ComFiM: A Cooperative Serious Game to Encourage the Development of Communicative Skills between Children with Autism

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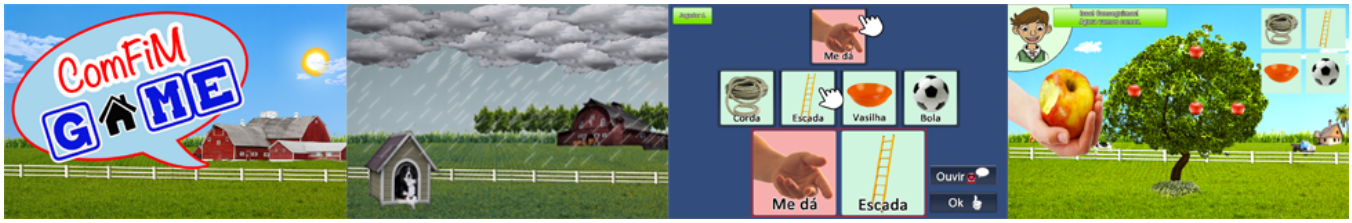

Figure 1: *ComFiM Game*

Abstract

About 50% of people with autism have problems in developing any kind of functional language. Working with the concept of serious games and with the impairments that children with autism often have in the communication field, this paper presents the development of a game called ComFiM. ComFiM aims to encourage communication between people with autism as an interactive and dynamic process, first building player knowledge while interacting with a virtual character, and later encouraging communication with another human player in a muti-player segment, using the knowledge gained in the single player segment. Results show that aesthetic experiences addressed in ComFiM aligned to a multi-player environment and that the proposed game architecture has been able to create situations of communication between the players.

Keywords:: Autism, Communication, Serious Games, Cooperative Game, Multi-player

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1 Introduction

Autism is a developmental disorder mainly characterized by impairments in skills related to social interaction, communication, and repetitive and restricted behavior and interests [Cunha 2011] [Silva et al. 2013].

In the communication field, about 50% of the people diagnosed with autism have problems in developing any kind of functional language [Massaro and Bosseler 2003]. Besides, those who develop some kind of language usually have delays in their languages milestones, such as in verbalizing their first words or in building communicative phrases. Others learn some words but show difficulties in using them to interact with others.

Games have been used to assist children with autism [de Urturi et al. 2011] [Moore and Calvert 2000]. Nowadays, a considerable number of games have been developed for mobile devices. Besides the mobility itself and the easier interaction through multi-touch, one of the advantages of using tablet devices, is the potential to use the device to engage more than one user at a time in a social context, when applying this technology aligned to cooperative strategies [Gal et al. 2009].

With this knowledge, we aimed to develop a game for tablet devices to encourage communication among children with autism. This game is called ComFiM (acronym in Portuguese for Picture Exchange Communication for Multitouch Devices). ComFiM was developed taking into account specific features of the target group, which consisted of children with a severe degree of autism. The game development also focused on providing a multi-player environment so that these children, in partnership with other children (with autism or not) and/or with people who interact with then, such as therapists or family members, could improve or acquire some communicative skills.

The game was developed with the assistance of an expert, in order to better understand the needs of the target group and to provide a game suitable to them.

The main contributions of this study are:

- Development of a cooperative multi-player game to encourage communication as an interactive and dynamic process;
- Provision of an environment that can be customized according to the target group needs;
- Evaluation of the contribution of ComFiM in generating communicative situations and the intentions of communication observed in the children during the experiment.

The remainder of this paper is organized as follows: Section 2 describes some concepts needed for the comprehension of this paper and the game development; Section 3 presents some previous work related to the proposed one; Section 4 relates to the game development process; and finally, Section 5 presents the results achieved with a group of children with autism who played the developed game.

2 Concepts

In this section, we describe some concepts utilized throughout the paper that are important for its understanding, such as the concept of games, specially the serious games category, and the MDA framework from Hunicke et al. [Hunicke et al. 2004].

2.1 Games

According to Huizinga [Huizinga 2010], the idea of game is inherent to human culture and to society. Still, a definition of game has been sought by many authors [Huizinga 2010] [Crawford 1984] [Salen and Zimmerman 2003]. It is in [Jesper 2003], a work that compiles and synthesizes the previous game definitions in a new one, that we find the definition of game that we use throughout this work: games are a formal system delimited by rules in which the player decides to take part, and exerts some effort to influence

it's results, being emotionally attached to the result, and the consequences of the game are negotiable and optional.

Games can be classified in different categories [Crawford 1984] that help group similar games together for comparison and discussion. Many kinds of categorization exist, such as Crawford's [Crawford 1984] and Gularte's [Gularte 2010, pp.142–165], which is based on previous work by Crawford and Rollings & Adams [Rollings and Adams 2003]. In Gularte's taxonomy, games can be classified according to:

Playability Action and ability, Shooting, Strategy, Simulation, Sports, Educational

Number of players Single-player, Multi-player

Specific themes Adult, Arcade, Advergames, Artillery, Music, Puzzle, Pinball, Interactive movies, Labyrinth

Genre Adventure, War, Adult, Action, Terror, Police, Fantasy, Children

In this sense, "playability" refers to the larger set of skills that are involved in the mechanics of the game. Gularte's work [Gularte 2010] describes the larger categories and its subsets. "Number of players" relates to the number of players involved in the game at any time. For an example, Mario Party games can be played in single-player or multi-player modes. "Specific themes" [Gularte 2010] relates to games that are considered niche games or have a specific playability that deserves a category apart from previous classifications. "Genre" [Gularte 2010] refers to the story and script of the game's narrative.

According to Koster [Koster 2004], the fun that players look for in games they choose to play is related to their abilities in overcoming the challenge proposed by the game, often in the form of patterns that the player must recognize, understand and assimilate. The kind of challenge that brings fun to the player is dependent on many factors that can be grouped into motivations for demographic classifications [Koster 2004] [Novak 2011] and psycho-types [Bartle 1996].

To delimit our work, we focus on computer games and video games, games that are mediated by an electronic computer apparatus. Furthermore, according to Gularte's combined taxonomy [Gularte 2010], the game developed in this work can be classified as an educational puzzle game, as its purpose is to develop player's skills and its mechanics involve the resolution of puzzles. Specifically, it pertains to a certain subset of educational games, the serious games, discussed in Section 2.2.

While many games were first designed as single player or competitive multi-player [Fullerton et al. 2008] [Novak 2011] games, ComFiM was designed as cooperative multi-player game, where more than one player is necessary and all players must work together to achieve a common goal. The decisions and mechanics used to develop this kind of game are described in Section 4.

2.2 Serious Games

The idea of blending computer games and education had its dawn in 1980 with the game Army Battlezone, developed by Atari to train soldiers in battle situations [Modesto and Scavaciniline 2013]. The concept of serious games [Fullerton et al. 2008, p.93] is associated with the education and learning of new concepts and skills, but can also work for training and simulation of various activities in real life, such as surgery and military activities [Novak 2011].

Although games have always been associated with the learning or development of skills through challenge [Koster 2004], [Huizinga 2010], or mainly entertainment [Novak 2011], according to De Urturi et al. [de Urturi et al. 2011], a serious game should have an evident connection between the real and virtual world, and a purpose beyond pure entertainment.

In this sense, ComFiM can be viewed as a serious game in that its purpose is to enable the players, children with autism, to develop and improve communication skills while entertaining themselves with a puzzle game.

2.3 The MDA Framework

The Mechanics, Dynamics and Aesthetics framework [Hunicke et al. 2004] was developed to serve as a tool to understand the game from both the perspectives of the player and the developer, allowing a two-sided view of the game. This framework analyses the relationships among the mechanics the game uses, it's interactions with the player, called dynamics, and the aesthetic experiences it aims to make the player experience.

From the perspective of the mechanics developed, the developer can project aesthetic experiences for the player. From the aesthetic experience and the dynamics of the game mechanics, which are the interactions of the player and the mechanics designed, the player can understand and evaluate the relationship between the mechanics of the game that can lead to completing the game's goals.

Figure 2 symbolizes this approach, where M stands for Mechanics, D stands for Dynamics and A stands for Aesthetics.

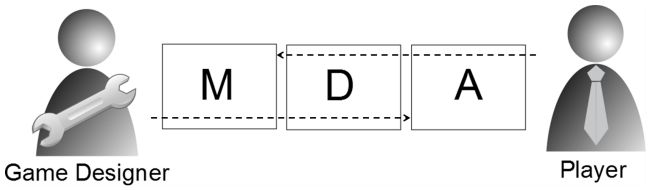


Figure 2: *The MDA Framework. Perspectives of the game designer and the player.*

There are eight aesthetic experiences suggested in the taxonomy proposed by Hunicke, LeBlanc and Zubek [Hunicke et al. 2004], but they are not limited to these. These aesthetic experiences can be viewed as a more directed vocabulary that relates to the fun that players look for during the play. They are described as follow:

Sensation Game as sense-pleasure

Fantasy Game as make-believe

Narrative Game as drama

Challenge Game as obstacle course

Fellowship Game as social framework

Discovery Game as uncharted territory

Expression Game as self-discovery

Submission Game as pastime

Costa [Costa 2010] relates some problems for the acceptance of educational games by children from the lack of interest in the game knowing that it is educational, and the lack of fun, to the focus of development being on the educational part and not on an investment in searching for ways for the player to enjoy the game.

We aimed to overcome these problems by using the MDA framework for the development of the game, focusing on which aesthetic experience we want the player to have, by designing the game mechanics. Section 4.1 describes the mechanics and section 4.2 describes the use of the MDA framework in the design of ComFiM.

3 Previous works

Studies aligning games to the development of specific skills in children with autism can be found in the literature.

Neto et al. [da Silva Neto et al. 2013] presents a game prototype for tablets which aims to assist professionals in psychology who use the Applied Behavior Analysis methodology to teach children with autism. The game focuses on activities to assist the learning of colors. Results showed that the game achieved its goal and that the children seemed to be stimulated by the use of technology and the dynamic learning process.

In [de Urturi et al. 2011], the authors present the development of a mobile system composed by several serious games oriented to first

aid education for children with autism. The authors affirm that the application demonstrated that it is possible to enrich and increase the education/therapy impact through the introduction of technologies. They also said that individuals with autism have accepted the mobile devices well and with educational games, they feel more relaxed doing the activities.

In the communication field, however, most of these studies aim to evolve the vocabulary [Cunha 2011] [Massaro and Bosseler 2003] [Moore and Calvert 2000] of the children, but do not focus on the communications skills that can happen between them in an interactive process. Most of these studies also focus on the needs of people with a high functioning autism, which means a mild autism, with a lesser degree of language and social interaction impairments.

Our work differs and improves on the other works results by focusing on the development of the children's communicative skills using a customizable multi-player environment, where children must work together to achieve the goal of the game.

4 Game Development

ComFiM was developed using the Unity[1] game engine. This engine is well documented and it has a variety of available resources. Besides, it is versatile, allowing the use of a variety of programming languages, such as C#, JavaScript and Boo. Moreover, Unity supports deployment to multiple platforms, such as Windows, Mac, Linux, Android and iOS.

4.1 Game Design

ComFiM was designed to provide a multi-player environment for children with autism to work on their communication skills. In it, two players can play the game and work together to achieve the game goals. To provide the desired environment, we opted to use two tablets as an interface for the players communication. We also chose to use a TV as a common place for the players, to avoid them having to focus only on his/her own tablet. In fact, the idea that a common place provides a better interaction between the players and doesn't cause an interruption in the communication was a hypothesis to be evaluated.

To develop ComFiM, we also took some design decisions in order to provide a game that better fits the needs of the target group. They were:

- Simple Interfaces: They were designed to be simple, without much visual stimuli, in order to maximize the chance of concentration, comprehension and learning of the players.
- Guided Interfaces: Difficulties may be reduced by using a small set of answers from which one has to be chosen [Tincani 2004].
- Visual Interfaces: People with autism often have impairments in abstract thinking and in paying attention, and ease in concrete thinking, memorization and in understanding visual-spatial relationships [Ministry of Education 2000]. They usually learn easily through visual representations [Marks et al. 2003].
- Real Images: We opted to use images as close to real objects/situations as possible, instead of infantile or cartoon style images. According to an expert in autism that worked with us in this research, this provides a greater chance for these people to recognize objects/situations.
- Use of Tutor: A tutor is used to guide the user through the game. He explains how the game works and presents the tasks that have to be accomplished by the players.
- Communication based on the Picture Exchange Communication System (PECS): This is a system based on images specifically developed for children with impairments in communication. Through it, children can communicate creating sentences by selecting pictures which represents objects and actions – a card "I want" and a card "Eat". Figure 3 shows examples of PECS cards.

Figure 3: *PECS Cards*

- Customized Environment: As each child with autism has particular characteristics and skills, ComFiM allows a variety of customization, according to the needs of each player. As many of these children are also non-verbal and/or illiterate, the game makes extensive use of images and audio. However, all of these features can be customized. For a child who cannot read, for instance, text can be deactivated. Table 1 presents all possible configurations.

Table 1: *ComFiM Possible Configurations*

Game Configurations	
Text	Yes/No
Audio	Yes/No
Tutor	Yes/No
Animations	Yes/No
Detail Level	High/Moderate/Low
Level	Learning/Ask-Receive/Collaboration

ComFiM has a farm as a scenario and is composed of three levels. The respective scenario was chosen by an expert, who assists the target group, in order to supply an interesting environment for the majority of the children. In this farm, some tasks, which are presented by the tutor, have to be accomplished.

- Learning (level 1): The player has to communicate with the tutor to perform some tasks, asking for an object or giving an object to achieve the goals. The tutor presents a situation to the player and various objects from which the player must choose the appropriate one. E.g., the tutor communicates to the player that some flowers have to be watered and presents four objects that could be used. The player sends a message to the tutor via the tablet, asking for, in this case, a watering can to complete the task.
- Ask/Receive (level 2): The players have to accomplish tasks exchanging objects via their tablets. Here, the tutor is a mediator of the communication, presenting situations that the players have to solve jointly. The roles vary according to each move. E.g., assuming that Player 1 started the move, he/she should ask ("Give me") Player 2 for an object to complete an specific task. So, Player 2 should give ("I give") this object to Player 1 in order to complete the task. Then, at the second move, Player 2 should start the move and the roles will reverse.
- Collaboration (level 3): This level is similar to the previous one. However, now, in a single move, each player has to play each possible role, helping each other to achieve a common goal. E.g., Player 1 should ask Player 2 for an object to complete part of the current task. So, as in the previous case, Player 2 should give it to Player 1. Then, to complete the task, Player 2, in the same move, should now ask for an object from Player 1, who should give it to Player 2. So, the basic difference is that in this level a deeper communication degree is required.

As Figure 4 shows, in the upper right of the TV interface, four objects are presented. To accomplish an specific task, the players have to use some of these objects. Then, in the tablet interface of the current player, a set of actions and these objects are shown. It is

[1] unity3d.com

possible to choose between two actions: “I give” and “I want”. We opt to work just with these two actions as an expert recommended, identifying them as essential actions and challenging enough to start to encourage communication among members of our target group. The players have to work together exchanging objects and creating sentences (Figure 5), formed by an action and an object, to communicate.

Figure 4: *ComFiM TV Interface*

Figure 5: *ComFiM Tablet Interface*

4.2 Use of the MDA framework

From the game design perspective, we used the MDA framework [Hunicke et al. 2004], described in Section 2.3, to build the mechanics that led to the following aesthetic experiences:

1. Challenge, in overcoming the challenges proposed by the tutor;
2. Fellowship, in the interaction between players to solve the challenges;
3. Discovery, in the learning of new vocabulary.

The mechanics of asking and receiving, described in Section 4.1, help the player in communicating with the tutor NPC[2] or the other player, and are related to the aesthetic of fellowship between the players and are the means from which they can overcome the challenges.

4.3 Game Architecture

ComFiM uses a client-server architecture as presented in Figure 6. The server is represented by the TV, which manages the communication of the two players.

Figure 7 complements Figure 6 as it shows the game structure. Firstly, the game level has to be chosen, which specifies if it will be individual (level 1) or cooperative (levels 2 and 3) and the difficulty. The configuration can also be modified at this point. Then, the tablets, as clients, will connect to the server trough HTTP / HTTPS connection, and after that, the game itself will start, with the server being a mediator of the communication sent by the players tablets.

[2]A non-player character (NPC) in a game is any character who is not controlled by a player.

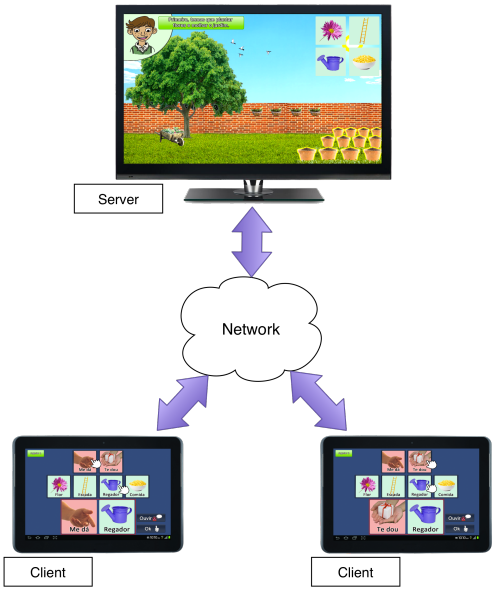


Figure 6: *ComFiM Architecture*

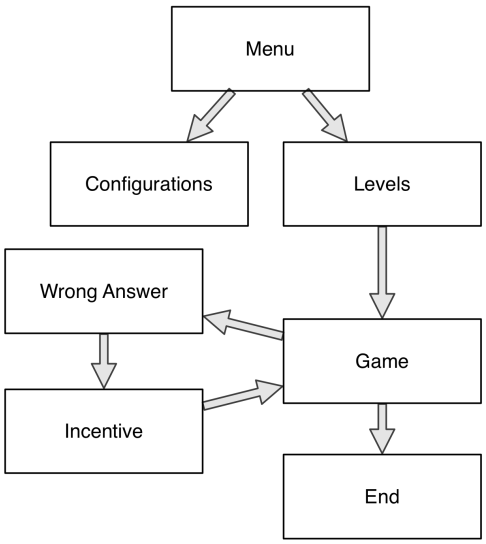


Figure 7: *ComFiM Structure*

5 Results and Discussion

Four children – *A*, *B*, *C*, *D* – participated in this research, all of them diagnosed with a severe degree of autism. They attend a specialized institute, which collaborated with this study. Table 2 shows some characteristics of the players, followed by a more detailed description.

Table 2: *Characteristics of the Players*

Player	Age	Gender	Verbal	Literate
A	11	F	Y	N
B	11	M	N	N
C	5	M	N	N
D	5	M	Y	N

- Player *A*: She is used to playing on computers and mobiles, at least once a week. *A* has a good degree of communication intentions and a considerable vocabulary, although, *A* has impairments in pronouncing words and in creating dialogue with others. Her communication intentions show mostly when *A* wants to play or demonstrate interest in something.

- Player *B*: He uses a computer at least once a day, also for entertainment. Still, *B* is used to playing on mobiles and with video-games. *B* has difficulties and is unclear when answering or asking questions and when talking about his feelings. He doesn't show many communication intentions, which are restricted for situations when *B* wants to participate in a game.
- Player *C*: He uses a computer at least once a day, mainly to navigate the internet. He often presents interest in technology. Besides computer, he is used to playing video-games. *C* has a mild impairment to communicate, talking seldom and by single words. He shows his communication intentions mainly by pointing to things and smiling.
- Player *D*: He uses a computer at least once a day, mainly to play games and navigate the internet. He also plays on mobiles. *D* presents a moderate communication impairment, talking mostly when he sees something that he considers interesting.

The tests were carried out for 9 weeks, always with the help of with a therapist to assist the children in case of need, mainly at level 1 (learning level). However, during the tests, we tried to reduce the degree of help offered to the children, so that they could acquire independence when playing ComFiM. On the recommendations of an expert, pairs were formed between *A* and *B* and *C* and *D*, respectively. Also, at the tests, we used a Smart TV LG 42" connected to a MacBook Pro running OS X Mavericks to display the game and two tablets, a Motorola Xoom and a Samsung Galaxy Tab 2, both of 10.1" running the Android 3.2 system.

The results obtained will be presented by levels; once each of them has its specific goals.

5.1 Level 1

At the children's first contact with the game, the tablet was given to them only when they needed to communicate with the tutor of the game to accomplish the tasks. We opted to use this approach to gradually integrate the children with the game structure.

This level aims to familiarize the player with the game, so he/she could start working his/her communicative skills individually, only interacting with a virtual character. This also contributes to the gradual increase in the development of communication skills, since the child starts to work on them alone and then to work with another child. This level also aims to identify how the player receives and perceives the messages sent by the tutor.

When first playing with ComFiM, all children seemed to be motivated with the technology, mainly to the responses obtained using the touch screen on the tablet.

Player *A* had no problem with the vocabulary adopted in the game and at the end of the first interaction with it, she had full control of the tablet. However, *A* showed difficulty in sharing attention between the tablet and the TV, focusing on the first one. This situation exposes the difficulty of people with autism in sharing attention. To overcome this difficulty, the therapist helped her to understand at which moments she had to pay attention to the TV and which to the tablet, i.e., to identify when the tutor was talking to her and when he was expecting an answer from her. After this assistance, *A* didn't have any other problems, understanding the game, the interface elements and the elements of communication that defined when the player had to pay attention to the tablet or to the TV. So, *A* recognized that she had to answer some messages sent by the tutor and identified the need to ask for and give objects shown in the game to accomplish the tasks.

Player *B*, on the other had, presented some impairments with the vocabulary. Nevertheless, in other sessions of this level, he showed to have acquired it. At first, *B* appeared not to be motivated with the game, which could be related to the existence of little interest in the topic addressed in it. But in other sessions, he appeared to be more interested, paying attention to the proposed activities and trying to accomplish them. Furthermore, *B* had some confusion between the concepts "Give me" and "I give you", which should be used by the players to request objects or deliver them. *B* seemed to understand that when the tutor presented a task, he should reply via a message. However, *B* always answered with "Give me", not differing the situations. Thus, the aid of the therapist was essential.

Player *C* demonstrated a good degree of interest in the game and the technology. However, he had some difficulties in paying attention to the TV and handling the device. Such difficulties were related, according to the therapist, to the young age of *C* and his restless characteristic. Despite these facts, *C* didn't show difficulties in understanding the tutor, the vocabulary and his own roles in the game; his biggest problem was the difficulty of concentration. When the therapist could help him to concentrate, he had no problem performing the tasks.

Finally, player *D* proved to be very motivated with the game. Besides demonstrating motivation through gestures and facial expressions (Figure 8), a few times, after choosing the correct answer, he liked to click on the other options just to hear the sound which described each item. In other moments, *D* answered verbally to the tasks that the tutor presented. The therapist explained that he should respond using the tablet so that he could see an action as a consequence of his answer. We can analyze this verbal response as a positive factor, since it is generating some form of communication. Furthermore, *D* may have seen a communication partner in the tutor. Similar to player *C*, *D* also showed some degree of anxiety in the interaction. This suggests that the different characteristics of each range of age need more study. Perhaps, even shorter tasks could be necessary for this age (5 years).

At the end of the sessions playing this level, all players had full control of the tablet.

Figure 8: *Player D expressing motivation when waiting to play*

5.2 Level 2

This level is cooperative, requiring that two players work together to accomplish the tasks presented by the tutor. Here, the tutor is just a mediator of the communication between the players. Then, the goals of this level are:

- Identify how each player understands the role of the tutor as a mediator and of his partner as a collaborator.
- Identify communication intentions showed by each player to motivate some action of his/her partner and thus achieve the game goals.

At the first time playing this level, *A* had some difficulty to understand that she would no longer interact directly with the tutor, but with another player. However, this was considered normal, since she was being presented to a new level which works differently from the previous one. After minor interventions of the therapist, *A* understood that now she should have to communicate with the other player in order to accomplish the tasks. *A* presented a large number of initiatives to help her partner. At first, *A* tried to carry out tasks for him, as her partner presented more difficulties than her.

Yet, during the sessions, *A* began to indicate the answer (Figure 9), sometimes even holding the hand of her partner and making the move with him. Furthermore, *A* repeatedly expressed herself verbally, when she or her partner made a mistake or chose the correct answer.

Figure 9: *Player A indicating the correct answer to her partner*

Player *B* still showed difficulty in understanding the difference between delivering and requesting an object, always answering with "Give me". Then, the therapist continued working with these concepts with him. Despite this fact, when the other player tried to make the move for him, *B* showed discomfort by pushing the hand of his partner so that he could try to accomplish the move by himself (Figure 10). Another interesting point was that *B* seemed to be more motivated to play the game when working with another child, i.e., with a real partner. This may show that, besides the difficulty that children with autism present in interacting and communicating with others, they want to be with others and to develop this kind of skill.

Figure 10: *Player B showing discomfort when Player A tried to make moves for him*

C, despite having an interest in video-games, exhibits a naturally restless behavior, which harmed his concentration. So, many times the therapist had to help *C* to properly pay attention and make the move. When *C* focused, he had no difficulties in performing the tasks. *C* is a non-verbal child and we did not observe communication intentions using the tablet between him and his partner, besides exchange of glances and interest in his partner's activities. But, due to the specific characteristics of *C*, these discrete intentions can be considered a significant result.

Finally, *D* remained motivated with the game and the technology. *D* quickly understood his role in the game, also understanding that in this level the tutor was only a mediator between him and his partner. As his partner had difficulties in keeping focused, the performance of *D* was affected by them, since they caused breaks in the communication between them. So when the move returned to

Figure 11: *Player C showing interesting on his partner activities*

D, sometimes he had already forgotten what he should do. *D* had many verbal communication intentions, telling the answer to his partner when he did not answer.

5.3 Level 3

This level has the same goals as the previous one. The difference is that, in this level, at the same move, both players must collaborate to accomplish a common task. So, in a single move, both players play the two possible roles, i.e., they have to request and deliver objects in the same move and have therefore to differentiate the moments in which each of the roles has to be played. Here, the tutor remains as a mediator between the players.

When adapting to a new level, both players *A* and *B* required an initial help from the therapist to understand that they have different roles in the same move. However, they had no difficulty in understanding that the tutor continued as a mediator between them.

After the therapist assistance, *A* had no difficulty in playing the different roles, having a good performance at this level. *A* continued to show variable intentions of communication.

Player *B*, unlike what was observed in the other levels, showed an increased number of intentions of communication such as gestures and smiles when his partner made a mistake. *B* also showed interest in the activities of her partner, paying attention to his actions. Furthermore, *B* did not present any more difficulties in differentiating the concepts of "Give me" and "I give", knowing when to play each role.

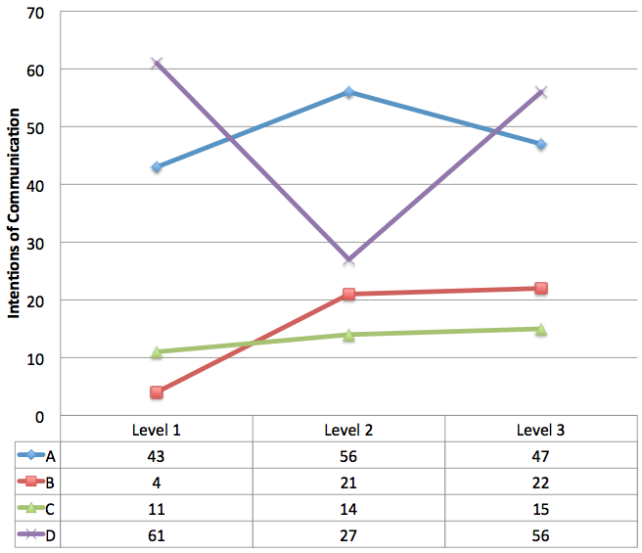
Player *C* kept showing restless behavior. Thus, *C* had difficulty staying focused on the game. This may have occurred, besides the fact that *C* has this natural behavior, due to the fact that *C* lost interest after repeated sessions, since at level 1 *C* showed good results.

Player *D*, as in the previous levels of the game, presented himself as motivated. *D* had no difficulties in performing the proposed activities; this only occurred when the move began with his partner and, as his partner had difficulties in focusing, it caused a break in the communication between them.

Figure 12 shows the observed types of intentions of communication by player and level. As can be seen, Players *A* and *D* had the higher number of intentions of communication observed at the first level. As described in Section 5, *A* had a good number of communication intentions and a considerable vocabulary, presenting, however, some difficulty when pronouncing words and making dialogue with others. However, *A* made use of verbal communication with her partners at different moments in the game, trying to help or encourage them. *D*, on the other hand, despite his difficulty in communicating, as was described by the therapist, presented the higher number of intentions of communications.

It is interesting to note that the intentions of communications presented by Players *B* and *C*, the ones who had more impairments in communicating, increased when playing with another child. This may show that, besides their difficulties in this field, they want to interact with someone else and are receptive to approaches that encourage then to communicate. The number of communication pre-

sented by *D* decreased at level 2 due to the fact that his partner presented some difficulty in staying focused, which broke the communication between them. However, at level 3, we changed his partner in some sessions and we could see an increase in the number of communication intentions.



	Level 1	Level 2	Level 3
A	43	56	47
B	4	21	22
C	11	14	15
D	61	27	56

Figure 12: *Types of Intentions of Communication by Player and Level*

Figure 13 shows the intentions of communications observed by level. As the image shows, fourteen different intentions of communications were observed during the sessions, some more discrete and some more expressive then others. The most frequent intention was "Look to the partner", which is a discrete one; however, more expressive ones, such as to "Talk to help/encourage/correct the partner" were also observed.

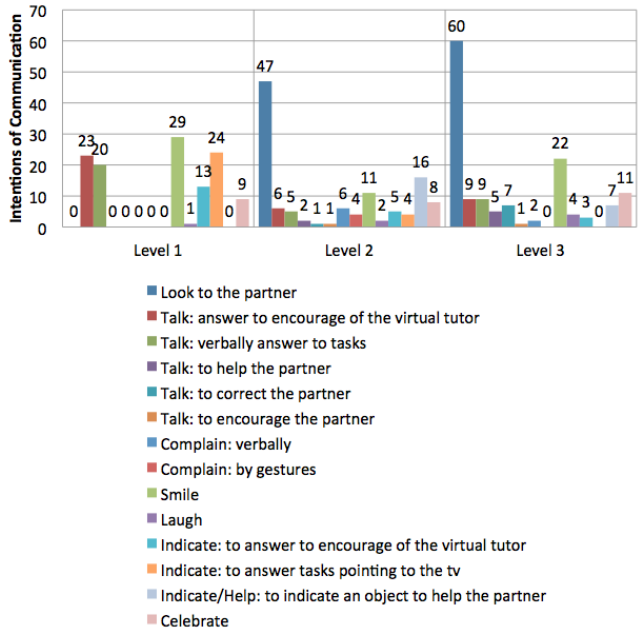


Figure 13: *Intentions of Communication by Player and Level*

6 Conclusion

This paper presented the architecture of a customizable cooperative multi-player serious game designed for children with autism using the MDA framework to focus the game design on the aesthetic experience of challenge, fellowship and discovery, in order to stimulate the development of communication skills.

The results indicate that the designs decisions taken to develop ComFiM lead to a multi-player game which was able to provide an environment in which communicative situations could be observed between the players. As mentioned before, fourteen different intentions of communication were observed during the tests.

Also, one can conclude that the use of technology, aligned with strategies to jointly encourage activities, may provide a way so that people with autism can improve their interaction, communication and collaboration skills. Besides, the results contradict the fact that computer activities could, instead of providing a collaboration environment to people with autism, contribute to their isolation [Moore and Calvert 2000].

Although the results have been satisfactory, further studies are needed with a larger group of children and with other age groups to assess the different kinds of needs that may occur between different children with autism, since their characteristics may differ substantially.

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