Junkbox, a waste management educational game for preschool kids

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Abstract. Waste management is becoming an increasingly important issue in contemporary society.
The growth in consumption, the increase in urbanization and economic development have as main consequence an increase in the production of waste. Moreover, the population's bad recycling habits are becoming more and more entrenched.
In this context, sustainable development has gained considerable importance and the need to teach new generations the value of protecting the environment is key and what through our research we are experimenting is the way of playing. In fact, basic but very significant behaviours can be activated through a game and they may become stable habits and then proper lifestyles.
This paper describes an educational game that might support educators and trainers to raise environmental consciousness in kids.
Starting from several co-design sessions conducted with teachers, children and parents, we elaborated an idea to target the stakeholders' needs: making the separate collection an enjoyable experience by collectively awarding children after the correct disposal of waste. This idea foresaw a touchpoint finalized to become an integral part of every child's routine during school hours.
"Junkbox" thus becomes a vehicle for learning how to recycle and turning waste separation into a game. This ritual helps children to achieve one of the most important goals of recent years: actively contribute to reduce the environmental costs of our bad habits and lifestyles.

Keywords: Gamification, Educational tool, Green awareness.

1 Sustainable development goals and environmental education challenges

Waste management is becoming an increasingly important issue in contemporary society [6].

Nowadays, the growth in consumption, increasing urbanization and economic development is leading to an ever-increasing rise in waste production. Moreover, bad recycling habits are progressively becoming more and more consolidated among the population [2].

Every era has its own challenges, and our generation's goal is to guarantee a sustainable future for our planet. This is the concept behind 17 Sustainable Development Goals signed by the 139 UN member Countries in 2015 and to be achieved by 2030.

SDGs are identified as common objectives on a range of important development issues such as fighting poverty, eradicating hunger and ensuring sustainable consumption and production patterns.

Especially, of fundamental importance for the concept of sustainable development connected to waste management is 12 - to guarantee sustainable models of production and consumption - It highlights how the world population currently consumes more resources than those ecosystems are able to provide. For social and economic development to be part of the carrying capacity of ecosystems, fundamental changes are needed in the way societies produce and consume. SDG 12 aims to chemicals and wastes' ecological management, as well as a substantial reduction in waste production through measures such as recycling. Particularly, it points: to decrease to half overall per capita amount of food waste; to reduce waste production through prevention, reduction, recycling and reuse; to manage by environmentally way the waste throughout their life cycle and to reduce sharply their release into the air, water and soil, in order to minimize their negative impacts on human health and the environment.

Goal 12 unavoidably links to Goal 14 - to conserve and sustainably use the oceans, seas and marine resources for sustainable development - and 15 - to protect, restore and promote a sustainable use of the terrestrial ecosystem. Greater awareness of waste, their correct management and the possibility of giving them new life guarantees the possibility of conserving and protecting marine and terrestrial ecosystems in a more responsible manner [10].

In this regard, there are two fundamental aspects related to the concept of waste disposal. The first is about the attention toward the environment, its flora and fauna, and the relative awareness that this issue causes significant damages to both categories. The second is about the discovery of materials' second life, which allows us to reuse, in another form, something that had already been in our hands in the past and that now returns to us through a transformation process.

The World Summit on Sustainable Development, held in Johannesburg in September 2002, also proposed to consider education for sustainable development as one of the main priorities of the world community's activity [13].

Understanding the contemporary worldview in the conditions of geopolitical changes and economic crisis is a key pedagogical problem of modern education which demands to be updated based on the principles of ecological and moral imperatives. By doing so, the idea of sustainable development should become a conceptual base and a foundation of the entire system of education [13].

In the European Union, sustainable development has become very relevant in educational contexts; environmental education has been integrated into the activities of primary and secondary school curricula. The environmental study is a fundamental topic in preparing children to build a green future and live in a sustainable society [12].

Environmental education is actually defined as the tool that promotes respect for the environment from childhood, sensitizing children to acquire an attitude of responsibility and respect for the world of nature, making them aware of the value of recovery and recycling.

1.1   The Fun Theory in Education

Advertising campaign "The Fun Theory" was introduced in 2009 by Volkswagen and it was based on a simple concept: "if things are fun, they are better". It means that

among two activities that share the same contents but are different in the approach, the most fun option is the best and preferable.

The concept was developed through a series of projects in which some sustainable behaviors were stimulated by hilarious experiences.

However, besides some "Fun" big company marketing campaigns, neuroscientific studies have shown that game's practice directly affects some primary human instincts such as the need for self-expression or the willingness to pose new challenges and overcome them, allowing to create involvement, motivation, loyalty and therefore to achieve goals that it are difficult to achieve with other tools [16].

Gamification is an extremely effective tool able to convey messages of various kinds, depending on the needs, and to induce active behaviour in users, allowing them to achieve specific objectives, both personal or professional. The implementation of playful dynamics is one of the most effective methods to involve people in an activity; it is a particular type of active participation in which the end user intervenes by interacting [20].

The strength of gamification is, therefore, its ability to exploit the challenges of the game and apply them to daily activities, pushing people's desires and needs and providing goals to be achieved, rewards to be earned and encouraging within the community on the one hand collaboration and on the other competition [11].

To involve the player, a challenge must respect the balance between its difficulty and the player' skills. Any imbalance would cause an oscillation towards conditions of boredom or anxiety. The oscillation between these two states of mind has been studied by psychologist Mihaly Csikszentmihalyi within his "theory of flow" [4]. He asserts that fun is at its best when the challenge's level is suitable to player's skill and if the degree of difficulty increases while skills increasing. In this state of "flow", the individual lives a strong sense of self-awareness and effectiveness, thus generating a virtuous circle capable of increasing personal satisfaction and performance towards the final goal, while manifesting a condition of high concentration, intense involvement and loss of sense of time.

Csikszentmihalyi defines the flow as the "optimal experience". This sensation of flow can be extremely involving and able to enrich the perceived value of daily activities in which it is inserted if generated within a gamification activity [10].

1.2   Gamification and habits

The conditions of flow theorized by Csikszentmihalyi are generated by those activities that are able to totally involve one person; they are defined as autotelic. Among all the autotelic activities, the author defines playing the experience of flow par excellence [3].

Chemistry and neurology confirm the biological factors related to the involvement that comes from the game: when we play, we develop a form of positive stress called eustress.

From a physiological and neurological point of view, the eustress is identical to negative stress: the body produces adrenaline and increases the flow of blood to brain.

Against its opposite, eustress involves psychological awareness of having voluntarily generated the situation of emotional pressure and turns the tension, potentially harmful, into optimistic thrust.

This is the key element of gaming exploited by gamification, which is based on the autotelic aspect of games.

As demonstrated by MIT studies on habits [5], for human brain, games have the very same structure of habits. They discovered that the habit loop is managed by brain in three phases: (1) the signal, or cue, that makes the brain understand that it is time to activate the routine; (2) the mechanical execution of the action, or habit; (3) the mo-

ment of reward that helps the brain to define the loop is just finished and deserves to be remembered for the future. As time goes by, the repetition becomes automatic.

This process triggers the same mental process enabled by a game but in a mechanical way and it shows us how it is possible creating or changing a habit through the use of game techniques and dynamics.

1.3   Gamification of learning

Education and entertainment are often seen in contradiction with each other but, instead, they are closely connected [18]: playing is actually one of the ancestral methods we have always used to learn; it is the most natural tool through which our brain learns [1]. By observing children and puppies, it is evident how they develop their physical abilities and their selection's faculties through playing [8].

The training model currently used is still based on the logic defined by Prensky's tell-test - and finalized to the execution of exams, in which the student is seen only as a passive receptor of notions, but now the world of education and learning is experiencing a profound revolution, born and quickly developed starting from the last decade of the years Ninety, with the rapid spread of digital technologies. The meaning of knowledge, in fact, today has shifted from being able to remember and repeat the acquired information to be able to find them, evaluate them and use them convincingly at the right time and in the right context. Many experts believe that the success of the twenty-first century depends on an education that develops skills such as the ability to think, solve complex problems or interact through the language of the media [17].

And, in 2001, Prensky recorded that there is a profound gap between the generation of teachers and trainers and that of students, the first grown up in the analog age and educated according to the style of the past, the second born in the digital age and entertainment, grown up with Sesame street, MTV and videogames; the two groups are so different in approach that dialogue is deeply complex. The scholar defined the first digital immigrants and the second digital natives. Almost twenty years later, the digital natives (also called Millennials or Generation Y, or the generation of people born at the end of the 80s and 90s) were followed by the generation Z, those born after 2000; this generation uses digital technologies in an almost unconscious manner; it is obvious to all that preschool children learn to use digital tools such as smartphones and tablets, long before they learn to read and write.

Prensky suggests that, in the face of this great social revolution, it is the task of educators to reconsider both the contents and the teaching methods so far considered valid. It is essential that today's teachers and trainers learn to communicate with their students in the new language and new style typical of the digital age. Prensky indicates that the most correct way to convert the traditional teaching methodology is *edutainment*, a form of education based on entertainment: there is no need to invent new materials, but adapt those that already exist to the new learning style and probably the best is the use of educational video games, even for the most serious contents [17].

On the other hand, since the beginning of the twentieth century, learning educators and reformers such as John Dewey, Maria Montessori, Seymour Papert [15] and Elliott Masie, have promoted and experimented alternative learning methods based on pleasant and engaging learning experiences [17].
Recently, the advent of new digital technologies pushes towards a teaching model that takes advantage of new media and playfulness [14].

The concept that playing can have a very productive relationship with studying is the basis of the "Institute of play", founded in New York in 2007. The institute's mis-

sion is to use typical game motivation and involvement to make the learning experi-
ence optimal.

This assumption underlies the gamification applied to e-learning, also known as
gamification of learning [11].

2   Apps, videogames and educative projects about differentiated waste: state of art

Prior to the drafting of this paper, extensive research on the state of the art of games
and educational projects addressing good behaviour in natural resource management
and waste disposal was carried out.

Currently, many videogames and school projects deal with environmental education,
stimulating in children the formation of an ecological awareness and the adoption of
good practices through play (fig. 1).

The main purpose of most of these is to raise children's awareness of the environment,
teaching in an engaging way how important it is to respect the resources at our dis-
posal and avoid waste.

However, this sensitization is limited only at a theoretical level: none of the activities
analyzed influences the child's daily habits but remains limited to playful experience.

Fig. 1. Race to recycle, a waste disposal videogame

3   The chosen target: Kindergartens' children in Palermo

Palermo is one of 15 Italian municipalities with a resident population of more than
200,000 inhabitants.

In 2016, these cities had a resident population of 9.9 Million inhabitants (16.4% of
the Italian population) with 18.1% of waste production on the national total.

Among these, Palermo (673,735 inhabitants - data from the National Institute of Sta-
tistics) has a waste's production of 347,008 Tons, with an annual per capita figure of
515.1 kg (with an increase of 2 kg/inhabitant per year compared to the previous

years). Of these, only 7.2% is the amount reached by separate waste collection, which places Palermo among the worst metropolitan cities in the country in terms of separate waste [12].

In this context, teaching the younger generation the importance of protecting the environment is crucial.
Young people need to be encouraged to reduce waste and use sustainable materials, to be made aware of waste prevention measures and, above all, to be guided in their use of secondary raw materials.

We can do it in a very easy way through play. In fact, simple but very significant behaviours can be activated by simply playing a game and they may become lifestyles through habit.

Thus taking inspiration from the previously mentioned teaching methods based on learning experience, and capable of combining pleasant and necessary teachings, moving from the concept of edutainment theorized by Prensky, and passing through the fun theory experiences we choose work with children between 3 and 5 years old from kindergartens in Palermo, to teach them the correct disposal of recyclable waste in a playful way.

3.1   User research and co-design sessions

It is chosen to conduct a pilot experience in collaboration with the association "I bimbi di Giocomondo" which works in the field of early childhood and has made available its professional figures and its time to test the experience of our project with children.

In particular, four teachers and their two classes collaborated: the first consisting of 12 (6 females and 6 males) children of three years, the second composed of 21 (12 females and 9 males) children aged between 4 and 5 years.
 Several co-design sessions were conducted between November 2017 and January 2018 with the interested parties of Giocomondo: teachers, children and parents.
A first analysis phase, conducted between November and December 2017, was carried out in collaboration with kindergarten's teachers, in order to understand what their opinions and didactic needs were in the field of recycling. During these first meetings it emerged that their goal was to teach children the concept and practice of recycling as stated in the targets for the skills's development suggested by the ministerial programs.

Specifically they pointed to:

- pass on to children the habit of proper disposal;
- give them greater awareness of waste production;
- to make them aware of negative aspects of incorrect waste treatment.

The meetings also showed that these objectives are difficult to achieve for the following reasons:

- little time is allocated within the annual program to organize projects dedicated to separate collection;
- children do not feel particularly involved and therefore bored;
- there is poor assistance from the municipal body not yet organized for differentiated waste management in every area of the city.

In these meetings we evaluated together the main waste that a child produces during his stay in school , from which it was clear that every packaging material is

known to children already in pre-school age and therefore it was necessary to provide a container for waste separation that it considered all packaging can be given new life. We therefore decided to proceed with the design of a container for waste separation that had a compartment for each of the recyclable materials: glass, paper, plastic and aluminum; as will be shown later in the text, this choice was modified later after the preliminary test phase in the company of the children.

In the same period, the parents were also interviewed in order to understand how the children collaborate about waste management within the domestic context and how many of them actively do recycling operations. Following this preliminary investigation, we appreciated that around 35% of parents actively involved their children in the operation, while for the remaining 65% it was not a routine operation; however, our proposal was welcomed by 100% of the parents with favor and curiosity.

Subsequent revisions with teachers have served to modify the initial idea so that it answered completely to the needs of the teachers and it provide a 100% pleasant experience for the children.

Their pedagogical experience was fundamental for the understanding, the involvement and the correct development of all the phases of the project: the colors of the Junkbox, the cartoons to be presented as a reward, their duration and the ideal moment in which to insert the junkbox experience into the school routine have in fact been agreed together, always "trying to balance the playful aspect with that didactic

During the codesign sessions, various feedbacks of the project were requested to the teachers, who gave their opinion useful for improving its characteristics, immediately identifying the pedagogical potential and their doubts about it.

So they expressed themselves:

«Excellent initiative to raise awareness of the civic and moral sense of children already at this tender age; the idea of the Junkbox has a lot of potential»;

then again:

«Strength is certainly learning through play and the practical involvement of children themselves».

Finally:

«I think that the initiative is extremely valid for developing an ecological conscience from an early age, but relies on the concept of reinforcement / reward that, not being reproduced at home, is not continuous and therefore effective. Perhaps the project should provide for the involvement of parents to make sure they succeed».

Starting from these insights, with the support of PUSH design lab, an idea was elaborated in order to target the stakeholders' needs: making the separate collection an enjoyable experience by rewarding kids after their correct disposal of waste. This idea foresaw a touchpoint designed to become an integral part of every child's routine during school hours.

3.2 The idea in practice: Junkbox.

The solution, named Junkbox, is a container for the separate collection that aims to educate children between 3 and 5 years old about the correct disposal of recyclable waste in a playful way. It has three baskets to dispose distinctly recyclable. The three baskets are integrated into the shell that externally covers the entire structure and that can be used by three access holes located on the front. The last ones can be customized according to municipal needs.

The children, after lunch, will have to deliver the waste produced at the table in the Junkbox, which, once all the waste has been collected, will offer them a prize for proper disposal.

The box is designed as a jukebox, or an arcade game of the 80s, in fact, it is made up of a rectangular body with a monitor on top and the "bridge command" on the

bottom. Instead of buttons, it has holes that allow throwing waste in the correct baskets for recycling.

Just like a jukebox that returns a song as soon as the coin is inserted, the Junkbox gives a cartoon as soon as children recycle their waste. It is the reward for taking the right attitude towards disposal and works as a positive reinforcement in the habit loop, as described previously in this paper.

Junkbox's counting system checks the activity of use: every time a waste is introduced, the screen produces light and sound feedback that attracts children to take advantage of its functionalities (fig. 2).

By lowering the lever, monitor starts cartoon. So, after children recycle their waste, the teacher actuates Junkbox's mechanism that starts the cartoon, so the reward is paid only when all have contributed to the operation.

Fig. 2. Junkbox rendering

4   The testing phase

After a rough design phase of Junkbox, the idea was tested by a minimum version in order to check the operating margins and the changes to be made before producing any prototype.

The alpha version of Junkbox was based on the principle of the Minimum Viable Product (MVP) which is the simplest product that can be made and tested to get immediate feedback from customer segment with a minimum economic risk.

The MVP is considered the basis of the Lean Startup method devised and distributed by Eric Ries, who proposes the launch of innovative ideas using a process that

involves a cycle of conception-verification-continuous modification to adapt the product to customers' needs, step by step [19].

Following this approach, a model in cardboard polystyrene with four holes corresponding to four containers (each identified by a different colour and associated with one of the four recyclable materials) and a monitor on top has been made. So, the model thus created possessed only the Junkbox's two core features: the baskets and the monitor to screen the prize at the end of the experience.

The practical experience was conducted at two different times one week apart from each other in December 2017.

Fig. 3. On the right preliminary experience with the cards. On the left Junkbox prototype's experience

During the first meeting the children were prepared for the topic and the practice of recycling by carrying out a first preliminary exercise: through four series of cards, distinguished by color, which show the typical waste produced during the meal - glass, metal , plastic and paper -, they had to recognize the material and put it in the right area of a billboard. The game was played in two tranches, already from the first, the response of the participants was largely positive. Children in the first class (3 years) learned the game mechanism in a time period of about 10 minutes, 70% of them needed further clarification regarding the association between the represented waste' material and the card's color; 90% of them solved the game correctly in the 2nd round; while 100% of older children immediately understood and solved the game by themselves from the first round in few minutes.

Following the Junkbox prototype was tested: in front of it the children showed interest and curiosity, when they saw the monitor they were immediately excited by the idea of an imminent screening that, as they had been explained to them, would have happened only at the end exercise correctly performed (fig. 3).

Giving away the experience, also in this case, the response by 100% of the older students was immediate, while once again for the little ones it took a little more time (fig. 4).
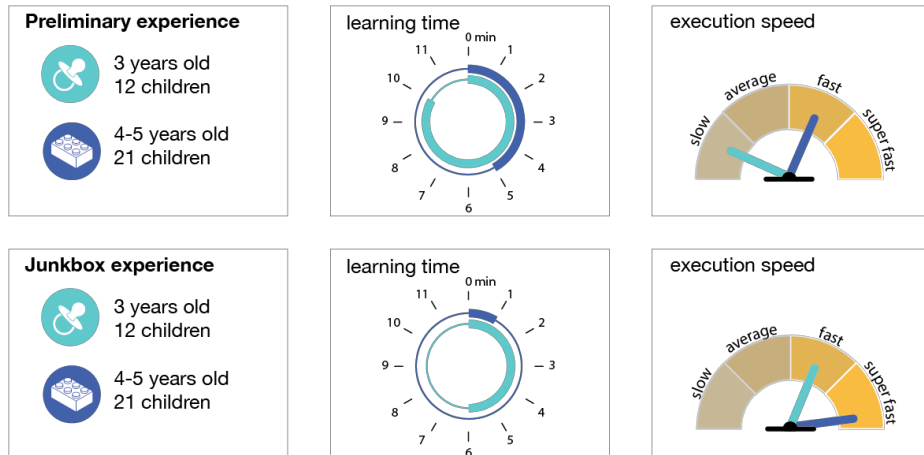

Fig. 4. Children's learning time and execution speed during preliminary experience and test with the Junkbox

One by one, however, the children of the two classes correctly disposed of their waste within the container and all together looked forward to the prize they had been promised.

At the end of the screening, all the children showed great enthusiasm and a desire to repeat the game.

From this first approach it emerged how the playful involvement of a daily operation had caught on in children's awareness that learned how to recycle by playing.

During the experience, therefore, it was found that the mismatch between the colours chosen for the Junkbox and those of street bins for recycled created some confusion in some children. Such element led to a change in the initial design of the structure, with the elimination of one of the baskets and a greater adherence to municipal standards regarding differentiation.

Junkbox's experience was, as previously anticipated, repeated by the classes a second time after a week. At Junkbox's sight the children immediately remembered the game's rules and wanted to put them back into practice.

In an interview immediately after this second experience, teachers and parents pointed out that in the previous week children asked to repeat the waste sorting ritual proposed by Junkbox after each meal both at school and at home.

5   Conclusion

Even if this research is not yet complete - Junkbox has only been tested in one school and just in a city and a lot of data still needs to be collected before the project outlined in this document can be declared valid - following the experience with children we are convinced that learning through a didactic method based on game dynamics, just like Fun theory projects, works also with kids. Moreover, reward systems are an added value to learning concepts that would otherwise be boring and abstruse. The

touchpoint makes it possible to investigate, in all its aspects, the issue of waste recycling: the implementation of separate waste collection leads children to want to learn more about the subject; the service is adaptable to every school, regardless of the system of separate collection adopted by the municipality.

On emotional waves with which the young Swedish activist Greta Thunberg has managed to raise public awareness, Junkbox thus becomes a vehicle to learn separate collection and turn it into a game. This ritual becomes part of everyday life helping children to join one of the most important goals of these years: a more sustainable development aimed to protect the planet in which we live, highlighting the future for us and for subsequent generations as hoped by the SDGs and in particular by Goal 12. As mentioned above, in fact, for our survival and for survival, it is necessary to change the way society consumes and consequently produces waste, so that their negative impacts on human health and the environment can be minimized.

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