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Evaluation of Engagement and Desirability of Different Teaching Techniques of Energy Concepts:

How to Raise the Energy Literacy of the General Public in Educational Institutions

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INTRODUCTION

It is a usual perception that energy use related concerns such as carbon emissions or energy efficiency are gaining popularity over the last decades. This has been mainly driven by a rather generalized view of the need to reduce energy generation from fossil fuels. Scientific evidence has been pointing to the fact that energy savings come only if the population targeted have a working knowledge about how energy is used and why it has to be used efficiently. Therefore, it is vital to the sustainable future of the planet to raise awareness on this issue and explore the potential of different methodologies to accomplish this objective.

This book chapter aims at describing a real-world experience that will be of great use on the evaluation of different educational activities on the field of energy literacy, environmental education and climate change. The evaluation has been done with structured questionnaires and state of the art statistical analysis of the results.

BACKGROUND

Energy Savings and Citizen Awareness

According to the latest report of the International Panel of Climate Change (IPCC), the world is undertaking a series of changes in its climate which are resulting in serious concerns for the future of society (IPCC, 2016). This fact that now counts with a majoritarian consensus across the scientific community, is permeating into the political agendas, and the goals of policy makers and institutions in most countries around the globe.

There are several initiatives that aim at reducing the energy use to lower down the carbon emissions, and that promote the use of renewable energy to make the emissions carbon neutral, or non-existent. At a global scale, the International Energy Agency is joining efforts agglutinating highly recognized academics and other influential agents into its annexes. These are world-wide projects looking into specific facets of the issue that may help in the fight against emissions. At a European scale, the Horizon 2020 stream of funding and the LIFE program have had a substantial weight on promoting initiatives that will help with the objectives or reducing carbon emissions.

Although these projects are having a substantial effect, a great deal of the scientific literature is pointing towards the fact that energy use reduction will have to be human-centric, and that only if we promote that citizens have low-energy habits, the objectives will be fulfilled (Mogles et al, 2018). This comes in contrast with the generally low citizens' awareness of the concept of climate change, and more particularly their role to stop this challenge that society is confronting today. Several studies are starting to appear to bridge

the gap of knowledge in energy and climate change. Some of these studies aim at developing the science that will allow to create educational frameworks that will ensure more educated citizens in energy matters.

Dewaters and Powers have been highly influential on the field of energy education (Dewaters & Powers, 2013). In their work, they stablish measuring criteria for the cognitive, affective and behavioral dimensions of literacy. They focus on secondary students, what has been for many authors considered the level at which a course on energy could be placed. Dewaters and Powers consolidate in their work the concept of Energy Literacy that has been used ever since often, and that defines well the concept that this paper is built around.

The idea of teaching energy to the general public goes beyond the works of Dewaters and Powers. Lawrenz et al., proposed in 1988 an education of energy that would include affective and cognitive dimensions. In this way it would be possible to form a society willing to save energy. With this work, Lawrenz was stablishing that energy literacy had to be induced considering more than the cognitive aspect.

Although the relationship between what students learn in the classroom and what they do in their daily life is complex, we firmly believe that learning energy matters thanks to a good motivation and engagement is sin-equa-non condition to change behaviors towards a greener society. More can be seen in this relationship on Jensen (2002). However, the cognitive aspects that make people have an environmental behavior are still to be understood (Culen & Volk 2000).

Energy Literacy

When looking at the concept of literacy, Hirsch (1988) considers literacy as a share wealth of knowledge that allows to communicate with each other and understand the world around us. We can consider therefore energy literacy as the cognitive features that will allow us to make more effective the communications about energy matters such as energy efficiency or climate change.

We currently live in a highly technological society, but it was not that long ago, that even knowledge about science was not that popular. Science and technology have had a great spread during the last decades, and although that spread has been led by researchers and technologists, the general population is now familiarized with basic knowledge of science such as the concept of DNA, gravity, or electricity. Concepts related to climate and energy, however have proven to be more difficult to naturally spread across the general public.

Energy has always been a concept which is difficult to define. Energy can have many different representations, and it can be considered in the form of chemical energy, potential energy, kinetic energy, and so forth. This together with the fact that it is immaterial, could make more difficult to conceptualize energy. Depending on the country, the sources of primary energy have been very different, but after the industrial revolution, fossil fuels have been the main source of primary energy that has been transformed in heating, electricity, or other forms of energy. The oil crisis of the 70's placed oil as a critical source of energy in the minds of all citizens, and this had a twofold effect: (1) society understood that oil was at the center of modern society, and (2) the dependency on oil started rising environmental concerns.

These beliefs have been evolving, and researchers have found that the awareness of energy and environmental concerns have grown differently in different regions. The report of the European Commission (European Commission, 2009) has shown that from 32% to 82% of European citizens, consider climate change a serious issue, as pointed out by (Christensen and Knezek, 2015). One of the reasons for the disparity of these results could be the existence (or absence) of environment contents in the curricula of students (Choi et al., 2010). Considering that currently a great deal of information in social media is fake or inaccurate. One could think that it is more necessary than ever to find for a trusted conduit to educate students on environmental issues.

Enacting Change (Better Intentions or Desire to Self-Learn More About the Topic)

The fact that beliefs have a great impact on behavior can be perceived directly by many, but there also exist the theoretical framework that proves it. Azjen's theory of planned behavior (Azjen 1991) explains that the behavior id built over intention, control and beliefs. The theory of Azjen can be seen as a cascade of attributes. People that have a positive intention, beliefs, and perceive the possibility of carrying out that behavior, are likely to do it, if any of the steps fail, then the behavior will not occur.

The guidelines of the Government Social Research of the UK, has stablished a series of guidelines that show effective strategies to trigger a change in behavior thanks to interventions. This work agglutinates the learnings that have been acquired in a variety of studies within different topics (GSR, 2008). The framework proposed as more successful is based on nine principles. As the framework is for any kind of intervention that aims to change behavior.

When making an intervention, the behavior to be changed is identified, and the actors and actions relative to that are identified in order to direct the intervention. In our case, the identification of audience led to students in the latest years of High School and students in the early years of university. This social group will build the society of the near future, and changing their intention towards environmental issues will have a large effect in the next decades. In this regard, the work of (Darnton et al., 2007) shows that, when tackling energy efficiency concerns, the effects seem to vary according the specific measure being chosen.

Another pillar of changing behavior is the creation of models. Models are mental artefacts that allow us to understand a phenomenon. As human behavior is rather complex, models tend to isolate a given operation of behavior in a specific aspect. This principle selects a model that will be the basis used to build the intervention. In our case and due to previous successful experiences, we have chosen the theory of planned behavior by Azjen. This model has been used in the past by the authors in Mogles et al. (2015) with good results. The models represent the factors that will have to be taken into consideration for the definition of the intervention. In that respect, Shove (2003) has shown that the factors chosen for the behavior of energy consumption could be socio-technical regimes, in terms of energy efficiency behaviors Wilson and Dowlatabadi et al. (2007) have considered the factors to be information, cost, and incentives; Thogersen (2007) however, considered personal norms to be the factor for pro-environmental behavior. These factors underpin the justification of selecting the theory of planned behavior for an intervention as the one chosen here.

Incorporating Energy in Curriculum (Mainly at Primary/Secondary School Levels)

The works of DeWaters and Powers were the stepping stone for inserting the topic of energy in the curricula of mandatory education. The questionnaires developed by them can give an idea of the necessity of educating the students in this regard. Some countries have made the teaching of energy matters a reality in recent years.

Although in the United States there have been pioneers in the education of energy, there are several countries in which the energy resources are central for the economic activity of the country. This has placed an emphasis on the inclusion in the curricula of energy matters, which is the case of the Gulf Arab States. The work of Qandile et al. (1998) included in the late 90's solar energy in the curricula of school science, when most countries where still rather behind in the literacy of energy and even more in solar energy. With this indicative, the Gulf Arab States managed to homogenize the knowledge of the current society on matters as important as the renewable energies available in their territory.

In the UK, the energy literacy of students in high schools has also been the focus of scientific studies. The work of Cotton et al. (2015) shows a large study (1136 responses) in which students' energy literacy was evaluated to define an effective intervention that could improve the knowledge on this topic of future generations. The findings of the work show that for bringing together the formal and informal curricula into effective improvement of energy literacy the 4Es model has to be adopted to enable, engage, exemplify and

encourage. The results of the investigation we present here, aligns with this principle as it will be shown later in the manuscript.

The work of Maddock and Kriewaldt (2014) shows the developments in this area in the Australian territory. In this case, they used the territorial dimension of the situation of the students to help the understanding to the energy matters. They used the geographic curriculum in Australia to insert the knowledge about energy. The study showed that concepts such as energy and society, growth and sustainability and energy and environmental change, could arise within this subject. It is not unexpected that the topic of energy literacy is related to climate change and sustainability. Interestingly, the work of Maddock and Kriewaldt shows that in the case of introducing in the curricula the energy literacy, the degree at which the education in energy is enhanced is highly dependent on the knowledge and capacity of teachers.

Teaching Methodologies

Anticipating to the lack of energy professionals in the near-to-come society of the United States, Chen et al. investigated the possibility of enhancing the knowledge of people at an early stage via summer programs (Chen et al., 2014). This was oriented to middle and high school students, and included basic concepts on renewable energy. The experience was evaluated designing and carrying out these summer programs and evaluating the learning of the students via questionnaires. The results indicated that this method was an effective way of enhancing energy literacy, but also, it showed that school students had improved their image towards the degrees on engineering. Although this method is an effective way of increasing energy literacy, it does not contribute to widespread the knowledge as it would do in compulsory secondary education.

In the case of including education at high school level, Visa et al. (2008) developed an integrated approach. In this work, the authors show the results of the Comenius Socrates project that aimed at the development of a tool that would help the teaching of energy related matters at high school levels. This is one of the earlier tools with this purpose, but a substantial number of tools have been created later (as the ones used in this research).

MAIN FOCUS OF THE CHAPTER

Issues, Controversies, Problems

The exploration of the related work has raised the energy and climate challenges that we are facing, and how to educate and raise awareness across the population in order to mitigate this issue. This has led to the following research questions that were investigated in the work presented on this paper.

1. **An analysis of the change in beliefs and intentions after conducting different types of learning activities related to energy concepts and climate change.**
2. **An evaluation of the learning and engagement experienced after performing different types of learning activities related to energy concepts and climate change.**

METHODOLOGY

The methodology consisted of setting up three activities based on different learning methodologies and making them available to 103 total participants at random. The participants interacted with the activity that had been chosen randomly for them. They filled a detailed designed-for-purpose questionnaire, and they were asked afterwards to fill a second version of the survey. Each aspect of the methodology is explained in detail in the following subsections.

Case study and context

The activity took place within the context of the project "ODSesiones" at the University of Murcia. This is a project that seeks to raise awareness and promote the objectives for sustainable development of the United Nations. The 17 Sustainable Development Goals (SDGs) represent the skeleton of the 2030 Agenda for Sustainable Development of the United Nation. These objectives were accepted by all member states on 2015 and aim at having a global view of the development of the planet that brings peace and prosperity. The 17 objectives are defined considering that the sustainability has to come as a global change in which the different aspects of the wellbeing of the global population has to be achieved (UN, 2017).

Among the university community and society within the region of Murcia, one of the activities that comes out from this project was the organization of monthly events by the different faculties. Each monthly event is devoted to a specific sustainability or social transformation aspect.

Our case study took place in one of these events, and it was organized by the Faculty of Computer Science. The topic of this event was focused on energy sustainability, more specifically, we initially had a talk on technologies to save energy, and then we organized the interactive workshop on energy consumption that we describe next as the core of this research. The interactive workshop had three stations with different activities all placed next to each other. We established the stations in the hall of the Faculty of Computer Science what is an open space close to 300 m^2. The activity was previously advertised by the university through common institutional channels (newsletters, social networks, and so on), so that students and staff members would come by to participate.

Incentives

The participants of the experiments came from different faculties as prior to this session we advertise these incentives in the university newsletter. There were two incentives: one was an energy-saving LED lightbulb, and the second was the participation on a raffle. The LED light has an approximated value of 2€, and the raffle gave the possibility of winning a set of headphones of a value of around 200€.

Experimental design

We designed a factorial experiment with the objective of analyzing the potential effects of three types of learning activities with different pedagogical bases. We designed our workshop on energy consumption so that it included as the experimental condition one of these learning activities. We randomly assigned participants to one of the three activities and encouraged participation through the incentive system. The experimental case study had the following phases:

1. **Introduction:** When a participant came to our station to do the activity, we made a brief introduction of five minutes explaining what they would need to do as part of the activity. If they decided to stay, then we would move to the next phase.
2. **Pre-test**: In the pre-test questionnaire the participants responded a series of questions regarding demographics and background, as well as the beliefs and intentions constructs. As part of the pre-test they also fulfilled a consent form to participate in the study so that their data could be used for research purposes.
3. **Activity (experimental condition):** Participants were randomly assigned to one of the three activities, so they completed either the booklet, the bicycles or the interactive game activity, and only one of those.
4. **Post-test:** After participants completed the activity, they responded to a post-test. In this post-test, they again responded to the questions related to beliefs and intentions constructs, in order to

analyses the variation after conducting the activity. Additionally, they also responded to questions related to the learning and engagement experienced with the activity.

5. **Incentive:** All the participants that completed the aforementioned phases received as a reward a LED lightbulb, and they entered the raffle where one of them could receive a set of headphones as a prize.

We selected three learning activities with different pedagogical bases to analyses differences in the variation of the beliefs and intentions constructs, as well to analyses the perceptions of students in terms of learning and engagement experienced. The three activities were the following ones:

- **Passive content:** This activity involved a passive consumption of contents by reading a booklet on energy consumption (see Figure 1a). The booklet is one of the outcomes of Project FIESTA[1], an Intelligent Energy Europe Program project with 19 partner institutions from five European countries that has the aim at cutting the energy consumption of families with children. Because of this, the booklet is designed to be understandable for all audiences, and it is created with plenty of infographics and mnemonic rules to facilitate the understanding of the energy concepts and to make it more appealing. The document used was the "FIESTA Energy Efficiency Guide for Families", that was reduced to create a shorter document. Pages 1 (front page), 8 (Energy consumption depending on use), 9 (Energy consumption of appliances), 16 (energy saving advice), 17-18 (reduce heating), 19-20 (reduce cooling), 28-29 (lighting), 36-37 (how to help the environment), 44-46 (summary).

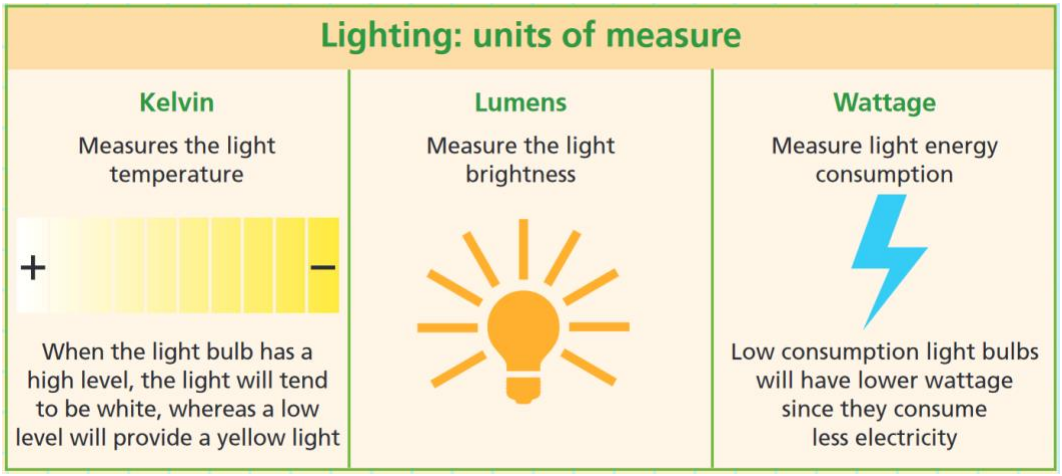

Figure 1. Example of infographic from the booklet.

- **Embodied activity:** This activity involved students experiencing the effort required to generate energy in an embodied way (see Figure 1b). They had to cycle on a bike that had three different bulbs connected to a dynamo. One was a normal incandescent bulb, another one was a LED domestic light-bulb, and the last one was a set of electronic LEDs. Therefore, it was trivial to light the electronic LEDs (around 30mW) easy to cycle enough to light the LED domestic light-bulb

(6W), and it was truly difficult for the incandescent light to light up (60W, only two participants managed to turn it orange). They had a switch to commute between the three different bulbs. This embodied activity can help students to transfer energy from a physical activity effort to an electricity context, hence encouraging them to do a mindful use of electricity.

- **Interactive digital activity**: This activity involved an interactive game that helped make the learning process more playful (see Figure 1c). The game used was one of the series called "The My Sust House Games" within the project sust. of Architecture and Design Scotland (A+DS). More specifically, it was the one called Environment and Building game[2]. The game has been designed to be used on a learning session of about 30 minutes. The game challenges the participants to plan the design of a building having to select building materials, insulation, power and heating. The game has been designed to be "usable" for people above the age of 12. During the design of the building, the player can see the impact on the energy consumption of the house depending on their decisions. Also the cost and the balance.

Finally, image in Figure 2 shows the overall scenario where the case study took place with active participants in each one of the activity stations.

a) Booklets

b) Bicycles

c) Interactive computer game

d) Overall view of the three stations

Figure 2. Overview of the different activities.

Instrument design

This research required of an instrument that allowed us to measure the response to a series of constructs which are indicatives of the energy literacy, the attitudes toward energy use and environmentalism and other related concepts. In our case this took the form of a questionnaire. We have created our own instrument to ensure that the evaluation was accurate, and no extra length was given to the questionnaire. In this regard, we have prioritized using items that have been previously used and validated in past research. When necessary, we have adapted the item text to our context. We have the following constructs:

- **Demographics:** We have five items about the demographics of participants regarding gender, age, level of education, area of knowledge and current work status. These items were retrieved from previous questionnaires from MITx and HarvardX systematically used for their massive open online courses (Chuang & Ho, 2016).
- **Background:** We have three items regarding the background of participants in terms of energy consumption. These items have been retrieved from a previously validated questionnaire on energy literacy (DeWaters, 2013).
- **Beliefs:** We have six items regarding their beliefs about climate change and the potential impact we can have on it. We selected six items from the previous validated questionnaire from Christensen & Knezek (2015). There is one reversed item.
- **Intentions:** We selected four items regarding their intentions for climate. Since previous research has theorized the relationship between intentions and behavior (Montaño & Kasprzyk, 2015), we can use these questions to envision future potential actions of the participants regarding energy consumption. We took the four items from Christensen & Knezek (2015) as well. There are three reversed items.
- **Learning:** We selected four items to evaluate the three activities in regards to learning. We took these items from the WBLT Evaluation Scale, which has been already validated (Kay, 2011).
- **Engagement:** We also selected four items to evaluate the three activities in regards to the engagement that learners experienced. We also took these items from the WBLT Evaluation Scale (Kay, 2011).

The specific items for each one of these constructs can be reviewed in Appendix A. Finally, we randomized the survey question order of background, belief, intentions, learning and engagement constructs, instead of grouping the questions by construct, since based on previous research (Goodhue & Loiacono, 2002), this seems to provide better results in terms of Cronbach's alpha reliabilities. Since all of these items have been already validated by the previous studies, we have not conducted an additional validation within this study.

Data collection and validation of participants per experimental condition

As part of this case study, we collected data from 103 participants. The main demographic highlights are: We have 74% male and 24% female. In terms of age, 76% of the participants have from 18 to 24 years, 10% have 25-34 years and 11% 35-54 years. In terms of occupation 71% are full time students, and 29% are either full-time workers or they both work and study. In terms of level of education 22% already have a master or doctorate and 76% have either a bachelor degree or are completing one. Finally, 90% of the students belong to engineering or technology knowledge area. Therefore, the majority of participants are young and are studying an engineering degree (or already have it), three out of four participants will be male, which is a demographic distribution that makes sense considering the current ratio of the Faculty of Computer Science at UMU.

The participants were distributed almost equally per condition with 34 participants for the booklets, 36 for the bicycles and 36 for the interactive computer game. To confirm that the demographics were equitably distributed across the three conditions, we conducted Chi-Squared tests for the distribution of gender, age, work status, level of education and knowledge area, and all of the tests were non-significant, indicating that there was no difference between the demographic distributions across the experimental conditions.

In terms of the background of the participants, we have an average value of 3 (SD 1.2) for "*With frequency I talk with family…*", an average value of 2.3 (SD 0.9) for "*I consider myself an expert…*", and an average value of 3.6 (SD 0.9) for "*... I always try to save energy*". We analyzed the differences in these distributions across experimental groups applying a MANOVA test, and the non-significant results ($F = 0.5$, $p = 0.75$) indicate that there are no differences in the background responses of the participants per condition.

Therefore, we can conclude that the participants of each one of the experimental conditions have similar demographics and background, and that the methodology was executed correctly to ensure the validity of the results.

RESULTS

The experiment performed on this investigation produced valuable results which gave light to the research questions. In this section, the results from the detailed analysis are explained.

Analysis of beliefs and intentions

This first section of the results aims to answer the research question regarding the potential change in the beliefs and intentions after conducting the different learning activities. Figure 3 shows the results for the pre- and post-test for both beliefs and intentions for each experimental condition.

First, in terms of the beliefs on the left of Figure 3, there is a clear agreement with average values of around 4.75 regarding the existing evidence of climate change, however, it does go below to around 4 for the belief in the impact that individual actions can have. The overall change of the beliefs taking all activities together was not large, with only two of the items, "Impact in 10 years" ($t = 2.7$, $p < 0.01$) and "Actions of individuals" ($t = 2.1$, $p = 0.01$) being significant based on a t-test, but with small size effects. We analyses if there are significant differences in the change of beliefs for the different learning activities, and we find that there are no significant differences based on a MANOVA test ($F = 1.2$, $p = 0.29$). Therefore, we conclude that in general there were no significant differences in the change of beliefs based on the different learning activities, and that the overall change in the beliefs was low.

Second, in terms of the intentions (on the right of Figure 3), the participants raised "Efforts on problems" as the most important one. The overall change of the beliefs is significant for only two items, "Effect quality environment" ($t = 2.66$, $p < 0.01$) and "Work to solve problems" ($t = 4.9$, $p < 0.1$) based on t-tests. On this, we found again, that there are no significant differences between this change of the intentions based on the different learning activities based on a MANOVA test ($F = 0.16$, $p = 0.99$). Therefore, we conclude that the change in the intentions was significant for only two items which were "Effect quality environment" and "work to solve problems" and that there were no differences between the learning activities.

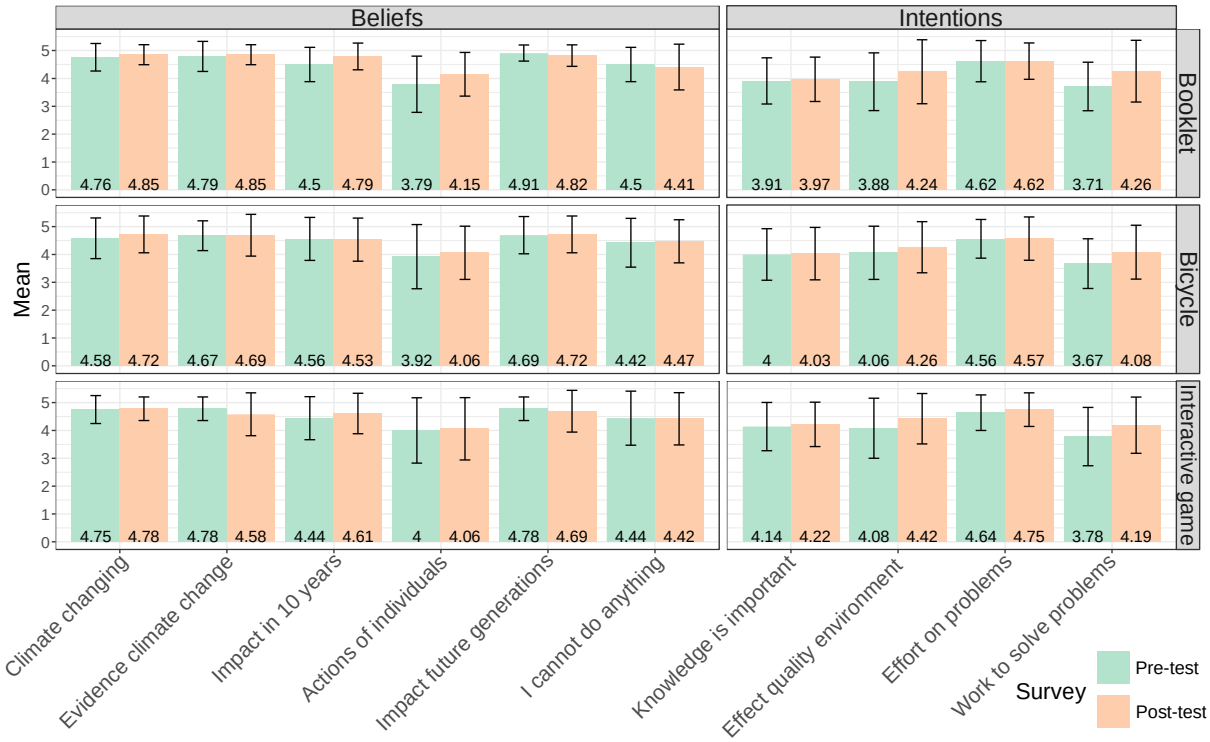

Figure 3. Bar plot with the average value of the responses for each item, with the beliefs on the left and the intentions on the right. The rows are split based on the experimental learning activity. The green column shows the average value in the pre-test and the red column the average value in the post-test. The error bars are based on the +/- SD.

Evaluation of learning activities

This second section of the results is focused on the research question regarding the differences in learning and engagement between the three experimental learning activities. Figure 4 shows the results of evaluating the learning items on the left and engagement items on the right, for each learning activity.

First, in terms of the evaluation of the learning, we see that in general participants thought that the activities were useful for learning purposes with an average value for all items around four. We do not observe statistically significant differences between these responses for each separate learning activity based on a MANOVA test ($F = 0.96$, $p = 0.46$). Second, regarding the engagement with the activities, we do see significant differences between the results of the three learning activities based on a MANOVA test ($F = 3.8$, $p \ll 0.01$). In terms of engagement, the bicycle activity was regarded clearly as the most engaging of the three.

Therefore, we can conclude that there were no significant differences in terms of the learning experienced by the participants on the three activities, but they felt that the bicycle was the most engaging activity.

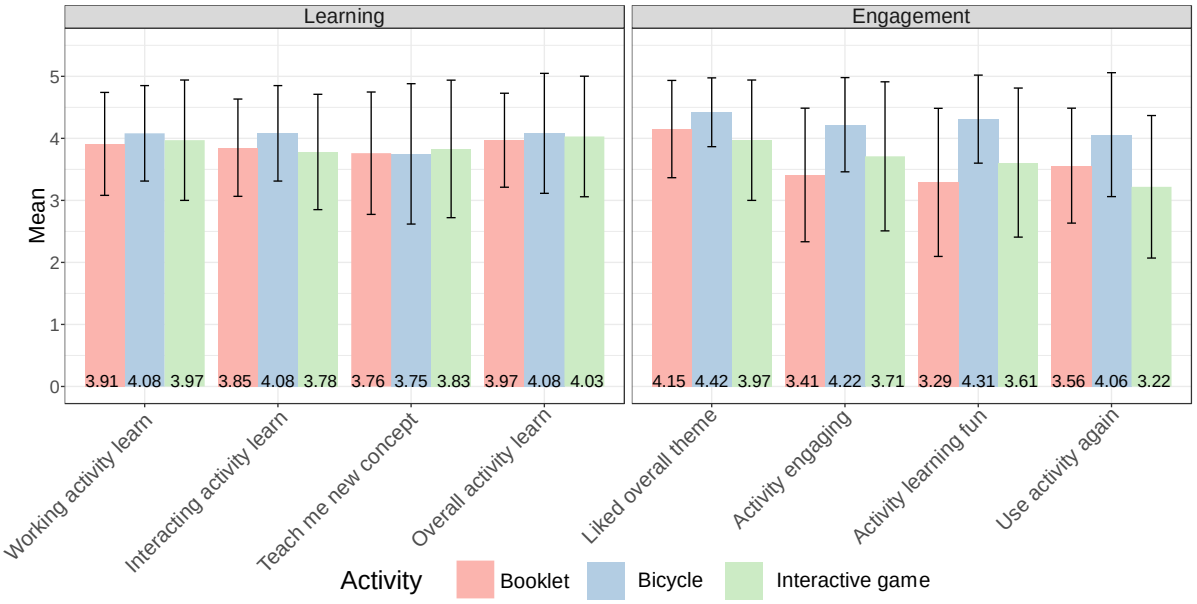

Figure 4. Bar plot with the evaluation in terms of learning on the left, and engagement on the right, of each one of the learning activities.

FUTURE RESEARCH DIRECTIONS

The results of this research have shown that the embedded activity provide advanced performance on a variety of aspects of the educational experience. This is interesting because it is a natural trend on this digital era to use software and other digital technologies to teach complex concepts. Considering the good results, we consider a promising new line of research the comparison of different embedded activities to teach concepts related not only to energy, but also to the environment and climate change. Energy has a clear implication, as the exercise performed by the participants is directly the matter of the test, but with climate change concepts, it is more likely that the subject will be separated to the phenomenon to a larger extent.

CONCLUSION

We can see from the results that the population examined has a very strong baseline belief of the existence of climate change. It might be for this reason that the activity has not being seen to produce a significant increase on this specific belief. On the other hand, it is easy to believe that someone that does not support this environmental event, will not change opinion after a short intervention like this one.

As a general impression, the cohort used on this experiment shows a rather high initial awareness on topics like energy and climate change. This comes with no surprise as the engineering students tend to have more self-motivation to learn about these topics. On this regard, it should be considered that when applying these findings to the general public, one should expect lower average scores on the general facets of energy awareness and literacy.

With respect to the belief about how important are individual actions, and how much effect they may have over climate change, this indicator is also rather high, and as in the previous case the value does not increase significantly after the activity. This is more worrying as the resources used were designed specifically to show people how to save energy, and to directly remark the consequences of their actions. Nevertheless, it should be taken into consideration, that the value of this believe was already pretty high. This is indicative

perhaps, that to gain support on this objective once it is that high, stronger interventions are needed. We recommend this work direction as part of the future work.

On the other hand, we have seen a higher change on intentions than on beliefs. Participants might be noticing that small actions from individuals of population can have a larger collective impact. This can in turn enact change in the habits of these individuals. The region in which the experiment was done is highly agricultural and therefore environmental problems influence highly the general population and economy. This could be the reason why we have seen that, with the adequate push the population may change their intention to make an impact on the environment as a whole (as what they see surrounding them an agricultural environment], is more visible than the global climate change which is to this extent invisible). This is an interesting finding considering that specific contextual environmental problems can be drivers for a more general conduct of the individuals according to the results we found on this respect.

With respect to the evaluation of the activities in terms of learning and engagement. This was a core research question of our study. As seen on the introduction, energy concerns are about to be included on the curricula world-wide, and thus we need to further explore different teaching methodologies and types of activities to transfer the knowledge of such concepts in depth. We did not observe significant differences in learning, but it was statistically significant than the most engaging activity was the bicycles. This is an important insight as it reinforces the philosophy of "learning by doing." Even though the reported learning was equivalent, a crucial aspect that educational centers need to pursue is generating engagement, as this will imply self-motivation of students to stay up to date and therefore the creation of environmentally friendly citizens. This is important because some research suggests that when students engage more deeply on an activity, they can learn more (such as Bryson and Hand (2007) or Dunleavy and Milton (2018)). Future work can aim to combine activities of different nature during educational events, to alternate between more engaging activities and those that can provide more structured contents. We would also like to raise some limitations of our work. The main one is due to our biased population sample, most of the attendants where university students or staff, and therefore, most of them are highly educated individuals. Additionally, since it took place in a computer science faculty, the majority of them also had an engineering mindset. Therefore, our sample is not representative of the whole population.

The results of this work provide a better understanding about the beliefs of the cohort under study. Although the results should be extrapolated carefully to the general public due to possible bias of the sample, it is important to take into account those beliefs as they will be the origin of the day-to-day habits of the citizens. Being able to design educational systems that ensure a certain level of beliefs on the people will lead to a society that is more concerned with current environmental and energy issues. This more educated society can adapt their habits, leading to a noticeable reduced energy use, and ultimately a mitigation of climate change.

Our findings suggest that the profiles with a rather technical flavor tend to have already quite a good level on energy literacy, positive intentions and beliefs to improve climate change, even if they do not have dedicated courses on high schools (as it is the case in Spain). Still, it will be necessary to create citizens that are aware and literate about energy concepts, and we have seen that embodied activities can be a great tool for engagement. The results showed that the activities on which the citizens have a way of "visualizing" and embodying the energy they produce can be an ideal way to engage them more meaningfully with the issue than consuming passive or interactive contents like books or games. We did not observe an important change in beliefs or intentions with any of the activities, partially due to the fact that these values were already quite high.

This idea of making citizens more aware of energy use can improve over the following years thanks to new technologies, such as IoT technologies and devices/apps that can help track the amount of energy consumed, and thanks to the raise of hybrid (man-power / electric) transportation systems such as scooters or bicycles. One can anticipate that society may learn more about energy as a by-side effect of the new paradigm. It is interesting to see that also a strong tool is the reminder to the general population that small actions can have

an effect, not only on the global climate change, but also on the local environment. This has been seen to motivate the people and make them more prone to adopt environmentally friendly behaviors.

Educational institutions such as high-schools and universities should leverage some of the lessons learned. Future research should aim to keep exploring different ways to engage citizens with energy-related activities, analyzing how these can affect their beliefs and habits, so that this can eventually have a positive effect on climate. The future of the planet might depend on changing the behavior of their inhabitants.

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APPENDIX 1: QUESTIONNAIRE

This appendix provides the text of different items grouped by construct. First, in terms of the demographic construct, we included the following items:

- What is your gender?
    - Female
    - Male
    - Other
- What is your year of birth? (e.g. 1985)
    - Numeric input field
- What is your current employment status?
    - Employed
    - Unemployed
    - Student full time
    - Retired
    - Other
- What is the highest level of education you have completed?
    - Doctorate
    - Masters
    - Bachelors
    - Secondary/High school
    - Elementary/Middle school/Jr. High or lower
- If you have studied or are studying higher education studies, which knowledge area includes those studies?
    - Engineering or technology
    - Basic sciences
    - Health or social sciences

- Humanities, history, religion or education

Find next the items regarding the background, beliefs, intentions, learning and engagement. Note that the order of the items here does not represent the one presented to the participants, as explained in the Instrument Design section. It can be seen in Table *1*

Table 1.

Indicate your level of agreement with the following questions	**Level of agreement**				
Background					
With frequency I talk with my family and friends about saving energy to mitigate climate change.	1	2	2	4	5
I consider myself an expert with respect to knowledge about energy and climate change.	1	2	3	4	5
With respect to mitigating climate change, I consider that I always try to save energy.	1	2	3	4	5
Beliefs					
I believe our climate is changing.	1	2	3	4	5
I believe there is evidence of global climate change.	1	2	3	4	5
Global climate change will impact our environment in the next 10 years.	1	2	3	4	5
The actions of individuals can make a positive difference in global climate change.	1	2	3	4	5
Global climate change will impact future generations.	1	2	3	4	5
We cannot do anything to stop global climate change.	1	2	3	4	5
Intentions					
Knowing about environmental problems and issues is important to me.	1	2	3	4	5
I do have no effect on the quality of the environment.	1	2	3	4	5
It is a waste of time to work to solve environmental problems.	1	2	3	4	5
There is not much I can do that will help solve environmental problems.	1	2	3	4	5
Learning					
Working with the activity helped me learn.	1	2	3	4	5
The interaction with the activity helped me learn.	1	2	3	4	5
The activity helped teach me a new concept.	1	2	3	4	5
Overall, the activity helped me learn.	1	2	3	4	5

Engagement					
I liked the overall theme of the activity.	1	2	3	4	5
I found the activity engaging.	1	2	3	4	5
The activity made learning fun.	1	2	3	4	5
I would like to use the activity again.	1	2	3	4	5

ENDNOTES

[1] http://www.fiesta-audit.eu/en/the-project/

[2] http://www.mysusthouse.org/game.html

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