Wageningen
University & Research

Education and Learning
Sciences group

Exploring gamification's contribution in engaging pupils to Solid Waste Management in the context of Environmental Education in Greece

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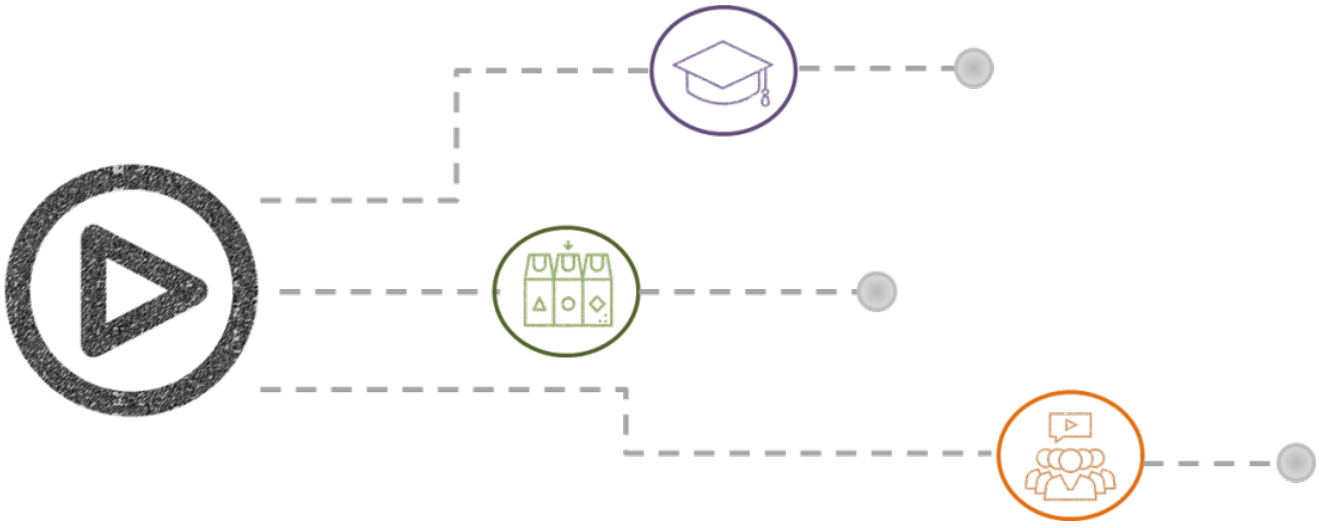

Acknowledgements

I would first like to thank my dear study advisor, Marjo, for encouraging me in pursuing my academic goals from the beginning of my Master's degree and in every step along the way. I pledge my sincere gratitude to my supervisors, Valentina and Omid; without their enthusiasm for the topic this Thesis would not be conducted. Their constructive feedback showed me the way to improve my academic skills and challenged me to think –and work- interdisciplinary.

Last but surely not least, I want to thank my family for their enormous and unconditional support in this journey, and most of all, my baby daughter Maya for always being my inspiration and drive.

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Abbreviations

BE	Behavioral Engagement
CE	Cognitive Engagement
EE	Environmental Education
EmE	Emotional Engagement
MSW	Municipal Solid Waste
SDT	Self-Determination Theory
SWM	Solid Waste Management

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Abstract

Municipal Solid Waste is one of the most burdening environmental issues in Greece, yet Greeks seem to struggle with Solid Waste Management practices. It is commonly admitted that Environmental Education can play a determinative role on engaging people to environmental behavior. This study focuses on (a) identifying the engagement gaps that Greek elementary school children have on the topic of Solid Waste Management in terms of cognition, emotion and behavior, and (b) evaluating the contribution potential of the concept of gamification. Gamification is here set under the scope of education as a tool that can potentially increase overall engagement to the subject matter. Findings show that there is indeed a need for support of Environmental Education in the particular context, and more specifically in (i) supporting knowledge of the topic (ii) increasing the interest for the topic and (iii) promoting recycling persistence and reuse. Suggestions are made on the game elements that can provide this support and future work on gamification as a tool for engagement is recommended.

Keywords: solid waste management, environmental education, gamification, engagement

Introduction

The children of today will be the citizens of tomorrow and will define the future state of the environment. This certitude entails the notion that their thoughts, feelings and actions can predominantly affect the environmental outcomes and therefore, are worth being scrutinized by environmental scientists. Children in the western societies spend a significant part of their weekly routine for education, whereas about a third of the children's free time is spent on unstructured activities that most often include the element of fun (Hofferth & Sandberg, 2001). Both home and school are influential to the children's attitudes and behavior towards environmental-related problems and can promote or inhibit environmental awareness (Spiropoulou, Roussos & Voutirakis, 2005). Environmental Education (EE) plays a central role on shaping children's perceptions and level of participation in pro-environmental actions and learning activities and is often associated with increased environmental concern and behavior (Zilahy & Huisingh, 2009; Zsóka et al., 2013).

EE is by nature multidisciplinary and comprises a variety of sciences such as biology, chemistry, physics, mathematics, sociology and geography. It is an ever-evolving continuum which includes information and communication strategies, pedagogical processes and capacity-building (Scott & Gough, 2003). In the Greek context, environmental education is in practice still relatively based on traditional didactic practices though there is a clear intentional shift towards constructivist approaches[1]. However, not much attention has been paid so far to the evolution of the pedagogical practices of EE, whereas numerous environmental problems have been raised during the last decades (Valavanidis & Vlachogianni, 2015).

Municipal Solid Waste (MSW) is one of the most predominant and urgent environmental problems that Greece is called to act upon for the last decades (Valavanidis & Vlachogianni, 2015). Rapid agglomeration effects and

[1] The differentiation of the two pedagogical approaches, as referred by literature on the Philosophy of Education, relies on the dynamics between the student and the teacher or the learning environment. In traditional education, the student holds a passive role towards the rhetoric of the teacher and has little or no active participation in learning, whereas constructivist pedagogy places the student in the center of the educational practice and builds upon his active participation in class (Otto, 2013).

urbanization have led to increasing amounts of waste burdening the major urban hubs of Athens and Thessaloniki with immense responsibilities and impacts. Despite the imperativeness of the topic in the local context, Solid Waste Management (SWM) is rarely addressed in the educational textbooks and appears mostly as individual incentives in the form of projects within the School Activities Programme. The integration of SWM into the school curricula is crucial yet challenging because of the complexity of the topic and its sense of remoteness.

The importance of the aforesaid environmental issue calls for focused interventions on the existing educational basis of EE in the Greek context that will be able to support children's learning in a meaningful way. A very common concept used in both educational and environmental psychology is this of **engagement**, which refers to a state where one is actively participating in learning by building mental, emotional and behavioral connections to the learning content (Fredricks, Blumenfeld & Paris, 2004). Engagement has been thoroughly studied in various sciences that demand strategic approaches, such as education (e.g Appleton, Christenson & Furlong, 2008) and management (e.g. Johnson, 2004) and consistently entails a sense of devotion to a given task.

One prominent approach that has the potential to optimize student's engagement to the learning process and, in this case to assist EE in the particular topic of SWM is this of **gamification**. Gamification is a relatively new concept that suggests the integration of game elements into non-game contexts (Deterding et al., 2011). The concept of gamification in education has arisen from the urge of educators to optimize learning processes and experience of students and achieve better educational performances, and it is concretely based on the notion of "fun" and its influence on task performance. Explicit research on the value of games and gamified learning environments has repeatedly found significant relations to cognitive strategies, emotional attachment and behavioral persistence. For instance, Ruchter, Klar & Geiger (2010) with their comparative studies on how different game interventions can promote environmental literacy observed gains in environmental knowledge among all participants (children and adults), likewise numerous other studies (Ruchter, Klar & Geiger, 2010; Aivazidis, Lazaridou & Hellden, 2006; Costabile et al., 2008). Robert Sylwester, an award-winning educational neuroscientist and academic, emphasizing on the importance of emotional engagement in learning argued that *"…(educational) activities that emphasize social interaction and that engage the entire body tend to provide the most emotional support. Games, discussions, field trips, interactive projects, cooperative learning, physical education, and the arts are examples"* (Sylwester, 1994). Others have also noted increases in student engagement in terms of performance in school (da Rocha Seixas, Gomes & de Melo Filho, 2016).

Game-based learning has been introduced in various school courses, such as mathematics (van Eck & Dempsey, 2002; Jorgensen & Lowrie, 2011), geography (Tüzün, Yılmaz-Soylu, Karakus, Inal, & Kızılkaya, 2009), computers (Papastergiou, 2009) and language learning (Liu & Chu, 2010). Efforts have also been made to assist learning on SWM with the help of gamification. Some notable examples are NASA's online sorting game (NASA, 2017) that introduced children to basic material segregation, the Australian Carbon Reduction Institute's online interactive simulation to raise awareness on river pollution –caused by solid waste- for primary school children (Carbon Reduction Institute, 2010) and Terracycle's Facebook game that rewarded players for cleaning up a virtual city and promoted upcycling (Terracycle, n.d.; the game was shut down after a year online). These games however have poor educational value due to design-related problems that mostly have to do with game time (e.g. the game time was very short) and goal achievement (e.g. the goal was achieved but the game continued on). In the Greek context, the online Learning Object Repository, namely Photodentro, has introduced both educational classroom activities, such as waste sorting games, and web-based educational games, such as an online recycling game (Photodentro, n.d.). Remarkably, these initiatives have also failed to perpetuate on a regular basis for the same exact reasons that so did the aforementioned international ones; design flaws such as short game endurance (e.g. the online recycling game lasted for a maximum of five minutes) and poor interface (e.g. a

static screen that asks you to put ten recyclables on the correct bins) seem to have demotivated students from repeating the gameplay, and, consequently the engagement potential of the games to fall short. These examples have repeatedly highlighted the influence of game design on the learning outcome, therefore served as pioneers to game-based learning on the topic of SWM from which we should learn and advance.

This study will first identify the gaps of knowledge that children in the middle grades of the Greek elementary have in respect to SWM and their current level of engagement to the topic. The findings will then shed light on whether such an intervention is indeed needed and if gamification can contribute to that engagement.

Research Objective and Questions

Environmental technologies, policies and action plans often fail to prosper in the local context due to the fact that information around complex issues, such as environmental ethics and applications is confided amongst academics and active stakeholders. Moreover, the topic is likely to be considered uninteresting or irrelevant to someone that is unfamiliar with environmental sciences. A valuable source of information about these topics is provided by EE throughout the Greek school curricula. Emphasis on EE is given mostly during elementary, where it is placed as a core subject for the first four grades and later as an integrated topic in other disciplines. Given the fact that MSW is one of the most important issues troubling Greek urban hubs, education on the specific content should be scaffolded with interventions that will allow future citizens to critically think their waste behavior. The objective of this study is to explore what is the potential of gamification to provide such a scaffold. In other words,

What is the current engagement of pupils on the topic of SWM and how could gamification contribute to that engagement, in the context of Greek elementary?

In order to evaluate whether gamification could be an appropriate approach for this purpose we should first identify what are the exact gaps of student engagement to the topic of SWM. We should therefore ask:

1. What is the current knowledge that children perceive as acquired on the topic of SWM?
2. What is the children's emotional engagement to the topic of SWM?
3. What is their perceived behavior towards SWM?

Contextual Background

SWM in the local context

SWM includes all practices and regulations regarding generation, collection, transfer, treatment and ultimate disposal of solid waste. It has been observed that solid waste are highly responsible for atmospheric and soil pollution as well as surface and groundwater degradation of Greek resources (Valavanidis & Vlachogianni, 2015). Despite the heavy EU fines for malpractices in the waste sector -such as illegal landfilling and failing to reach recycling goals- national authorities seem to be insufficient to implement policies and guidelines, and frictions between local authorities and the citizens are often and mostly due to a "not in my backyard" mentality. The National Waste Management Plan and the National Waste Prevention Programme are shaping the country's waste management action plan, however the hitherto condition of the MSW sector is still highly problematic, with more than 85% of the total waste ending in landfills across Greece (Eurostat, 2014). Recycling is the most adopted practice by Greek authorities, while energy recovery and composting are still at their infantry (Eurostat, 2014).

A major determinant of the country's failure to handle its own waste is the presence of a severe economic crisis since 2009, which significantly impedes top-down efforts and calls for independent bottom-up approaches. At the same time and regardless of the economic recession, the generation of MSW per annum keeps increasing (Bakas & Milios, 2013).On top of that, national attempts to cope with the sector are stagnating in a politically changing

environment, which supports even more the argumentation that there is a profound need for a shift towards other approaches.

The metropolitan area of Thessaloniki is the second largest in Greece in terms of both population and size and accounts for more than 16% of the country's total solid waste production (Valavanidis & Vlachogianni; 2015). Almost half of the produced MSW are organic fractions (46%) followed by paper waste (19%) and plastics (9%) (Hellenic Solid Waste Management Association, 2010). There are two main municipal waste streams, which are the recyclables (glass, paper, plastic and metal packages) and the non-recyclables (organic, synthetic material, inert and unclassified); the rest include e-waste, as well as demolition and hazardous waste and derive from sectors other than the domestic.

Recyclables are collected in blue colored bins and non-recyclables in green colored bins. These are available in all neighborhoods and respective to the local population in service. The former are collected by trucks and transferred to the sorting stations before reaching their final recovery facility. The latter are also collected by trucks and sent to the transfer station in Finikas, prior to their long journey to the sanitary landfill of Mavrorachi (a distance of 60km) (Giannopoulos, Dimoudi & Plakas, 2010).

Although waste segregation at source is minimal and simplified to a two-dimensional practice (recycling and non-recycling that is), Greeks seem to be struggling to manage their waste appropriately. Wastes that cannot be recycled are recurrently found mixed with the recyclables in the blue bins, while packages are frequently removed during sorting from the general waste stream. In other cases, one chooses to discard a package in the recycling bins without making the prior effort to cleanse it from food leftovers, which can be destructive for the waste mix. More than often, people just do not know what sort of materials can be recycled and what not (e.g. plastics and multi-layer packages).

Eurobarometer (2008) conducted a comprehensive survey that was scoping for the Greek mentality towards SWM, among various environmental issues. Their findings showed that Greeks are not particularly worried about their growing waste (a slight 13% of the respondents expressed a concern over the topic in comparison to the average 24% of the rest EU participants). When questioned about their recycling behavior, only 32% answered positively for separating recyclables (against 59% of the EU average) and a 17% claimed to have reduced the consumption of disposable items (against 30% of the EU average). The study also revealed that more than 40% of the respondents did not feel that they are well-informed about environmental issues (Eurobarometer, 2008). The reasons for these malpractices are usually numerous and rather complicated, but undoubtly education is one of the most influencing factors on changing environmental behavior.

Environmental education and orientation on SWM in the Greek elementary

Primary education in Greece is a six-year compulsory curriculum which introduces children to both hard sciences, such as mathematics, chemistry, biology and physics, and theoretical disciplines such as literature and history. The incorporation of EE in the elementary school curricula was established a couple of decades ago as a core subject, namely "Study of the Environment", for grades 1-4 as well as an integrated topic in other courses and educational activities (Trikolas, 2015). From grade 5 and until the end of the secondary school, EE is assimilated thematically into relative subjects, such as geography and biology.

The course of EE is taught mostly in a teacher-centered way and learning is mainly based on the use of a textbook titled "Environmental Education in the Elementary". The book was first published in 1995 by WWF and is since then the primary informational source that introduces children to broad environmental topics which include biodiversity, climate change, water pollution as well as air and soil and degradation. The structure and graphic

layout of the book is for some researchers considered to be successful on providing students with both cognitive and emotional stimuli (Michailidis, 2012). The topic of SWM is introduced gradually and in accordance with the spatial context; grades 1-2 refer to scales "my school-my neighborhood-my community", grades 3-4 to "my community-my city-my country" and grades 5-6 (as an integrated topic) to "my country-my world". During the course, students familiarize with SWM terminology, waste treatment methods, the role of human activities in respect to SWM generation, consumption patterns, pollution and many more. A summary of the principal subject matters which are taught throughout the elementary is found in Appendix 1. Independent teacher initiatives are irregularly occurring, most commonly implemented with field projects that can provide students with empirical evidence and food for thought and discussion (Girbas, 2011).

Apart from the school curricula, the Panellenic Educational Association for Environmental Education in collaboration with various non-governmental organisations provides additional material that is optionally available to teachers and educators. Worth mentioning is the work of MEDIES (Mediterranean Education Initiative for Environment and Sustainability) which facilitates student-teacher matters and the educational community on EE, stimulates innovation and produces comprehensive educational input (Scoullos & Alampei, 2007). Additionally, an important contribution to the field of EE is this of the Lifelong Learning Centres for the Environment and the Sustainability (https://kpe.inedivim.gr/), which focuses on teacher capacity-building, experiential learning and participatory approaches to environmental management and often organizes informatory workshops and structured school activities.

Seemingly, the efforts made by educators and facilitators of EE can indeed provide students with a relatively high level of knowledge on the topic of SWM. It is widely believed that the more people know, the higher the concern for the environment is (Durant, Evans & Thomas, 1989), yet for some this seems as a rather linear and simplistic assumption (Prelle & Solomon, 1996). Evaluation of the learnt content thus, and especially on environmental matters as the present, should be critical and reflective to other aspects of learning that exceed rhetoric and knowledge-proofing, such as interest and empirical stimuli (Le Hebel, Montpied & Fontanieu, 2014). This suggests that the success of EE in engaging the students is bound to other factors that have to do with the students' perception of the topics covered by the curriculum.

Theoretical Background

Engagement, one word with a handful of meanings

The concept of engagement is explicitly addressed in social sciences issues related to human behavior. It is most commonly discussed in the fields of education (e.g. Appleton, Christenson & Furlong, 2008) and management (e.g. Johnson, 2004). While the term may be contextually different from one discipline to another, there is a general consensus on the psychological value of it. For instance, Kahn's (1990) perception of employee engagement as a physical, cognitive and emotional process (Kahn, 1990) is similar to that of Fredricks, Blumenfeld & Paris (2004) who distinguish it as a behavioral, cognitive and emotional learning outcome (Fredricks, Blumenfeld & Paris, 2004). The reason that this correspondence occurs lies on deep philosophical inquiries (e.g. those of Popper & Eccles, 1977; last edited in 2012) and psychology (e.g. Meece, Blumenfeld & Hoyle, 1988). Engagement, whether defined as a process or an outcome, implies personal investment, some form of participation and willingness to ameliorate and self-regulate one's cognition, emotion and behavior.

A significant body of research on engagement refers to academic achievement and is rooted in theories of drop-out prevention (Reschly & Christenson, 2012). From the primary traces of the term in literature (Mosher & MacGowan, 1985), to contemporary conceptualizations (Poskitt & Gibbs, 2010) scholars widely acknowledge that engagement is a composite concept which encompasses students' cognition, emotion and behavior (Fredricks,

Blumenfeld & Paris, 2004). In this spectrum, **Cognitive Engagement (CE)** includes attention, concentration and absorption of the learning content; **Emotional Engagement (EmE)** involves fun, enjoyment and personal satisfaction; and **Behavioral Engagement (BE)** encompasses effort, determination and persistence (Skinner & Pitzer, 2012). The three types of engagement are highly correlated to each other; cognitive engagement can sparkle both emotional and behavioral engagement, while at the same time attending emotional and behavioral needs can be foundational for deep cognitive learning (Poskitt & Gibbs, 2010). This multifaceted engagement is concretely rooted to motivational theories and particularly the Self-Determination Theory (SDT) (Fredricks, Blumenfeld & Paris, 2004; Skinner & Pitzer, 2012; Reeve, 2012).

Advocates of this relationship between the concept (of composite engagement) and theory (of self-determination) suggest that engagement happens when one has developed self-determination to learn by drawing intrinsic motivation through *autonomous* learning (Reschly & Christenson, 2012), *competence* building (Skinner & Pitzer, 2012) and obtains a sense of *relatedness* to the learning content (Furrer & Skinner, 2003)[2]. Autonomy can foster engagement and the lack of it can detrimentally influence the learning outcomes (Reeve et al., 2004). It is also consistently confirmed by literature that the higher a person's competence to follow through instructions and successfully complete tasks, the higher his level of engagement the task itself becomes (Linnenbrink & Pintrich, 2003; Ryan & Deci, 2000). Environmental research has shown that self-efficacy can minimize the psychological distance of a person to an environmental topic (Corner et al., 2015) and educational strategies that endorse both personal and collective competence are vital for resolving environmental problems (Chawla & Cushing, 2007). Relatedness is a highly relevant concept in the field of educational engagement and directly linked to achievement motivation (Wang & Eccles, 2013). In the EE context, relatedness plays a crucial role on facilitating behavioral change by providing the opportunity to minimize distances between urban citizens and the natural environment. However, it is not particularly clear in literature whether these conceptualizations exclusively influence either of the subtypes of engagement and are claimed to have strong interrelationships both with each other and with the different types of engagement; self-determination theorists more likely address engagement as a psychological continuum (Deci et al., 1991; Deci & Ryan, 1985).

This congruent relationship between engagement and motivation has often caused the interchangeability of the two terms in literature (e.g. Fan, 2011; Barber & Buehl, 2013) and research has raised a debate whether the two constructs can or cannot be considered as independent variables (Appleton, Christenson & Furlong, 2008). The scope of this study identifies motivation as a precursor of engagement or the means to an end, yet keeps the constructs separate and conceptually distinctive from each other. According to Reeve (2009a), "*motivation refers*

[2] In the spectrum of SDT, *autonomy* refers to one's freedom of learning in his own pace and accumulating knowledge in accordance to his cognitive abilities. Autonomy consists of three components of supportive actions, namely allowing *personal choice*, providing a *rationale* and recognizing other's perspective (Deci et al., 1994). It is often coupled to *perceived control* as independent constructs that act as motivational predictors (Patrick, Skinner & Connell, 1993). Researchers have studied the dynamics of both autonomy and perceived control in regard to educational tasks and their effect on the level of task engagement (De Naeghel, et al., 2012; Barber & Buehl, 2013). *Competence* or *self-efficacy* is an attribute that responds to a person's perception of (own) performance capacity (Bandura, 1991). A person that feels competent to succeed in a given task is more likely to keep pursuing it, while low competence can be demotivating and lead to task (or behavior) drop-out. Persistence and commitment to a task are also increasing when perceived self-efficacy is strong (Bandura, 1991). *Relatedness* refers to a person's need to feel related to others and to the context itself, as a sense of belonging to a community or a group (Skinner & Pitzer, 2012). Even though it is a more recent concept in motivational theories than autonomy and competence, research has proved a strong relationship between the level of relatedness of oneself to motivation and engagement in situated contexts and is considered to be a valid indicator of behavioral change (Booker, 2006; Eccles & Midgley, 1989; Furrer & Skinner, 2003; Ryan, Stiller, & Lynch, 1994). The work of Assor and colleagues (2002) has emphasized that autonomy is merely effective when relatedness to the taught context is weak or absent (Assor, Kaplan & Roth, 2002).

to any force that energizes and directs behavior" (Reeve, 2009a). Motivation is here conceptualized as intrinsic – power from within the self- and/or extrinsic –power from the external factors- and extrinsic motivation is classified as internalized (self-regulation is sourced from external variables and embodied into one's mindset as the new norm), externally-regulated (as in the case of rewards vs punishment), introjected (action results from internal coercion) and identified (willingness to do something not because it is interesting but because it feels important to do it) (Ryan & Deci, 2000). Intrinsic and extrinsic motivation can coexist and complement each other (Lemos & Veríssimo, 2014).

Although the present study is well-grounded to SDT, goal and expectancy-value theories cannot be overlooked or undermined. Goals can lucidly depict and steer motivational urges (Locke & Latham, 1990), and their level of proximity is highly interrelated to the concepts of self-efficacy and perceived competence (Bandura & Schunk, 1981). In fact, the same later work of Deci & Ryan (2000) on SDT has clearly portrayed goals' determinative power in human motivation (Deci & Ryan, 2000). Furthermore, research on goal setting in respect to both instructors and students has revealed that multiple aspects of learning, such as learning motivation and self-regulation, can be enhanced when the goals are proximal, meaningful and adjusted in respect to their difficulty (Turkay, 2014).

How is gamification relevant?

"If we take everything game developers have learned about optimizing human experience and organizing collaborative communities and apply it to real life… I foresee games that tackle global-scale problems like climate change and poverty… I foresee games that augment our most essential human capabilities-to be happy, resilient, creative- and empower us to change the world in meaningful ways."
(McGonigal , 2011, p. 14).

Gaming –independently of its nature of application- occupies a significant part of one's life, especially of those in childhood, and should be taken into consideration in discussions about fundamental social factors, such as education. Experience has empirically taught us the success of games on sustaining motivation and advancing skills. For instance, children that regularly engage into physical games, such as playing "hide and seek" or football, acquire a better physical condition and cognitive gains over time (White, 2012). Studies have further shown significant relationships between play and self-regulation (Meyers & Berk, 2014). Similarly, though still controversial, digital gaming has proven to have positive effects on cognitive development due to the fact that it most often requires both critical thinking (Green & Bavelier, 2008) and reflection (Greenfield, 2009).

Fun is consistently confirmed by literature to have a positive influence on cognitive development through childhood (Lockhart & SPECIALIST, 2010; Goldstein, 2012). In his book *What Video Games Have to Teach Us About Learning and Literacy*, Paul Gee, a well accredited scholar on linguistics and expert in video games, argues on how players cognitively engage into complex tasks that require critical thinking and problem solving skills, by repeatedly developing and testing hypotheses on how to proceed with the gameplay (Gee, 2003). From a physiological point of view, studies have shown that controlled exposure to video games can induce structural brain plasticity, which is fundamentally linked to mental learning processes (Kühn et al., 2014); Green & Bavelier (2003) have found that a person's abilities to cope with tasks demanding both perception and attention are heightened by a 10-20 hour exposure to video games (Green & Bavelier, 2003). Furthermore, Chandra and colleagues (2016) with their recent experimental research on cognition in youth, observed decreases in stress levels and cognitive improvements in action video game players (Chandra et al., 2016).

In an educational context, evidence has shown that the cognitive learning gains of game-based interventions are highly attributed their ability to incorporate and build on prior knowledge and provide instant feedback and assistance to the student (Iten & Petko, 2016). Bahrami et al. (2012)'s findings on the higher effectiveness of educational games for teaching math comparing to traditional teaching methods in both learning and retaining the content taught (Bahrami et al., 2012) are aligned with these of Shin et al. (2012), who found positive impacts of game technology on teaching arithmetic to elementary school students (Shin et al., 2012). The experimental research held by Mubaslat (2012) suggests that using educational games is also effective in language learning (Mubaslat, 2012). These are all strong evidence that gamified environments, whether these are game-based educative tools or games per se, can strongly influence students' CE to the subject matter.

Independently of their nature, games have an inherent ability capture the player's attention and successfully preserve it, which immediately proves their engaging power. Motivational benefits of game-based learning are frequently banked on the game's ability to induce fun into learning (Tobias & Fletcher, 2007; Rieber, 2005; Moreno & Mayer, 2007). An important argument of the advocates of game-based learning is that playing computer games can significantly enhance learners' motivation, in terms of affection (Kirriemuir & McFarlane, 2004; Brom, Preuss & Klement, 2011), thus cause a behavioral change. This assertion is heavily founded on the games' ability to create intrinsic motivation by targeting curiosity using elements such as fantasy and challenge (Cordova & Lepper, 1996). The rise of gamification in educational contexts is substantially anchored to the intervention's power to engage learners both emotionally (EmE) and behaviorally (BE), which can be easily explained if we draw back to the aforementioned motivational theories. Research on Goal-Setting Theories has clearly pinpointed two main types of goals, namely mastery and performance goals (Ames & Archer, 1988; Pintrich, 2000). These are of particular importance to game-based learning, since they can incite learning towards a certain educational direction (Erhel & Jamet, 2013). Mastery goals refer to those goals that aim to maximize the player's capacity to gain mastery of the game itself (e.g. to gain knowledge at a mastery level), whereas performance goals correspond to a more competitive behavior that seeks to surpass others' performances (e.g. to be the first on a leaderboard). Relationship between the concept of gamification and the SDT is also quite evident, since in essence the concept addresses all the theory's constructs. As already elucidated, the SDT suggests that the key to student engagement is to provide the learner with autonomous learning, through progressive competence building, and along with feelings of relatedness with both the content and the context (Deci & Ryan, 2000). Game-based learning seems to fit ideally in this case, where the player/learner has the freedom to adjust the learning pace according to his own perception of self-efficacy and receive constructive feedback that will further enhance his competence skills. Furthermore, playing games has exhibited the most of a human's eagerness and ability to get connected to the context so persistently that it becomes a habit; after all, why do we collectively invest 3 billion hours a week playing videogames without receiving external rewards (McGonigal, 2011) if we don't really feel deeply related to the games we play?

Conceptual Framework and Operationalization of the terms in use

Gamification is broadly acclaimed by academics as a way to successfully engage people into activities, whether these are to motivate employees (Cardador, Northcraft & Whicker, 2016) or enhance learning (Kirillov et al., 2016). This paper addresses engagement as a multi-dimensional construct that encompasses people's cognition, emotions and behavior and goes in line with many other studies (Fredricks, Blumenfeld & Paris, 2004; Poskitt & Gibbs, 2010; Skinner & Pitzer, 2012). In order to clarify which –if any- are the engagement gaps of students to the topic of SWM and evaluate if gamification can contribute to this engagement, the definitional term of engagement must be operationalized into its sub-components, as depicted in Table 1.

CE is a process that consists of a cognitive component, such as perceived knowledge and knowledge building through mental strategies (e.g. self-regulation and gradual accumulation of information) and a meta-cognitive component, which includes reflective mechanisms and critical thinking. It is often introduced as the **"head"** of transformative learning in the broader fields of sustainability (Singleton, 2010). CE is reported to be highly dependent to the other two types of engagement (Poskitt & Gibbs, 2010), since it demands both physical effort (behavior) and understanding which is achieved by getting somehow attached to the context itself (emotion). In order for information to be mentally absorbed, learning should be self-adjusted and autonomous; otherwise information is just memorized for the time it remains useful and fails to reflect back to habitual behavior. Cognitive reflection is often derived by our interactions with each other from which we get the necessary feedback we need to review and perpetuate our knowledge. Applied to the context, a highly cognitively engaged child builds on prior knowledge to identify problems related to SWM (cognitive component) and the cause of them (meta-cognitive component). Signs of CE would then be the perceived knowledge of the basic concepts of SWM (e.g. recycling) along with the use of logic to crystallize more complex information (e.g. knowledge of different waste treatment methods) and acknowledgement of the relationship between human actions and the environment.

EmE is a psychological procedure in which a person develops attachments to the context to a level that shapes his thinking and scaffolds his actions. The emotional dynamics between the students and the school context have for some a determinative power to the students' engagement to school, and consequently, to learning itself (Pietarinen, Soini & Pyhältö, 2014). EmE occurs when the emotional distance between the context and the self is minimized, thus the experience becomes joyful (Fredricks, Blumenfeld & Paris, 2004). EmE is what environmentalists call the **"heart"** of learning for the environment (Singleton, 2010). Motivation plays a paramount role in this type of engagement because it steers feelings towards a certain direction. From an educational perspective, providing a rationale or a narrative is consistently found in literature as a bridge of emotionally connecting people to –even uninteresting- tasks (Jang, 2008; Corner et al., 2015). In the present study, EmE is operationalized as the children's level of motivation towards the topic, after taking into account the categorization of different types of motivation as provided by Ryan & Deci (2000) (for details see theoretical background). Indicators of intrinsic motivation in this case are inner positive feelings towards the topic, such as interest in learning, discontent to other people's malpractices (e.g. throwing waste on the street) and contextualization of the importance of SWM beyond personal boundaries. Influence of extrinsic motivators must also be taken into account, because they can predict behavioral choices and thus give direction to future actions aiming to enhance EmE (e.g. effects of social norms).

BE includes physical attention and effort in activities and is broadly used to forecast students' learning outcomes (Fredricks, Blumenfeld & Paris, 2004). Behavioral engagement implies a level of participation, whether that is in an individual or collective task and is referred as the **"hands"** of environmental behavior (Singleton, 2010). Participation is often a core element in environmental education and is claimed to increase behavioral engagement through learning to see and learning to act (Chawla, 2008). A significant body of environmental research has argued that youth behavioral engagement through participatory strategies can influence collective goals and urban sustainability (Reid et al., 2008; Chawla, 2008; Bellino & Adams, 2017) and is often linked to democratic values (Lotz-Sisitka & O'Donoghue, 2008; Schusler & Krasny, 2008). BE is also significantly related to motivation, in two particular ways; an intrinsically motivated person is more likely to engage behaviorally in activities that support his inner beliefs (as for instance environmental activists do), while an extrinsically motivated person might act likewise yet not because he feels so but because an external force is making him comply with a certain kind of behavior (as in the case of law enforcement). Context-wise, actions might be induced by either intrinsic

feelings or extrinsic limitations; for example, a child might recycle on a habitual basis because he either feels it is important (for himself) to do so or because his family's normative behavior suppresses him to do so. This study focuses on two types of BE in regard to SWM: habitual behavior, which refers to action frequency and persistence (e.g. to recycling), and social behavior, which refers to interaction with the surroundings and others in parent-free or merely limited contexts, such as the school or neighborhood. Another indicator of high BE to the topic is agency (social behavior), which is in this case the ability of oneself to externalize his behavior in order to influence others' (e.g. denounce negative behaviors).

Table 1. Operationalization of the terms in use

Target Variable	Sub-variables	Indicator
Cognitive Engagement (CE)	Cognition	Perceived knowledge on SWM
	Meta-cognition	Acknowledgement of human impact
Emotional Engagement (EmE)	Intrinsic Motivation	Willingness to learn about SWM
		Values/morals
	Extrinsic Motivation	Influence of social norms
		Influence of regulations
Behavioral Engagement (BE)	Habitual Behavior	Recycling/ reusing frequency
		Persistence
	Social Behavior	Contextualizing behavior
		Agency

The instrument that is in the following chapter used to evaluate CE, EmE and BE was built with respect to the indicators provided by the operationalization of the terms (Table 1).

Methodology

Research design

The present research is of exploratory nature and uses a mixed-methods approach to answer the defined sub-questions and provide a qualitative input for addressing the research objective (Figure 1). Data collection was based on literature on the concepts of engagement and gamification, as well as from background information on the particular context. Additionally, in order to identify the current state of engagement of the children to the topic of SWM and in regard to the three distinct variables, a questionnaire survey was constructed. Convenience-sampling was selected for regional specificity, followed by the draw of a random sample of elementary schools inside this sampling area. Selection of the participants and the survey procedure are analyzed below. Inputs from both instruments were then used in the data analysis that led to answering the main research question.

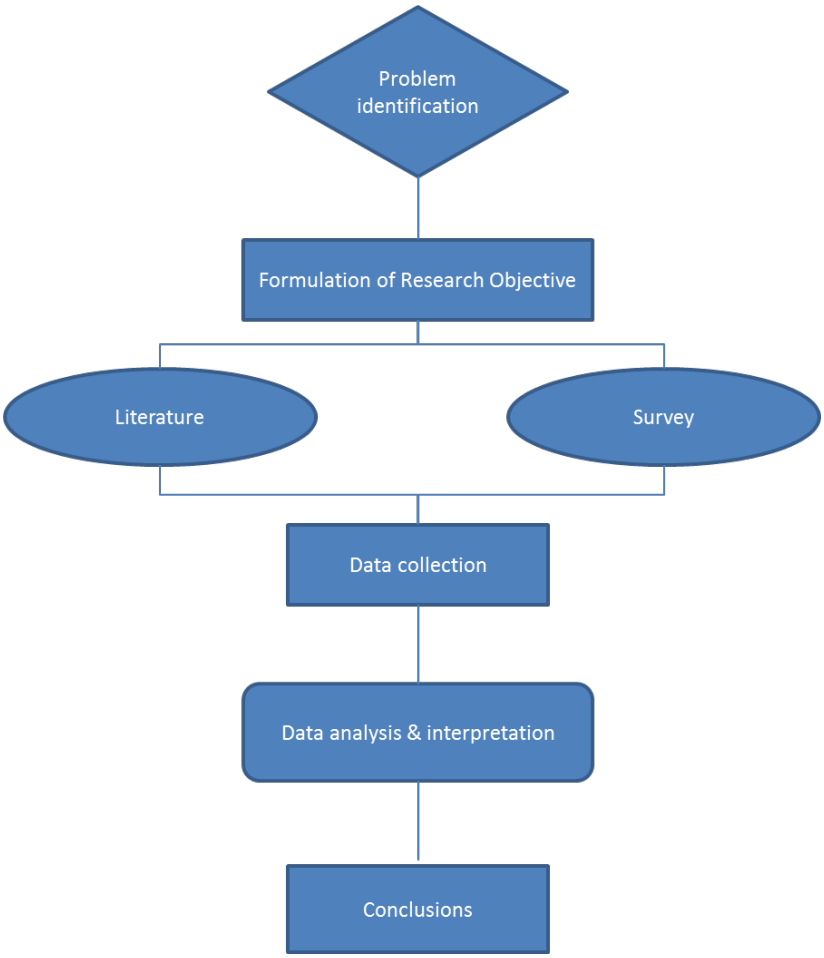

Figure 1. Research design

Survey

Participants

The questionnaire was distributed in hard-copies in five random public elementary schools of the metropolitan area of Thessaloniki, in the beginning of the second semester (early December). The sample was drawn in this particular area mainly because (i) it is a good representative of a Greek urban environment and (ii) for practical reasons, such as the ease of distribution and collection of data and budget limitations, since the network with schools in Thessaloniki was already established, thus questionnaires could be catered personally. The responding grades were grades three, four and five, which refer to children of 8-10 years old. This particular age range was selected for two main reasons. First, the selection was based on Piaget's theory of Cognitive Development which characterizes the age range between 7 and 11 years old as the "Concrete Operational Stage" of a child's evolution of cognition and suggests that children of this age have started to build their thinking by using logic (Piaget, 1976). Inductive reasoning is also introduced by Piaget at this developmental stage, which is highly relevant with processing subjects that concern other than the self, as EE and its sub-components are. Second, EE in the elementary changes in 4th grade from being a core subject to an integrated subject in other relevant courses, such as biology and chemistry (Trikolas, 2015); this may cause discrepancies in the children's knowledge of the topic of SWM and thus this transition phase should be examined.

A total N=177 students participated in the survey, which is above satisfactory in regard to the metropolitan population which corresponds to 1.109.969 citizens[3]. All students in the sampled classes filled in the questionnaires during class sessions.

Procedure

The questionnaire consisted of seventeen items divided in three sections, namely CE, EmE and BE; the first section (items 1-6) aimed to evaluate the knowledge and cognitive skills that children perceive as acquired, the second (items 7-12) provided an insight on how the children feel about the topic of SWM and the third (items 13-17) targeted their perceived behavior regarding waste. A three-point Likert scale was used in fifteen items, while the rest two items were constructed differently (see Appendix II); the first was a quiz matching question which was placed in section one (the children were asked to match four materials according to their degradability); the second was an "expression cloud" with words that described emotions and allowed children to express how they feel about the topic, placed in section two (later removed in the analysis). The choice of the three-point scale was based on preliminary conversations with the school teachers, who suggested that this range of responses was appropriate for the children's current cognitive abilities. The measurements of all subtypes and constitutes of engagement were taken on different scales in respect to each target variable, namely as "limited or no knowledge-high knowledge", "negative affection-positive affection" and "negative behavior-positive behavior".

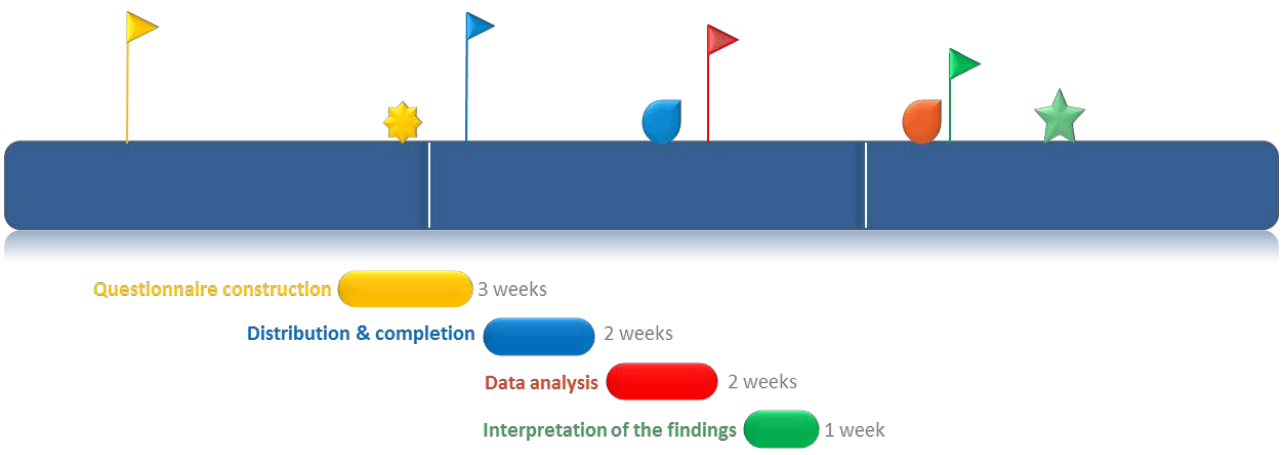

Figure 2. Survey timeline

The survey started with a brief introduction to the research and the researcher and the respondents were assured of the confidentiality of their responses. The children were then asked to complete their gender and school grade and proceed with the questions. A thank you note was placed in the end of the questionnaire, as an act of gratitude for participation.

The survey was conducted in Greek and all results and quotes in this paper were translated to English as literally as possible. Data were collected and analyzed and the findings were interpreted qualitatively. A timeline of the survey procedure is depicted in Figure 2.

[3] Source: Eurostat 2016.Retrieved from http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

Analysis

Survey Findings

The instrument used aimed to provide the research with qualitative information about the children's current level of engagement to the topic of SWM. Therefore, the statistical methods used in this study mostly consisted of descriptive statistics of frequency count, percentage and standard deviations. Responses were relatively dispersed equally among girls and boys, with 50.8% and 49.2% respectively. Most respondents attended 4th grade (41.8%), followed by 5th graders (30.5%) and 3rd graders (27.7%). The sample was rather homogeneous in terms of ethnical background, with a minority of students (a little above 3%) having an other-than-Greek nationality. Demographic characteristics of the participants are presented in Figure 3. The assumption that the sample responds to middle-class families was made, based on the fact that all elementary schools participating on the study were public. After a preliminary test, one item (item 12) was excluded from the survey because it returned confusing facts. Responses were measured with regard to both discriminative factors and their individual components.

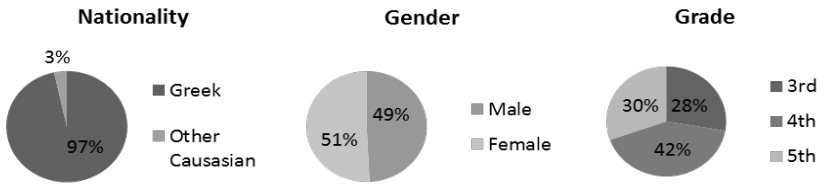

Figure 3. Background of the participants

Overall knowledge of and around the topic of SWM seems to incrementally develop throughout elementary, which aligns with findings from other studies (e.g. Kollmuss & Agyeman, 2002), and no significant differences were observed amongst girls and boys. Meta-cognitive tendencies were found to be mutually high for all grades and genders, with nearly all respondents (96.6%) acknowledging the negative relationship between waste and the environment. The vast majority of kids (92.7%) knew what recycling is, but only one third of the students seemed to know which materials can actually be recycled and which not. Technical knowledge on waste treatment methods were, as expected, harder to find among all ranges (62.6% of the total respondents was familiar with composting whereas 52% with waste-to energy treatment), which however tends to increase along the school years. About 40% of all participants (13 cases were missing) knew the average lifetime of waste materials, such as glass, plastic, aluminum and biodegradable, and a low peak on knowledge was observed during the 4th grade. Considerable deviations were observed on items 3 (waste segregation), 4, 5 (waste treatment) and 6 (degradability), which may imply that deepened knowledge on SWM may derive from other than the school contexts, such as family or another close environment. Descriptives are presented in Figure 4.

Both intrinsic and extrinsic motivators were evaluated in an attempt to measure the children's EmE to the topic of SWM. Frequencies of positive affection were observed to increase with age and no significant differences were found between genders (Figure 5). Both intrinsic and identified motivation were found to be considerably high for both genders and for all grades, with 97.7% of the respondents exerting a feeling of annoyance towards others' inappropriate behavior and a 99.4% having contextualized the importance of SWM on both a personal and communal level. While most of the children reported that their positive affection towards SWM is not substantially reluctant to regulations, 19% of the total respondents admitted that their intentions were malleable to the absence of punishment. Social norms heavily affected the children's EmE through all corresponding grades (more than 70% of the children reported influence from family and friends) and girls presented a slightly stronger

dependence to their social environment than boys. Eagerness to learn about SWM was found catholically high, yet more than 13% of the respondents had minimal or absent interest in learning, which reflects to the fact that either they found the topic boring or difficult to grasp. Though EmE was found relatively high amongst participants, increasing the interest to SWM might substantially increase engagement and yield cognitive and behavioral benefits.

Sub-variables			Frequency	Percent	Valid Percent
Meta-cognition/ waste impact	Valid	limited or no knowledge	3	1.7	1.7
		not sure	3	1.7	1.7
		high knowledge	171	96.6	96.6
		Total	177	100.0	100.0
	Std. Deviation .287				
Cognition/ definition of recycling	Valid	limited or no knowledge	3	1.7	1.7
		not sure	10	5.6	5.6
		high knowledge	164	92.7	92.7
		Total	177	100.0	100.0
	Std. Deviation .342				
Cognition/ material segregration	Valid	limited or no knowledge	65	36.7	36.7
		not sure	54	30.5	30.5
		high knowledge	58	32.8	32.8
		Total	177	100.0	100.0
	Std. Deviation .835				
Cognition/waste treatment_composting	Valid	limited or no knowledge	9	5.1	5.2
		not sure	56	31.6	32.2
		high knowledge	109	61.6	62.6
		Total	174	98.3	100.0
	Missing		3	1.7	
	Total		177	100.0	
	Std. Deviation .592				
Cognition/waste treatment_waste-to-energy	Valid	limited or no knowledge	14	7.9	8.2
		not sure	68	38.4	39.8
		high knowledge	89	50.3	52.0
		Total	171	96.6	100.0
	Missing		6	3.4	
	Total		177	100.0	
	Std. Deviation .642				
Cognition/ degradability	Valid	limited or no knowledge	51	28.8	31.1
		not sure	45	25.4	27.4
		high knowledge	68	38.4	41.5
		Total	164	92.7	100.0
	Missing		13	7.3	
	Total		177	100.0	
	Std. Deviation .848				

Figure 4. Response frequencies CE

Sub-variables			Frequency	Percent	Valid Percent
Intrinsic motivation/values towards SWM	Valid	negative affection	2	1.1	1.1
		neutral	2	1.1	1.1
		positive affection	170	96.0	97.7
		Total	174	98.3	100.0
	Missing		3	1.7	
	Total		177	100.0	
	Std. Deviation .238				
Extrinsic motivation/ identified importance of SWM	Valid	negative affection	0	0.0	
		neutral	1	0.6	0.6
		positive affection	172	97.2	99.4
		Total	173	97.7	100.0
	Missing		4	2.3	
	Total		177	100.0	
	Std. Deviation .076				
Extrinsic motivation/ regulations effect	Valid	negative affection	33	18.6	19.0
		neutral	17	9.6	9.8
		positive affection	124	70.1	71.3
		Total	177	100.0	100.0
	Missing		3	1.7	
	Total		177	100.0	
	Std. Deviation .795				
Extrinsic motivation/ social environment effect	Valid	negative affection	29	16.4	16.7
		neutral	20	11.3	11.5
		positive affection	125	70.6	71.8
		Total	174	98.3	100.0
	Missing		3	1.7	
	Total		177	100.0	
	Std. Deviation .764				
Intrinsic motivation/interest to learn SWM	Valid	negative affection	5	2.8	2.9
		neutral	18	10.2	10.4
		positive affection	150	84.7	86.7
		Total	173	97.7	100.0
	Missing		4	2.3	
	Total		177	100.0	
	Std. Deviation .441				

Figure 5. Response frequencies EmE

Waste management behavior includes all individual and collective behavior that children actively engage to. Recycling was reported as a well-adopted practice for both boys and girls, with an 88.1% claiming to recycle on a habitual basis. Yet, less than half of the respondents (44%) reported persistence on recycling which may result from other influencing factors, such as emotional or contextual. Reusing was observed to be less common among all participants (68.8% responded positively), with girls exhibiting more interest in rethinking their waste than boys. Deviations in the latter two items were significant (.881 and .601 respectively), which implies that these particular activities may be the result of family influences. Moreover, most children (85.8%) claimed that when

they find waste on their home, school or the street they usually collect it and then discard it in a garbage disposal bin. Lastly, a significant percentage of respondents (77.8%) reported that they exert agency towards others by discouraging inappropriate waste-related behaviors. The descriptive statistics of BE are depicted in Figure 6.

Sub-variables			Frequency	Percent	Valid Percent
Habitual behavior/ recycling frequency	Valid	negative behavior	6	3.4	3.4
		neutral	15	8.5	8.5
		positive behavior	155	87.6	88.1
		Total	176	99.4	100.0
	Missing		1	0.6	
	Total		177	100.0	
	Std. Deviation .446				
Habitual behavior/ recycling persistence	Valid	negative behavior	59	33.3	33.5
		neutral	38	21.5	21.6
		positive behavior	79	44.6	44.9
		Total	173	97.7	100.0
	Missing		1	0.6	
	Total		177	100.0	
	Std. Deviation .881				
Habitual behavior/reusing frequency	Valid	negative behavior	11	6.2	6.3
		neutral	44	24.9	25.0
		positive behavior	121	68.4	68.8
		Total	176	99.4	100.0
	Missing		1	0.6	
	Total		177	100.0	
	Std. Deviation .601				
Social behavior/ contextualizing	Valid	negative behavior	1	0.6	0.6
		neutral	24	13.6	13.6
		positive behavior	151	85.3	85.8
		Total	176	99.4	100.0
	Missing		1	0.6	
	Total		177	100.0	
	Std. Deviation .372				
Social behavior/ agency	Valid	negative behavior	3	1.7	1.7
		neutral	36	20.3	20.5
		positive behavior	137	77.4	77.8
		Total	176	99.4	100.0
	Missing		1	0.6	
	Total		177	100.0	
	Std. Deviation .466				

Figure 6. Response frequencies BE

In summary, the findings suggest that any interventions aiming to increase engagement to the topic should primarily:

- focus on simplifying information on the topic of SWM, especially in transferring information about source separation, material degradability and waste treatment methods and allow for gradual accumulation of knowledge
- increase the children's interest towards the topic while considering external influences (social environment and regulations)
- aim to minimize behavioral tentativeness on recycling, promote reusing, and leverage the children's agency

Research on engagement literature and motivational theories has revealed some focal points where contextualized engagement on learning can occur. These refer to personal attributes that have been observed by other researchers to increase each subtype of engagement distinctively, as well as to overarching goals that steer motivation and behavior. The survey was successful to provide the research with some valuable findings about the children's perspective on the topic of SWM in terms of their cognition, emotion and behavior and therefore can serve as a baseline on which a gamification intervention can be designed.

How can gamification contribute to these findings?

Game elements

Gamification is more often defined as "the use of game design elements in non-game contexts" (Deterding et al., 2011). All games are constituted from some fundamental elements –or core elements- that determine game progression and dynamics. Deterding et al. (2011) with their literature review identified five levels of game elements: (1) Interface design patterns, such as points, **levels**, **badges, rewards** and **leaderboards**; (2) game design patterns or game mechanics like **time constraint**, **finite resources**, **turns** and **feedback**; (3) design principles, heuristics or 'lenses' as **clear goals** and **game endurance**; (4) conceptual models of game design units such as **challenge** and **fantasy** and (5) game design methods and design processes like **playtesting** and **playcentric design** (Deterding et al., 2011). Figure 7 depicts a screenshot from the popular game "Fishdom" which I chose as a clear example to portray game elements in application.

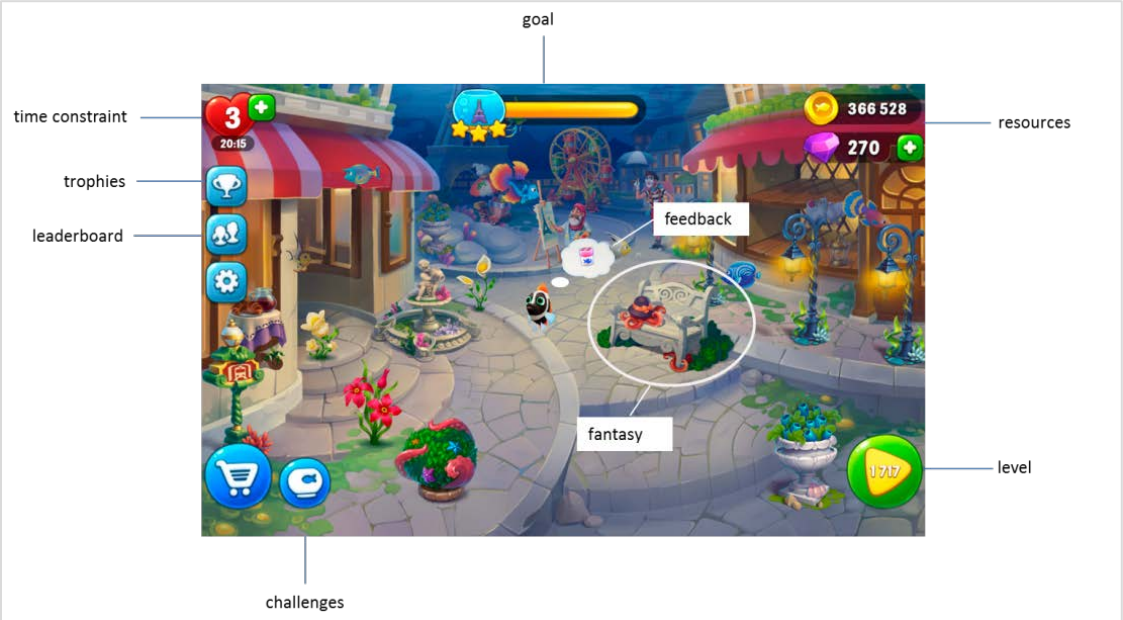

Figure 7. Game elements. Example from the popular game "Fishdom".

These elements can potentially be applied in seemingly irrelevant contexts in order to achieve a specific goal. The concept of gamification has been researched extensively in topics related to employee motivation (Perryer et al., 2016; Cardador, Northcraft & Whicker, 2016), marketing (Yang, Asaad & Dwivedi, 2017; Rodrigues, Oliveira & Costa, 2016), health and nutrition (Berger, Miesler & Hari, 2014; Baranowski et al., 2008; Alahäivälä & Oinas-Kukkonen, 2016) and education (Kirillov et al., 2016; Geelan et al., 2015; Huizenga et al., 2009) with positive results concerning its power to engage people. Gamification has also been examined under the scope of environmental sciences but is noticeably confined to energy related practices (Bång, Torstensson & Katzeff, 2006; Gustafsson, Katzeff & Bang, 2009; Reeves et al., 2015.; Bång, Svahn & Gustafsson, 2009; Barrios-O'Neill & Hook, 2016). A very comprehensive practical demonstration of gamification is Volkswagen's Fun Theory (http://www.thefuntheory.com), in which people get motivated to recycle (see the Bottle Bank Arcade), to exercise (see the Piano Staircase), to drive under the speed limits (see the Speed Camera Lottery) or to keep on their seatbelt (see the Play Belt) by engaging into fun activities.

Some game elements are actually already applied in education –such as grades (points) and classes (levels)- but are usually unsuccessful in engaging students, which for some presents an example of bad gamification (Smith-Robbins, 2011). Undoubtly, the concept of gamification seems promising to enhance engagement in learning, yet evidence show that a careful design is what will make a gamification intervention effective or not.

Design principles for a targeted intervention

The first and probably most valuable finding of the survey was the children's knowledge deficiency on principal SWM components, such as material segregation, degradability and waste treatment methods. However, nearly all participants recognized that waste is harmful for the environment, which indicates that children of this age are able to comprehend the cause-effect relationship between their actions and the particular environmental problem. This immediately proves that the current pedagogical approach of the Greek elementary on the topic of SWM is failing to convey the concepts effectively to students, despite the fact that all of them seem to be adequately introduced by the course of EE (for detailed references see Appendix I). Gamification can provide the cognitive scaffold that is needed for two main reasons. First, because it leaves space for autonomous and self-paced learning, known in the gamers' world as ***leveling***, thus helps children understand these concepts by allowing failing and re-probing of hypotheses; levels also represent ***clear goals***, both in the long-term (as reaching an ultimate goal) and in the meantime (as achieving sub-goals). Second, students are given the opportunity to increase their cognitive competences on the subject matter by receiving immediate ***feedback*** on their progress. So to speak, information about the foresaid SWM components should be delivered through the gamified intervention incrementally and with immediate interaction with the student, and it is suggested that successful comprehension of the previous information is a prerequisite to proceed further (e.g. completing levels or achieving sub-goals).

The second finding refers to the lack of interest of some children to the topic, which can possibly be sourced into either cognitive or emotional disengagement; the relationship between interest and prior knowledge is mutual (Tobias, 1993), thus it can be safely assumed that the more they get a grasp of the topic, the higher their interest will be and, subsequently, the more the interest they get the better are the chances for retainment of information. A ***narrative*** could in this case be the proper facilitator that helps children first understand and then relate to the topic. Familiarizing with the environmental topic of SWM through gamification can also be done by providing a sense of ***epic meaning*** to the design, which according to Chou (2015) can be one of the most important tools to emotional engagement (Chou, 2015). Observed influences of social environment and regulatory limitations could be leveraged for increasing interest to SWM if elements like ***collaboration*** and ***rewards*** are used in the design. Collaboration was argued from Franklin, Peat & Lewis (2003) as a "*useful tool for effective teaching*" (Franklin, Peat & Lewis, 2003, p.82) and could be used in this case as a building block of the intervention's

dynamics. Rewards should nevertheless be designed with high precaution, since they have been long accused for attenuating intrinsic motivation based on the fact that the receiver might at some point feel that his behavior is controlled by the rewarder (Deci, Koestner, & Ryan, 1999).

Another significant observation was the lack of behavioral persistence to recycling. This may be caused by the observed deficiencies in CE and EmE in a way that (a) the lack of knowledge might result to unintentional actions (e.g. the children do not comprehend why persistence is important on recycling); (b) emotional amotivation might lead to negative behavioral choices (e.g. they do not find the topic interesting enough to commit to recycling). However, persistence may also be low due to contextual parameters (e.g. recycling infrastructure provision is inadequate for their neighborhoods), which yet cannot be verified in this study because effort is often subjective (Von Helversen et al., 2008). ***Challenges*** are claimed to increase persistence and self-regulation, yet the challenge should be neither too difficult (so that the learner gets demotivated) nor too easy (as becoming boring) (Cannon-Bowers, 2010). Chou (2015) places challenges in priority among game elements because, as he explains, they can satisfy core human drivers, such as development and achievement needs (Chou, 2015). Challenges can also foster learning on reusing, which was found to be unpopular amongst all, in terms that they could –again if difficulty is appropriately adjusted- push students to think beyond the common practices like recycling. Analyzing the children's social behavior in respect to the subject matter revealed a high potential of agency that can be outsourced to increase BE; children should be free to exchange opinions and ideas with their peers in a common ground, such as a ***forum***, which is said to increase engagement in terms of participation in learning (Tan & Hew, 2016).

The suggested gamification elements that can potentially support EE in the Greek elementary on the topic of SWM are summarized in Table 2.

Table 2. Gamification potential in respect to the different variables and suggested game elements

	Gamification potential	Game element
CE	Supporting knowledge	levels
		clear goals
		feedback
EmE	Increasing interest	narrative
		epic meaning
	Leveraging social influences	collaboration
		rewards
BE	Increasing persistence	challenges
	Promoting reusing	
	Exploiting agency	forum

Discussion & Limitations

Answers to the sub-research questions derived from the survey which included different aspects of engagement. Self-reported data are often said to cause response biases (Yu, 2010), especially in reflecting behavior (Carver & Scheier, 1981). In this case, particularly responses regarding social behavior might be distorted under the influence of social acceptability. The data could further be cross-examined with additional input from the children's closest observers, such as their teachers or parents in order to increase the validity of responses. The

data may also be highly vulnerable to selection bias in respect to the geographic location for sampling; for instance, municipal laws regarding SWM might be stricter or looser in the particular area comparing to others or teacher initiatives are more and more frequent, and thus results might differ if the research was repeated in another relevant location in Greece.

Responses to the questionnaire brought forward notable deficiencies in all sub-components of engagement, whereas gender did not quite affect response distribution between participants as with many other researches on engagement of children to environmental topics (Eagles & Muffitt, 1990; Ramos & Pecajas, 2016). Grade also did not influence responses noticeably; though overall engagement to the topic seems to slightly increase with age, no particular findings suggest that the targeted intervention should be adjusted with respect to the different elementary grades. This stagnation effect might however be due to the questionnaire's distribution time and results may be affected if the survey is held towards the end of the school year.

Results of the survey in respect to the cognitive part of engagement are similar to those of Hausbeck, Milbrath & Enright (1992) who found that although the knowledge of 11th grade students on environmental topics was rather low, their concern for the environment was significantly high (Hausbeck, Milbrath & Enright, 1992). The prevalent influence of extrinsic motivations towards waste management, such as social norms and regulations, was hereby observed, likewise in other recent studies (Cecere, Mancinelli & Mazzanti, 2014). Behavioral patterns were found in line with the those of Barr, Gilg & Ford (2001), with most of children having adopted recycling, whereas reusing is still far from becoming a habit (Barr, Gilg & Ford, 2001). According to Cecere, Mancinelli & Mazzanti (2014), waste reduction –which is by nature associated with reusing- is subject to intrinsic rather than extrinsic motivations, thus adopting the habit of reusing is more likely to happen when the interest for the topic is maximized (Cecere, Mancinelli & Mazzanti, 2014). This implies correlations between the emotional and behavioral parts of engagement, as already suggested by theory (Fredricks, Blumenfeld & Paris, 2004). Due to time limitations, the instrument was not designed to measure these correlations, which should be analyzed before any intervention is implemented. A correlational research of the three engagement types in respect to SWM would further validate the results and provide a clearer answer to *how* this intervention should be implemented in the Greek context. Psychometric properties of the sub-variables should also be measured in the future, in order to increase the reliability of the data and enhance internal consistency of the research instrument.

This research initiative attempted to trace the engagement defects that children demonstrate on the topic of SWM in a Greek elementary context, and unfold the potential of gamification on addressing them. Literature review suggested that investigation of the problem of SWM in such a precise scope and context is still lacking, thus this study serves as a ground for further research. The lack of actual applications of gamification in Greek education prompted for a rather theoretical approach to the subject. The conceptualization of engagement was here anchored to particular motivational theories which served as foundations in exploring gamification's contribution in learning of the particular content, which may have however narrowed the theoretical scope of the study. Nonetheless, gamification is rapidly becoming a trending topic in the research community and the links between the concept and psychological theories are yet to be further explored, thus any concrete perspective can be considered of an academic value.

Conclusions & Future Work

Since the current national strategies and policies do not seem to be effective in engaging Greek citizens to sustainable waste practices in order to mitigate the problem of MSW in urban hubs, targeted interventions in EE could potentially be the solution which we need to focus our efforts on. The present study shed light on the

current level of engagement of pupils on the topic of SWM in the Greek context and provided suggestions for a gamification design that can contribute to that engagement and support EE in the particular content. The concept of engagement was broken down into sub-variables in respect to theory and distilled to individual indicators to provide clear answers on the current knowledge, affection and practices on SWM among children. The analysis showed that there is indeed a need to provide a cognitive, emotional and behavioral support on learning of SWM in the Greek elementary and gamification so far seems a promising approach to serve for this purpose. This research has shown that in theory, embedding the specific game elements –levels, feedback, clear goals, narratives, epic meaning, collaboration, rewards, challenges and forums- in the school curricula can contribute to increasing engagement to the topic, which in the long-term might result to improved behaviors towards waste management. Analyzing the engagement gaps between children and the topic revealed, among others, severe knowledge deficiencies, despite the fact that EE in its current state is actually addressing all the components of SWM that have been tested in this research extensively throughout the curriculum. Reasons behind this occurrence should be further examined so that future gamification design parameters take into account the relevant weight of each type of engagement, as well as its influence to the others. Methodological flaws of this research should be eliminated in the future so that a detailed gamification design can be formulated and, eventually evaluated for its effectiveness. Gamification should however be also explored in other related topics as a tool for educational engagement, so the theoretical relationship between the two concepts is further concretized. Nonetheless, this study serves as a first endeavor to explore how gamification can contribute to pupil engagement on environmental issues in the Greek context and provide support to the existing curriculum of EE on the topic of SWM. Using gamification as a strategic approach to engage people is already proved in many other fields of studies and exploring its educative potential remains a priority in the future agenda.

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Appendix I- Main educational themes on waste in the Greek elementary. Translated from Greek

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Topic	1st Level (1st-2nd grade) "Our school / our neighborhood / our community"	2nd Level (3rd-4th grade) "Our community / our city / our country"	3rd Level (5th-6th grade) "Our country / our world"
Waste	Core environmental concepts (waste, recycling, waste, re-use, landfill)	Core environmental concepts (sustainable management, segregation, waste treatment, composting, ecological footprint, natural resources re-use)	Core environmental concepts (radioactive, chemical and toxic waste, energy, climate change, greenhouse effect, environmental degradation, landfills, waste water)
	Pollution of the environment	Waste collection and treatment process	Solid and other (liquid and gas) waste management
	Waste in the school unit	Reduction, reuse, recycling	Energy saving
	Categorization of different types of waste	Causes of waste generation	Conservation of natural resources
	Human activities that generate waste	Natural resources and production	Environmental, economic and social consequences of waste generation
	Over-consumption	Modern lifestyle and increase of waste	European and National Legislation on Waste
	Impact of waste	Water and soil pollution	Organic waste
	Ways to deal with the waste problem	Environment friendly packaging	Modern consumer standards
	Cleaningness of common areas	Consumer habits and waste generation	Services, bodies and waste management teams

Appendix II- Questionnaire items

Section	No.	Item
1 (CE)	1	Waste is harmful for the environment.
	2	Separating packages and throwing themin the blue bin is called recycling.
	3	All materials can be recycled.
	4	Fertilizer can be created by using organic waste, such us tree leaves and banana peels.
	5	Energy can be created using our waste as a primary material.
	6	How long does the rubbish stay in the environment? Help me match the below!
2 (EmE)	7	I get annoyed when I see people throwing their rubbish on the street.
	8	I feel that recycling is important because it is good for my health, the environment and our city.
	9	I am allowed to throw my rubbish on the street, as long as nobody will scold me for that.
	10	If people around me were recycling, such as my school, family and friends, I would do it too.
	11	I like learning about waste management.
	12	I feel that waste management is….Please circle the three words that express you the most!
3 (BE)	13	I separate packages from the rest of my waste and I throw them in the blue bin, so that they can be reused.
	14	I sometimes throw items that can be recycled, such as glass or plastic bottles, in the green bin of general waste.
	15	Before I throw something away, I think of ways to reuse it or transform it into something new.
	16	If I notice rubbish in my home, school or the street, I usually pick them up and throw them in the trash can.
	17	When I see a friend of mine throwing rubbish on the street, I scold him for that.