'Acoustical Pursuit'—Playing To Learn Acoustical Engineering*

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This paper presents the development method and process of designing a board game as a new educational experience at the Polytechnic Engineering Faculty of Elche, at Miguel Hernandez University, Spain. The main objective of this educational action is to motivate students to learn general aspects of a subject, by designing, creating, and playing with a traditional board game, using general questions from different areas of knowledge of Acoustics and Acoustical Engineering. During this process, students reinforce skills such as working in a group, decision making and looking for references, in addition to learning the general aspects and fundamental concepts of the subject. As a result of the experience, students show a significant improvement in their knowledge, and a higher motivation to learn more about this subject. Survey results show that they are proud of their work, and they feel that they will turn this teaching experience to their advantage.

Keywords: learn through playing; board game; working in a group

1. Introduction

Acoustical engineering is the branch of engineering dealing with sound and vibration. It is the application of acoustics, the science of sound and vibration in technology, and it is typically concerned with the manipulation and control of sound in different environments. The main goal of this subject is the measurement, assessment, control and reduction of unwanted sounds. Specifically, 'Acoustical Engineering' is a multidisciplinary subject, which means that it includes different knowledge areas related to civil and mechanical engineering, architecture, psychology, environmental sciences, and physics.

At Miguel Hernandez University in Spain, the subject 'Acoustical Engineering' is taught in the final year of a Mechanical Engineering Degree. It is an elective subject that has as its main objective to show students a different concept of engineering, and try to open their minds to define their professional future, giving them the chance to learn about the subject with a view to continuing their studies with a specific postgraduate course. The main problem of a subject with such an extensive syllabus is the limited number of lectures hour in the curriculum degree (60 teaching hours in all), giving as a result that there is not enough time for students to absorb all the important aspects of the course. That is the reason why it was decided to develop an extra teaching methodology as a means of improving the students' rate of learning, and subject motivation [1] [2]. Anyway, this educational experience was carried out during a semester without removing on it any traditional theoretical lecture.

2. Educational games

Traditional games are usually related to leisure time, but previous experience shows that they can help in the learning processes. In fact, the use of games in education is well documented in literature [4]. They have been used at pre-school, primary and secondary school, and universities [6–8] as a learning tool and as a proposal for student's motivation [10]. One particular category of game is the 'board game'. A board game is played by multiple players who move pieces across a board using counters and dice. Adding board games to the educational process can lead to an interactive learning experience [9]. With a board game, players often learn from one another whilst at the same time having fun in a competitive environment. It is also believed that while playing, students have a unique and enjoyable opportunity to evaluate their own level of learning by identifying concepts not yet mastered [3] [5]. But playing is not the only way that a board game can help students in their learning process, given that they can work to organise and create the game, achieving thus to develop other important skills.

Considering the successful experiences of other authors using games in learning and the motivation process, we encouraged 'Acoustical Engineering' students to propose, design and use a game that could help them to improve their knowledge and motivation on the subject. Following a brainstorming session and having considered other options, the selected game was called 'Acoustical Pursuit'.

Acoustical Pursuit was born as a board game which progress is determined by a player's ability to answer general acoustical engineering questions. The objective of the game is to move around the

board by correctly answering different kinds of questions. These questions are split into six categories, each having its own identifying colour.

- *Brown colour*. Fundamental principles of Acoustics. This group of questions mainly includes general aspects of acoustical engineering such as magnitudes, noise levels or noise indexes.
- *Yellow colour*. History of Acoustics. Mainly scientific, the most important dates and other curiosities relating to historic events in the acoustic world.
- *Pink colour*. Architectural Acoustics. These questions raise general aspects of acoustic isolation, absorbent materials and other aspects of room acoustics.
- *Green colour*. Environmental Acoustics. Environmental legislation restrictions, noise in open spaces, noise maps and traffic noise in urban and inter-urban areas are considered in this section.
- *Orange colour*. Noise sources and noise control. This group of questions includes general aspects of noise in an industrial environment and the characterization of noise sources such as pumps or engines.
- *Blue colour*. Underwater Acoustics and Psychoacoustics. Finally, in this section, questions are based in SONAR systems and other general underwater acoustics applications. Also on general aspects of human subjective responses to acoustics stimulus.

The number of players (students in this case) may vary from 2 to 36, and they can form groups of 6 players maximum. During the game, students move their playing pieces around a track which is shaped like a wheel with six spokes. This track is divided into spaces of different colours, and the centre of the board is a hexagonal shape. At the end of each spoke is a 'category headquarters' space. When a player's counter lands on a square, the player answers a question according to the colour of the square, which corresponds to one of the six question categories. If the player answers this question correctly his turn continues; if the player's piece was on one of the category headquarters spaces, he will collect a wedge of that same colour, which fits into their playing piece. Some spaces are marked 'roll again' giving an extra roll of the dice to the player landing there. Any number of playing pieces may occupy the same space at one time. Questions are written on cards. There are six questions on each card, one from each category. The answers to the questions are on the back of the cards.

Once a player has collected one wedge of each colour to fill up the playing piece, the player has to make his way toward the hexagonal hub in the centre of the board and answer a question from a category selected by the other players. If the question is answered correctly, the player wins the game. Otherwise the player must leave the centre of the board and try again on his next turn.

3. Working to play

After deciding the kind of game that was going to be developed by the students and its main characteristics, a methodology was devised to ensure that students, in collaboration with lecturers, use the learning experience to improve their knowledge in Acoustical Engineering meanwhile they developed some other new skills.

For this proposal, students were encouraged to work in groups to prepare a series of questions for each category. To prevent different groups creating similar questions, it was decided that each one would focus their questions on a specific category, see section 2. For this task, they had to use recommended bibliography, technical papers, and other information sources such as the internet or research journals.

They were asked for 'open questions' with a unique answer, even though, in some specific cases, students could propose questions with four options to choose from. To assist the students work, some rules on the composition of questions were established. To start with, students had to be careful that each question was in the correct category and it did not overlap with another group of questions. Besides that they had to be aware that the main objective in the game is to improve and verify the general knowledge in Acoustics of the players; consequently they should not be worried about the difficulty of the question and they must ask questions about important topics already explained by the lecturer or in the subject curriculum. A further rule was that it is not permitted to ask for 'definitions' nor to ask for lists of matters or subjective answers. Moreover, they should avoid using multiple choice questions or those which can be answered 'yes or no'. Finally, each question must have only a single answer, and not several possible solutions. To achieve all these criteria, students had to reconstruct some of the original questions and understand perfectly the theoretical fundament of each.

For example, a wrongly structured question could be:

Q: Which are the main characteristics of a dissipative material?
A: Porous, soft, etc.

The correct structure for the same question should be:

Q: Which kind of absorbent material is usually soft and porous?

A: Dissipative materials.

Once rules had been defined, each group had two weeks to prepare and collect between 60 and 80 questions of their category, using more than 30 different information sources and references related to the subject. During and after this period, lecturers' work has different phases:

(1) They have to emphasize the importance of the experience, motivating students to prepare the questions and showing that a group effort is involved in the experience.

(2) Lecturers have to supervise students' work. They must solve any doubts that may arise during the students' research and subsequently they must check all the prepared questions, looking for those which do not keep the rules and those that are not sufficiently precise.

(3) Furthermore it is necessary to add some extra questions to each category, to complement the quantity of questions and to avoid students only memorizing their own questions.

(4) Finally, it is necessary to prepare the materials required for the game. This consists of designing a board and the question cards. The designed board is 40×40 cm, see Fig. 1, and cards are 18×12 cm, see Fig. 2. It is also necessary to have a dice, six playing pieces that move along
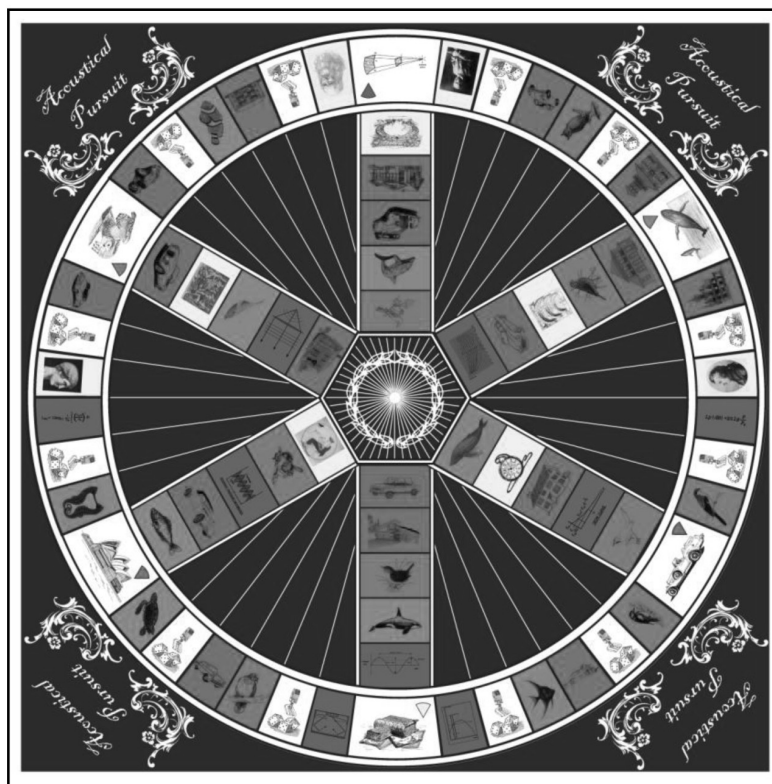

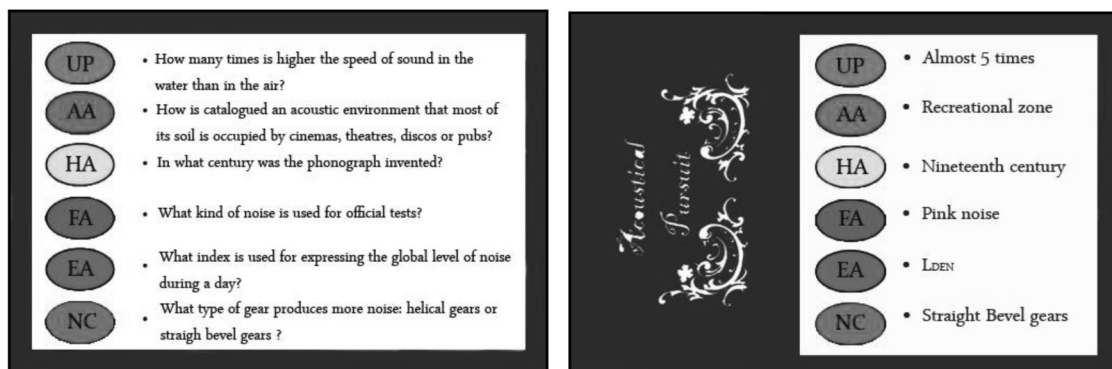**Fig. 1.** The Acoustical Pursuit board designed for the experience.

Fig. 2. The Acoustical Pursuit card designed for the experience. Left, questions; right, answers.
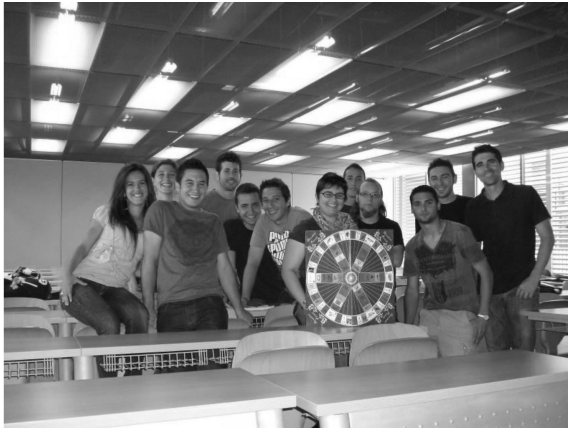
Fig. 3. Group of students playing Acoustical Pursuit.

the board and six wedges of each colour required to complete the playing pieces.

After collating all the questions and suggestions from the students, each supervisor revised the questions giving to the students the feedback in order to correct, modify or replace the questions. The final result was a total of 80 questions in each category, totalling 480 questions and 80 complete cards. As a result, on average students had used more than 4 different references and 12 working hours, which in itself became the first successful learning step.

All these questions together with the other material, board, dice, etc, where edited ready to be used.

4. Learning through play (playing to learn)

Reached this point of the experience, the next step was to define how and where students could play the game.

It has been explained before that the main goal of this game is to consolidate and assess student's knowledge of the subject. So, before playing, they had to prepare themselves for the game. For this purpose, all references used were provided to them, so they have two extra weeks to look up, summarise and study all the information they may need during the game. Each student already knew the answers to the questions he had prepared for his category, but after, he had to learn more about the other categories included at the game. During these two weeks, on average, each student spent 25 hours looking up references.

After students reviewed all references and main concepts of the subject were explained at the classroom, during the last lecture of the session students were encouraged to play the game. At that moment, the whole group was split up into 6 subgroups; the lecturers explained the games rules and the contest began.

5. Knowledge assessment and students 'feelings'

Throughout the game, students reasoned, discussed and took decision, realising how the time studying acoustics bears fruits, see Fig. 3. At the same time, the lecturers assessed each student checking up their improvement and how they reason with their group partners.

The winner group, apart from having considerably improved their knowledge in acoustics, was also rewarded with a book on acoustics for each student that they could choose from amongst a selection of specialized publications.
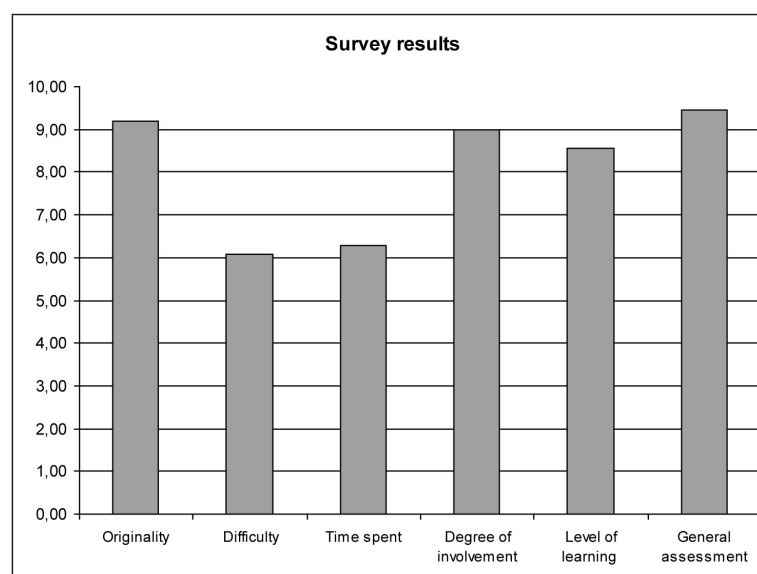

Fig. 4. Survey results.

Table 1. Qualitative results of students of current and last year sessions

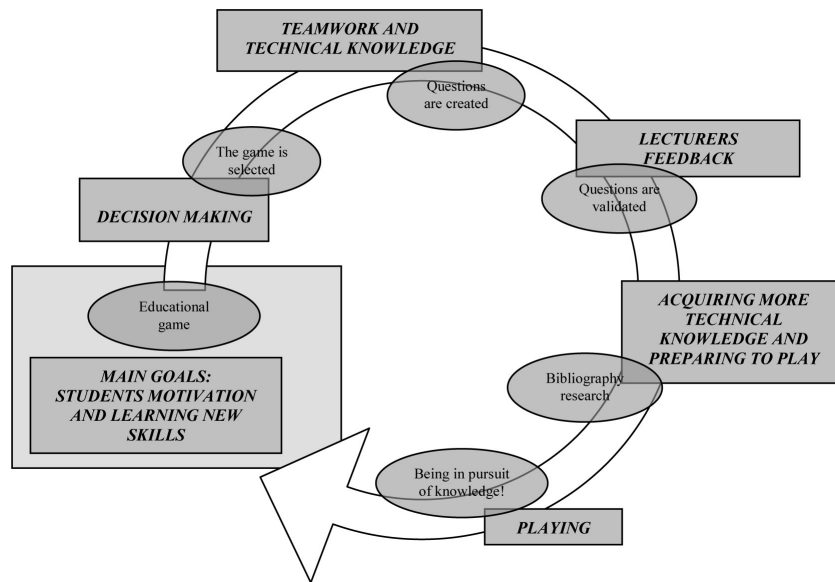|	Session 08/09	Session 09/10	Comparative
Average grade, out of 10	7.1	8.1	Improve by 10%
Percentage of 'exam not taken' out of enrolled students	35%	7%	Improve by 28%
Percentage of 'passed' out of enrolled students	58%	93%	Improve by 35%
Percentage of 'failed' out of enrolled students	7%	0%	Improve by 7%

Fig. 5. Sketch summarising the learning process.

Finally, on the scheduled date, students made a classic evaluation test and in order to assess how the game influenced them in relation with the subject. They made the same test that previous session students did (in previous session this teaching experience was not developed). Table 1 shows the results of each session and how the learning methodology improves significantly.

The same day, students were asked to answer a short survey in order to obtain their opinions of the work carried out and the time spent in all learning steps. The survey consisted of 6 questions where they had to assess between 1 and 10 the originality, difficulty, time spent, the degree of student's involvement, the level of student's learning, and a general assessment of the whole educational experience, results are summarised at Fig. 4.

6. Conclusions

As a general conclusion of this teaching experience, we had a great feeling of having passed good moments both during the work and the play.

Figure 5 shows the learning process carried out on this educational experience, in which students had been able to develop different educational skills:

- Acoustical pursuit is a board game that improves student's motivation and arouses their creativity.
- During the creation phase of the game, students have to make decisions, administer their time, and work in a group. Additionally, students have to work with different references related to Acoustical Engineering.
- Preparing the game questions and later playing, students learn new definitions and a general knowledge of Acoustical Engineering. Specifically, the Fundamental Principles of Acoustics, the History of Acoustics, Architectural Acoustics, Environmental Acoustics, Noise sources and control, and Underwater Acoustics and Psychoacoustics.
- As the questions are prepared in the English language, students also became used to English technical terminology in acoustics.
- Quantitative results have improved compared with students of previous sessions.
- Finally, in order to discover the opinions of the students about the whole experience, they assessed different aspects of the game, and their work. As shown in Fig. 4, students consider originality, degree of involvement, and level of learning are high. Difficulty, and time spent in the experience are medium. As a conclusion, the

general assessment of the educational game and the working methodology comes higher than any other aspect with an average value of 9.45 out of 10.

References

1. A. Kumar and A. W. Labib, Applying Quality Function Deployment for the Design of a Next Generation Manufacturing Simulation Game, *The International Journal of Engineering Education*, **20**(5), 2004, pp. 787–800
2. F. Ruiz, Learning Engineering as Art: An Invention Center, *The International Journal of Engineering Education*, **20**(5), 2004, pp. 809–819.
3. S. Retalis, Creating Adaptive e-Learning Board Games for School Settings, using the ELG Environment, *Journal of Universal Computer Science*, **14**(17), 2008, pp. 2897–2908
4. Marc Prensky, *Digital Game-Based Learning*, McGraw-Hill, 2001
5. Anne P. Massey, Susan A Brown, Johnston, It's All Fun and Games . . . Until Students Learn, *Journal of Information Systems Education*, **16**(1), 2005, pp. 9–14.
6. M. M. Tanner and T. M. Lindquist, Using Monopoly and teams-games-tournaments in accounting education: A co-operative learning teaching resource, *Accounting Education*, **7**(2), 1998, pp. 139–162.
7. K. Kiili, Digital game-based learning: Towards an experiential gaming model, *Internet and Higher Education*, **8**, 2004, pp. 13–24.
8. D. Burgos, C. v. Nimwegen, H. v. Oostendorp and H. v. R. Koper, Game-based learning and the role of feedback. A case study, *Advanced Technology for Learning*, **4**(4), 2007, pp. 188–193
9. C. V. Helliar, R. Michaelson, D. M. Power and C. D. Sinclair, Using a portfolio management game (Finesse) to teach finance, *Accounting Education*, **9**(1), 2000, pp. 37–51.
10. Janis P. Terpenny, Richard M. Goff, Lohani, K. Vinod, - Jennifer Mullin and Jenny Lo, Preparing Globally and Socially Conscious Engineers: International and Human-Centered Design Projects and Activities in the First Year, *International Journal of Engineering Education*, **24**(2), 2008, pp. 409–419.

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