Children Learning about 'Urban Sustainability' through Playing and Re-constructing a Half-Baked Microworld

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Abstract

The study reported in this paper is based on the implementation of an educational activity which was designed to engage Greek students of the 6th grade in collective meaning-making processes on the concept of 'urban sustainability' while collaboratively playing and de-constructing a game microworld. A half-baked digital game on the idea of sustainable city was created by the researchers based on the Sus-X microworld template. The study's findings indicate that the students' understandings of what 'sustainability in a city' pertains seem to evolve as a result of the processes involved in the constructionist activity. Patterns of their interaction with the microworld show that the students managed to realise in varying degrees the existence and interplay of the three axes of sustainability (environment - society - economy). We discuss the learning gains of treating complex and abstract concepts, such as that of sustainability, through applying constructionist pedagogical designs.

Keywords

Sustainability, sustainable city, Constructionism, digital games, half-baked microworlds

Introduction

Constructionist frames of epistemology and learning have been traditionally applied to subject domains such as mathematics education, science education and computers education. Extending constructionist thinking beyond these fields to social sciences, humanities and the arts is a major challenge yet to be undertaken. This is particularly true for educational domains that promote interdisciplinary, systemic and critical knowledge about complex concepts and issues related to contemporary realities such as those dealt within the context of Environmental Education (EE) and Education for Sustainable Development (ESD). Does Constructionism offer new tools along with a new platform for thinking about how to gain new ways of understanding these concepts and issues and consequently how to design learning in these domains in both appropriate and more effective ways? The study reported in this paper has been designed to explore the implementation of a constructionist framework in teaching and learning about the concept of urban sustainability within the context of an EE activity.

Sustainability has become a fashionable word in environmental policy discourse over the last two decades not only among scientists, politicians and policy-makers but also among the general

public. It is nevertheless a notion by nature 'difficult' to work with as it lends itself to numerous interpretations (Daskolia, Kynigos & Yiannoutsou, 2012). As a means to overcome the inherent vagueness of the concept, it is suggested to be approached through its core dimensions. There is some consensus that sustainability brings together three different axes: environment, economy and society (UNESCO, 2005). They constitute the tree pillars of sustainability, three interdependent and overlapping systems, the proper functioning of all three is a necessary condition for achieving sustainability. The environmental axis refers to the effective protection of nature and the physical environment as well as the prudent use of natural resources. The economy axis stems from the need for establishing a prosperous and viable economic exchange which has to take into consideration the limits of economic growth and to be based on a redefinition of the personal and social levels of consumption. As far as the society axis is concerned, sustainability has to be founded on healthy communities and to promote democratic and participatory systems and processes that allow free expression of views and the rigorous building of social consensus. Human welfare and rights, peace and the establishment of a sense of security among the citizens, gender equality, cultural diversity and health are some of the aspects which are closely related to the societal axis.

Over the last twenty years the concept of sustainability has been closely associated with education. Learning about sustainability is acknowledged as an essential strategy for achieving sustainable societies and as a tool to enhance quality in educational practice (European Council, 2010). However, current school practices face many difficulties in promoting sustainability due to the resistance placed by traditional school structures, which remain greatly normative and conservative, to respond to this challenge, as well as to the reluctance of teachers to deal with 'difficult' concepts and issues (Stevenson, 1987).

In order to address this problem innovative approaches and pedagogies need to be explored so that children and young people are encouraged to get involved in meaningful educational processes aiming to promote sustainability (Kynigos & Daskolia, 2011; Daskolia, Yiannoutsou, Xenos & Kynigos, 2012). Digital game-based learning is among those fields whose potential for sustainability education rests to be further explored, as it is argued to support the development of important skills, such as strategic thinking, planning, communication, negotiation, group decision-making and data-handling (Kirriemuir & McFarlane, 2004). It is worth noting that the number of digital games on themes related to sustainability has grown exponentially over the last years. The learning potential of some of these software tools lies in that they provide players with opportunities to 'experiment' with applying sustainability principles and virtually experience the consequences to them otherwise impossible to occur in the real world; or that they evoke their involvement as prospective citizens into individual and collective action associated with sustainability goals (Liarakou et al, 2011).

One of the most popular themes addressed by current digital games on sustainability is the urban environment (Liarakou et al, 2011). Contemporary cities as complex agglomerations of human-made and physical environmental systems are among those cases offering many opportunities for identifying, defining and testing the application of sustainability. According to Yanella and Levine (1992) all initiatives towards sustainability should be centred on strategies for designing, redesigning and building sustainable cities. Although many would see the city as an ecological entity or as the extended version of an ecosystem (Newman, 1999), the idea of the sustainable city calls for a more elaborated and systemic conception of all its interconnected components (social, cultural, economic, and environmental) and for a consideration of the impact of our choices and everyday practices on each of them. For a city to be regarded as sustainable it has to be designed, run and lived by people who not only take into account how to protect its natural

environment and how to minimize their inputs (in terms of energy and other resources) and outputs (in terms of the waste produced and the pollution caused) (Register, 1987). In a sustainable city people have to regain control of their communities, cultural diversity needs to be protected, urban violence to be reduced, while the economy has to be self-sufficient and contributing to local wealth, energy conservation and reutilization of resources.

In this study we designed and implemented an educational activity with the aim to engage students in addressing the complex and multi-faceted character of 'urban sustainability'. Playing and re-constructioning a game microworld were employed as pedagogical strategies to incite students to identify and delve on the game's embedded concept of sustainability and to help them frame their own view of a 'sustainable city'. Our approach moves within a constructionist perspective viewing learning as an experiential process of collaboratively constructing knowledge through active engagement with the construction and de-construction of meaningful digital artefacts with the use of microworlds, that is appropriately designed technological environments and tools (Papert, 1993; Kynigos, 1995). By following this approach we made use of the technological and pedagogical construct of 'half-baked microworlds' (Kynigos, 2007), that is pieces of software explicitly designed so that their users/ learners would want to build on them, change them or de-compose parts of them in order to construct artefacts that better suit their ideas of the concept, phenomenon or situation represented by the microworld. In this sense, the microworld grows along with the knowledge of its users (Hoyles, 1993).

The study

A half-baked game microworld (Perfectcity) was created by the researchers based on the idea of the sustainable city. Our aim was to employ it as a pedagogical tool within the context of an educational activity focusing developing understanding among 6th grade students on the concept of sustainability. The main research question was to explore whether and in what ways the students' collaborative play, de-construction and construction of the Perfectcity microworld could support learning about sustainability.

The Perfectcity Microworld

We constructed the Perfectcity game microworld (see Figure 1) based on the Sus-X template (http://etl.ppp.uoa.gr/_content/download/eslate_kits.htm), a digital authoring system for SimCity-like games. This is a game template which leaves open to user manipulation, construction and de-construction the part of the mechanism that contains the 'model of sustainability' upon which the game is built, while keeping away the syntax and the information that might be noise for the users. Perfectcity consists of the map and the main sites of an imaginary city. In order to play the game users have to decide which sites to visit in a city in a sequence of 10 possible moves. While playing users have to take into account (a) the indicators and values of each site, (b) the changes in their "resources" caused by visiting sites and (c) the possible risk to run out of "resources" before the time set for ending the game.

The idea of the city represented by the game is one allowing for a few sustainable and many more unsustainable choices. The eighteen city-sites that were chosen by the researchers to appear in the city map are: the power station, the recycling plant, a landfill, a car parking area, a park, the car and the metro (as two means of urban transportation), as those city-sites referring more to the axis of environment; home, cinema, a library, the City Council and a volunteer work agency, as those sites referring to the axis of society; and the office, two shopping centers (the Mall and Golden Hall), two fast foods (Goodies and Mc Donald's) and a supermarket, as those sites more related to the axis of economy. The criteria against which each of the sites was evaluated were chosen by

the researchers to represent the three axes of sustainability (environment, society and economy). The environmental dimension was expressed by the criteria of 'energy' and 'waste'; society was assessed by the criteria of 'contentment' and 'citizenship'; nevertheless, no criteria for evaluating the economic dimension of the city-sites were used. The specific criteria were chosen by the researchers because they were considered important for a good function of the city and at the same time easy to be understood and employed by 6th graders.

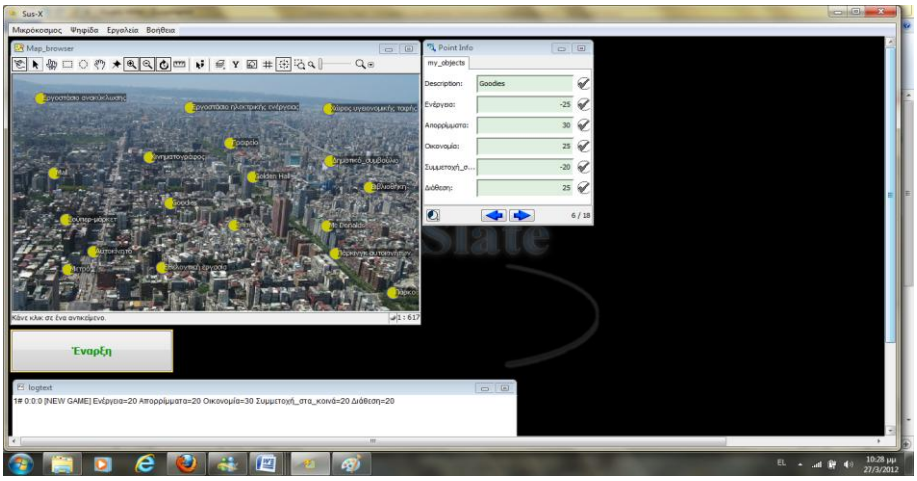

Figure 1. The Perfectcity microworld

Perfectcity is based on the principle of purposefully inciting students to identify and question the sustainability idea on which the game's model of the city was built as they interact with it. In doing so the students are expected to discuss and reflect on it in terms of both the infrastructures provided by this city and the practices its citizens are involved in. In the study reported in this paper the students were first asked by the teacher to play the game, then they got into a discussion about the sustainability of the city with the moderation of the teacher, and finally they collaboratively deconstructed and re-constructed the game microworld to better express their own conception of a sustainable city.

Participants to the study and stages of the educational activity

Six students – three boys and three girls- participated in the study. They were all 6th graders from a Primary school located in the wider Athens area. Participants were asked to take part in a study and contribute to the design of a new educational digital game. The activity took place in a school classroom and the necessary equipment for running the study (such as laptops) was brought from the school's computer lab. The students worked in pairs during two face-to-face meetings for about five hours in total.

In their first two-hour meeting the students played Perfectcity. They were given 10΄ to decide and select ten sites to visit by taking care that their choices would not make them run out of resources. They could complete at least four successful paths. While playing the students were asked by the teacher/ researcher to think about how 'perfect' this city was and what kind of problems it may face. After the play the teacher (3nd author) initiated a discussion among all students about the model of the city represented by the game, how far from the ideal this city was, what were the problems identified by the students and what changes they could make to improve it.

During their second (three-hour) meeting the students were told they were able to modify the idea of the city represented by the game to get closer to sustainability. The teacher/ researcher introduced the students to the functionalities of the Sus-X microworld template and explained the

variety of options they had. No special technical skills were required for the students to use the Sus-X template to design and construct a new game. Although they were allowed to make as many modifications in the game as they wanted to, the students focused mainly on those having to do with whether to keep or change the city background, whether to keep or replace the sites on the city map, or whether to alter the criteria already used by the game and the values attributed to the sites.

The whole activity was moderated by the teacher who provided all necessary information to assist the students in their task, she posed questions to initiate meaningful discussion among them and supported the groups in identifying their own ideas of the sustainable city.

Data collection and analysis

Audio recording and screen capturing software was used to collect information on the students' discussions and actions while interacting with the microworlds. In addition the teacher kept notes on the process. The audio recorded data were transcribed and thematic analysis was applied to them (Boyatzis, 1998). The screen capturing data were analyzed to identify the students' moves and choices while interacting with the microworld.

Findings of the study

Students play with Perfectcity

The students' response to the teacher' suggestion of playing Perfectcity was quite enthusiastic. However, each group engaged with it in a different way. Although all three groups succeeded to complete four paths as they were asked to do and they all developed an awareness of the internal logic of the game, each of them followed a different approach. As a consequence, both their degree of familiarization with the game and their choices with regard to it varied.

The first pair of students (two boys) got familiar with the game and how they should play to win quite easily. They tried seven different paths, four of which were successful. After some first failed attempts they came out with a strategy to play the game. Following that, their choices were not random but based on a careful consideration of the points they would gain if selecting a site and on an estimation of their overall performance (the aggregate score) on the game. The selected city-sites selected showed a greater concern for the environment compared to the other two axes. The criteria that were mostly employed by this group were predominantly environmental (energy and waste). The next episode is quite characteristic of showing this group's concerns while playing Perfectcity:

S2: We got 90 [in terms of energy]. Isn't it a good score? And now our score in 'waste' becomes 50…

S1: What do you think if we go back and visit the 'landfill'?

S2: Right, yea, that's cool my friend!

Satisfaction from visiting the various sites was also an important criterion that led this group's choices. Least attention was given to 'citizenship' concerns and, not surprisingly, the choices in terms of the sites selected did not include any economic aspects of the city life. Their strategy was mainly focused on reducing waste and increasing energy.

The second pair of students (2 girls) met various difficulties while playing the game. Compared to the other two groups it took them more time to grasp and understand the internal logic of the game. As a consequence they followed twenty two (!) different paths while only four of them were successful. Their game play performance was characterized by deliberately ignoring almost

all warning messages and by randomness in most of their choices. Their final and more successful attempts were mainly characterized by environmental concern. In terms of the criteria used this group cared more about the energy consumption and waste production impact of their choices.

S2: We have to choose to visit a site to get more energy.

S1: What about the 'power plant'?

S2: If we select the 'subway'? [she clicks on the 'subway']... What is its 'energy' value? -30. Mmm! We'll lose much of our energy if we go there…

S1: Look at this, that's the one we need [she clicks on 'power plant']… It will give us 50 points on energy!

S2: Yes, let's pick it up. ['power plant' is selected]

The third group (one boy and one girl) faced some difficulties in getting into the game's rationale. After several unsuccessful attempts they managed to complete four paths. It took them many random choices to realize how it works and in order to identify a "winning" path to follow. As opposed to the other two groups, this group did not spend much time in looking at the criteria and the values of the various sites in order to decide what to choose. However, despite the initial randomness in their choices they gradually came to realize that there is some kind of interdependence between visiting a site and getting or losing points in the various criteria. They ended up considering the economic dimension of living in a city and they even examined which sites would augment the economy of the city. During their second successful path they managed to realize that many economic activities have an environmental impact:

S2: Economy, we should add some economy…

S1: Economy. Yes, ok! But, how do we add economy in this city? If we visit 'the Mall'? [They click on 'the Mall']...There is a lot of economic transaction going on there… I've told you so.

S2: Yes, but there is also a lot of waste produced there…

In another iteration of their game play this group concentrated mostly on the 'energy' dimension and tried to get the highest score on this criterion. They applied the same strategy (focus separately on each particular criterion). What is quite interesting is that at the end they put together all the various criteria and combined them in their last iteration of playing Perfectcity. By doing so they actually managed to view urban sustainability in a more holistic way, by taking into account all three axes of sustainability.

S1: [They click on the 'recycling plant'] Yes, it gives us 20 points on 'citizenship'. We should select it. You see? It decreases 'waste' as well!

S2: Yes, you're right! It reduces waste!

S1: We'll have -5 on 'waste'.

S2: What about the economy? What we gain in terms of this? [They refer again to the recycling plant]

S1: What does it mean having -5 on waste? [they ask the teacher/researcher]

Students construct their own Sustainablecity games

During the second phase of the activity the teacher explained that the students could intervene in Perfectcity, de-construct it and construct a new game. This was a real challenge to the students to which all groups responded with much enthusiasm. A discussion among all was preceded with the moderation of the teacher during which the students were aided to realize how "imperfect" the city model represented by Perfectcity was and to identify possible changes to improve it and make it more sustainable.

All three groups decided to change the picture/map of the city in Perfectcity. The teacher

provided them with 15 alternative pictures of cities and asked to select the one it was closer to the city their view. Subsequently, all groups either deleted or added new sites on their new city map. None of the three groups did they alter any of the criteria already incorporated in the game or introduced new criteria. However, the students had the chance to re-think of some of the criteria, such as those of 'energy' and 'economy', and admit that there was some confusion, misunderstanding or doubt about the actual meaning of them. For example, almost all the students equated the 'energy' of the city with the individuals' personal energy while some of the students confused economy as a structural societal process with home economics or money-saving practices. There were no major changes by the groups in terms of the initial values, check conditions and end conditions of the game, probably because of the time limitations of the activity.

As far as the changes implemented by each group, the first group retained twelve sites and added ten new ones. As a first step they decided to leave out two sites related to car transportation in the city (car and car parking area). Instead, they suggested the use of metro and bicycles as the most appropriate means of transportation in a sustainable city.

S2: That's why we don't need cars. Because all the people commute on their bicycles.

The students kept those sites related to energy production – the energy plant and the landfill – and added one more, photovoltaic, as a greener (renewable) energy source. They also deleted one site related to society – the town council. However, they added seven new ones: the primary school, the high school, the college, the gym, the ice skating rink, the playground and the health center. It is worth noting that among these sites there are three purely educational contexts (primary school, high school and university) and three sites combining recreation with sports (ice skating ring, playground and gym). It is obvious that their selections were based on some kind of projection of the students' everyday zone of experience in the city. This is why places of economic activity, such as the office and the second shopping mall, were left out. Since the students were least concerned about these places there was no point of keeping them on the map. An additional reason why the students left out the second of the two malls was its perceived negative environmental impact.

G1-S1: The city has two shopping centers, which both produce a lot of waste and consume much energy. We could have just one, downtown, and whoever wants to shop could go there.

It is worth noting that although the students' choices during game playing were mainly concentrated on the environmental aspect of the city, their engagement with the microworld while constructing their game made them consider the other two dimensions of sustainability too (society and economy). The game created by the first group consisted of six sites referring to the environment aspect, twelve sites referring to the society aspect and four sites referring to the economy aspect. The new values added in each of the criteria were not realistic or a result of thought. Some of them were chosen only for the sake of the game's usability without the students being able to specify the true values (e.g. the value given to University on 'satisfaction' was -35).

The second group kept seven sites of Perfectcity and added ten new ones. Similarly to the first group they retained those sites related to energy production while they added photovoltaic. They showed particular concern on transportation as they identified it a major culprit of urban air pollution. As a result they deleted all means of transportation of Perfectcity and added a cycling road.

R: We live in Athens, which is a big city. What problems do we face in this city?[from a discussion between the teacher and the students]

S2: There are a great number of car vehicles; their exhaust gases pollute the atmosphere.

The groups deleted four sites having to do mostly with the social axis: cinema, town council, library and home. Similarly to the first group they added seven new ones: the swimming pool, the playground, the ice skating ring, the private high school, the health center, gym and the water sports center. Again, their thinking parameters for selecting these sites were that they were related to education and entertainment, both close to the students' way of life.

In terms of the city sites that mainly related to economic transactions, it was this group's choice to leave out the two fast food restaurants, one of the two shopping centers and the supermarket. Instead, they added 'hotel' on the grounds that tourism is among the main sectors of a city's economic development. Their game consisted of seventeen sites, six of which were closer to the environment axis, eight to the axis of society and three to that of economy. Again, this group moved from focusing only on the environment when playing Perfectcity to recognizing society as among the city's sustainability dimensions. The values the students gave to the criteria for evaluating the city-sites were decided based simply on how much they added to the game's usability.

S2: We have given much higher values to some sites…

S1: We'd better use some negative values too.

S2: Yes, because otherwise the game won't work.

The third team made fewer changes than the other two. They kept twelve of the initial city-sites and added four new ones. Similarly to the other two groups they kept all sites that were adding to the city's energy. They were also concerned about transportation: they deleted 'car' and 'car parking' and added a new one, the 'cycling road'.

S1: Did you leave the 'car'? Delete the 'car'. This city doesn't have cars. [They also delete 'car parking']. We don't need cars.

From the society axis they deleted three sites: home, cinema and the volunteer work agency. They replaced them with gym, a football pitch and the school. They also left out the second fast-food restaurant (Mc Donald's). The game they constructed consisted of sixteen sites, six of which were much related to the environment, five to the society and five to the economy axis. They managed to apply a more balanced representation of the three sustainability components in the city. As far as the values with which they valued the criteria, they came out from much discussion and negotiation among the students.

S1: What value should we give to this site on 'energy'? Should it be positive or negative?

S2: Negative.

S1: Ok, negative.

S2: -20? -25?

S1: I suggest -25.

Concluding remarks

This small-scale study applied a constructionist framework to support primary education students' learning about 'urban sustainability' through playing and re-constructing a digital game microworld. The findings of our study indicate that interaction with the game microworld as an "object to think with" (Papert, 1993) aided the students to be introduced to the abstract and difficult concept of sustainability through engagements with more situated, appropriate and enjoyable learning activities, and to gradually develop a more balanced understanding of it, by identifying the interconnection among its various components (environment-society-economy). They almost unanimously started with equating sustainability with its environmental dimension

whereas at the end of the activity they were almost aware of the interconnections among all three axes. This can be viewed as a learning gain since research confirms a strong tendency from either learners or the general public to ascribe sustainability solely to the sphere of environmental management (Liarakou, Daskolia & Flogaitis, 2007).

Our study provides some evidence that the constructionist perspective applied to the pedagogical design of the activity supported students in identifying and formulating their ideas on 'urban sustainability' and in implementing them along with the design of the game. The microworld environment (the Sus-X template) offered not only the actual context where the students could construct their artefacts but also a structured agenda for them to think and share their ideas about the concept at stake. Thinking and learning about such an abstract and complex concept became more situated and thus more appropriate to the students' developmental readiness to deal with it. The students were more motivated to learn by being engaged in a playful task, far away from the instructionist logic of their curriculum. However, there seems to be an additional pedagogical potential in treating the microworld as a digital artefact both with a hidden conceptual and ideological logic that remains to be revealed and with an overt structure of specific functionalities that rests to be employed for re-construction and for the construction of new artefacts. In our study, the students were scaffolded to express and discuss their ideas on sustainability 'in the context of' playing Perfectcity and while employing the Sus-X template to construct their games. They wouldn't do so otherwise or anyhow, as it is not a natural process for them to focus and delve on the coordinates of such an abstract theoretical construct. However, they were aided into unravelling these dimensions and 'tinkering' with them both while playing the game and when considering what concrete changes to implement in the microworld in terms of the map to upload or the sites, criteria or values to change or add. The social context that was created from the teacher's intervention throughout the implementation of the activity and the exchange of views among students within the three groups facilitated the initiation and sharing of ideas.

This study gives some insight into the development of children's understanding of the complex concept of sustainability as a result of engaging with game-playing and game-design processes. However, more future research is needed to explore how the development of knowledge about environmental and sustainability concepts and issues is enabled during such processes, whether and how these knowledge gains are transferred to everyday life or other contexts, as well as to investigate all possible benefits EE and ESD can have via applying constructionist learning frameworks.

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References

Boyatzis, R.E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Thousand Oaks, CA: Sage Publications.

Daskolia, M., Kynigos, C., Yiannoutsou, N. (2012). Teachers learning about sustainability while co-constructing digital games. In the Proceedings of The International Conference on Higher Education (ICHE 2012). *World Academy of Science, Engineering and Technology, 66* (June), Paris, France, pp. 521-526.

Daskolia, M., Yiannoutsou, N., Xenos, M., Kynigos, C. (2012). Exploring learning-to-learn-together processes within the context of an environmental education activity. In the Electronic Proceedings of *The*

Ireland International Conference on Education - IICE 2012. Dublin, Ireland.

European Council (2010). Council conclusions on education for sustainable development, Brussels. Retrieved in 19/11/2010, from: http://consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/educ/117855.pdf

Huckle, J. (1999). Locating environmental education between modern capitalism and postmodern socialism: A reply to Lucie Sauvé, *Canadian Journal of Environmental Education*, *4*, 36-45.

Hoyles, C. (1993). Microworlds/Schoolworlds: The transformation of an innovation. In C. Keitel, & K. Ruthven (Eds), *Learning from computers: Mathematics education and chnology* (pp. 1-17). Berlin: Springer- Verlag.

Kirriemuir, J., McFarlane, A. (2004). *Literature Review in Games and Learning*. Report 8. Futurelab Series. Futurelab. http://hal.archives-ouvertes.fr/docs/00/19/04/53/PDF/kirriemuir-j-2004-r8.pdf

Kynigos, C. (1995). Programming as a means of expressing and exploring ideas in a directive educational system: three case studies. In A. diSSessa, C. Hoyles, R. Noss (Eds), *Computers and Exploratory Learning* (pp. 399-420). Springer Verlag NATO ASI Series.

Kynigos, C. (2007). Half-Baked logo microworlds as boundary objects in integrated design, *Informatics in Education, 6*(2), 1–24.

Kynigos, C., Daskolia, M., (2011). Collaborative design and construction of digital games to learn about sustainable lifestyles. In L. Gómez Chova, I. Candel Torres, A. López Martínez (Eds.), *International Technology, Education, Development Conference Proceedings - INTED2011* (pp. 1583-1592). Valencia, Spain.

Liarakou G., Daskolia M., Flogaitis E. (2007). Investigating the Associative Meanings of Sustainability among Greek Kindergarten Teachers, *International Journal of Interdisciplinary Social Sciences*, *1*(5), 29-36.

Liarakou, G., Sakka, E., Gavrilakis, C., Tsolakidis, C. (2011). Evaluation of Serious Games, as a Tool for Education for Sustainable Development. In M. Flate Paulsen and A. Szucs (Eds.), *Learning and Sustainability, The New Ecosystem of Innovation and Knowledge*, EDEN 2011 Annual Conference, Dublin, Ireland.

Newman, P. (1999). Sustainability and cities: extending the metabolism model, *Landscape and Urban Planning, 44*, 219-226.

Papert, S. (1993). *The Childrens' machine. Rethinking School in the Age of the Computer*. New York: Basic Books.

Register, R. (1987). *Ecocity Berkeley: Building Cities for a Healthy Future*. North Atlantic Books.

Stevenson, R.B. (1987). Schooling and environmental education: Contradictions in purpose and practice. In I. Robottom (Ed.), *Environmental Education: Practice and Possibillities* (pp. 69-82). Geelong: Deakin University Press.

UNESCO (2005). *UN Decade of Education for Sustainable Development 2005-2014*. International Implementation Scheme - Draft. UNESCO, Paris.

Yanella, E.J., Levine, R.S. (1992). Does sustainable development lead to sustainability? *Futures 24*(8), 759-774.