **cognitive learning**. In that regard, the learning space becomes diffused rather than traditional, as they are learning by doing. The user can experience **social learning** by mirroring and attuning to another user's movement. However, this complex task requires a sense of physical and cognitive understanding of another user. To promote social learning, the system rewards the users whenever they perform a high-five. This feature can draw the users in proximity and make them more aware of each other's movement and enhance their social interactions. The users can play more together and synchronised rather than playing the game in parallel to each other. To make the users aware of the intersubjective interaction, a voiceover in the system encourages the users to perform high-fives. Thus, the users can interact with content in **multimodal ways of communication** by dancing, moving, and reaching for physical contact of other users when performing intersubjective interactions. For the system to work as a **joint activity**, it is set up in a common room of the rehabilitation centre. This room provides a space to either participate in the activity, observe it, and meet people, creating a similar **marketplace atmosphere** as experienced in the main corridor. This way the joint activity extends beyond the game, and the room itself provides this experience with the music players in the front and close to the screen, while the audience is in the background (see Fig. 2). The audience can be staff members providing support for the music players, e.g. by clapping. The audience can also be other adolescents observing the gameplay or waiting to play the game. Thus, the activity provides **different levels of participation**.

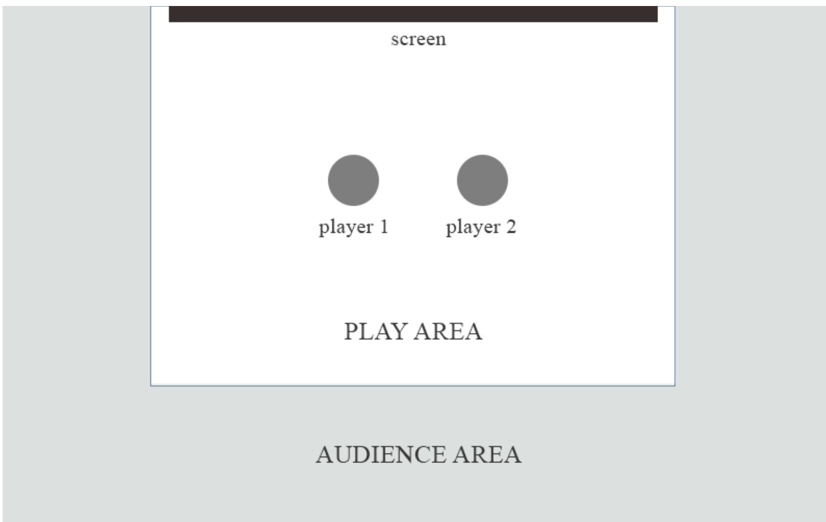


Fig. 2. Sketch of the joint activity including space for playing and observing.

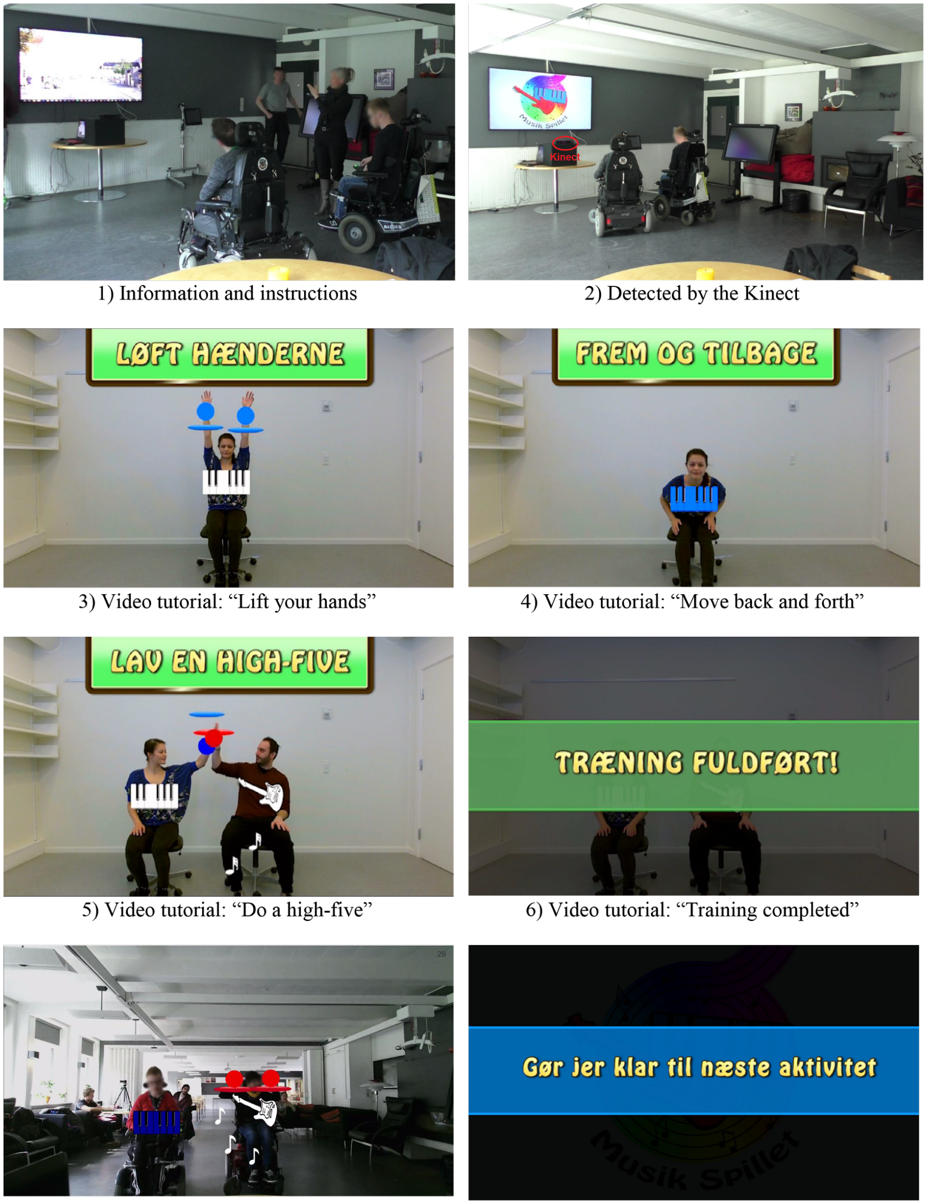
The goal is that the residents can use the prototype on their own or with as little support as possible, transferring the instructor role from the staff and to the system. We learned from the workshops that new users must be taught how to play the game, and they also required instructions from a staff member to feel comfortable with the new technology and challenges. Although the residents had played the game in the workshops before, it is no prerequisite that they remember the game interactions due to challenges with storing long-term memory. Integrating the joint activity in a weekly routine worked in the workshops, and after more than a week some residents start forgetting essential parts of the game. The game is therefore most suitable for the residents when it is integrated in a weekly routine as **one building block in the SLE**. The following sections describe some of the key implementations, concerning how user motions were mapped to sounds, the music system, the reward system of social interactions, and the Kinect setup.

6.1 Procedure of the Game

The users see a self-projected image of themselves that is captured from Kinect V2 and deployed in Unity game engine. The system is designed to run constantly whenever a person is within the detection range of the Kinect, as shown in Fig. 3 illustrating the procedure of the game. The Kinect is set up in a common room at the rehabilitation centre to capture user movement. This setup required a large room with enough space to move around and no objects that occlude the users from the Kinect sensors. When initialised, the system enters a passive mode, waiting for users. If Kinect detects a person, the system becomes active and continues to a video tutorial before continuing to an actual play session. The tutorial ensures that new users learn how to play the game and remind experienced users of the game interactions. The instructor in the tutorial video gives verbal instructions and shows the different interactions: moving hands, moving wheelchair, and performing high-fives. The tutorial video is paced for the adolescents to have time to imitate the movements, and the instructor shows the interactions repetitively. Although, the instructor encourages them to imitate the motions of the instructor, it is not a requirement for continuing to the game. After the tutorial, the users start the game after a countdown. A game session last around 2 minutes, corresponding to the duration of the underlying soundtrack. After each play-through, the users get a short break before continuing to the next song, allowing turn-takings if other residents wish to play.

6.2 Mapping Motions to Sounds

The users hear their instruments when they move, and they can see themselves with applied visual feedback on a large screen (see Fig. 4). The first two workshops showed that the adolescents were eager to play music by moving their body. When they were not directed in how to move, they mainly moved one hand, two hands, or their wheelchair. The residents have various preferences and limitations in their movements, which led to designing a dynamic and relatively versatile interpretation of their interactions with the system. For the hand movements, a virtual line separates the two different inputs. This line is calibrated within the possible movement range of each individual hand, so that the line ascends when the user reaches higher. By moving their wheelchair back or forward they also perform these two inputs, producing the same sounds as when moving their hands. In this approach, the users are not restricted in their motions, as any movement can be an input for the system to generate a sound output. The system only plays pre-recorded music; thus, the users do not produce or improvise music, but rather choose when it should be played. An underlying beat with a fixed duration keeps playing throughout the game to avoid complete silence and to stimulate the users into moving. Once the beat finishes, the game ends as well. The user plays the music corresponding to his/her instrument, and the output is always timed to fit the underlying beat. Thus, they are never out of beat, and a user get stimulated by their own music as well as others.



1) Information and instructions

2) Detected by the Kinect

3) Video tutorial: “Lift your hands”

4) Video tutorial: “Move back and forth”

5) Video tutorial: “Do a high-five”

6) Video tutorial: “Training completed”

7) Playing the game

8) Break scene: “Get ready for the next activity”

Fig. 3. The procedure of the game, showing how the users start the system, how they learn the game interactions, how they play, and how they continue to the next game session.

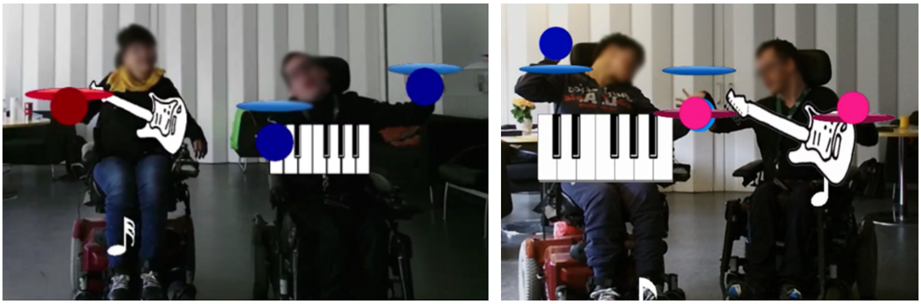


Fig. 4. Two users playing the game (left) and performing a high-five interaction (right).

6.2 Rewarding Social Interactions

When the two users are active at the same time, the system increases visual and auditory feedback as reward. The music will sound fuller when both instruments are active, and when playing simultaneously musical notes are displayed on the screen. This system encouragement was designed to give incentive to play together and pay attention to each other rather than playing individually.

The workshops revealed that a resident's activity would decrease over time unless they regularly got verbal encouragement to move and interact with each other. This was addressed in the reward system by including voiceovers that praise the users with phrases, such as: "Good teamwork" and "You are doing really well". The feedback system also encourages the users to perform high-fives with each other to celebrate their achievements. The adolescents had previously performed the gesture in the first workshop when they celebrated their good efforts in the game. Thus, we implemented the high-five interaction, as it might come naturally for them in the game setting. The system detects a high-five when the position of the hands of two users intersect (see Fig. 3). As feedback it displays animated fireworks and plays the sound of people applauding them. This feature was implemented to promote more physical interactions between the users and forcing them to be aware of their physical surroundings. In other words, a successful high-five indicates that the two users are attuned to each in the intersubjective interaction.

7 Evaluating Intersubjectivity in the Joint Activity

The study investigates how the residents interact with each other when playing the game. Although people express social interactions and intentions in various ways, we focus on the high-fives as the intersubjective interactions encouraged by the system. In this context, we predict more occurrences of intersubjective interactions when increasing the frequency of the encouragement from the system. This prediction is based on the observations of the adolescents during the workshops. When the staff members encouraged and instructed them to play together, they reacted almost instantly. Hence, we assume to observe a similar response with the reward system. To investigate our prediction, we annotate the discourses of intersubjectivity (e.g. the number of high-fives performed by the users). Moreover, we measure for how long the participants were actively playing at the same time, as it indicates how synchronised and how engaged they are in the activity. Lastly, a qualitative study evaluates the prototype and describes how the participants used the game. These findings are analysed from observations from the game sessions and a focus group interview with three staff members.

7.1 Data Collection: Video Analysis and Game Metrics

A coding scheme is used for annotating the discourses of intersubjectivity, based on video recordings. The categories were adapted from a study of the emerging behaviours of affect attunement in a music therapeutic setting [9, 10]. The categories were modified with the music therapist according to the interactions in the game (see Table 3). The first four categories describe discourses of each user, while the last category accounts for interruptions from any observer. The discourse analysis is cross-validated by a second coder who annotated 10% of the dataset. The two coders analysed one participant at a time and annotated instances of each sub-code with timestamps. The coders counted a new instance of the same code every 5 seconds after the initial count.

Table 3. Categories and codes for annotating intersubjectivity discourses.

Category	Code	Description
Physical approach	1.a	Attempting to do a high-five
Physical contact	2.a	High-five when getting encouraged by the system
	2.b	High-five without getting encouraged by the system
Countenance	3.a	Looked directly at the other user.
	3.b	Looked directly at observers/facilitators
	3.c	Look around to orientate
Communication	4.a	Make a sound/speaking
	4.b	Body language, gestures and use of communication board
Observer	5.a	Speech from observer
	5.b	Verbal praise/Clapping
	5.c	Physical approach from an observer

The data collection of the game metrics proceeded automatically in the program. The game metrics describe how much time in seconds the user spent on synchronous and asynchronous actions (see Table 4). The durations of the games are of unequal size, as they depend on the length of the music piece. A game can be 127 or 169 seconds long, and the metrics are normalised to these lengths.

Table 4. Synchronous and asynchronous actions logged as game metrics.

Metrics	Synchronous / asynchronous action
PlayedTogether	Time spent playing music alone while the partner gives no input
PlayedAlone	Time spent playing music at the same time as the partner
BothDidntPlay	Time spent when both users give no input

7.2 Test Procedure and Participants

The prototype was deployed for four consecutive days during daytime, and all the residents at the rehabilitation centre were invited to participate. The facilitators informed everyone at the centre that the system was set up in the common room, freely available for them to use. The residents participated when arranged by the staff or in recess while they roamed in the corridor. At least one facilitator was present in the room to assist the participants if needed. The staff members supported and explained the game to the new users, while experienced ones were invited to play primarily without support. A few staff members watched a session or two to analyse and share observations with the facilitators. Eleven residents participated during the four days, and four of them had tried an early state of the game prototype. The adolescents played the game with each other whenever possible; otherwise, they played with a facilitator or staff member. For the data analysis we only include games with only adolescents playing together, hence, we excluded game sessions played alone and game sessions with assistance from staff members. To this end, we selected 37 out of 80 games for the dataset.

8 Results Indicating Intersubjectivity

The study evaluates the game prototype based on quantitative and a qualitative study. The former investigates the effect of promoting intersubjective interactions through the voiceover by comparing one group of residents receiving fewer encouragements (Group 1) in contrast to another group (Group 2). The intersubjective interactions are measured in the annotated video data and the logged game metrics. The latter analyses general uses of the game based on a dialogue with three staff members. The dialogue focused on the user enjoyment, factors influencing their behaviour (e.g. group dynamics and turn-takings), and learning possibilities with the system.

8.1 Quantitative Results: Video Annotation and Game Metrics

The correlation coefficient between the two coders is computed using Cohen's kappa coefficient for each code (see Table 5). The correlations are considered as fair and good (above 0.40), and most of them indicate excellent agreement (above 0.75) [40]. A Kruskal–Wallis test by ranks was applied between Group 1 and Group 2 due to non-normal distribution of the data. Significant differences between the groups were found the code about verbal praise/clapping of the observer (code 5.b) and in the codes about physical approach, physical contact, countenance, and communication (category 1-4). The mean values show that Group 2 had significantly more instances of intersubjectivity for nine of the codes, whereas Group 1 had significantly more instances concerning looking around to orientate (code 3.c).

Table 5. Kappa values computed between the two coders for each code, mean values of the counted instances, and p-values computed between Group 1 and Group 2. *p-value below 0.5.

Code	Description	Kappa	Mean 1	Mean 2	p-value
1.a	Attempting to do a high-five.	0.58	0.73	7.36	**0.0000***
2.a	High-five encouraged by the system.	1.00	1.88	6.18	**0.0011***
2.b	High-five not encouraged by the system	1.00	1.35	3.73	**0.0053***
3.a	Look at the other user	0.77	10.65	20.36	**0.0077***
3.b	Look at an observer	0.68	4.46	19.18	**0.0000***
3.c	Look around to orientate	0.60	1.38	0.09	**0.0248***
4.a	Make a sound/speaking	0.77	3.23	8.55	**0.0114***
4.b	Body language	0.84	0.19	6.09	**0.0259***
5.a	Speech from observer	0.78	7.85	12.09	0.8940
5.b	Verbal praise/Clapping	0.92	1.62	6.64	**0.0011***
5.c	Physical approach from an observer	0.96	1.88	9.09	0.0822

A Kruskal–Wallis test was applied on the logged metrics between the two groups (see Table 6). Group 2 spent significantly more time playing together (PlayedTogether), while they spent significantly less time giving no input (BothDidntPlay) compared to Group 1. No difference was found between the groups when the participants played alone (PlayedAlone).

Table 6. Normalised mean values and p-values between the two groups for each game metric. *p-value below 0.001.

Metrics	Mean 1	Mean 2	p-value
PlayedTogether	0.33	0.57	**0.0001***
PlayedAlone	0.35	0.32	0.7000
BothDidntPlay	0.32	0.11	**0.0000***

8.2 Discussion of Quantitative Results

The results from the logged metrics and the discourse analysis show significant more instances of intersubjectivity in Group 2 compared to Group 1. The analysis of the game metrics supports the initial prediction, as Group 2 spent significantly more time playing together. It suggests Group 2 are more synchronised and attuned. The participants in Group 2 had significantly fewer breaks together where both users gave no input to the system. The result advocates that Group 2 played more together, and hence, have more time to engage in intersubjective interactions. The findings from the video annotations also supports more engagement in Group 2. The discourse analysis showed this finding in discourses of physical approach each other, physical contact, countenance, communication, and when observers praised or clapped. The video data showed that the high-fives interaction and high-five attempts in Group 2 occurred with and without the system prompting for the interaction. This suggests that the encouragement from the system influenced the participants' attention towards performing the intersubjective interaction. In addition, the participants in Group 2 spent significantly more time looking at their team player and the observers, indicating higher awareness of others. The discourse of looking more frequently at the observers can be connected to how the observers behaved, as the observers praised the users significantly more in Group 2. Although insignificant, annotations from the video analysis also show higher participation from the observers for Group 2 in the form of speech and a physical approach, and they can have influenced the other kinds of behaviours. As a behaviour is not a single instance but a successive sequence of actions, one action influences another; and our results suggest that more frequent high-fives interactions increased the frequency of praises and applause from the observers. On the other hand, a pitfall in the test conditions is the various uncontrolled variables, meaning that the significant findings between the groups can be due to other factors than the change in the voiceover encouragements.

The discourse analysis showed that Group 1 had significant more instances of looking around to orientate oneself while moving. This can be explained by how the participants in Group 2 move their body to play music. Two of them only moved their arms to play music, and consequently, when never moving their wheelchair they have less incentive to orientate themselves. Thus, some significant findings can have been influenced by specific users due to a small sample size. This might also be the case for the significant difference in how frequent the participants communicated. These discourses are most likely based on how well the participants can express themselves verbally and with gestures, or how eager they are in communicating while playing the game.

8.3 Discussion of Qualitative Results: Focus Group Interview

The observations during the game sessions were generally positive responses to the game. The adolescents either smiled or made sounds to communicate their excitement. Some participants experienced a level of flow that gave them reason to continue playing until they became visibly tired. At times they appeared so tired that they started becoming passive. Consequently, a facilitator or staff asked them to take a break, but the adolescents often responded that they wanted to keep playing. Especially, two adolescents communicated their interest and enjoyment in the game. The first resident was able to express himself with regular speech and held a full conversation while playing the game and even after the game sessions. He expressed great interest in the project and the people behind it, e.g. by asking if we had used his feedback from the workshops. The other highly engaged resident spelled "crazy", "funny", or "concert" with his communication board while using thumbs up gestures.

After the game sessions, he told other people about his experience with the game in a group therapy session, in the corridor, and his family when they were on visit.

Social interactions are a network of actions based on different incentives. The focus group interview presented some of the incentives or factors that can have influenced the residents' interactions in the game. One factor is the group dynamics of the users. According to the staff, the adolescents spend a large amount of energy on attempting to read another person, and as a result, they either mirror the other's behaviour or restrain their behaviour when feeling too insecure. In the opposite case with a familiar person, they can focus more on the game or activity, and thereby they often become more actively engaged, with increased intensity of their motions. Another factor influencing their behaviour is the number of people in the room, and if the users have to consider turn-takings with residents waiting to play. When more than two adolescents were present at the time, we facilitated turn-takings and used the break scene between game sessions, to confirm that the resident agreed to let someone else play. We observed that some of the residents became aware of the turn-takings rules introduced to them, and they would actively ask or indicate their participation in the rotation, showing social awareness. Potentially, other residents can learn the same type of behaviour by experiencing such scenarios that challenge their social behaviour.

The system convinced the staff members that it is usable as a mean for entertainment and therapy, regarding physical and social learning. During the four testing days, two physical therapists explored how the game could be used in their therapy sessions. They lifted the weaker arm of a resident to activate it, moved the wheelchairs, laid on the ground, and used other equipment. One of the physiotherapists stressed the importance of the residents moving their body and the challenge of motivating them in physical therapy. The physical exercise presented in a game helps in boosting their energy level, and hence, it is a fitting activity for recess rather than being idle. This helps motivate and activate them to do more than sitting still. The residents also broke out of their regular habits and movement patterns to accommodate to the game, e.g. a resident moved her arms rather than pushing the wheelchair with her legs as she normally would. Another benefit of the system is that the residents stimulate their need for social contact when playing with each other. Particularly, the verbal encouragements from the system and the subsequent interaction of initiating a high-five is important for this stimulation. It supports and to some extent replaces the staff support that the residents need, aiding their confidence and motivation. This benefit is reflected in their behaviour, when the residents performed well in the game without support from the staff and kept playing more games in a row. Especially, one resident expressed more confidence with the game after playing it multiple time. In our first encounters in the workshops, she constantly needed support workers to confirm her performance, but she grew confident in six weeks and played the game without any support.

9 Discussion

This project has transformed the main common room at the rehabilitation centre to a space for joint activity, facilitating social learning as a part of the SLE design principles. We designed the activity to include different types of learning as provided in therapy at the centre and balanced the challenges with the skill level of a resident. In co-creating with the staff and residents, we designed how the users should interact with the technology and with each other through workshops at the centre. Designing with the users, gave us the tools to understand the affordances for this user group when learning in a playful experience. One limitation of these workshops is that the residents had difficulties of abstract thinking and expressing themselves. Asking the residents questions related to what they know from their world, such as how they move/dance to music, gave much better response from them compared to extracting knowledge of their perceptions/preferences regarding the prototype. For future work we recommend having a dialogue about their expectations/ideas to achieve a full PD, as we had with the music therapist. Other approaches can be considered for similar target groups, such as more generic (action-based) meta-design [42].

In the design process, we focused on including as many residents as possible, and the system should highlight their abilities, instead of focusing on their limitations. Therefore, we chose to work with motion sensors as in [24, 28] to capture user movement and social interactions. In creation of the prototype, we developed a system in line with the design principles established in workshops at the rehabilitation centre [11]. Firstly, it includes multiple users who can play music together, while spectators can observe the interactions on a large screen. Secondly, we proposed to install the system in a common room, where people can see the activities and meet other people from the centre. Thirdly, the users interact with the system through different types of movements and receive audio visual feedback. Lastly, the users can experience three types of learning: cognitive learning in following rules to play music, physical learning as they are encouraged to move their body, and social learning in interacting with other players.

Two other objectives of the SLE were addressed in the study. One objective was to maintain the appeal in the activity, as formulated in [12]. The appeal was addressed in a playful context within a game that motivates the residents, in which the design of flow should maintain and continuously increase the level of attractiveness. The other objective provides independence for the residents when using the system without relying on the help from personnel. The residents can benefit from doing activities independently as the practise becomes useful for them when they have to live in the community. It also moves resources from the staff members to have time for other work tasks. We provided independence of support workers, using a voiceover that encourages and directs the users. Moreover, the game interactions can be performed with little movement of the residents, and the largest challenge is performing a high-five together. This interaction provides a practise for the residents to adapt and attune to each other in the joint activity. Thus, the high-fives are the indicator of intersubjectivity between the residents when we deployed the prototype at the rehabilitation centre.

The staff pointed out the potential of using the game as a tool for physical therapy. They also commented that the game appeared to have a motivating effect on the residents to perform movements that otherwise were difficult to get them to perform. Thus, this motivation from the game enhances their physical learning. The staff also explained that certain residents would change their behaviour to accommodate both the game but also whoever they were playing with at the given time. This way the rules of the game, influenced their behaviour to be more attuned with each other and their surroundings, whereas a staff member normally would correct their behaviour. This applies when the residents had to adapt to each other's movement and position themselves to perform a high-five, and that they have to orientate themselves when they move backwards and forwards in their wheelchair. Thus, playing the game for longer period can benefit not only physical, but also cognitive and social learning. The joint activity was extended to any observers in the common room. As an audience at a music concert they gathered around the scene and cheered on the adolescents. In this regard, the joint activity can also invite family and friends both as audience and as music players, as different group dynamics can stimulate new social interactions for a resident which is important for social learning and maintaining social relations with people outside the centre.

The prototype can be improved in various ways to be useful for the staff and the residents at the centre. A first step would be to extend the verbal encouragements from the system with an Artificial Intelligence (AI) that detects and logs interactions for each user separately via facial recognition. Thus, creating personal profiles and knowing learner characteristics can support a personalised learning experience [41]. In context of rehabilitation, the therapy session can adapt to the physical, cognitive and social limitations as well as the learning progress of an individual, e.g. it can give personal feedback according the user interactions and previous sessions. This way the AI can assist the residents so that they can use the system without help from staff in recess. Implementing such AI is in line with the SLE conventions in [10], as the AI can more effectively and efficiently guide the residents in the game interactions, while the support workers are experts in guiding the residents outside the game. The pitfall of the system is that the residents are unable to bring the joint activity with them when they leave the rehabilitation centre. Instead, they bring their social skills gained from the experience, and therefore, their learning progress is essential for the effect of the joint activity.

10 Conclusion

In this article we have presented how cognitively impaired people can be activated to perform social interactions in a game. The system was designed to transform a common room at a Danish rehabilitation centre to a place for people to interact by playing music together, promoting social learning as a component in modeling a smart learning ecosystem at the centre. For this purpose, we developed a multiuser system, using music and dance to facilitate a joint activity with music players and an audience. The feedback system gave encouragements and instructions to activate the users in performing social interactions. Increasing the frequency of the feedback, increased their interactions with each other. Even though other factors such as group dynamics can have influenced the observed intersubjective interactions in the game, the system opened for interactions between people who normally would not engage with each other by themselves. Furthermore, the activity motivated the residents to move their body in new ways while adapting to each other's movement. Thus, the system has potential for physical, cognitive, and social learning, and according to the support staff some of the residents already improved in these aspects within four days of deploying the prototype at the rehabilitation centre. Having carried out one full system life cycle from conceptualisation, design, implementation to analysis of the system, we now feel confident in continuing the work.

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References

1. Whitehouse, R., Chamberlain, P., O'Brien, A.: Increasing Social Interactions for People with More Severe Learning Disabilities Who Have Difficulty Developing Personal Relationships. Journal of Learning Disabilities 5 (3): 209–20 (2001).
2. Hogg, J.: Competence and quality in the lives of people with profound and multiple learning disabilities: Some recent research. Tizard Learning Disability Review, 3(1):6–14 (1998)
3. Emerson, E., Hatton, C.: Moving out: The impact of relocation from hospital to community on the quality of life of people with learning disabilities. HM Stationery Office (1994)
4. Howard, S., Spencer, A.: Effects of resettlement on people with learning disabilities. British Journal of Nursing, 6(8):436–441 (1997)
5. Walker, C., Ryan, T., Walker, A.: A step in the right direction: people with learning difficulties moving into the community. Health & Social Care in the Community, 3(4):249–260 (1995)
6. Joyce, T., Close, W.: Auditing Service Quality in Residential and Supported Housing Services: Creating Conditions for Service Improvement. Tizard Learning Disability Review 2 (4): 18–26 (1997)
7. Burton, M., Kagan, C.: Social Skills for People with Learning Disabilities: A Social Capability Approach'. London: Chapman and Hall (1995).
8. Bullowa., M.: Before speech: The beginning of interpersonal communication. CUP Archive (1979)
9. Raglio, A., Traficante, D., Oasi, O.: Autism and music therapy. intersubjective approach and music therapy assessment. Nordic Journal of Music Therapy, 20(2):123–141 (2011)
10. Raglio, A., Traficante, D., Oasi, O.: The evaluation of music therapy process in the intersubjective perspective: the Music Therapy Rating Scale. A pilot study. Pragmatic and Observational Research, 2, 19-23 (2011).
11. Krummheuer, A. L., Rehm, M., Lund, M. K. L., Nielsen, K. N, Rodil, K.: Reflecting on Co-Creating a Smart Learning Ecosystem for Adolescents with Congenital Brain Damage, Springer, (2017). (Smart Innovation, Systems and Technologies).
12. Giovannella, C.: Smart Learning Eco-Systems: "fashion" or "beef"?.Journal of e-Learning and Knowledge Society, 10(3) (2014)
13. Chang, M., Li, Y.: Smart Learning Environments. Lecture Notes in Educational Technology. Springer-Verlag (2015)
14. Bandura, A., Ross, D., Ross, S. A.: Transmission of aggressions through imitation of

aggressive models. Journal of Abnormal and Social Psychology, 63, 575–582 (1961)
15. Mayer, R. E.: Cognitive Learning. In Encyclopedia of the Sciences of Learning, edited by Prof Dr Norbert M. Seel, 594–96. Springer US (2012)
16. Cross, E. S.: Observational Learning of Complex Motor Skills: Dance. In Encyclopedia of the Sciences of Learning, edited by Prof Dr Norbert M. Seel, 2491–93. Springer US (2012)
17. Simsek, E.: Social Learning. In Encyclopedia of the Sciences of Learning, edited by Prof Dr Norbert M. Seel, 3107–9. Springer US (2012)
18. Bartolomé, N. A., Zorrilla, A. M., Zapirain, B. G.: A Serious Game to Improve Human Relationships in Patients with Neuro-Psychological Disorders. In 2nd International IEEE Consumer Electronics Society's Games Innovations Conference, 1–5 (2010)
19. Hayes, M. L.: Social skills: The bottom line for adult ld success. Retrieved November, 21:2007 (1994)
20. Murray, J., Goldbart, J.: Augmentative and alternative communication: a review of current issues. Paediatrics and child health, 19(10):464–468 (2009)
21. Giovannella, C., Rehm, M.: A critical approach to ICT to support participatory development of people centered smart learning ecosystems and territories. Aarhus Series on Human Centered Computing, 1(1), 2 (2015)
22. Spector, J. M.: Conceptualizing the emerging field of smart learning environments. Smart Learning Environments, 1(1), 1-10 (2014)
23. Brereton, M., Sitbon, L., Abdullah, M. H. L., Vanderberg, M., Koplick, S.: Design after design to bridge between people living with cognitive or sensory impairments, their friends and proxies. CoDesign, 11(1):4–20, (2015)
24. Brooks, A., Petersson, E.: 'Recursive Reflection and Learning in Raw Data Video Analysis of Interactive "Play" Environments for Special Needs Health Care'. In Proceedings of 7th International Workshop on Enterprise Networking and Computing in Healthcare Industry. 83–87 (2005).
25. Reinders, N.: 'Dancing with Autism Spectrum Disorder: A Mixed Methods Investigation'. Theses and Dissertations (Comprehensive) (2015)
26. Bugnariu, N., Young, C., Rockenbach, K., Patterson, R. M., Garver, C., Ranatunga, I., Beltran, M., Torres-Arenas, N., Popa, D.: Human-Robot Interaction as a Tool to Evaluate and Quantify Motor Imitation Behavior in Children with Autism Spectrum Disorders. In Virtual Rehabilitation (ICVR), 2013 International Conference on Virtual Rehabilitation (ICVR), 57–62 (2013)
27. Luhtala, M., Kymäläinen, T., Plomp, J.: Designing a Music Performance Space for Persons with Intellectual Learning Disabilities (2011).
28. Borum, N., Christiansen, L.G., Jepsen, H.W., Kristensen, K., Lam, J.N.T., Lindholm, D., Brooks, E.P., Brooks, A.L.: The effects of mirroring in a playful virtual environment: a comparative study with children and adults having impairments. In International Conference on Universal Access in Human-Computer Interaction (pp. 427-435). Springer, Berlin, Heidelberg (2013)
29. Yuan, T., Chen, W., Shan, C, Rocha, N., Arias-Carrion, O., Paes, F., Sa, A. de, Machado, S.: Activity-Dependent Neurorehabilitation Beyond Physical Trainings: "Mental Exercise" Through Mirror Neuron Activation. CNS & Neurological Disorders - Drug Targets 14 (10): 1267–71 (2015)
30. Wendy, M. L., Baker, M.: The Use of Music Therapy in Neuro-Rehabilitation of People with Acquired Brain Injury. British Journal of Neuroscience Nursing 5 (4): 150–56 (2009).
31. Czisikszentmihalyi, M.: Flow - The Psychology of Optimal Experience. Harper & Row (1990)
32. Manero, B., Torrente, J., Serrano, Á., Fernández-Manjón, B.: Are serious games working as expected?. In Emerging Issues in Smart Learning Springer Berlin Heidelberg, 89-96 (2015)
33. Lave, J., Wenger, E.: Situated learning: Legitimate peripheral participation. Cambridge university press (1991)

34. Sanders, E. B. N.: From user-centered to participatory design approaches. In Design and the social sciences: Making connections, pages 1–8. CRC Press (2002)
35. Schuler, D., Namioka, A.: Participatory design: Principles and practices. CRC Press (1993)
36. Spinizzi, C.: The Methodology of Participatory Design. Technical Communication. 163-174 (2005)
37. Svabo, C., Simonsen, J., Hertzum, M., Samson, K., Hansen, O. E., Strandvad, S. M.: Situated Design Methods. (2014).
38. Harald, H., Herstad, J.: Three tensions in participatory design for inclusion. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2903-2906. ACM (2013)
39. Galliers, J., Wilson, S., Roper, A., Cocks, N., Marshall, J., Muscroft, S., Pring, T.: Words are not enough: empowering people with aphasia in the design process. In Proceedings of the 12th Participatory Design Conference: Research Papers-Volume 1, pages 51–60. ACM (2012)
40. Fleiss, J. L., Levin, B., Paik, M. C.: Statistical methods for rates and proportions. John Wiley & Sons (2013)
41. Graf, S., Kinshuk, K. B., Khan, F. A., Maguire, P., Mahmoud, A., Rambharose, T., Zhang, Q.: Adaptivity and Personalization in Learning Systems based on Students' Characteristics and Context. In Proceedings of the International Symposium on Smart Learning Environments, 2012, 33-36 (2012)
42. Fischer G., Fogli D., Piccinno A.: Revisiting and Broadening the Meta-Design Framework for End-User Development. In: Paternò F., Wulf V. (eds) New Perspectives in End-User Development. Springer, Cham (2017)