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Enhancing Student Performance through a Competitive Team Tournament

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Abstract

In some engineering subjects, the nature of the material requires a maturation time in the student's mind before being fully understood and the time constraints of modularization can become an impediment to the successful achievement of their learning outcomes. This paper presents a novel and efficient way of helping students to timely meet their learning outcomes by means of a Team Game Tournament. The principle behind a Team Game Tournament is that the success of a team lies on the success of the individuals composing the team. Therefore, team mates help each other and study more than individually because they care for them and for the team. A variation of Team Game Tournament inspired by the UEFA 'Champions League' is used here to address learning outcomes for two different age groups, four modules, four engineering degrees and two countries during the 2013/14 and 2014/15 academic seasons. It is noticed that the more games between the teams, the more effective the team work and learning has become. Confidential questionnaires and end-of-semester exams confirm the success of the competition in enhancing student satisfaction and learning.

Keywords: *Team Game Tournament, Cooperative Learning, Student Engagement.*

1. Introduction

Engaged students are successful students and the ongoing challenge for educators is how best to engage students during instruction [1]. There is evidence in the literature that games can be fun, highly motivational and help people to learn something challenging while enjoying it. Two games based on television shows ('*Family Feud*' and '*Name that Tune*') are used to teach content and enhance students' critical thinking abilities in nursing [2]. A game-based approach, this time, based on a sport competition ('*The Champions League*'), is used to promote active learning in civil engineering [3]. In both cases, the class is divided into teams that play against each other, i.e., solving problems posed by the facilitator or themselves. Often, clicker-based software (also known as Student Response Systems), also has options to introduce team competitions or games to make the questioning more attractive to students.

More specifically, the approach by [3] is based on a Team Game Tournament (TGT). TGT, first introduced by [4], falls within a type of cooperative learning methods known as *Structured Team Learning* (which also includes Students Teams-Achievement Divisions, Team Assisted Individualisation and Cooperative Integrated Reading Composition) [5]. All cooperative learning types have the following pillar stones in common [6]-[8]:

- *Positive Interdependence*: Students must perceive that each group member is linked to others in a way so that a group member cannot succeed unless others do.
- *Individual Accountability/Personal Responsibility*: Each member must contribute to the group and be accountable for helping the group reach its goals. The performance of each student is assessed and the results are given back to the group and the individual.
- *Face to Face Interaction*: Each group member promotes each other's success by helping, encouraging, and supporting each other's efforts to learn.
- *Interpersonal Skills*: Each group member must be motivated, provide effective leadership, be able to make decisions, to build trust, to communicate and to manage conflict, etc.
- *Group Function*: It is necessary to ensure group members openly discuss how well they are achieving their goals and maintain effective working relationships.

The aim of this paper is to test a form of TGT that combines the benefits of cooperative learning together with the high levels of engagement achieved by students in games and sports. It is expected to enhance student learning and satisfaction significantly via this novel form of competitive teamwork, which involves rewards to teams based on the learning progress of their members. The main objectives of the intervention are:

- developing an efficient way for students to practise the material taught in lectures and to meet the learning outcomes,
- promoting critical thinking, and provide feedback to students if further study was needed,
- promoting peer-learning by helping other team mates,
- promoting high levels of retention,
- making tutorials more fun and engaging,
- making students work harder, and
- making students better team players.

2. The Intervention

This paper builds on the work by [3] to extend a variation of TGT inspired by the UEFA '*Champions League*' to multiple backgrounds in the 2013/14 and 2014/15 academic seasons including students:

- at two stages of their degree: 3rd and 4th year,
- in four modules: Surveying; Elasticity; Analysis of Structures; Structural Analysis, Design and Specification,
- in four engineering programmes: Forestry and Natural Resources Engineering; Civil Engineering; Structural Engineering with Architecture; Engineering with Science and
- in two Universities/Countries: University College Dublin (UCD, Ireland) and University of Oviedo (UO, Spain).

2.1. The Sample

The number of students registered at each of the programmes and modules under investigation is listed in Table 1. In the second row of this table, "Trad." stands for the academic season where tutorials have been carried out in a traditional format (2012/13 for the three modules in UCD and 2013/14 for the module in UO) and "TGT" stands for the seasons where the new intervention hast taken place (2013/14 for the three modules in UCD and 2014/15 for the module in UO). Here, a traditional format to deliver tutorials refers to a facilitator providing a question or number of questions that students must answer and submit within an allocated time.

Table 1. Number of students registered to each module and programme.

Module	Programme	No. students	
		Trad.	TGT
Elasticity (UCD)	3rd year Civil Engineering	21	16
	3rd year Structural Engineering with Architecture	13	15
	Total	34	31
Analysis of structures (UCD)	3rd year Civil Engineering	20	19
	3rd year Structural Engineering with Architecture	15	13
	Total	35	32
Structural analysis, design & spec. (UCD)	4th year Civil Engineering	41	11
	4th year Structural Engineering with Architecture	25	13
	4th year Engineering with Science	6	4
	Total	72	28
Surveying (UO)	3rd year Forestry and Natural Resources Eng.	22	27
Total (UCD + UO)		163	118

Table 2 provides details on the sample regarding the gender ratio and the number of national and non-national students. It must be noted that students experience this variation of TGT by the first time in all modules, except in '*Analysis of Structures*' (2nd semester of academic season 2013/14) when most of them already saw TGT in '*Elasticity*' (1st semester of academic season 2013/14).

The questions in a TGT round relate to relevant learning outcomes taught at the time in lectures. In '*Elasticity*', learning outcomes involving calculation of stresses and strains, constitutive equations, Mohr's circle and stress functions are tested with TGT. In '*Analysis of Structures*', calculation of internal forces and displacements in statically indeterminate structures and influence lines are topics subject to TGT. In '*Structural Analysis, Design and Specification*', moment distribution, elasto-plastic analysis of beams, yield analysis of slabs, reinforced concrete columns and prestressed beams are covered. Finally, in "*Surveying*", prevision vs accuracy, random error theory, random error propagation and basic concepts on Geodesy and Cartography are the themes for the TGT matches.

Table 2. Characteristics of the sample.

Module	Total no. of students		Male/ Female		National/ Non-National	
	Trad.	TGT	Trad.	TGT	Trad.	TGT
Elasticity (UCD)	34	31	29/5	24/7	30/4	26/5
Analysis of structures (UCD)	35	32	31/4	23/9	29/6	28/4
Structural analysis, design & specification (UCD)	72	28	58/14	23/5	59/13	24/4
Surveying (UO)	22	27	15/7	20/7	21/1	27/0
Total (UCD + UO)	163	118	133/30	90/28	139/24	105/13

It must be noted that the overall score in the modules under investigation is calculated from a weighted sum of continuous assessment results and an end-of-semester examination. Continuous assessment consist of tutorials (and labs in some cases), and it is within these tutorial slots that TGT is implemented. The percentage distribution of marks between Exam/Tutorials/Labs towards the overall grade is 80/10/10 for '*Elasticity*', 80/15/5 for '*Analysis of Structures*', 80/20/0 for '*Structural Analysis, Design and Specification*' and 60/20/20 for '*Surveying*'.

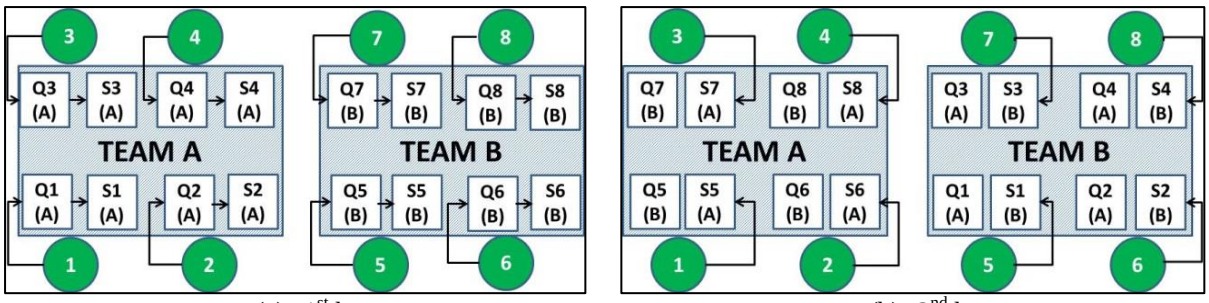
2.2. The Tournament

The competition is established by dividing the class into a number of small academically balanced teams that play against each other. The classes under investigation have a size of about 30 students (Table 2) that are divided into 4 teams. The composition of each team is maintained throughout the tournament. Two simultaneous matches take place in 2 h slots allocated to tutorials. The teams are paired against different opponents for each tutorial. During a match, students sit together at the table of their team (Figure 1).

(a) UCD (Ireland) (b) UO (Spain)

Figure 1. Arrangement of teams for the competition

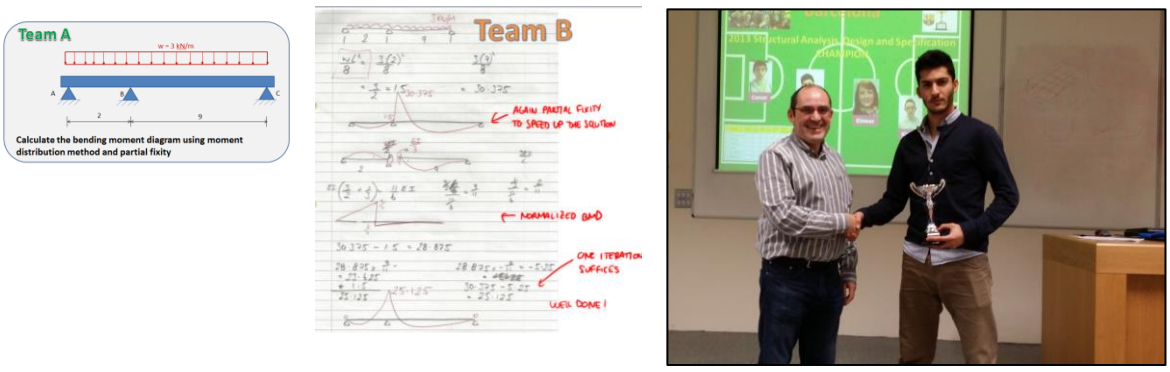
A specific match between two teams, 'A' and 'B', consists of posing questions (one question per team player) to the opponent team and answering the opponent's questions. In the four TGTs, the questions assess knowledge that requires calculations and numerical solutions. In the case of a game between two teams with 4 players each, there will be a total of 8 questions and 16 answers. During the 1st hour, the students prepare the questions and their solutions. For example, in Figure 1(a), each student 1, 2, 3 and 4 of team A produces one question (Q1(A), Q2(A), Q3(A) and Q4(A)) and the solution (S1(A), S2(A), S3(A) and S4(A)) to his/her own question Figure 2(a)). At the end of the 1st hour, the facilitator collects all questions and solutions by all teams. At that point, the solutions (S1(A), S2(A), S3(A), S4(A) by team A, and S5(B), S6(B), S7(B) and S8(B) by team B are stored by the facilitator, who right after interchanges the questions between the teams (Figure 2(b)).



(a) 1st hour (b) 2nd hour

Figure 2. The two halves of a match

Students are held accountable for their own questions and answers, and also help and learn from their team mates as they want their team to win. Students are rewarded according to their individual performance (80 % of the total TGT score is assessed individually depending on how challenging the question of each student is and the accuracy of his/her answers) as well as their team performance (20 %, 10% and 0% are obtained for a victory, draw and defeat respectively towards the total TGT score). To decide the winner a match, solutions from students from both teams to the same question are compared together. If the solution by one student is better than the answer by a second student, then, the team of the first student will score a goal in their favour. However, if both solutions are equally good or poor, then, none of the two teams score. By adding the goals achieved counting all students in the two teams playing against each other, it is possible to obtain a final match result. Selected questions posed by the students and their solutions are scanned and discussed in lectures after completion of a round (Figure 3(a)). In UCD, these questions are made available online via a Blackboard VLE. There is a schedule with pre-stablished dates for the games and an overall classification that is updated after each round/tutorial. At the end of the competition, the champions are rewarded with a prize (Figure 3(b)).



(a) Feedback in lectures (b) Player of winning team collects trophy

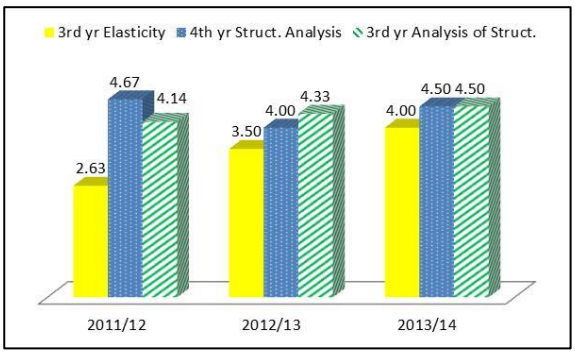
Figure 3. Follow-up of tournament

3. Student Feedback

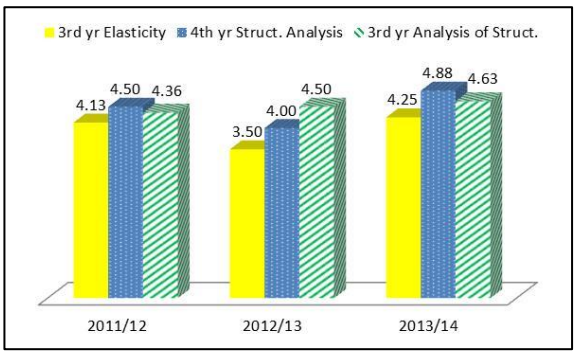
This Section reports on how students feel about the intervention. There are three types of feedback: An online end-of-semester survey, confidential questionnaires before completion of semester and open-ended comments.

3.1. Survey at the end of Semester

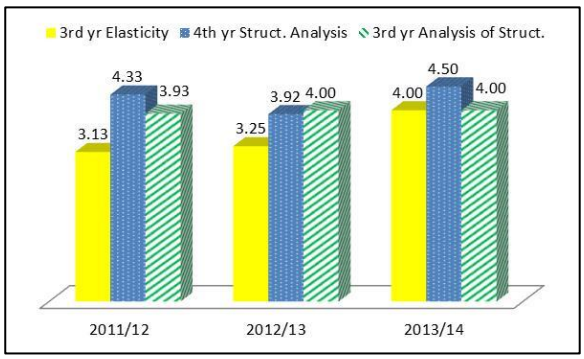
UCD collects information on answers to a survey with core questions on each module that are repeated every year through an online Blackboard VLE. The impact of the TGT intervention in 2013/14 is very obvious when compared to previous years when a traditional tutorial format has been employed (Figures 4(a) to (e)). The values in the figures below correspond to the average obtained from the score assigned by students according to a Likert scale with 5, 4, 3, 2 and 1 being “Strongly Agree”, “Agree”, “Neither agree nor disagree”, “Disagree” and “Strongly Disagree” respectively. Although results are very positive and peak values can clearly be seen in 2013/14, they must be interpreted with caution as only a small percentage of the class typically fills the online feedback (Figure 4(f)) and some do it after the end-of-semester examination which could introduce some bias in the answers.



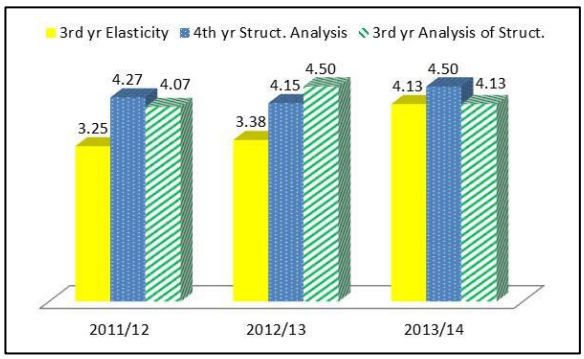
(a) I have a better understanding of the subject after completing this module



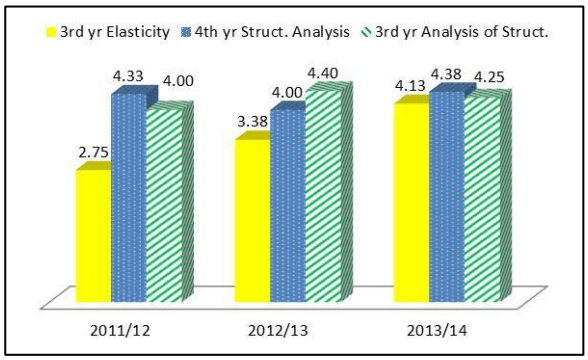
(b) The assessments to date were relevant to the work of the module



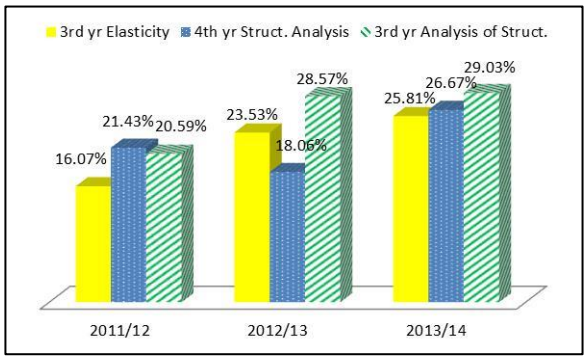
(c) I achieved the learning outcomes for this module



(d) The teaching on this module supported my learning



(e) Overall I am satisfied with this module

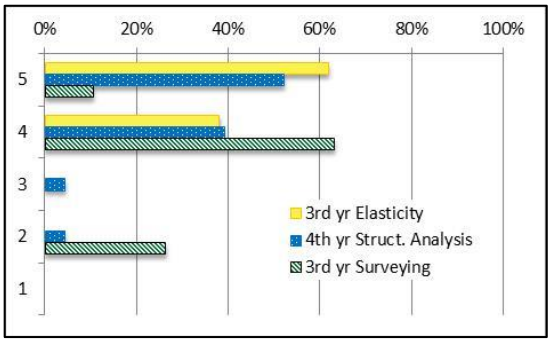


(f) (%) responses from total registered students provided in Table 1

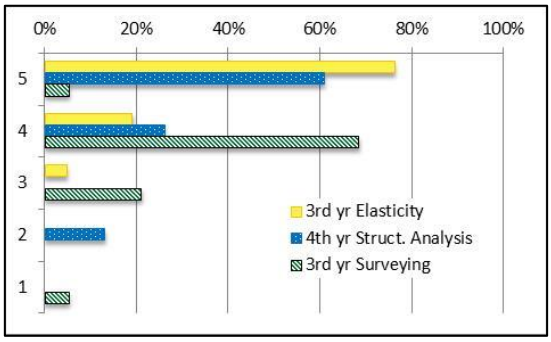
Figure 4. End-of-semester survey

3.2. Confidential Questionnaires during the Semester

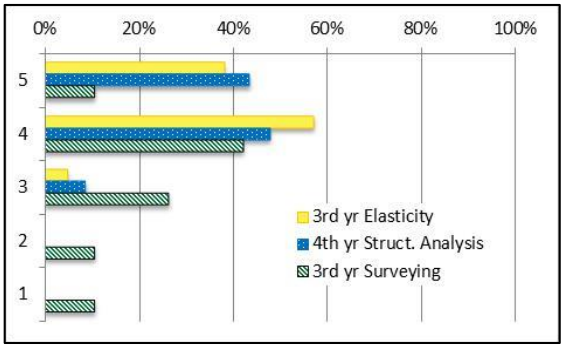
A hard copy confidential questionnaire focused on the fulfilment of the objectives of the intervention is circulated amongst students during lectures once the TGT has started and before the end-of-semester examination takes place. The questionnaire was not distributed to '*Analysis of Structures*' students as most of these students already took the same questionnaire in 'Elasticity'. The level of participation is 67.7 %, 82.1 % and 70.4 % for '*Elasticity*', '*Structural Analysis, Design and Specification*' and '*Surveying*' respectively with respect to the total number of registered students given in Table 1. Student absenteeism and dropout rates are extended problems in Universities [9] [10] that commonly prevent a higher % of responses. Figure 5 shows that positive results are found for all modules under investigation. Again a Likert scale is employed with 5, 4, 3, 2 and 1 corresponding to "Strongly Agree", "Agree", "Neither agree nor disagree", "Disagree" and "Strongly Disagree" respectively.



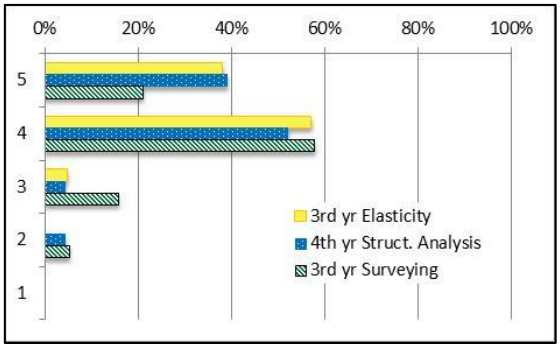
(a) The new tutorial format is efficient in allowing me to practice the material taught in lectures



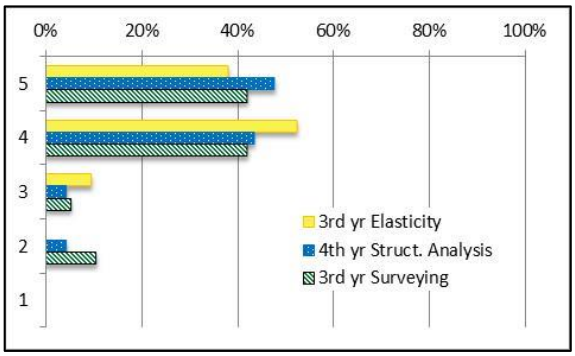
(b) Defining questions and answers and solving other team's questions let me reflect on the topic and makes me aware of what I must revise/reinforce



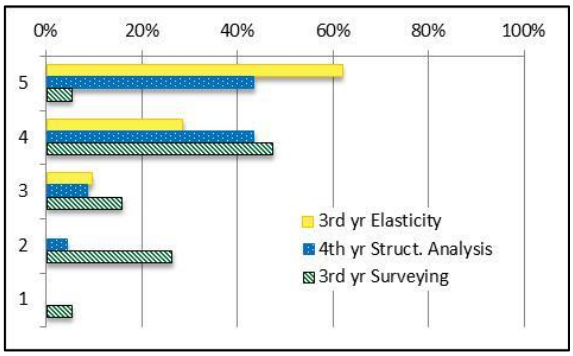
(c) I work harder to improve the score of my team



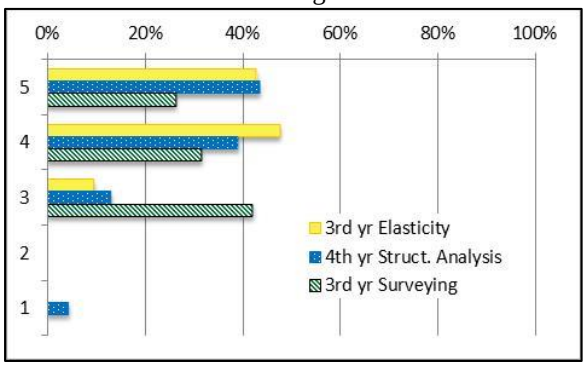
(d) I help my team mates during or for the games



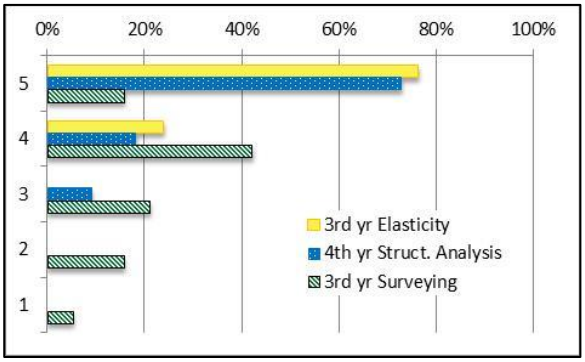
(e) I am provided assistance by my team mates during or for the games



(f) I enjoy participating in the tournament



(g) My links with my peers are being strengthened during the tournament

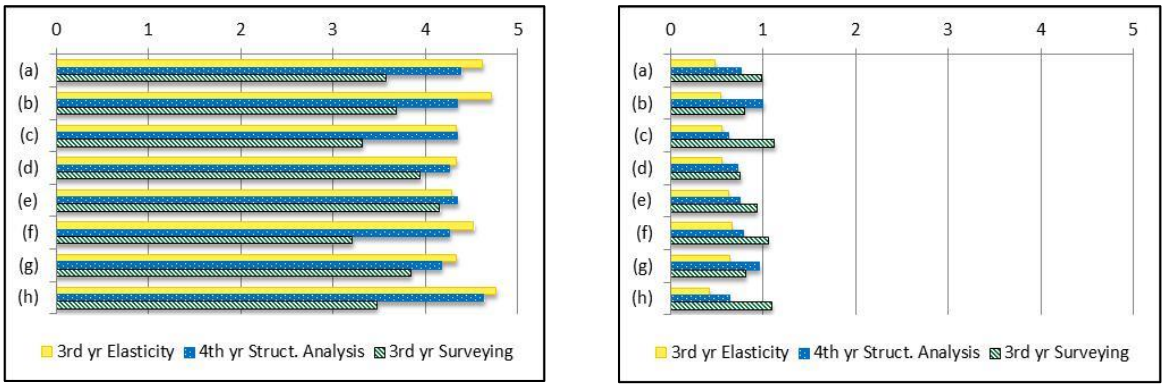


(h) Overall I recommend using this tutorial format in the future

Figure 5. Results from confidential questionnaires

Figure 6 provides the overall statistics (mean and standard deviation) for answers in '*Elasticity*', '*Structural Analysis, Design and Specification*' and '*Surveying*' to questions (a), (b), (c), (d), (e) and (f) defined in Figure 5. It can be seen that mean results for '*Surveying*' are consistently lower than in the other two modules. These

differences between the modules at UCD and the module at UO can be attributed to a lower level of dissemination of the *Champions* in UO and to a human factor. Here, dissemination refers not only to the communication of partial results and overall classification which are periodically updated online in UCD via Blackboard, but also to the large database of questions and answers generated by the students and made available to them via the same platform. Unlike '*Elasticity*' and '*Structural Analysis, Design and Specification*', the lecturer for '*Surveying*' is not the same person as the 'TGT' facilitator, and possibly, the connection between lectures (i.e., including feedback) and TGT has not been established to the same extent. Another possible cause is that a TGT based on '*The Champions League*' may not be as appealing to female students as to male students. Therefore, the proportion of female students in '*Surveying*' (Table 2) is significantly larger than in the other modules. The larger standard deviation in '*Surveying*' is evidence of a more spread variety of opinions about the intervention.



(a) Mean (b) Standard deviation

Figure 6. Overall statistics

3.3. Comments

Some open ended comments from the confidential questionnaires are reproduced literally below:

"*Champions League format of tutorials was fun, engaging and helped learning, lots of examples helped understanding*"

"*Good creative idea that makes tutorials fun*"

"*Champions League was very enjoyable and really helped our learning*"

"*Champions League made me work harder, and made me aware of what I was falling behind on*",

"*The new tutorial style of doing matches was brilliant and made a definite difference to my learning*"

"*I have a keen interest in the Champions League, so the theme was very entertaining. The idea of competing against someone while also being able to work as a team was thrilling. Strongly recommended!*"

"*Very enjoyable + I feel I am learning a lot more*"

"*I love the Champions League*"

4. Impact on End-of-Semester Exams

In the academic season prior to the application of the TGT intervention, the average score in the end-of-semester exam was 39.8%, 49.7%, 52.5% and 36% for 3rd year '*Elasticity*', 3rd year '*Analysis of Structures*', 4th year '*Structural Analysis, Design and Specification*' and 3rd year '*Surveying*' respectively. It must be noted that the pass threshold is set at 40% in UCD and at 50% in UO.

In the three UCD modules under investigation, the end-of-semester exams represent 80 % of the overall grade. The content representing TGT material represents approximately 50 % of the syllabus assessed in the exam. As a result of the intervention, the average exam score increases by 7.9 %, 5.1 % and 4.8 % in '*Elasticity*', '*Analysis of Structures*' and '*Structural Analysis, Design and Specification*' respectively, compared to the previous academic season. The impact of TGT is felt more significantly in the modules that are apparently more difficult to students, i.e., with a lower average exam score.

In the UO '*Surveying*' module, the end-of-semester exam weighs 60 % of the overall grade. However, this exam is theoretical and the practical material tested in TGT is assessed within the remaining 40% allocated to the continuous assessment. Under these circumstances, the effectiveness of TGT cannot be compared to UCD in the same terms. Even so, the positive effects of TGT may be indirectly captured (i.e., students liking and understanding the subject better) in an increase of the average score of the theoretical exam by 4.2 %, and in a

very significant increase of the final module score (combining both exam and continuous assessment) by 35.1 % with respect to the previous season.

5. Authors

Principal Author: Arturo González holds a BE degree in Civil Engineering from the Universidad de Cantabria (Spain), and MSc and PhD degrees from Trinity College Dublin (Ireland). At present he is college lecturer at University College Dublin where he imparts mostly structures-related subjects.

Co-author: Enrique Covián holds BE degree in Agronomical Engineering and a PhD on teaching and learning of Newtonian Physics in Engineering Schools with emphasis on the use of software simulations, from Technical University of Madrid (Spain). He is currently a college lecturer specialised in Geomatic and Surveying techniques at University of Oviedo.

6. Conclusion

This paper has investigated the use of a TGT to improve engineering students' problem-solving abilities, teamwork skills, knowledge and attitudes. A TGT set up as the soccer '*Champions League*' has been introduced as part of the tutorials of four modules. The tournament could have also taken the form of any competition that would be engaging for particular student cohorts. More than 100 engineering undergraduates from multiple backgrounds have been exposed to the intervention. Students have shown to be very focused and participative in matches and no less importantly, to have enjoyed themselves. The success of the tournament in promoting deep thinking and in engaging students has been confirmed by students' feedback and by results in end-of-semester examinations.

7. Acknowledgements

The authors would like to thank Loreto Manríquez for her assistance in the analysis of the samples. Also special thanks to Arturo González Revuelta, for sharing his experience in the Escolapios Secondary School of Zaragoza (Spain) during the 1940's, when students divided into teams would compete against each other by posing questions and answering questions to other teams in a process of elimination until only one team was left. His enthusiasm encouraged us to develop the TGT presented here. Finally, the authors would like to express their gratitude to the University of Oviedo 2014 programme of invited guest lecturers from foreign Universities of international prestige (BOPA 22/III/2013) for their financial support.

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