Paper 15. The use of board games in the engineering education for the purpose of stimulating peer participation in lecture theatre discussions

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Abstract

In this paper, an innovative approach for stimulating students to participate in lecture theatre discussions is described. The course module in which this approach was attempted is an introduction to sustainable development, which is a subject that demands a high level of reflection among students for being efficiently learnt. In this case, the module is part of the introduction course for students just beginning their education in mechanical engineering at the Royal Institute of Technology in Stockholm. In particular, in this case, the board game GaSuCo (Gaming in Sustainability through Communication) was used at four occasions intermediary to five large-class lectures. The lectures were planned in a way as to invite to a large number of discussions and debates in the theatre, for the purpose of stimulating student reflection. The challenge of having meaningful discussions in a lecture theatre of 160 students is well known and by introducing some of the discussion subjects within the framework of a board game prior to each lecture, most students would have already come across many of the discussion subjects of the lecture on beforehand and tried their arguments on their peers for several of these subjects making the leap to participate in the discussions of a larger group less frightening. The major lessons learnt from having tried this approach for the first time is that lecture theatre discussions are indeed stimulated by the use of board game discussions in between the lectures. Although the effect of the interactive lectures and the board game were strong by their own, it is when the two tools are combined that synergetic effects become evident enhancing the effect even further. Another beneficial effect that was evident is that by being presented to three randomly selected peer students at each board game event, many students that did not know each other before this course module have now got to know each other, facilitating cross-contacts between subgroups within the larger group.

1 Introduction

In this work, a course module in sustainable development has been developed and given to a class of first year students of mechanical engineering at the Royal Institute of Technology, Stockholm (Sweden). The course module was included in an introductory course that spanned over the first semester, introducing various aspects and engineering subjects, during the fall semester of 2012 with 165 students. A similar course module was given in another course during the spring semester of 2013 with 29 students.

The course module in sustainable development included five large-class lectures and four small-class exercises, scheduled so that they were occurring alternately. The large-class lectures were not

traditional, one-way communication lectures but rather to a large degree discussion driven but moderated by the lecturer. A number of dilemmas and discussions with connections to the subject of sustainable development were addressed each time, for each lecture within the theme of that lecture. Discussions were varied with more traditional-style presentations by the teacher, leading from one discussion to the next. During the exercises in between the lectures, the students were playing the board game GaSuCo (Gaming in Sustainability through Communication), especially developed for the course (however, the prototype version of the game had another name during the course).

The purposes of the large-class lectures were to:

- give the students insight in key areas by introductory presenting basic material. This part was done in a rather traditional way although the interrupting effect of the discussions decreased the risk for monotony in the presentation.
- provide an arena for discussion and debate, with student participation and teacher moderation.
- inspire students to reflect and to reach their own conclusions on the subject.

In the small-class exercises the students were divided into groups of four, each given a copy of the board game GaSuCo. The board game is a question based game, with mainly two types of questions (presented on playing cards): *knowledge* questions and *discussion* questions. The knowledge questions are various and with varying degree of difficulty, within the subject of sustainable development. The discussion questions are unique for each game session (a new deck of cards was provided at each session), and many discussions were identical to discussions that came up at the following lecture.

The rules of the game are very self-instructive and even without much instruction the students were playing within ten minutes. The purpose of the exercises were to provide an arena for students to interact around the dilemmas that would be brought up on the following large-class lecture, as well as being an effective tool for stimulating learning in itself. By playing GaSuCo the student would:

- be exposed to a large number of knowledge questions, which would help building a general knowledge base within the subject.
- familiarise themselves with the dilemmas and discussion subjects for the next class on beforehand, so that they would be known and understood as well as properly thought trough.
- test arguments, and test discussing the subjects in small groups with the support of each other, and thereby strengthening the self-confidence in more students to participate in the large-class discussions.
- get to learn more peer students in their class, facilitating networking.

To a very high degree all these purposes were met in reality even the first time this course module was given. The observations of the teachers and other professionals involved constitute the base of the analysis presented in this paper as well as student interviews and questionnaires. Since the first course module, another course module was recently given to another class of students (spring semester 2013) and the results from that occasion are also included in the analysis. The extent was slightly smaller (3 large-class lectures and 2 boards game sessions) but the general implementation was similar and based on the successful implementation of the first occasion.

A more general background to teaching sustainable development in engineering programmes and using board games in higher education is given in section 2. In section 3, the research strategy and methodology of the evaluation of this project is described. In section 4 the results are presented and discussed whereas conclusions are drawn and future work described in section 5.

2 Background

In the Swedish legislation for higher education it is explicitly stated since a few years back that sustainable development must be included as a learning objective in engineering educations. Thus, in recent years more thought-through strategies have been worked on for meeting this criterion, even in universities as the Royal Institute of Technology in Stockholm where sustainable development in practise have been integrated in most programmes for many years. In the mechanical engineering programme this has led to a strategy implying an explicit introduction of the subject in year 1 and a subsequent explicit integration in higher courses throughout the programme. In that way, sustainable development is not taught as an exterior subject but integrated both explicitly and implicitly.

Sustainable development is in one respect an extremely large and broad subject covering in principle every aspect of modern society, with implications in various dimensions both influencing and being influenced by other disciplines such as economics, ecology, engineering and social sciences. In another respect, though, sustainable development is an extremely narrow subject of which the basic understanding could be easily explained in one lecture or one chapter of a text book. This rather unique characteristic of this subject suggests that it should be taught in close association with other disciplines, introduced and justified on its own qualities but connected to other disciplines fairly swiftly.

There is another characteristic of sustainable development that makes teaching this subject a challenge, perhaps especially in an engineering programme. This stems from the fact that there is no generally accepted definition of either *"sustainability"* or *"development"*. Since any definition of the very meaning of the phrase *"sustainable development"* holds in itself a position of view, which affects the implications of how that definition is then further used, one could argue that the subject should not be taught without a thorough discussion on the underlying meanings and implications.

The most common definition in practical work is found in the report of the United Nations World Commission on Environment and Development (WCED), "Our Common Future", and says that a sustainable development is a:

> "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland *et al*. 1987)

A common practice for concretising the definition into a practical methodology that can be used for actually working with the sustainable development of an organization, a nation or internationally, is to define an economic, an ecological and a social dimension of sustainability – the triple bottom line (Elkington, 1997). However, one should be aware of the fact that both the mentioned definition and such structuring are based on a particular point of view. To define sustainable development is to take a stand on certain aspects. For example, the mentioned definition only recognises human society and human individuals as having value by its own. The nature or the environment does only have value as a potential means of meeting the needs of human beings. Taking the position that nature does not have a value by its own may be contradictory to what some students believe and even though the definition can be effectively used in the remainder of the education on the subject, it is perhaps somewhat careless to do so without first appropriately justifying such position.

This is only the first of many positions that can or must be taken by those who work in the field of sustainable development, and as the subject unfolds dilemmas such as choosing appropriate energy conversion technologies, legislation and tax structures, policies etc. become evident.

Taking a collective stand as a democratic society in these and other questions can only be done in a transparent and publicly accepted way by including discussion and debate in the decision process, with

the double purpose of subjectively and collectively evaluating and comparing parameters that are measured with different measures (a process that is intrinsically sub-optimising and demands for subjective decision making) as well as weighing were the majority vote of the public eventually ends.

The authors of this paper argue that any deeper education in the subject should be discussion driven and based on reflection and debate. If done in that way, the students could take with them from the course not only the most common definitions and working tools of sustainability but also the working skills of practically handling the subject in a realistic context. However, reflection and debate can only truly happen if the students have a chance to discuss among themselves and with their educators the dilemmas that are encountered in the non-straight forward process of making society sustainable.

Games have been introduced to various education related contexts and in some cases validated scientifically. A study from 2004 examined the use of a role-playing game in education, in a course framework for facilitating the development of knowledge and skills in conflict management (Swanelid, 2004). Board games have been used as well and been evaluated in several studies, for example was the game Kalèdo used in a course in nutrition science in Naples (Amaro *et al*., 2006) and another board game was used in Brazil to investigate whether board games can be a source of effective learning of concepts and terms in biomedicine and stem cell research (Girardi *et al*., 2005). A prototype version of GaSuCo, which is the game that was used in the study of this paper, has also been tested under various conditions and the effects on the learning outcome have been examined from a scientific perspective (Larsson, 2011). All of these studies showed that there are positive effects of the use of games in education, and that this can be a powerful tool for enhancing student learning and inspiration.

3 Methodology

In order to evaluate to what extent the described course module in sustainable development met the intended purposes, the following measures of analysis has been conducted:

1. Direct observation by involved teachers and other participating professionals.
2. Precursor questionnaire given before the course module began.
3. Written hand-ins by students during lectures.
4. Concluding questionnaire given to the students after the completion of the course module.
5. Deep interviews with two participating students.

The course module has been given at two occasions:

- 165 first year students in mechanical engineering (five lectures and four game sessions).
- 29 second year students in engineering materials (three lectures and two game sessions).

All five measures were implemented at the first occasion and measures 1, 2 and 4 were implemented at the second occasion. The most important measure were in both cases direct observation by the lecturer, by the inventor of the board game (who sat in on all lectures and participated on all game sessions at the first occasion) and by informal interview of an observing experienced teacher.

The precursor questionnaire was used to measure the level of understanding the students had before the course module began. The written hand-ins were used to track the progression of understanding during the five weeks.

The difference between the concluding questionnaires at the first and second occasions respectively, was that at the first occasion emphasis was to collect qualitative answers whereas at the second occasion also quantitative answers were collected.

The deep interviews were on semi-structured form and about one hour each. Initially ten students were asked to participate but in the end it was only possible to perform the interviews with two of them.

In general, mostly qualitative information was collected and it must be understood that any conclusions based on such information is to some degree subjective in nature. However, the conclusions are still extremely interesting and of very high value. Also, much effort has been made to involve several people in the analysis and to ask for second opinions from people not directly involved in the teaching events themselves as to ensure that conclusions are as objective as possible.

4 Results

In section 1, three specific purposes of the large-class lectures are specified. It is also stated that the purpose of the small-class exercises/gaming sessions was to stimulate student learning and to prepare them for the large-class lectures.

This study is an attempt to make observations for determining whether the purposes of the learning activities were successful or not. Observations were performed by the five separate means explained in section 3. From those, the most important one is the actual observations that were performed by the responsible teacher and other professionals during the course module (section 4.1). Supporting those observations were the questionnaires given before and after each course module (section 4.2) and the deep interviews with two students (section 4.3). However, the hand-ins during the course itself were not particularly useful as a means to determining the outcome of the project, but served rather as a type of assessment, which also was its main purpose.

The major outcome of this study is:

- Lecture theatre discussions are indeed stimulated by the use of board game discussions in between the lectures.
- The board game worked well as a tool for inspiring student learning.
- The effect of the interactive lectures and the board game were strong by their own but when the two tools are combined, synergetic effects become evident enhancing the effect even further.

Another beneficial effect is that by being presented to three randomly selected peer students at each board game event, many students that did not know each other before this course module have now got to know each other, facilitating cross-contacts between subgroups within the larger group.

4.1 Direct observation

The responsible teacher, who was also giving the five large-class lectures, confirms that students participated with a high degree of commitment in the discussions that were held in the lecture theatre. Although that class size was up to and over 160 students, there was not a problem of getting the audience to actively participate in the way that the lecturer had intended. For most discussions, various teaching tools were used such as the *one-minute-paper* (Angelo & Cross, 1993) and the *structured lecture* (Gibbs & Jenkins, 1992). However, as the students became more and more comfortable in the situation, good discussions started to appear spontaneously. The teacher then had to decide which of the spontaneous discussions to use for the progression of the subject and which to terminate more swiftly.

In the small-class exercises/gaming sessions, students were exceedingly active in non-moderated discussions among themselves. Listening in to the students' discussions, the course professionals were able to confirm that they were very active, and that they indeed were reflecting over the subject. The

lecturer also had a chance to hear the students' non-moderated and uninfluenced views before he would raise the same subjects as moderated discussions in the lecture theatre.

The direct observations alone seemed to confirm very efficiently that all purposes were met and that the learning activities indeed worked perfectly as planned. Questionnaires and interviews were however held independently to further confirm that picture.

4.2 Questionnaires

The students' answers in the questionnaires reflect that they really liked the concept, both with discussion driven lectures and board game exercises. Also, by comparing the answers from the questionnaires before and after the course module it is apparent that although many students had a good understanding of the subject already (presumably from their high school studies or based on a genuine interest) an apparent increase in the understanding of the subject took place. The answer ratios were in general very high even though it was completely optional to answer the questionnaires (with only a small external incentive given for answering the questionnaire after the first occasion), with the exception of the ratio of the last questionnaire (which may be considered moderate); see table 1.

Table 1: Questionnaire answers: number of students and ratio of total.

	Before occasion#1	After occasion#1	Before occasion#2	After occasion#2
Number of students	165	165	29	29
Number of answers	84	102	22	9
Answer ratio	50%	61%	75%	31%

Questionnaire answers illustrate that the combining effect that comes from having the students interacting in small groups among their peers before interacting in large class lectures is extensively better than traditionally performed lectures. Responses argued that "*what I liked with the course was that we had to argue and see things from several perspectives*", "*The board game was a good way to create discussions and when you participate in a group you listen and understand better. It should have been more group assignments and such with possibilities to think creatively*". Another response argued that "*I thought it was a very good approach, that it was varied with games and lectures. The lecturer was very dedicated and invited us all into discussions even in the lecture, which made us very much involved*".

The questionnaire after the second occasion also included quantitative measures in the form of twelve questions that students should answer one of the following:

- Agree very well
- Agree well
- Agree to some extent
- Do not agree

All statistics is not relevant to show here, neither is there space to do so, but we believe that the three most interesting questions and answers are:

Q1. "The course module on Sustainable Development is suitable for engineering students."

Q2. "In the exercises, questions and dilemmas relating to Sustainable Development were encountered and by having to discuss them they were familiar when they reappeared in the large-class lectures."
Q3. "In the large-class lectures many dilemmas and debates were encountered, which is better from a learning point of view than traditional lectures based on one-way communication."

Answer ratios are presented for these three questions in table 2.

Table 2: Questionnaire answers: quantitative measure.

	Agree very well	Agree well	Agree to some extent	Do not agree
Q1	44%	33%	22%	0%
Q2	22%	44%	33%	0%
Q3	44%	33%	22%	0%

As always in questionnaires given to students, the answers are subjective, but at least these numbers indicate that the students' experience from this course module is very positive, and that it corresponds to a very high degree with the intentions of the effort. They are also in agreement with the observations made by the teachers and professionals (section 4.1).

4.3 Student interviews

Two deep interviews were performed after the first occasion. Here follows some highlights from what the students said during interviews:

Regarding the mix of lectures and exercises, one student explained that *"I personally liked the mix of lectures and exercises". "It was very good to have the lectures in the way that they were, with active lectures and that* [the lecturer] *had a dialogue with us rather than lecturing us"*. The response in regard to the lectures in comparison to reading a book: *"The idea of the lecture was to create discussion, and it is difficult to create a discussion while sitting alone with a book"*.

"To have dialogues in small groups in the classroom and then in the larger group at the lecture worked fine. The cards containing discussions that were in the game clearly tied to the lectures. However, there was a clear difference between the discussions in the classroom and the lectures since we talked briefly for a couple of minutes with new people at each session. I liked to be able to discuss in smaller groups first and then bounce it out with the other groups in the lecture".

Regarding the structure of the lectures:

"The lectures were very fun, there were questions to us, and you got to hear the thoughts of others, it was very interactive."

Regarding the connection between exercises and lectures:

"It was great, the mix between discussing with each other in small groups and then larger group [in the lecture]. *I guess it was a bit mixed who dares speak in front of so many people, but with those who did it was very fun to listen too and it shows their opinions and what they think and stand for. Right or wrong does not matter, because the discussions are such, that there is no right or wrong."*

"It was clear to see that the board game and lectures were coherent, and that the discussions in the previous game session came up on the lecture after. Those who do not dare to talk in front of a large

group can talk in the small groups so it works both ways; thus from game to lecture and from lecture to game."

Regarding the level of difficulty:

"Some of the discussions in the board game were similar and it's always a question how to read the cards. But otherwise, I think it was a great variation on the level of difficulty, some were hard and I had no idea of the answer at all and some I had heard on the lecture."

Regarding the fact that gaming groups were selected randomly:

"Of course if you end up next to your friends when playing the game, you might skip some of the discussions while sitting next to new faces you play entirely by the rules."

The input from the deep interviews was to a high degree in consistence with the input from the observations made by the teachers and professionals (section 4.1).

5 Conclusions and future work

The major lessons learnt from having tried this approach for the first time is that lecture theatre discussions are indeed stimulated by the use of board game discussions in between the lectures. Although the effect of the interactive lectures and the board game were strong by their own, it is when the two tools are combined that synergetic effects become evident enhancing the effect even further. Another beneficial effect that was evident is that by being presented to three randomly selected peer students at each board game event, many students that did not know each other before this course module have now got to know each other, facilitating cross-contacts between subgroups within the larger group.

Word of the course module in sustainable development has spread throughout the Royal Institute of Technology and during the fall semester of 2013 it will be given (in slightly various forms) in five different courses for engineering students (of which three will be for first year students) with group sizes ranging from 30 to 180. In total, over 500 students will be taking the course module during the fall semester.

Based on the experiences from the two occasions described in this paper, a few changes will be applied during the 2013 fall semester course modules:

- A new version of the lectures has evolved and a partly new selection of discussion topics has been chosen.
- A compendium has been written by the responsible teacher to be used as course literature, which will be advanced into a text book during year 2014 by a Swedish publisher (Studentlitteratur AB).
- A new version of the board game GaSuCo has been developed, with the following updates:
  - Discussion cards are now explicitly written by the responsible teacher and lecturer, which are to an even further extent aligned with the lectures.
  - Knowledge cards are now explicitly written by the responsible teacher and lecturer, which are now aligned with the course literature and the final exam.
- Some adjustments have been made in the way the schedule for the gaming sessions is set up.
- A final exam will be held, which will work as assessment in combination with active participation in class room discussions.

The general outline of the course module and the appearance of the board game will remain the same, drawing from the successful implementation at the first two occasions. However, what worked less

satisfying the first time was some of the logistics during gaming sessions (due to how the schedule was set up) and to some extent the assessment method (which was only through active participation). By these changes, a new iteration is concluded that takes the course module a step further from a educational standpoint and the implementation is expected to work much more smoothly.

With such many students taking the course module, even more data will be gathered during the fall of 2013 – both quantitative and qualitative data – with the objective of even further testing the hypothesis that board games in education may be used to stimulate peer participation in lecture theatre discussions and thus enhance student learning through reflection.

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