Open Classroom through an Artificial Intelligence Challenge: an Educational Experience with an International Online Competition

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ABSTRACT

This paper presents a new educational experience developed in the third and fourth year of Computer Science degree at the University of Huelva (Spain). In order to make learning processes more interesting and captivating, a pilot project was incorporated into classical teaching of Artificial Intelligence (AI) subjects. This paper relates how the students changed their classroom sessions during some days for an international competition. As a result, the methodology and work plan followed by the teacher and the students are described. We found that the experience improved student motivation, facilitating the understanding of AI concepts and allowing students to test their skills in an international context. This provided a real life experience in Engineering Education, which could not have been provided by many traditional practical lessons.

Keywords: artificial intelligence; engineering education; online competition; teaching innovation

I. INTRODUCTION

Learning through play is one of the most successful techniques in teaching and learning, even in Engineering Education. Traditional classroom often involves several drawbacks resulting in a decrease of student motivation due to limitations of formal learning. To address this shortcoming, we started a new pilot experience with the goal of improving student performance in two Artificial Intelligence (AI) subjects. In order to validate this basis, we participated in an online competition called *Google AI Challenge* with 17 students from the University of Huelva (UHU) during a semester. We describe the followed methodology and how the students reacted to being involved in an international competition. The experience allowed us to assess the educational experience benefits and estimate the extra efforts required by teacher and students. Finally, we discuss how knowledge, motivation, skills, and workload have been influenced.

This paper is organized as follows. Section II surveys the state-of-the-art of competitions in this area. Section III presents the educational experience background, the *Google AI Challenge* overview, and highlight the educational goals involved. Section IV explains how the students accomplished the work and discusses the results of the methodology. Section V is intended to validate the educational experience so far, evaluation questionnaires and student grades are presented. Finally, this paper contributes the conclusions and discusses new expectations on Engineering Education.

II. RELATED WORK

Artificial Intelligence has challenged researchers for a long time aiming to create autonomous systems capable of taking decisions and adapting flexibly to unknown situations (Pitrat, 1968). Since *Alan Turing* first establish that games could be played automatically using the *Min-Max* algorithm, (Turing, 1950), these have served as a teaching methodology to address different aspects of AI. This turned games into a potential tool to teach a wide variety of practical methods (Moursund, 2007). Some of the examples more used in teaching are classic board games as *Backgammon*, used for exploring by reinforcement learning algorithms (Moursund, 2006); *Checkers*, used to develop search-based problem solving techniques (Sturtevant, 2008); *Tic-Tac-Toe*, used for Min-Max and Alpha-beta pruning (Michulke, 2011); *N-puzzle*, used for state-based search (Markov, 2006); or *n-Queens*, used for constraint problem solving (Letavec, 2002), among others.

Teachers have found, thanks to the competition games, that student motivation and teaching methodologies have been enhanced by challenges proposed within subjects. For example, the *Open Racing Car Simulator* (TORCS) —an open source and highly portable multi-platform framework— has been used as ordinary 3D car game for the teaching of mechanical principles at the Northern Illinois University (Coller, 2009). Also, several *RoboCode* leagues have been organized in the National University of Maynooth

Table 1: Main Features of Challenges Used as Educational Methodology by Some Authors

Challenge	Competition Context	Teaching Level	Game Mode	Educational Goal	Used Methodology	Programming Language	Project Year
FLL	National / Physical	K12 Students	Team Players	Real-world Basics Related to the Sciences	Mechatronic Design & Robot Programming	NXT-G, Robolab	2003
RoboCode League	International / Web Server	University	Multi Player	Language Programming	Intelligent Agents	Java™, C#, VB, .NET	2003
Pac-Man vs Ghost League	International / Web Server	University	Multi Player	Artificial Intelligence	Reinforcement Learning	Java™	2007
MLExAI	Multi-Institutional / Laboratory	University	Single Player	Data Mining, Neural Networks & Machine Learning	Web Recommender & Classification, Pattern Recognition, Data Mining, Games	Java™	2008
TORCS	Laboratory / Client-Server	University	Multi Player	Mechanics	Dynamic Systems & Control	C++	2009
Mario AI Champ.	International / Web Server	University	Single Player	AI Techniques	Reinforcement Learning	Java™ , C++ & Python	2009
Simulated Car Racing	International / Client-Server	University	Team Players	AI Techniques	Intelligent Agents	C++	2009
StarCraft AI Competition	International / Web Server	Professional	Single/ Multi Player	Advanced AI Techniques	Planning, Data Mining, Machine Learning, Case-Based Reasoning	C++	2009
Facebook Hacker Cup	International / Web Server	Professional	Two Players	Identify Top Engineering Talents	Algorithmic-based Problem Statements	Any	2011
Google AI Challenge	International / Web Server	University	Multi Player	AI Techniques	Intelligent Agents	Any	2011
Physical Travelling Salesman	International / Web Server	University	Single Player	Combinatorial Optimization Problems	Intelligent Agents	Java™	2012

with the aim of teaching programming languages (O'Kelly, 2006). In them, students are challenged with the design of intelligent agents —called bots— to compete against other bots trying to mimic human behavior (Eisenstein, 2003). In other cases, competitions help to discover students with great talents and skills from schools of engineering. As an example, the *Facebook Hacker Cup* international competition has been proposed since 2011 for this purpose, which consists in solving a number of algorithmic-based problem statements using any programming language or development environment. Also, Wichita State University has actively used *Lego Mindstorm* for the *First Lego League* (FLL) in many different classes with different objectives. This competition has shown to be a useful teaching tool for elementary and middle school students (Whitman, 2003).

With the aim of using AI systems as testing platforms and promoting research in this field, several national and international contests have been appeared in the recent years. For example, Stanford University revealed the relevance of *AAAI General Game Playing* (GGP) to the goals of AI in a summer competition focused on general game players (Genesereth, 2005). GGP has proven an excellent development framework to create systems capable of learning to play a wide variety of unknown games —without human intervention— based on previously defined rules (Thielscher, 2009); the University of Hartford has developed and tested a suite of projects —called *MLExAI*— that can be closely integrated into an introductory course to teach AI through machine learning (Neller, 2008); the University of Essex started the *Ms Pac-Man vs Ghost League*, an environment to play the famous arcade video game from the 80's. The aim of this competition —previously tested with success on AI courses (Szita, 2007)— is to program the most effective bot —as either Pac-Man or the ghosts— to compete against bots submitted by other competitors. Other recent gaming competitions regularly hold by universities are e.g. the *Physical Travelling Salesman Problem*, a single-player game aimed at solving combinatorial optimization problems with AI controllers (Perez, 2012); the *Simulated Car Racing Championship*, an event comprising three competitions applying computational intelligence techniques on car controllers for a racing game (Loiacono, 2009); the *Mario AI Championship*, a benchmark used in a number of competitions associated with international conferences for research and/or teaching (Karakovskiy, 2012); or the *StarCraft AI Competition*, an advanced strategy game for which AI-based bots have to beat expert human players in real time (Togelius, 2010), among others.

In this context, the *Google AI Challenge* appeared as a bi-annual online contest initially organized in 2009 by the University of Waterloo and sponsored by Google. Every year a game is chosen and contestants submit specialized automated bots to play against other competing bots. The topics of this series of competitions have been *Rock-Paper-Scissors*, *Tron Light-Cycles*, *Planet Wars*, and *Ants*. Although the first edition was based on a widely known game, the following series pursued the design of completely original games. As a result, participants were promoted to explore new approaches, experiment with different ideas and, ultimately, find solutions to their own problems.

III. Development of the Educational Project

Students involved in this experience were doing *Artificial Intelligence Laboratory* (AIL), and *Artificial Intelligence & Knowledge Engineering* (AIKE) subjects; both in the first semester of the 3rd and 4th year of Computer Science degrees at the University of Huelva (UHU). In the first years, students usually showed an excellent motivation. Nevertheless, this interest gradually decreased in the following years. Thereby, we have used mobile robots in the past —year 2008/09— as a means of teaching intelligent agents attractively (Carpio, 2011).

The new pilot experience started in fall 2011 and it gave the teachers the chance to test the experience with different teaching systems; both the old degree and the new one being introduced in the European Higher Education Area (EHEA). In addition, the subject AIL was optional in contrast with the subject AIKE, which was required for students. This different nature has provided an ideal scenario for testing various educational goals addressed with the same experience. To this end, the international competition *Google AI Challenge* was used as a novelty educational methodology. This has provided the teachers valuable information to meet new challenges on AI education.

In order to present the contributions of this teaching innovation project, different features and properties are compared to some of the aforementioned educational experiences (see Table 1). The *Google AI Challenge* is distinguished for being an international contest —played online in multi-player mode— for both university and professional levels. It has been used herein to teach a variety of AI topics, while illustrating new ways of teaching programming methodologies through the implementation of intelligent agents. As a result, the *Google AI Challenge* has contributed to a significant improvement in the work and skills of students while consolidating theoretical concepts (see Section V).

A. Goals and Rules of the Competition

The *Ants* game was used as the basis for the *Google AI Challenge 2011*. The strategy of this game consisted in managing an ant colony in order to fight against other colonies for domination. The game took place on a map where participants initially had one or more anthills. The purpose of an anthill was to generate ants, which should be controlled by each participant bot. Through a turn system —over a total of 1000 in each game— participants must perform the movements they deemed appropriate at a given time. Actions to get points by bots were to explore the map, attack enemy hills, gather food, avoid collisions, and not block own anthills. The game rules stipulated that each participant had to give a token indicating the completion of movements before the turn expires. If the token was not submitted on time, the player received penalty points and was prevented from making movements in the remaining turns. However, this did not imply the disqualification and a player could win the game if got to accumulate enough points (further goals and rules of the *Google AI Challenge* are available at http://aichallenge.org).

B. Developed Methodology

To conduct this project, we extended regular classroom lessons with additional work —performed by teachers and students— and that may not be provided by many traditional lessons. It comprises the possibility of discovering AI techniques with the aim of an international competition. Then, this educational experience is not only understood as a series of practice sessions at lab (see Table 2). On the one hand, AIL subject comprises a total of 120 hours of student work divided into 50 and 70 hours of classroom and non-classroom instruction respectively. The aim of this subject is to introduce AI in a completely practical way by programming AI techniques and algorithms. On the other hand, AIKE subject comprises a total of 290 hours of student work divided into 130 hours and 160 hours of classroom and non-classroom instruction respectively. This subject —of a more advanced level than the previous one— intends to give students greater theoretical and practical knowledge on AI, including other fields such as robotics and computer vision.

In a first introductory session of 1.5 hours (see Table 2) — two months before the end of the competition — the teacher made a brief description of the challenge goals (ID1). Meanwhile, the students learned to use the competition website, activated their user accounts, and sent its first basic entry to the virtual platform of the organizers. During the following preparatory weeks, the teacher explained the workings of the game and the students were guided on the implementation of intelligent agents (ID2-ID4).

Google AI Challenge philosophy allows our students to start writing simple codes for their bots without high programming skills. Students could write their code in different languages such as C++, Python, and Java,

Table 2: Integration of the Educational Experience in the Teaching of Artificial Intelligence Subjects

ID	AIL Program	AIKE Program	Competition Status	Milestone Date	Teacher Work	Student Work	Additional Lab Work
1	Overview of AI	Overview of AI	Competition Starts	25th Oct, 2011	Quickstart Guide	Setting-up User Accounts, Website Overview & First Basic Working Entry	1 Session
2	Genetic Algorithms	Statistics, Uncertainty & Bayesian Networks	-	-	Traditional Classroom	Read Tutorials, Use Tools & Forums	-
3		Machine Learning				Learn New Programming Languages (optional)	-
4		Logic and Planning				Implement Intelligent Agents	-
5	Neural Networks	Markov Decision Processes & Reinforcement Learning	First Phase	18th Dec, 2011	Customize Strategies	Testing & Debugging Own AI Algorithms	1 Weekend
6		Hidden Markov Models & Filters	-	-	Traditional Classroom Work	Share Information Between Students	-
7		Adversarial & Advanced Planning				Upload Bots to On-line Contest	-
8	Fuzzy Logic	Image Processing & Computer Vision	Final Competition	24th Dec, 2011	Bots Competition	Get Final Ranking	-
9		Robotics & Robot Motion Planning	Offline Competition	26th Dec, 2011	Knowledge & Skills	Feedback on AI algorithms & Intelligent Agents	-
10		Natural Language Processing & Information Retrieval	-	9th Jan, 2012	Educational Evaluation	Validation of Student's Opinion & Educational Experience	1 Session

among others —using a starter kit available— and send their controllers to an application program interface (API) built by the competition organizers. Since most of the students had not previously programmed in Python —one of the educational goals intended herein— they were encouraged to learn by themselves some basics of this language using the context of the competition. Although learning a new language was a further commitment, it allowed the students to acquire new knowledge without affecting the performance of their subjects (see Section V).

The first phase of the competition took place during a week (ID5-ID7). For this purpose, a programming marathon was organized by teacher and students at the UHU for a weekend (ID5). The aim was that students in 3rd and 4th year meet in a common place to share ideas about their programs. During this phase, tasks consisted in designing strategies and testing AI algorithms while the teacher followed up their works. The teacher established the premise that information on programs could be shared and each student should implement its own solution. In this phase, the students were able to make changes to their bots and upload new versions to the virtual platform of the competition. However, bots position down to the tail of the classification with each new version and they must acquire new skill points. The waiting time between games was 1-4 hours. At this stage, sharing information between students to learn the techniques used by their class-mates became essential in the progress and quality of the programs. This short period of time was the most productive of all the time spent in programming. As an example, some students worked up to 30 hours from 16:00h on Friday to 06:00h on Monday.

Once the final phase of the competition began, it was not possible upload new versions of bots to the platform competition (ID8). Thus, participants only monitored their matches against other players and waited to know what places their bots took in the final ranking. We want to emphasize that our students improved their algorithms and intelligent agents in the days after the

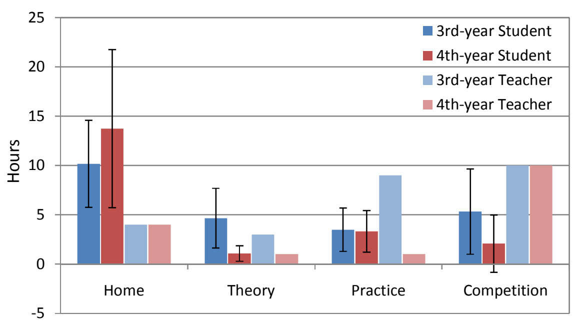

Figure 1: Average hours devoted to the project development depending on the role of the person.

competition as a consequence of the motivation provided by the *Google AI Challenge*. This was possible since the virtual platform of the *Google AI Challenge* was available offline (ID9). Finally, the students were asked in order to ascertain the impact of this educational experience about teaching in engineering (ID10). In summary, the cost of putting into practice this experience required an average time of 24 hours and 20 hours per student —in each subject respectively— and a total time of 22 hours and 32 hours by the teacher respectively (see Fig. 1).

C. Educational Objectives

One of the pedagogical goals intended with this project has been to improve the motivation and interest of our students. In a previous experience, the teachers could realize how promoted the fact of changing —for a few days— the traditional classroom for a robotics competition hall (Carpio, 2011). In the case of the *Google AI Challenge*, new parameters as the lack of having a real space in which develop the competition were added. To our knowledge, the shortage of a physical meeting point not limit the startup of new teaching experiences based on virtual environments. In addition, the *Google AI Challenge* offers no monetary reward to contestants so, unlike other competitions, this is not a factor that conditions student participation.

Furthermore, we found that participating in an international event has been a much more decisive factor. This has allowed our students to measure themselves against students from other universities, many of them prestigious ones. Thus, the students were able to test —without having to move physically to the competition site— the knowledge acquired during their years of study within the context of a challenge. This way, the students discovered through play they could solve challenges in the same way than students from prestigious universities and professionals from around the world. Consequently, their self-esteem is reinforced and it causes positive changes in the perception of their abilities.

Other educational goals intended in this project have been promoting teamwork and information sharing. In previous editions, the participants shared information from the very beginning of the competition facilitating the creation of high quality intelligent agents. However, such spirit was not lived in the *Google AI Challenge 2011* from the beginning. As an example, a post published by *a1k0n* —winner of the *Tron Light-Cycles* edition— called attention to this circumstance (Sloane, 2011). The message sent to the organizer's forum began with the following paragraph:

"I miss the collaborative nature of the Tron contest where everyone basically revealed their strategy in the forum and generated better ideas. Everyone's been much more tight-lipped since then. So I'm going to reveal mine here and now".

The message claimed the collaborative spirit of the competition and determined the beginning of the collaboration between contestants. Thus, our students found that —regardless of the position obtained in the final classification— information sharing and teamwork was essential to carry out the project.

IV. Results of the Competition

This section describes the different methodologies followed by the students to address the competition and analyzes the results obtained.

```
function ChooseStrategy()
  initialize ArraySchedule
  for i=0 to size(ArraySchedule)
    if ArraySchedule[i] == 'h' then
       HunterBotMode()
    else if  ArraySchedule[i] == 'l' then
       LeftyBotMode()
    end if
  end for
end function
```

Figure 2: Example or programming code for intelligent agents

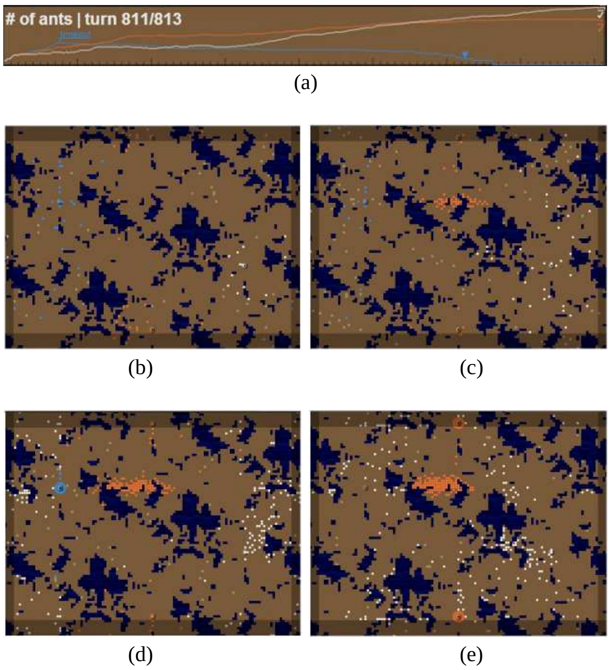

Figure 3: Evolution of the strategies for a 3-player match during 813 turns: (a) evolution of the community of ants, (b) turn 117, (c) turn 370, (d) turn 618, and (e) turn 811.

A. Strategy for the Intelligent Agents

There were no restrictions on the techniques used and any AI algorithm learned in the course was allowed in order to promote the creativity of the students. Thus, students in 3rd and 4th year followed two different methodologies for developing intelligent agents.

As a starting point, students in 3rd year studied some sample bots provided by the organization. After making and testing the first versions, the students found that the best performance was obtained by combining two basic bots —namely *Lefty* and *Hunter*— instead of using an intelligent agent as a single best solution. Thus, the proposed strategy consisted in alternating the two bots in a series of turns, each one with a different behavior. Figure 2 shows the basic structure of the algorithm used in the competition. Variable *ArraySchedule* sets the number of turns for bots, which allowed controlling the bots' strategies to combat with more efficiency. Thus, little variations in the cycles influenced the expansion rate of ants on the map. This methodology of algorithm was used by 90% of our students.

This strategy was also provided as a possible implementation for the students in 4th year. However, these students chose to implement their own bots using AI techniques learned in the subject during the months prior to the competition. The prototype of intelligent agent used by these students mostly consisted in searching techniques based on the A* algorithm —pronounced "A star"— used to compute optimal routes between ants and targets (Cowley, 2012). As an example, Fig. 3 shows a match between three competitors during 813 turns: the teacher (gray color), and two contestants (orange and blue). Different behaviors carried out by the bots can be seen. The sequence shows how the evolution of gray ant colony has greater dispersion than the rest as a result of an exploration strategy for food and enemy anthills. Thus, the students learned that the success of an intelligent agent is determined by a middle commitment among several fitness (i.e. collecting food —brown pixels— and attacking anthills —surrounded by a circle in the figure).

B. Competition Assesment

Games were played on the server of the organizer during the challenge and contestants were able to play them on the website after each round. Thus, our students were able to upload different versions of their programs to test ideas and improve their intelligent agents. In the final phase entries were closed, the classification was restored, and the latest version of each bot played several matches to determine the final classification (Savchuk, 2012). During the competition, user ranking were constantly updated through TrueSkill™ (Herbrich, 2007). This tool represents a Bayesian classification algorithm developed by Microsoft Research, which allowed obtaining a ranking based on the skill of each intelligent agent. Thus, after each game, the system tracked skills by determining the individual abilities of each player regarding the other contestants.

The competition was held by 7897 contestants from 116 countries. Table 3 shows a comparison of the official ranking of the students from UHU regarding the winners of the competition. After observing the ranking we found a relationship between the position of a

Table 3: Comparison of the Final Ranking of the Google AI Challenge 2011

Rank	Username	Role / Level	Language	Versions	Games Played	Skill
1	xathis	2nd year Student	Java™	3	169	90.68
2	GreenTea	Professional	Java™	15	170	89.98
3	protocolocon	Professional	C++	5	171	87.37
472	ignacio	4th year Student	C++	18	171	65.25
1514	alvaroberin	4th year Student	Python	17	55	51.57
1516	darthest	3rd year Student	Python	13	54	51.54
1812	jcarpio	Teacher	Python	41	53	49.06
1873	daniel.al	3rd year Student	Python	26	51	48.62
2076	jesuscaraballo	3rd year Student	Python	8	49	47.26
2079	adrian.silvestre	4th year Student	Python	10	39	47.25
2194	geonosis	3rd year Student	Python	3	43	46.53
2254	jackpanzer	3rd year Student	Python	14	39	46.23
2296	alvaro_Inf	4th year Student	Python	3	38	45.96
2323	pepelidl	3rd year Student	Python	10	38	45.80
2414	amaretolidl	3rd year Student	Python	4	49	45.31
2647	miguel.bras	4th year Student	Python	1	41	43.79
4139	angel.canto	4th year Student	Python	29	17	39.99
4450	carlos.leco	4th year Student	Python	1	19	39.56
5157	albpb2	4th year Student	Python	21	16	38.29
5265	manuel.C89	4th year Student	C++	6	17	38.14
6126	lalvarez	4th year Student	Python	3	13	36.93

contestant and the number of versions implemented for an intelligent agent. The analysis —for a total of 300 persons— led us to discover significant differences between the programming languages used by the contestants and the number of versions (using T-test, $p = 0.147$ for C++ vs Java^{TM}; $p = 0.031$ for C++ vs Python; $p \leq 0$ for Java^{TM} vs Python). In addition, those bots with better skills were programmed by contestants who chose C++/Java^{TM} as programming language (using T-test, $p = 0.716$ for C++ vs Java^{TM}; $p \leq 0$ for C++ vs Python; $p \leq 0$ for Java^{TM} vs Python). As an example, winners' bots were programmed by contestants —namely *xathis*, *GreenTea*, and *protocolocon*— who participated in previous editions of the *Google AI Challenge* (Lichtenberger, 2011), some of them professional programmers (Voronyuk, 2011). On the contrary, the students from UHU —positions 472 to 6126— mostly used Python as preferred development language. This suggests that C++/Java^{TM}, more efficient and robust, are preferred by more experienced users. However Python, easier and faster to implement, is preferred by many other users. Since the final mark obtained by the students in the competition had little impact on their motivation (see Section V), we think Python is an appropriate tool to use the *Google AI Challenge* as teaching methodology to learn artificial intelligence.

Table 4: Evaluation Questionnaire of the Educational Experience

Question	**Knowledge**	**3rd-year Student**	**4th-year Student**
1	Previous level on AI	1.71 ± 0.84	2.00 ± 2.60
2	Final level on AI	3.14 ± 0.67	3.58 ± 0.91
3	The experience enables the consolidation of theoretical concepts on AI	3.57 ± 0.76	3.83 ± 1.35
4	The experience allows new theoretical concepts on AI to be acquired	3.86 ± 0.57	3.92 ± 1.68
5	The experience allows to discover new own ways to solve problems	3.57 ± 0.84	3.83 ± 1.35
6	The experience allows new theoretical concepts on language programming to be acquired	3.86 ± 0.67	3.25 ± 0.91
7	My ability to apply knowledge in practical and real problems after the challenge is positive	3.14 ± 0.84	3.27 ± 1.18
	Interest/Motivation		
8	My general assessment of the subject before the experience is positive	2.86 ± 0.67	3.25 ± 0.87
9	My general assessment of the subject after the experience is positive	4.00 ± 0.84	4.08 ± 2.18
10	The general assessment of my degree before the experience is positive	3.29 ± 0.45	3.42 ± 1.32
11	The general assessment of my degree after the experience is positive	3.71 ± 0.76	3.92 ± 1.08
12	The general assessment of my university after the experience is positive	3.71 ± 0.76	2.83 ± 2.83
13	The general assessment of my university after the experience is positive	3.86 ± 0.84	3.17 ± 1.80
14	My general assessment of the teacher before the experience is positive	4.14 ± 0.84	3.50 ± 0.00
15	My general assessment of the teacher after the experience is positive	4.29 ± 0.76	3.67 ± 1.41
16	The mark obtained in the challenge influences learning on AI	1.43 ± 1.03	2.33 ± 0.58
17	The mark obtained in the challenge influences interest and motivation	2.33 ± 0.42	3.33 ± 1.08
18	Competing in a national context promotes motivation and interest	3.86 ± 0.57	4.42 ± 1.32
19	Competing in a international context promotes motivation and interest	3.71 ± 0.76	4.50 ± 1.50
20	Programming through the play promotes motivation and interest	4.43 ± 0.97	4.42 ± 0.71
	Personal Skills		
21	The need to travel abroad to further my education before the challenge is positive	3.43 ± 0.57	3.75 ± 0.71
22	The need to travel abroad to further my education after the challenge is positive	3.57 ± 0.84	4.08 ± 0.86
23	The value of sharing information before the challenge is positive	3.71 ± 0.84	3.58 ± 1.11
24	The value of sharing information after the challenge is positive	4.29 ± 0.76	3.83 ± 1.00
25	The challenge has served to better understand personal skills	3.43 ± 0.67	3.50 ± 1.80
26	The experience allows knowledge on work organization to be acquired	3.14 ± 0.76	3.08 ± 1.22
27	The experience allows knowledge on cooperation and teamwork to be acquired	3.57 ± 0.45	3.00 ± 0.91
	Human Workload/Difficulty		
28	The difficulty and workload of this practice/experience is high	4.29 ± 1.10	3.33 ± 1.68
29	This practice/experience is feasible for implementation in the university context	3.86 ± 0.84	4.33 ± 1.32
30	The general assessment on development and organization of this practice is positive	3.14 ± 0.67	3.17 ± 1.00
31	My working capacity before the challenge is positive	3.14 ± 0.76	3.58 ± 0.71
32	My working capacity after the challenge is positive	3.57 ± 0.76	3.92 ± 2.18
33	My comprehension before the challenge is positive	3.43 ± 0.57	3.58 ± 1.32
34	My comprehension after the challenge is positive	3.57 ± 0.57	3.92 ± 1.32
35	**My general assessment about this practice/experience is positive**	3.43 ± 1.04	4.00 ± 1.41

V. VALIDATION AS EDUCATIONAL EXPERIENCE

With the aim of addressing innovative teaching and learning methods related to this experience, we have evaluated the students' opinion and their implications for Engineering Education.

A. Evaluation of the Students' Opinion

A comprehensive statistical study has been carried out on two groups of students (see Table 4). All participants were asked —at the end of each experience— to complete a questionnaire based on a five-level Likert scale (1= strongly disagreed, 5= strongly agreed). Four main areas of analysis were covered: acquired knowledge on AI (Q1-Q7), interest/motivation (Q8-Q20), personal skills development (Q21-Q27), and human workload/difficulty (Q28-Q34). With this purpose, a total of 17 students (7 and 10 students for each subject respectively) have been considered. In general, the results show the major differences mainly in the areas of interest/motivation and human workload/difficulty (see Fig. 4).

Regarding the area of acquired knowledge on AI, both groups of students claimed to have greater level after the educational experience (Q1 vs Q2). In this sense, we found a significant increase with respect to the final knowledge on AI acquired by students as shown in Table 5 for Wilcoxon-signed rank test (p = 0.028 and p = 0.002). The students agree that this experience enabled the acquisition of new theoretical concepts, allowing them to discover new ways to solve problems (Q4, Q5). In addition, the students well value learning new theoretical concepts on language programming (Q6). However, the average score is higher for those students belonging to the 3rd course, which is consistent with the fact that students in 4th course are more experienced in this matter.

Regarding the area of interest/motivation, we found a significant increase on the students' opinion about the subjects during the experience (for Q8 vs Q9, p = 0.043 and p = 0.028). This suggests that the contest positively influenced the feeling that students had about the subjects. We discovered that it is also applicable to 4th year students when asked about their degree (for Q10 vs Q11, p = 0.028). From this point, we found that answers from Q12 to Q15 are more positive for 3rd year students. In this sense, 4th year students opine that areas like motivation, interest, and AI learning were less influenced as a consequence of the mark obtained in the challenge (Q16, Q7). We suspect that the reason maybe that 4th year students had higher expectations as a consequence of joining an international contest than 3rd year students (Q18, Q19). However, both groups of students agreed that learning throw play promotes motivation and interest in the same level (Q20).

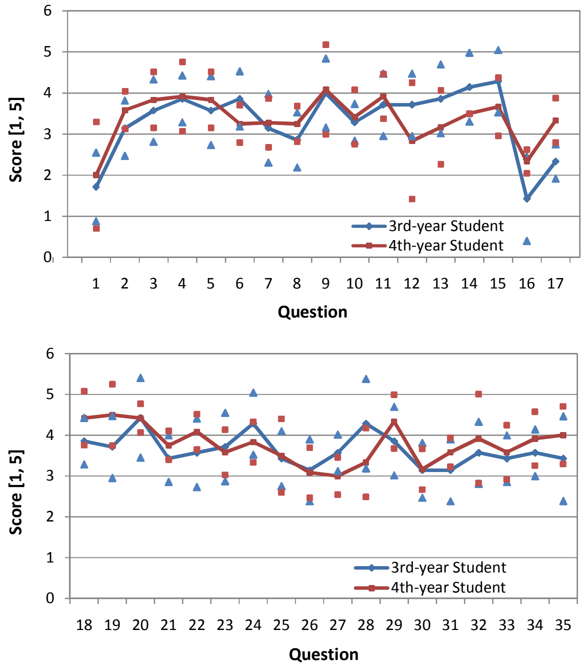

Figure 4: Average score for opinion of students in 3rd and 4th year

Table 5: Wilcoxon Signed-Rank Test for Some Parameters Measured Before and After the Educational Experience

Question	3rd-year Student	4th-year Student
1	p = 0.028	p = 0.002
2		
8	p = 0.043	p = 0.028
9		
10	p = 0.109	p = 0.028
11		
12	p = 0.317	p = 0.068
13		
14	p = 0.593	p = 0.179
15		
21	p = 0.317	p = 0.068
22		
23	p = 0.109	p = 0.109
24		
31	p = 0.109	p = 0.043
32		
33	p = 0.317	p = 0.068
34		

Regarding the area of personal skills development, 4th year students realized —after the challenge— the need to travel abroad to complete their education to a greater extent than 3rd year students (Q22). However, the latter better assessed the need of sharing information after the challenge as a means to share their experiences and provide feedback to their knowledge than 4th year students (Q24).

Regarding the human *workload/difficulty*, 3rd year students felt that the difficulty and workload of the practice was higher compared with 4th year students (Q28). We think this determined that 4th year students rated better the experience as feasible for implementation in the university context (Q29). This suggests that the assessment that students made about the implementation of an educational experience was proportional to the degree of difficulty of the practice. Because it, we only found significant differences about the working capacity development by students in 4th course before and after the challenge (for Q31 vs Q32, $p = 0.043$). Results are validated in Q35, where the general students' opinion about the educational experience was given as fairly positive and satisfying.

B. Evaluation of Academic Results

In order to evaluate the educational impact of this teaching experience, a statistical study of the academic performance over a total of 75 students for three courses has been made. On the one hand, Figure 5a shows a comparison of the average grade of the students (being A = 8-10; B = 7-7.9; C = 6-6.9; D = 5-5.9; and F = 0-4.9). In the case of 3rd year students, it can be seen that the trend of positive ratings remains upward (7.8, 8.0, and 8.1). In the case of 4th year students, the average grade in 2011/12 shows a significant increase regarding the previous courses (5.45, 4.42, and 7.16). By the other hand, Figure 5b shows a comparison of the percentage of students who did not attend examination sessions. In the case of 3rd year students, the percent in 2011/12 is reduced significantly compared to previous years (44.44%, 67%, and 17%). In the case of 4rd year students, the trend during the year 2011/12 remains similar compared to the previous year, and significantly improves compared to the year 2019/10 (56.52%, 33.33%, and 36.4%). These results suggest that it has been possible to successfully incorporate the *Google AI Challenge* in higher education without compromising the educational goals of the involved subjects. This validates the implementation of new educational experiences —by teachers and students— within subjects in order to make them more attractive and improve teaching.

VI. CONCLUSIONS

This paper presents a new teaching experience on Artificial Intelligence (AI) with the aim of improving students´ performance through play. To this end, we introduced the context of an online competition —called *Google AI Challenge*— into normal classroom lessons with two groups of students. In order to evaluate the educational impact, we conducted a statistical study over three academic years. From the academic results,

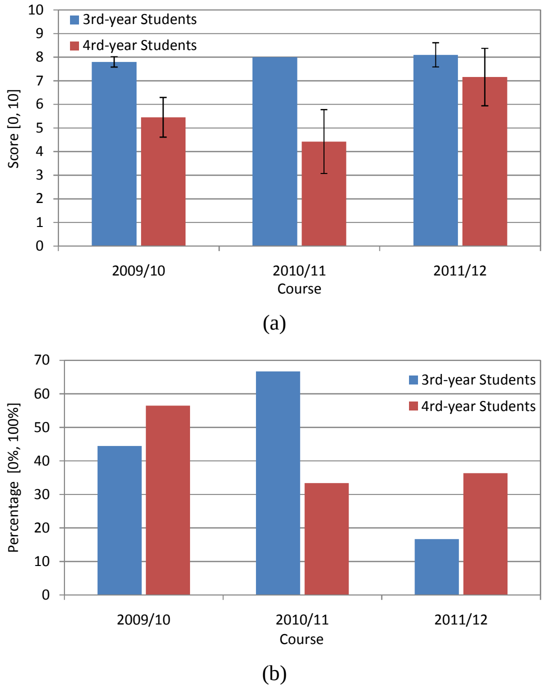

Figure 5: Statistics for students in 3rd and 4th year. Grades (a), and students non attending examination calls (b)

we found that students increased quite rather their average grades after the experience. Moreover, the truancy in exams decreased as a result of the positive feeling that students perceived due to the competition. Despite requiring a minimal extra work by teachers and students, this proves that the successful incorporation of computer competitions is possible without compromising educational goals.

In order to evaluate the educational implications, we present a pedagogical survey emphasizing the importance of working in group to develop a real bot for a real competition. According to the results, we found that participating in the context on an international competition gives students a broader vision on AI subjects, extra motivation, and the possibility to share knowledge with more experienced students from other universities. These benefits validate the proposed methodology with the aim of learning through play and making subjects more attractive to students.

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Nomenclature

AAAI Association for the Advancement of AI

AI Artificial Intelligence
AIKE AI & Knowledge Engineering
AIL Artificial Intelligence Laboratory
API Application Program Interface
EHEA European Higher Education Area
FLL First Lego League
GGP General Game Playing
K12 K through Twelve
UHU University of Huelva
MLExAI Machine Learning Experiences in AI
TORCS Open Racing Car Simulator

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