Studying Player Experience in a Collaborative Embodied Interaction Game

Konstantinos Karadimitriou
Department of Museum Studies
N.K. University of Athens
Ilissia 15784, Athens, Greece
kblacjim@hotmail.com

Maria Roussou
Makebelieve design & consulting
H. Attikou 10, Maroussi
15124 Athens, Greece
mroussou@acm.org

Abstract— In this paper, we describe a study carried out to evaluate the players’ experience with a collaborative full-body digital game; experience, in this case, is defined as both the feeling of learning and engagement. 97 primary school students (aged 10-11) were observed while interacting in groups with the game, which is installed as a permanent exhibit in an informal science education fun park. Both quantitative (pre- and post-tests, teacher questionnaires) and qualitative methods (observation, interviews) were used to collect data. Results indicate that the children perceived the educational attributes of the game as those of cooperation and practicing physical skills (e.g., equilibration of their bodies). At the same time, the game’s main engagement elements were described by its players as being: social interaction, free choice, movement, its clearly defined goals and interactivity. These characteristics worked in tandem with the learning goals of the exhibit.

Full-body embodied interaction; evaluating player experience; computer supported collaborative learning; informal education

I. INTRODUCTION

The intent of this study is to evaluate the player’s experience when interacting with digital exhibits in an informal educational context. We examined primary school children while playing with an interactive exhibit, installed in an interactive educational gaming centre in Athens, Greece called the ‘Polymechanon’ http://polymechanon.gr [1]. The Polymechanon centre has eleven collaborative embodied interaction games that are based on bodily shadow, weight and position recognition and involve groups of players (3-12 in number, depending on the game) interacting with digital representations on large projection surfaces. Full-body motion, gestures, use of language and interaction with digital representations are all an integral part of collaboration needed to control, affect or avoid moving objects on the screens.

For this research, we examined the “Wobble Board” as a representative game of the centre and a characteristic example of game-based activity requiring body movement and collaboration with other players in order to accomplish the goal of the game. In the Wobble Board (Fig. 1), up to 12 players move freely on a 5x5 meter wooden floor equipped with sensors under its surface. What the players see on a big screen in front of them is the virtual representation of the floor board balancing on its centre.

The virtual board has holes on its surface and a number of balls on it. The goal of the game is for the players, after collaborating to combine their individual movements with the movements of the other members of the team, to gain control of how the virtual board moves and lead the balls into the board’s holes. The game is divided into three levels of difficulty. The leaning of the virtual board depends on the sum of the weight of each player. In other words, changes in the measure and the location of the composite weight on the physical board results in displacements of the virtual wobble board. The underlying learning concepts embedded in the game include the ideas of forces, balance, weight, location and direction. The game also allows for various of these parameters to be adjusted, such as the simulated friction of the balls on the virtual floor, the depth of holes, the collision rules, etc., all of which change depending on the level reached in the game.

The basic concept of the Polymechanon centre’s exhibits is to combine learning and fun for visitors, specifically young students. In this sense, the choice of this venue and of the Wobble Board exhibit in particular, suits the purpose of this study as it represents an innovative test-bed for exploring and studying, in an informal yet practical real-world setting, full-body interaction for learning and play. Moreover, the educational goals of the Wobble Board game are correlated with physics taught in school, usually in the late elementary level or early high school years, depending on the school system.

According to the designers of the Wobble Board, the educational goals set for children in the age group targeted by the game are:

- To experiment on their own with the equilibration of the leaning surface and the movement on it.
- To investigate basic concepts of physics (angle, forces, friction, mass etc.)
- To develop strategical thinking
- To experience the aforementioned physics concepts so that the teacher is given the chance to use this experience for educational purposes later.
- To collaborate with their teammates

Based on the above learning goals, we formed research questions that sought to investigate whether the above objectives are met by fifth and sixth grade students and to explore whether engagement (or “fun”) is a factor that enhances learning in the informal education setting with interactive exhibits of this kind.
II. BACKGROUND RESEARCH

The increasing role of informal educational institutions in delivering technology-based activities and “learning-by-doing” processes is even more apparent in the case of highly interactive exhibits. “One of the most important advantages of informal learning is that it reminds us that learning can be fun, that it can be enjoyed as excitement, exploration, and play [2].” In contrast to formal settings such as schools, informal education settings are usually open and flexible enough to experiment with different learning methods as well as implement practices designed to attract visitors. For example, many science and children’s museums that are not bound by national standards and state-imposed curricula, employ methods which rely on visitors’ active participation in order to create learning environments that will continuously attract and fascinate visitors, especially children [3]. Similarly, constructivist theories, which support the role of the visitor as an active participant of the museum experience, have been increasingly applied to the design of interactive exhibits in informal education settings [4]. In this light, the non-formal learning world has recognized the popularity and appeal of computer games and is increasingly attempting to incorporate many of their attributes in the design of interactive exhibits.

Making learning fun through a game-based approach contributes to a seemingly ideal recipe for the informal education setting. This is backed up by several theories that tie the learning possibilities provided by games to motivation and engagement. Perhaps the best known is the work of Malone and Lepper, which considers games as providers of intrinsic motivations for learning [5]. The first four kinds of intrinsic motivations (challenge, curiosity, control, and fantasy) may be present in any learning situation, even those that involve only one person. The other elements of intrinsic motivation (competition, cooperation, and recognition) are categorized as interpersonal motivations, since they rely on the existence of other players.

The belief that learning occurs more readily in an environment of fun, challenge, and variety may seem obvious. However, fun is an elusive concept, making it difficult to determine in advance whether a setting has all those fun elements that apply to all of its potential users. Moreover, concern has been raised regarding the drawbacks of learning through play, especially if learning is made to be “too much fun.” Kay [6] makes the distinction between soft fun (when the environment does most of the things for you) and hard fun (playing a musical instrument as opposed to listening to it) that encourage children to “stretch and grow.” Some researchers associate fun with playing for pleasure and indicate freedom of choice and multimedia stimuli in software as significant clues for it [7]. Another approach is considering fun to be identical with emotional engagement. As Fullerton [8] mentions “all of the emotional and dramatic elements that drive a player to pick up your game, to try it out, and to continue to play it, are usually what players cite when asked about what makes a game fun”. In any case, if there is to link educational objectives to fun, the designers of an educational game must ensure that the latter works as a vehicle to the learning process and not impedes it.

The deep sense of engagement common in interactive game-based learning activities provides the motivation for a critical examination of the exact elements that link learning and fun in such activities. Despite its importance, the relationship between fun and learning has not been clearly determined through evaluation studies in either formal or informal educational settings. On the one hand, there have been many studies evaluating the educational aspects of digital environments designed purely for learning, using different, quantitative or qualitative methodologies. But, while there is a plethora of existing methods and research for the evaluation of the educational aspects of digital environments designed for learning, these methods follow conventional educational technology research and cannot be transferred to the evaluation of game-based interactive learning environments [9]. On the other hand, evaluation efforts that look at enjoyment, fun, playability or gameplay have been limited to the entertainment industry, mostly in the form of playability heuristics tailored to evaluate video, computer, and board games [10]. Finally, research in the area of artificial intelligence that examines player satisfaction through the development of player models [11], may not be easily applicable to embodied interaction games where the players’ movements cannot be captured in an easily quantifiable form.
Hence, it is empirical studies investigating the combination of learning and fun that are sparse. One such study assessing the relationship between usability, fun and learning in educational multimedia software, concluded, not surprisingly, that children prefer fun software and also that they have less fun when they face usability problems with it [12]. This study also highlights the difficulties in designing experiments with children and the difficulties in measuring the learning effect of educational software on them, mainly because of the numerous variables that should be considered by the researcher. Similar studies have been conducted by Read et al. [13]. Nevertheless, these studies were not carried out with interactive games that are set in an informal educational context and which afford a rich variety of attributes, from full-body interaction modalities to collaboration. These have been recognized by researchers as attributes that cannot be easily assessed and for which more empirically grounded research is needed to assess their effectiveness and guide their development [14].

In the remaining sections of this paper we describe the study that was carried out to explore players’ experience (learning and fun) in an embodied interaction game set in an informal education environment.

III. METHODOLOGY

Due to the nature of the interactive exhibit and the informal educational context in which it is situated, we chose to study the effect of learning and engagement by adopting a mixed-method approach, which enables the triangulation of multi-source and multi-perspective quantitative and qualitative data. Our study was informed by the methods and techniques suggested by researchers that are experienced in carrying out evaluations with young users [15].

A. Sample

A total of 97 primary school children participated in the study. All of the children were fifth and sixth grade pupils in urban public primary schools that were visiting the centre with their class as part of a scheduled school excursion. Fifth and sixth grade students (typically 10-11 year olds) form the usual visitor base of the centre. At this age, children are at the concrete operational stage of cognitive development, according to Piaget [16]. It is this stage where children classify things and can think logically, and when abstract thinking and mental models start to form. Hence, it is an ideal stage to investigate the understanding of the physics concepts (such as movement on a leaning surface, friction and mass, acceleration, etc.) embedded in the Wobble Board game. Additionally, the game was designed to correlate with the National Curriculum for late elementary and early high school. Furthermore, many of the game’s other characteristics, such as the need for collaboration and negotiation between team members have shown to be elements that make this game challenging for children of this age group [17].

The sample included 29 boys and 68 girls, most probably from middle to high income economical backgrounds, as judged by the district of their schools. The students and their teachers were informed in detail about the study immediately upon their arrival at the site and teachers provided the relevant permission and consent forms.

B. Instruments

In order to evaluate the learning experience of the children and also how much they enjoyed playing the game, we used pre and post tests, questionnaires and direct, in situ, observation captured on video.

A) Pre and post tests

The goal of the tests was to examine whether this exhibit helps children to explicitly understand some basic concepts in physics. In order to identify participants’ existing knowledge of the physics concepts relevant to the design of the game, we designed and pilot tested a written pre-test questionnaire. The test was created in collaboration with a physics teacher and first checked through a pilot trial with students of the same age as those of our sample. The pilot study helped in formulating the language used in the test and the timing, which was kept at ten minutes - an average time for children of this age to accomplish it. Children had no comments or misunderstandings about the questions of the test during the pilot study, thus it was retained for the final test. The test consisted of six questions that sought to examine the extent to which children understand the following three basic concepts in physics:

- The speed of a ball rolling on a leaning surface depends on the height from which it begins to fall.  
- The velocity of a ball rolling on a leaning surface depends on the friction of the surface where the object moves.  
- The velocity of a ball rolling on a leaning surface is independent of its mass (if there is no friction).

Each question of the test showed a pair of images with balls rolling on a leaning surface under different conditions (friction, mass, height, angle). Participants were asked to compare the two images and choose one out of two or three possible answers. One representative question of the test that examines the extent at which children understand that the speed of a ball rolling on a leaning surface depends on the height from which it begins to fall, is the following: Children were introduced to a pair of images showing two leaning surfaces with the same heel angle to the ground and two balls rolling on them respectively (ball 1 and ball 2). The difference was that ball 1 starts its movement from the top of the surface while ball 2 starts its movement from the middle of it. The student had to choose between three possible answers: A) both balls will reach the ground with the same speed, B) ball 1 will reach the ground with a higher speed than ball 2, or C) ball 2 will reach the ground with a higher speed than ball 1.

All the other five questions of the test were formed in a similar way.

The purpose of the posttest, administered after a single use of the Wobble Board, was to examine whether there was any improvement to the children’s score. The post-test included the same questions as the pre-test, therefore was, similarly, kept short, taking into account that participants were children and would have to complete the task after a potentially lengthy and exciting experience.
B) Observation

The children’s behavior while playing with the Wobble Board was observed in order to examine their strategy, their social behavior, signs of enjoyment or boredom, and the progress of their actions while playing the game. The same observer observed all groups silently, took notes, and audio and video recorded each session for subsequent analysis.

C) Questionnaires

We used a “user engagement” questionnaire to identify the elements that children liked and disliked about the Wobble Board game. Although different, engagement and fun have been considered as identical for this study. The questionnaire consisted of the following seven open type questions:

- Which game of all in the “Polymechanon” did you like the most?
- What did you like most about the Wobble Board?
- Is there something that you did not like in the Wobble Board?
- Which is the easiest thing about the Wobble Board?
- Which is the most difficult thing about the Wobble Board?
- If you were to play the Wobble Board again, what do you think you should do in order to drive the balls into the holes more easily?
- Do you believe that the Wobble Board is just a game or helps you learn something and, if yes, what is that?

Additionally, a questionnaire was specially designed for the teachers, asking their opinion about the Wobble Board game. Although different, engagement and fun have been considered as identical for this study. The questionnaire consisted of the following seven open type questions:

- Which game of all in the “Polymechanon” did you like the most?
- What did you like most about the Wobble Board?
- Is there something that you did not like in the Wobble Board?
- Which is the easiest thing about the Wobble Board?
- Which is the most difficult thing about the Wobble Board?
- If you were to play the Wobble Board again, what do you think you should do in order to drive the balls into the holes more easily?
- Do you believe that the Wobble Board is just a game or helps you learn something and, if yes, what is that?

D) Semi-structured interviews

To examine the deeper ways that children of this age think about the concepts we asked in physics, semi-structured interviews were carried out by the observer with 23 of the 97 children participating in the study. The interviews were based on the same questions as the tests, starting out with questions about participants’ satisfaction and engagement, but the researcher gave the opportunity to the children to explain their answers and reveal possible misconceptions. Thus, where possible, each interview continued by revisiting activity based on responses to the test. Chi [18] calls this type of approach a “complement approach” and considers it the most straightforward way to integrate quantitative measures along with the qualitative measures. This approach has been used widely, for example when collecting scores of the problem solving along with the verbalisations of problem solving. In this case, the quantitative data collected can serve as confirmation of the qualitative analyses and vice versa.

C. Procedure

The study was held at the Polymechanon with primary school visitors between April and June of 2010. As soon as the children entered the centre, their teachers were informed of the study and asked whether they consented to their students’ participation. Those agreeing to participate were then given the pre-test to complete. Upon completion of the test, all children were split into groups of twelve, with the help of the centre’s museum educators, and were distributed amongst the eleven exhibits of the centre, including the Wobble Board. The average time spent by the children on the Wobble Board was between seven and nine minutes (depending on the level of the game they finally succeeded to complete. Most groups were able to successfully complete the first and the second level of the game). Each level allowed a maximum duration of three minutes (through an embedded timer), while each group had three “lives” to accomplish its goal. Children’s actions were recorded on video only while they were playing with the Wobble Board. After the end of the experience, each child responded to the post-test questions and the user engagement questionnaire. Their teachers also completed the questionnaires that were specially designed for them. 74 of the children took part in the study by completing all instruments, while 23 out of the 97 participants took part only in the semi-structured interview.

IV. ANALYSIS AND RESULTS

We have analyzed data from the pre and post tests, the user engagement questionnaires, and the interviews. Additionally, all observation recordings have been transcribed. The transcripts that were derived include, in addition to the oral exchange, comments on the non-verbal communication that was taking place during the experience. This way, bodily expression and activity was also noted in conjunction to spoken words and long and short pauses, if considered important to the section that was being transcribed. The goal is to triangulate quantitative and qualitative data acquired through this multi-method evaluation approach.

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A. Pre and post test analysis

Each participant’s pre and post test was examined for right and wrong answers using Wilcoxon’s test for significant differences on a 0.05 level. No significant differences were found in any of the six questions between the pre and the post tests (p > .05 in all cases) (Table 1).

The result indicates that the Wobble Board did not help children understand the embedded physics concepts in a formal, explicit, manner by playing this game, i.e., in the
same way that they may have done, for example, when being taught physics in school. Or that they were not able to generalize the knowledge that they acquired by this game in the test’s context.

B. Questionnaire analysis

Children’s answers to the user engagement questionnaires revealed that the Wobble Board is among the five most favored exhibits in a total number of eleven games in the Centre. More specifically, when we asked the question “Which game of all did you like the most?” 5 out of 74 children mentioned the Wobble Board, which makes a 6.8%. This may not seem impressively high but it is significant when viewed in correlation to the other results: only seven of the eleven games in the Centre were favored by the children. Out of these, two topped the list of favorites, both preferred equally by 23% of those questioned: the Shuffle Puck, where visitors compete in a kind of interactive shadow hockey and the Reactable™, an exhibit combining the creation of laser effects and electronic music. We should also consider the fact that 9 children (12.2%) answered that they liked all of the games.

In the question “Do you believe that the Wobble Board is just a game or helps you learn something and, if yes, what is that?” 25 out of 74 children answered that the Wobble Board is just a game and that it did not help them to learn anything. In other words, 33.8% of the participants perceived no educational value in the game. The remaining 49 children (66.2%) consider the Wobble Board to be educative and that it helped them learn something. We categorized their responses under the following categories, beginning from the most frequent answers (N=74):

“The Wobble Board helped me…”
- …to cooperate, to work as a team -they connected the Wobble Board to social skills (31 responses, 41.9%).
- …to balance my weight, to coordinate my body -they connected the Wobble Board to physical skills (6 responses, 8.1%).
- …to make delicate movements -they connected the Wobble Board to cognitive skills (at a not significant frequency of less than three responses).
- …to make tactical moves -they connected the Wobble Board to cognitive skills (at a not significant frequency of less than three responses).
- …to cooperate, to work as a team on the board, etc.
- …to cooperate, to work as a team on the board, etc.
- …to move in a calm way, to move with patience -they connected the Wobble Board to emotional skills (at a not significant frequency of less than three responses).
- …to make tactical moves -they connected the Wobble Board to cognitive skills (at a not significant frequency of less than three responses).

One child correlated the Wobble Board with mathematics: “the Wobble Board is also mathematics because I had to calculate the corner I should send the ball to”. Some other children were more explanatory in their responses to the questions, for example, “the Wobble Board helped me to not exaggerate the movements of my body”, “to keep my balance in order to have a good time”, “to put some goals in life”. Some of these responses were considered as attempts to impress the researcher, and were thus not taken into account in the analysis of the results. The following responses were also not taken into account because they were considered to be too general or not well articulated: “all games helped me learn something”, “…to learn how to drive the ball into the hole” “…that heavy things should move without rush into the hole”.

To the question “What did you like most about the Wobble Board” children responded (N=74):
- Cooperation / working as a team (15 responses, 20.27%)
- The need for movement / free movement (7 responses, 9.5%)
- The fact that we tried to drive the balls into the holes (6 responses, 8.1%)
- Interactivity (4 responses, 5.4%)
- The fact that I managed to finish all the levels / that we won (5 responses, 6.75%)
- That it combined fun and cooperation / it was fun (3 responses, 4%)

Many children just responded that they liked everything (15 responses, 20.3%) and other responded that they could not identify something in particular (10 responses, 13.5%). The following responses were also mentioned but not in a significant frequency (one or two times):
- The need to combine movement and speaking
- The bright colors
- The fact that it was a little difficult
- The weight sensors
- The fact that the game was about gravity.

To the question “Is there something that you did not like in the Wobble Board?” children answered (N=74):
- The fact that it was too difficult (11 responses, 14.9%)
- When we could not co-operate / co-ordinate (6 responses, 8.1%).

The following responses were also mentioned but not in a significant frequency (one or two times): “I didn’t like the fact that… it was tiring / we were too many on the board / we lost / we had to move all the time”. The rest of the children did not identify things that they disliked about the game.

To the question “which is the easiest thing about the Wobble Board”, children answered (N=74):
- Nothing is easy (35 responses, 47.3%)
- The first level (13 responses, 17.56%)
- Everything was easy (7 responses, 9.79%)
- The third level (2 responses, 2.7%)

Six children did not answer this question (8.1%) and eleven children (14.86%) referred to things that make Wobble Board to be accessible, such as: “…to manage the board fast and easy, …to maneuver the ball, …to move all together as a team on the board, etc.

To the question “which is the most difficult thing about the Wobble Board”, children answered (N=74):
- To co-operate, to co-ordinate as a team (17 responses, 23%)
- Everything was difficult (16 responses, 21.62%)
- To drive the balls into the holes and keep them inside (13 responses, 17.56%)
- The second and the third level (11 responses, 14.86%)

Two children did not answer the question and two children answered in a not articulated way, which is 2.7% respectively.
The last question of the questionnaire was: “If you were to play the Wobble Board again, what do you think you should do in order to drive the balls into the holes more easily?”

Most of the children answered generally that they should co-operate and co-ordinate in a more effective way (41 responses, 55.4%). Fourteen children (18.9%) referred to more explicit tactics, such as: …to divide the area of the board in sectors of responsibility between the players, …to move all together to the same direction each time, …to stop every movement when the ball directs to the hole, etc. Nine children (12.2%) focused on skills improvement, like their balance and their accuracy. Finally, three children stated that they would do exactly the same things as at the first time they played the game and five children did not answer the question or answered that they do not know. One child responded that next time …he must do everything on his own and one more that he would not try to play the game again.

C. Semi-structured interviews

The main purpose of the semi-structured interviews was to help us better understand whether children of the targeted age group were able to identify the embedded physics concepts in the Wobble Board but also to examine the deeper ways that children of this age think about the concepts we asked them in physics. Apart from facilitating our analysis, these responses may help the designers of the game to refine the design and their educational goals for this age group in the future.

An interesting observation regarding the responses that we received through the interviews is that many children explained their answers to the pre and post test questions by recalling and correlating it to their Wobble Board experience. A representative response is the following: “this case is like the Wobble Board because when the ball was on the top of the corner and all of us ran to another corner the ball was accelerating”.

D. Teachers responses to the questionnaires

The teachers’ opinion about the game is important and contributes to a more complete approach of the issue. On the one hand, the educators accompanying the participants are in a position to know whether this experience was suitable for the children in their class. On the other hand, they represent, in a way, the view of the formal educational establishment.

Only one of the five teachers we asked believed that the Wobble Board is an exclusively educational game. He stated that “children consider that they can succeed if they cooperate”. Two of the teachers considered it to be a game exclusively made for entertainment because, as they stated, children were not able to identify the educational goals of the game and thus did not manage to “concentrate on them”. The other two teachers found the game to be both educational and entertaining because children were trying to achieve something by coordinating their body movement and, as long as they managed this, they felt enjoyment and excitement.

None of the educators had prepared their class before visiting the centre but all of them responded that they would use the experience for educational purposes in the classroom, for example, to introduce some basic concepts about gravity. The most satisfying outcome in terms of teacher engagement was that the teachers, inspired by what they saw in the game, stated that they were willing to support collaboration and enhance working in groups in the classroom from now on.

E. Observation

We analyzed observations and verbal interactions of the children’s activity while playing the game, in order to triangulate all the collected data. Video and tape recordings showed us that children were completely absorbed while they were playing the game and highly concentrated to their purpose. No signs of boredom were obvious. Their dialogues basically focused on their movements. Their faces were always looking at the virtual board on the screen.

V. DISCUSSION

The purpose of the study described has been to explore players’ experience (learning and fun) in a collaborative embodied interaction game set in an informal educational context. Children’s perceptions about the learning outcome of this game and their own assessments of fun have been analyzed quantitatively and qualitatively.

The analysis of the questionnaires revealed that most of fifth and sixth grade students recognize in the Wobble Board an educative role, which they identify as the cooperation with their team, and the coordination and control of their body movement. If we consider the whole context of this game, which is based on the collective movement of a group on a leaning surface, the children’s assumptions are very close to a number of the designer’s educative goals (as described at the outset).

On the other hand the analysis of the tests showed that the Wobble Board did not help children to improve their scores in the physics test on a significant level although they were able to identify the embedded physics concepts in the game, as we can conclude from their responses to the semi-structure interviews. Nevertheless, the nature of the game is not “didactic”, in the sense that it does not aspire to teach difficult physics concepts in the course of a few minutes and without any preparation, intervention, and reflective discourse by a teacher. In other words, the Wobble Board game does and could not stand on its own as a learning tool. In the informal educational context learning has the meaning of understanding the scientific concepts in a self-oriented way, motivated mainly by exploration and social interaction among others [19]; the Wobble Board is oriented to meet these criteria.

Furthermore, learning in informal settings is considered to be a personal ongoing process that requires time [20]. In the case of the Wobble Board, or any similar game for that matter, the experience may have long term learning impact on the individuals that can not be evaluated by a study of this kind. What children perceived by playing the Wobble Board may be a part of their further personal understanding about movement, acceleration, mass, friction, etc., correlated to other relevant experiences in different contexts. Further, carefully designed, longitudinal
studies would be required to examine if and when such an impact would and could occur.

A way to gain impact in terms of physics education would be to connect this game with appropriate teaching methods. Considering Bruner’s view about learning and the spiral curriculum “anything can be taught effectively in some intellectually honest form to any child at any stage of development” [21]. The need for further study in this area is cited also by previous research on the full-body games of this centre [22]. Unfortunately, however, none of the teachers had made any sort of cognitive preparation with the children before their visit to the centre, and thus we could not include this aspect in our study.

The other axis of this study had to do with the fun assessment of this game. The Wobble Board proved to be among the five most favorite exhibits in a total number of eleven in this interactive educational centre. The analysis of the children’s responses to the questionnaires revealed a variety of fun elements of the Wobble Board that may have contributed to this outcome.

Surprisingly, collaboration seemed to be the most engaging element of the game for the children, as derived by their responses to the question about what they liked the most but also what they disliked the most -a good percentage of participants cited that they disliked it “when they could not cooperate / co-ordinate with the others”. This means that social interaction was in fact the most important intrinsic motivational element of the game. One possible explanation is that this game helped children to develop feelings of belonging to a team. The analysis of video and tape recordings showed that children were constantly talking about their movements on the board and every member of the team had an active role because each player’s movements could affect the final outcome. Similarly children shouted and celebrated all together each time they managed to win.

The next most important element of engagement after social interaction has to do with the embodied form of interaction afforded by the game. Children cited “movement” as being one of the most fun aspects of the game. This seems natural, given that children’s physical development at this age makes them eager to move and the game incorporates movement and equilibration skills in its design, thus epitomizing kinesthetic interaction. Moreover, movement in the context of this game is correlated with control and free choice, elements that are considered to be challenge players in games [23] [24]. In general, interactivity, cited by the children among the most likeable elements of the game, is at the core of the experience and extends the level of the children’s engagement as long as it gives meaning to their actions on the Wobble Board by making the system respond to their choices [25].

Many children also mentioned that they liked the fact that they managed to finish all of the levels of the game and win. Similarly, others mentioned that they did not like the fact that they had lost. The design of the game, which included clearly defined goals and incremental challenge, supported sustained motivation and strengthened the sense of accomplishment. In addition, many children mentioned that they were also attracted just by the effort required to drive the balls into the holes. Consequently, another element of engagement is that the game fulfilled their need to achieve goals, at least trying to do so. This contributed also to the fact that goals were divided along the way into different levels, an essential characteristic of successful game design [26]. The level of challenge afforded by a learning game is a design element that requires attention from designers. Many children did not like the difficulty that they experienced when playing the game. “The sense of difficulty” is for the most part related to a player’s individual characteristics (developmental level, abilities, etc.) and can make a game either challenging or boring. For example, one participant, contrary to the others, cited “difficulty” as the element that she liked most in the game. But the fact that almost 15% of the children of our study characterize the game as difficult should be the motive for further investigation about the nature and level of challenge. The full analysis of our data will probably enlighten us further on this issue.

Finally, a fundamental aspect of this study is the relationship between learning and fun. Comments extracted by the teachers’ questionnaires summarize the link between the learning outcome of the game and children’s engagement: “children try to achieve something by coordinating their movement and as long as they manage this they feel enjoyment”. This seems to be working like a chain where what children liked most (i.e., social interaction, physical movement, free choice, clearly defined goals and interactivity) drive them to play the game and, at the same time, become exposed to its educational objectives. The accomplishment of the games’ goals is their feedback to keep on playing. From this point of view, “fun” works as a motivator, as a vehicle to learning and learning becomes “fun”.

VI. CONCLUSION AND FUTURE WORK

A study was carried out with 10-11 year old children in order to evaluate players’ experience (learning and fun) using an embodied interaction environment in an informal education context. The results of the analysis on the multitude of data collected points to the fact that learning and fun are linked, the latter leading to the former by motivating children to engage with the game and to thus become exposed to its educational objectives. Specifically, social interaction between the players, physical challenge, freedom of choices, interactivity and clearly defined goals proved to be elements of emotional engagement. Moreover, what children assumed that they have learned through this game is very close to the game designers’ educational goals (i.e., collaboration with their teammates, experimentation with the equilibration of the leaning surface and the movement on it, the investigation of basic concepts of physics, etc.). Furthermore, the physics concepts experienced can give the chance to their teachers to extend the experience in the classroom, although further research is needed to investigate whether this game can be exploited in a more formal context, for example in conjunction with formal teaching methods.

As the exact elements that shape the relationship between learning and engagement in embodied interaction games for learning cannot be determined through a brief experience such as this, our future work will extend the direct, in situ, observations made of the children playing the game to include longitudinal studies, analysing the effect of their experience at a later time.
An additional direction of future work will be to investigate whether the physical form of the interface, where interaction is based solely on the users’ movement, plays a role in shaping the kinds of interactions that users can and do perform when playing the game and, consequently, the kind of learning experience that can take place. Helpful in this direction will be an examination of previous studies, such as [27], where presence and engagement are examined under a physical interactive perspective.

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