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Patterns of Engagement: Using a board game as a tool to address sustainability in engineering educations

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Abstract

The Global Dimension in Engineering Education (GDEE) refers to all non-technical topics that will impact the engineering profession at a global level over the next couple of decades. As teachers at a Media Technology engineering programme at the KTH Royal Institute of Technology, School of Computer Science and Communication, we have definitely felt that substantial amounts of ingenuity is required to make students interested in such topics, since many of the students regard them as non-central or of little interest when compared to their (non-GDEE) “core” interests, skills and aspirations.

We here describe how we have worked to overcome students’ (potential) aversion to one particular GDEE topic, sustainability, by incorporating a board game, Gasuco, into the introductory module of a course about “Media Technology and Sustainability”. We describe and analyse our use of the game in terms of “pedagogical patterns for learning” (Laudrillard, 2012).

1 Introduction

The Global Dimension in Engineering Education (GDEE¹) refers to all non-technical topics that will impact the engineering profession at a global level over the next couple of decades. These topics include sustainability as well as globalisation, ethics, inequality, poverty, climate change etc. While the topics addressed by GDEE might draw some students to engineering educations, we suspect that the majority of students currently studying engineering educations do this for reasons that are unrelated to “the global dimension” and that it furthermore can be hard to motivate such students as to the importance of GDEE topics. As teachers, we have certainly felt that substantial amounts of ingenuity is required to make our students interested in such topics (Pargman & Eriksson, 2013, Eriksson & Pargman, 2014), despite the fact that the importance of several of these topics is already specified and embodied in the Swedish Higher Education Ordinance.

As a way of meeting these challenges, we have introduced a board game, Gasuco, into the first part of a compulsory course about “Sustainability and Media Technology” that is given to our fourth-year Media Technology engineering students. The course has been taught four times (2012-2015) and we have utilized the game in the course during the last three cycles. We have collected a wealth of materials about students’ attitudes and opinions about the game and the course as well as their attitudes to, and self-reported knowledge about sustainability through pre-course questionnaires, post-gaming questionnaires and course evaluations. We have furthermore conducted interviews with

¹ See further <http://gdee.eu>

students and have observed students playing the game during dozens of gaming sessions. This paper will however not primarily focus on the *effects* of using the game, but rather on the *justification* and the outcome of using the game in terms of its' pedagogical merits. What in the game itself, and what in the use of the game makes it successful for our purposes?

We answer these questions below by way of outlining the pedagogical theories and the thinking behind our use of the game Gasuco in our course. We discuss the use of the game through the lens of design patterns and analyse how we have used it as a tool for teaching a GDEE topic in terms of developing a “pedagogical pattern for learning” (Laurillard, 2012). We argue that a game such as Gasuco represents an activity that is appealing for a variety of reasons, and not the least because it constitutes a very low threshold to introducing GDEE topics to engineering students.

2 Theory

Design patterns have been described as “*semi-structured descriptions of an expert’s method for solving a recurrent problem, which includes a description of the problem itself and the context in which the method is applicable, but does not include directives which bind the solution to unique circumstances. Design patterns have the explicit aim of externalizing knowledge to allow accumulation and generalization of solutions and to allow all members of a community or design group to participate in discussions relating to the design.*” Design patterns have been applied in many different disciplines such as software engineering, hypermedia, and interaction design (Mor & Winters, 2007).

In pedagogy and Technology Enhanced Learning (TEL), the related concept “pedagogical patterns” has been suggested as a relevant way to describe the outcome of pedagogical research when seen as a design science (Laurillard, 2012). Laurillard suggests that a pedagogical pattern can be described as a sequence of teaching-learning activities. She has also linked pedagogical patterns to learning design principles through a Conversational Framework (ibid., p.103) that contains five different cycles:

- **Teacher-Communication-Cycle (TCC).** The teacher gives students access to the teacher’s concept (books, lectures, videos and so on) (TCC1), the students are motivated to generate questions or articulate their perceptions of these concepts (TCC2), and the teacher provides feedback on these questions or articulations (TCC3).
- **Teacher-Practice-Cycle (TPC).** The teacher provides a practice environment where the student can practice (TPC1) and get feedback from the teacher (TPC2).
- **Teacher-Modeling-Cycle (TMC).** The teacher provides a modeling environment where the students can practice (TMC1), but where the feedback is given by the environment itself (TMC2) rather than by the teacher.
- **Peer-Communication-Cycle (PCC).** The student modulates his/her concepts by communicating with, and getting access to peers’ concepts (PCC1), generates questions or articulates perceptions of peers’ concepts (PCC2), and peers provide feedback on these questions or articulations (PCC3).
- **Peer-Modeling-Cycle (PMC).** The student gets access to the output of peers’ practice, such as a chapter in a thesis, or a computer program (PMC1), which enables the learner to modulate their own practice by using their peers’ output as a model (PMC2).

In the board game we focus on, there are both Teacher-Communication-Cycles (TCC) and Peer-Communication-Cycles (PCC), but we are for the purpose of the paper primarily interested in the latter.

Our emphasis on the importance of Peer-Communication-Cycles (PCC) is based on a social constructivist view of learning, resting on Vygotsky observation that “*all the higher [psychological] functions originate as actual relations between human individuals*” (Vygotsky, 1978). However, not all kinds of peer discussions lead to actual learning. Results of several research studies conclude that peer discussions should have certain characteristics in order to support actual learning (Laurillard, 2012, p. 143). According to Laurillard, students in peer discussion activities should:

- *“Take a particular position with respect to a concept or conjecture*
- *Provide evidence and explanations for their arguments or position*
- *Consider, respond to, or challenge counter-arguments, share and critique each other’s ideas*
- *Reflect on their own perspectives in relation to those of others*
- *Work towards an agreed output, negotiating meaning, or collaborating on a decision.”*

We believe that Gasuco satisfy *all* of these characteristics.

3 Playing Gasuco

The course in which we use Gasuco is comprised of two relatively independent modules. The first module treats sustainability as a topic in its own right, while the second, larger module in various ways connects sustainability to the topics of computing and information technology. The game is a major component of the first module and it constitutes an important element of how we introduce the topic of sustainability to our students.

While Gasuco is used in several different educational programmes at KTH and elsewhere (Dahlin et. al., 2013, Dahlin et. al., 2015), we believe that ours is the only programme with an ICT profile that uses it, and, we have customized the game so as to better fit this particular group of student (Eriksson and Pargman, 2014). The game has been customized primarily by replacing approximately 25% of the Discussion cards (see below) with discussion topics that specifically relate to ICT and Sustainability. While the game has relatively simple rules, we will not exhaustively describe how it is played, but will here rather concentrate on game element that are of relevance to Laurillard’s Conversational Framework. Figure 3 (at the very end of the paper, below the references) does however provide a snapshot of a gaming session.

The nominal goal when playing Gasuco is for students to try to gain *EES cards* (representing Economical, Ecological and Social perspectives on sustainable development) and *Discussion cards* to fill their “Portfolio”. EES cards are won by successfully answering *Mini fact* questions (where students’ answers are either right or wrong), while Discussion cards hinge on the student successfully “leading a discussion” on the topic specified by the card for the duration of three minutes. *Opportunity cards*, finally, affect the EES cards in different ways and they come in two different varieties: *Association cards* that demand that the student connect three terms and talks coherently about them for one minute and *Concept cards* that allow a student to challenge another student to explain a concept by explicating and talking coherently about it for one minute. See Figure 1 and Figure 2 below for examples of the various cards. While all cards can lead to communication and discussions among students (peers), it is worth explaining how the Discussion cards in particular are used in the game. The instructions (from the short leaflet with the rules for the game) are as follows:

“The Discussion cards contain questions that players should motivate, discuss and reflect upon. The player who draws a Discussion card ... leads a discussion as follows: the player reads it out loud and

then motivates an opinion. The other players then actively contribute and either agree, dispute or emphasize another perspective. If the player manages to lead and involve all players in the discussion (as determined by a majority decision by the other players) the card is considered won”

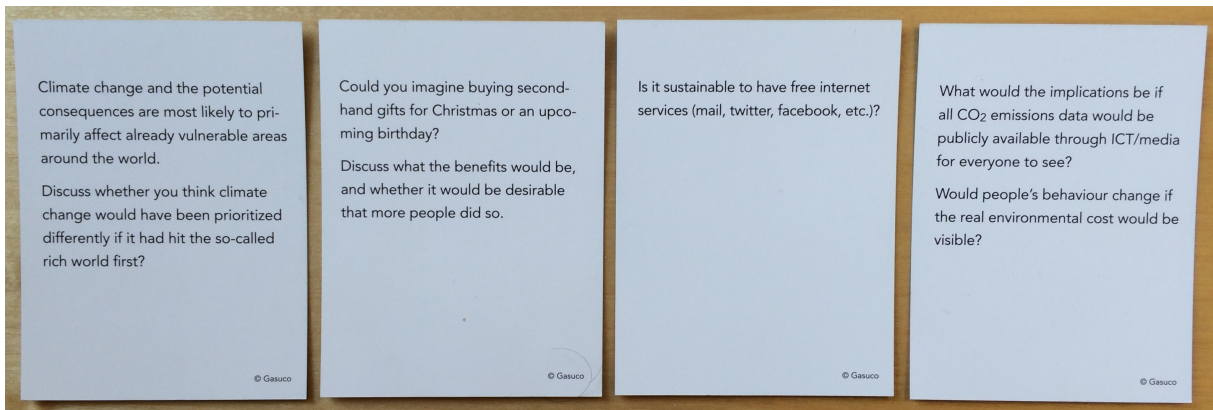


Figure 1: Four of Discussion cards from the Gasuco board game. The two cards on the left treat issues of sustainability in general while the two cards on the right treat issues about sustainability and ICT.

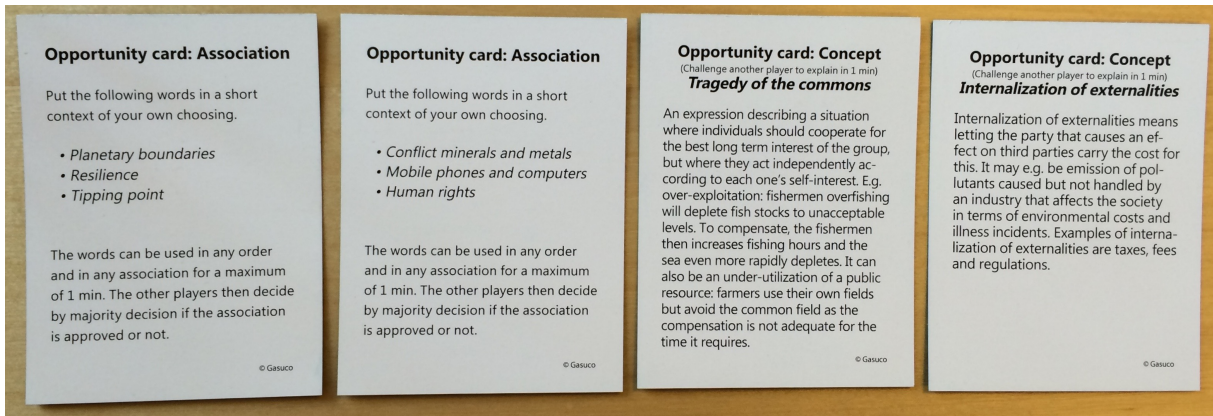


Figure 2: Four Opportunity cards from the Gasuco board game. The two cards on the left are Association cards and the two cards on the right are Opportunity cards.

The specified length of time that students should spend on each Discussion card (three minutes) makes this game element the biggest source of peer communication during a gaming session. Discussion card topics are usually very open-ended (see Figure 1) and they typically have no clear right or wrong answer. This makes them attractive in a learning setting as there is plenty of space for various and differing opinions, as well as fewer opportunities to reach consensus. This can at times lead to very lively discussions. Lastly, it is a matter of judgement (and negotiation) to decide if a student has succeeded in his/her role as discussion leader.

We have here very briefly described the game in terms of relevant gaming mechanics and gaming elements and will below analyse the use of the game in terms of Luarillard’s Conversational Framework and its five cycles of teaching-learning activities. These cycles can in turn be connected to the main objectives of using the game in the course; 1) spark and increase students’ interest in and motivation *for* sustainability, 2) increase students knowledge *about* sustainability and 3) support social process and opportunities for (primarily recently arrived foreign) students to extend their social networks. The latter goal lies outside the scope of Laurillard’s Conversational Framework and will not be further discussed in this paper.

4 Results and analysis

The overarching purpose of using the game is to engage students in the topic of sustainability, and the different game mechanics can be conceptualized in terms of different cycles in Laurillard's Conversational Framework. However, the game is not a stand-alone learning activity, but is coupled to preceding and succeeding lectures in the course module. This "package" (intertwined lectures and gaming sessions) mainly invokes Teacher-Communication-Cycles (TCC) and Peer-Communication-Cycles (PCC). A formalized way to analyse and describe these learning activities is to use a pedagogical pattern. We have used the "Teaching Method Template" (Derntl et. al. 2009) to describe that pedagogical pattern (see Table 1 below).

A series of lectures prioritises one single teaching-learning activity, TCC1, even if there is also (oftentimes very limited) time for student questions (TCC2) and for the teacher to answer those questions (TCC3). Such a structure decreases the opportunities for students' deep learning. By playing Gasuco, students have access to the whole spectrum of the Teacher-Communication-Cycle (TCC1, 2, 3) - even if it in fact are other students who might have to step in and try to take on the role of the teacher when explicating the teacher's concepts (TCC1). Students furthermore have access to the whole spectrum of the Peer-Communication-Cycle (PCC1, 2, 3) when playing the game. It is in particular the Discussion cards that engage students in Peer-Communication-Cycles and it is subsequently these cards in particular that we have chosen to customize so as to make the game more engaging for this particular group of students. We conclude that the game significantly increases the opportunities for deep learning and it is also more engaging than only listening to a series of lectures. What then do the students think about the game?

After the latest cycle of the course (2015), 42 out of 79 students answered the post-gaming questionnaire and 38 of them answered the free-text question "What is your opinion of the Gasuco gaming sessions?". While the vast majority of students were generally positive, there were also a few dissenting opinions.

Positive aspects were related to several areas, such as being fun and engaging ("*it was fun and engaging – memorable*"), peer learning ("*it helped me a lot to learn from my fellow peers, who were very willing to explain and share their views*"), getting new perspectives ("*it is important to discuss with other people to be able to understand the subject from another view*"), feeling more at ease with the course ("*it helps making students feel more at ease with the course: we are more confident that we've assimilated what we learnt during the lectures*"), learning terminology ("*it helped me get to know more important terms*"), learning in small groups ("*speaking in [a] little group with just four people is a good idea, because sometimes it is difficult to take the floor and speak in front of a crowded classroom*"), as a discussion starter ("*an easy way to start interesting discussions*") and to get to know other students ("*it was great to get to know the others in the group*").

There were also some negative comment, for example about game mechanics ("*why is the discussion card worth 2 points? They're so much easier to get than the mini fact or opportunity card*"), about game design ("*I didn't feel the need for the individual gaming board, you can just as well save the cards in a pile in front of you and count each card as a point*"), of not having sufficient knowledge ("*it was however a bit frustrating playing the game when I felt like I didn't know enough*"), of questions being too difficult ("*sometimes the questions were rather hard to understand or discuss therefore the level of learning from the conversation was rather low*") and of difficulties with different levels of knowledge among students ("*good, but there is a huge knowledge gap in the class, some people can barely discuss the topics.*").

Table 1: A Pedagogical Pattern for learning sustainability through a game.
Topic-specific parts are in brackets and in italics.

Title	Boardgame for learning [<i>sustainability</i>]		
Origins	KTH Royal Institute of Technology, Media Technology and Interaction Design		
Summary	In three cycles, students are, during lectures, introduced to a number of [<i>sustainability</i>] concepts. They later learn facts as well as discuss and motivate standpoints while playing a game in small (four-person) groups.		
Learning outcome	To be able to explain and discuss important topics related to [<i>sustainability</i>]; a significant non-learning outcome is to increase engagement and motivate the students for the rest of the course.		
Rationale	Social constructivism; peer learning		
Duration	3 x (2h + 2h)		
Learners	[<i>Fourth year Media Technology engineering students taking a course in Media Technology and Sustainability.</i>]		
Setting	Classroom		
Resources and tools	[<i>The Gasuco game.</i>]		
Learning cycles	Sequence of teaching-learning activities (repeated three times in two weeks)	Group size	Time (mins)
TCC1	A lecture about [<i>sustainability</i>].	70	2 x 45
N/A	Short introduction from the teacher about the game [<i>Gasuco</i>] and today's gaming session.	70	5
See below	Students are divided into small groups, each group playing the game for the remainder of time, in turns engaging in the activities described below.	3-4	100
TCC1,2,3	MiniFact cards - Another player draws and reads a question from a Mini fact card aloud. The player tries to answers the question. The correct answer is printed on the card.	3-4	1
PCC1,2,3	Discussion card - The player reads the card aloud and then states and motivates his/opinion opinion. The player then leads a discussion where the other players should actively contribute by agreeing, challenging or emphasizing other perspectives. The other player decides if the player succeeded in leading the discussion and in involving all the other players.	3-4	3
TCC1,2,3	Association card – The player should associate the different terms on the card in a context. The other players determine if the player succeeded.	3-4	1
TCC1,2,3	Concept card – The player challenges another player to explain or exemplify a concept written on the card in one minute. The answer is printed on the card.	3-4	1
Designer's reflection	Students often flaunt suggested time limits and discuss concepts and topics for as long as they feel like it, using the game more as a scaffold for discussions than as a goal-oriented activity. Various (national and other) student backgrounds oftentimes adds to the discussions.		

5 Discussion

The discussion cards and corresponding game mechanics facilitate each of Laurillard's (2012) five characteristics for making peer discussions support actual learning (see the theory section above). Answers from the student questionnaire back our conclusion that the discussions indeed *did* promote learning in the intended, hoped-for way. There is also clear evidence that a majority of the students considered playing the game a fun and engaging activity, thereby supporting our goal of engaging students in learning a GDEE topic that many could consider being peripheral to their education.

An important outcome of this paper is the pedagogical design pattern for using a board game for learning about sustainability in an engineering education (Table 1). Neither the pattern nor the game itself is by necessity tied to the specific topic of sustainability, as seen in Table 1 where all topic-specific parts are in brackets and italics. It should therefore not be too hard to transfer the same concept (i.e. the same pedagogical pattern) to other GDEE topics or to other engineering programmes.

The gaming sessions are easy to administer and the only hard requirements are a suitable locale and a sufficient number of games (one game for every four students). The main threshold would be to either find an existing game that is suitable (and perhaps customizable), or to design and produce a new game. Latching on to an existing game is convenient, but might require existing lectures to be adapted to the game, or for the game to be adapted to the lectures/course in order to, for example, make sure that the questions are not too easy or too difficult (see the negative comment above). Developing a new game makes it possible to customize it to the target learners and courses, but of course requires significant resources in terms of time, money, game-development skills and access to production facilities etc. As was described in the paper, we have customized the game so that 75% of the Discussion cards treat questions that are related to sustainability in general and 25% treat ICT and sustainability in particular. Based on our experiences, we are now considering increasing the proportion of ICT-related Discussion cards, perhaps aiming for a 50/50 balance between these two categories of questions.

Our experiences of using the game in our course are very positive, as are the experiences of (the majority of) the students. While it is possible to play the game competitively (there is a scoring systems), it is much more common for students to use the game as a scaffold for discussions, often flaunting the guidelines for time use, for example discussing a topic that catches their interest for five minutes instead of the allotted one or three minutes for Opportunity cards and Discussion Cards respectively. In the spirit of *not* playing competitively, we have also noticed that it is unusual for students to flunk other students in their role as discussion leaders. It seems to be more common for students to admit that they didn't know very much about a topic and that they themselves feel they are not "worth" winning the card in question. While students thus can blatantly disregard the formal rules of the game, no one is happier about it than us teachers. It is furthermore not unheard of for students to stay and to continue to play the game until the allotted time is up, rather than when someone has won the game. We find that it is especially beneficial to have these gaming sessions at the very start of the course as they tend to "draw in" students and make them interested in the topic of sustainability and the contents of the remainder of the course.

Acknowledgements

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Figure 3: A snapshot from a Gasuco gaming session.