

TEAMWORK ASSESSMENT IN ORDER TO PROMOTE ENGINEERING STUDENTS' INNOVATIVE ATTITUDE

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Abstract

This paper presents an outline of the evaluation of the active learning taking place in an engineering course¹ in the Universidad de los Andes in Colombia. The course intends to contribute to the development of the innovative attitude of Systems and Computing Engineering and Industrial Engineering students (average age is 20), through the development of competences such as:

- Engineering teamwork
- Effective communication in engineering processes
- Engineering systems design
- Management of engineering projects

Throughout the course the students work in interdisciplinary teams (5 students each). Each team has the following of the teachers (One Computing Engineering professor and one Industrial engineering professor) and one member of the entrepreneurs staff (ICT leaders). Each team should propose and develop an engineering project based on ICT innovation. This course is inspired on the CDIO proposal (Conceive, Design, Implement, Operate), with a particular emphasis in one additional first step: the Observe step. The OCDIO steps (observation, conception, design, implementation and operation) of the project are developed during two academic semesters. At the end of this process, the teams present their project in a fair that's open for the business public and in a contest. The winners of the contest continue the next year with the implementation of the project [1]. So far, 20 groups have participated each semester and there have been 4 winning teams (20 students). We tried to assess the teamwork evolution along the process and its relation with the innovation attitude. In order to achieve this, we've had gathered information from the entrepreneurs, teachers and students who, through observation tools, have allowed us to define indicators related to teamwork. For the analysis we have relied

¹ <http://innovacionconti.uniandes.edu.co/>

on the different evaluation instances (oral presentations, papers, the fair, and the contest), the tools we have designed (surveys), and video recordings of different processes.

Keywords: Active Learning; Innovative Attitude; Engineering Teamwork; Teamwork

Workshop topics

Beyond active learning; Is learning always evaluable?

I INTRODUCTION

The course Innovation Project with ICTs is one of the options that the students of 5th and 6th semester of the Engineering Faculty at Universidad de los Andes have in order to develop innovative engineering projects through teamwork. The course lasts for a year, at the end of which the students' teams may participate in an innovation contest. The winners of the contest may develop their project during the following year, thus these projects may become the starting point of their graduation work.

During the first year, the students undergo through two cycles, each one lasting 14 weeks. In the first cycle (PMC1) the students form workgroups, identify a problem in a specific area (business, health, entertainment, etc.), conceive a engineering solution using information and communication technologies, and design a prototype. In the second cycle (PMC2) the teams rethink their project, improve the design of the prototype, and implement the project. During the 29 weeks the teams, which don't exceed 5 students, are guided by a leader entrepreneur in the IT field and an engineering professors group.

The course intends to develop the students' skills to work in an inter engineering environment, communicate effectively in order to develop engineering projects, and of innovative projects design and management. For this purpose, the course is based in the Observe, Conceive, Design, Implement and Operate (Ocdio) stages, with a special emphasis in the Observe stage.

In order to develop these skills, the Department has undertaken an evaluation process for systematically assessing the contribution of this type of courses in the improvement of the teamwork and the innovative attitude in engineering students.

Next we'll present the actors of the evaluation process, the instruments designed for this process, the results of the 8 student teams that participated in the last year, the analysis, and the resultant conclusions.

II THE ACTORS IN THE EVALUATION PROCESS

The process of evaluation involves the evaluated students and the evaluators, which include the professors, the counseling entrepreneurs, guest entrepreneurs and students peers.

II.1 The evaluated students

The following graph presents a characterization of the evaluated students during the last year of work.

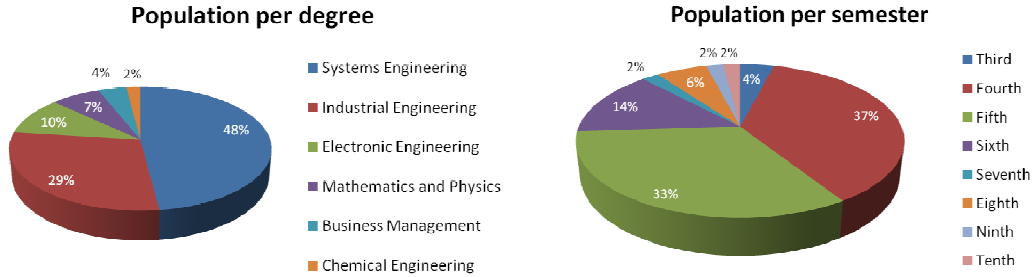


Figure 1

The teams assembled in the last year are:

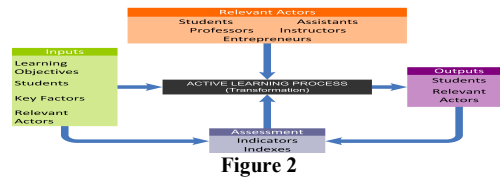
Table 1

| GROUP | PROJECT | WEB SITE | MEMBERS |
|-------------------|--|---|---|
| FOLLOW ME | To generate a new orientation concept in closed spaces through mobile technologies. | http://xue.uniandes.edu.co/~p mc-g11/2009-01-Follow_Me.html | 2 Systems Engineers 2 Industrial Engineers |
| PODER DE LA MENTE | To design a sketch for the reading and interpretation of sound waves as an analogy of brain waves. | http://xue.uniandes.edu.co/~p mc-g10/2009-01-poder_mente.htm | 5 Systems Engineers |
| LLEVAME | To adapt the carpooling concept as a solution for the cities' traffic problems. | http://xue.uniandes.edu.co/~p mc-g12/ | 3 Systems Engineers 1 Physicist |
| SIPOTI | To improve the companies interactivity with its clients in an innovative way. For this purpose, a mobile device captures the companies' logo and sends it to the SIPOTI servers. | http://xue.uniandes.edu.co/~p mc-g14/sipoti.html | 5 Systems Engineers 1 Industrial Engineer |
| SIRT | To provide centralized and updated real time information on routes and ETAs of public transportation buses. | http://xue.uniandes.edu.co/~p mc-g15/ | 1 Systems Engineers 2 Industrial Engineers 3 Electronic Engineers 1 Electric Engineers |
| MEDICASO FT | To propose the use of Internet as a communication channel for making medical appointments from any location without the inconvenience of phone calls or other factors that may delay this process. | http://xue.uniandes.edu.co/~p mc-g13/ | 3 Systems Engineers 1 Mathematician |
| SDC | To provide a service that informs its users quickly and efficiently about emergencies happening in the city which they find relevant. | http://xue.uniandes.edu.co/~p mc-g16/2009-01-SDC.html | 3 Systems Engineers 1 Mechanical Engineer 1 Industrial Engineer 1 Electronic Engineer |
| VRD | This project deals with the issue of the training for acquiring the driver license. Implementation of a virtual simulator. | http://xue.uniandes.edu.co/~p mc-g17/2009-01-vrd.html | 3 Systems Engineers 3 Electronic Engineers |

II.2 The evaluators

The evaluating team consists of two professors (a systems and computer engineer and an industrial engineer), 10 Colombian entrepreneurs (from companies such as HP, Unisys, Inalambria High Value Consulting Colombia, among others) and the students themselves.

III THE EVALUATION PROCESS



This investigation project intends to develop an entire evaluation process that incorporates the variables that will be presented soon. It is important to include in this process the perceptions of actors such as students, professors and entrepreneurs. The following is the initial stage of the evaluation process. In the future, a model that includes performance indicators and indexes shall be developed.

III.1 The instruments of the evaluation process

In order to evaluate the different competences that the course seeks to reinforce during the 29 weeks of work (1 academic year), the following activities take place. The activities highlighted in the table above have a particular emphasis in the development of teamwork and its relation with innovative attitude. In bold words corresponding activities there is a particular emphasis in the oCDIO stages as shown below.

Table 2

| DATE | ACTIVITY | INSTRUMENT | EVALUATORS |
|---|---|--------------------------------|------------------------------|
| Week 1 | Innovation with IT Seminar: <i>A means for generating value in the society.</i> | Exercise 1 | Professors |
| Week 1 | Socialization of the results from the research exercise. | Exercise 2 | Professors |
| Week 4 Problem Observation -Initial (ocdio) conception of the idea (ocdio) | Presentation session 1 | First entrepreneurs evaluation | Entrepreneurs and professors |
| Week 6 | Article reviewing by peers session | Article reviewing by peers | Students |
| Week 9 -Prototype Conception and Design (ocdio) | Presentation session 2 | Professors evaluation | Professors |

| DATE | ACTIVITY | INSTRUMENT | EVALUATORS |
|--|--|---|--|
| Week 13 -Prototype Design(ocdio) | SHOWCASE: INNOVATION WITH INFORMATICS TECHNOLOGY | Showcase evaluation format | Entrepreneurs, professors and students |
| Week 14 | Groups and projects reorganization workshop | Exercise N° 1 | Students |
| Week 18 -Problem observation and advancement in the design of the prototype (ocdio) | Presentation session 1 | Presentation session 1 – Grading format | Entrepreneurs and professors |
| Week 19 | Article reviewing by peers session | Article evaluation format 1 | Students |
| Week 20 | Projects technical evaluation workshop | Prototype evaluation | Students and the activity coordinator (William in this case) |
| Week 20 -Problem observation and advancement in the design of the prototype (ocdio) | Presentation session 2 | Presentation session 2 – Grading format | Professors |
| Week 23 | Article reviewing by peers session | Article evaluation format 2 | Students |
| Week 24 | Workshop for the development of the web site | The project's web template | Activity coordinator (William in this case) |
| Week 27 -Prototype Implementation (ocdio) | Pre-showcase Presentation | Pre-showcase evaluation criteria | Students |
| Week 28 -Prototype preliminary operation (ocdio) | INNOVATION WITH INFORMATICS TECHNOLOGY SHOWCASE | Entrepreneurs showcase evaluation criteria Students showcase evaluation criteria | Entrepreneurs, professors and students |
| Week 29 Self-observation of the learning process | Process Self Evaluation | | |

IV THE EVALUATION PROCESS RESULTS

Next, we display the criteria for the evaluation of the evolution of the teamwork and its impact in the innovative attitudes for each of the previously mentioned activities. The evaluation criteria in all the 29 week are:

Table 4

| | |
|--|---|
| <p>1. How would you grade the quality of the presentation's support material?</p> | <p>4. Research skills: Target market, project context, analysis/identification and definition of the user's requirements.</p> |
| <p>2. How would you grade the presentation skills of the group? (Are they clear and concise, show an adequate understanding of the problem)</p> | <p>5. Application of the Concepts/ Engineering Methodologies: In your opinion, does the group present concepts and/or engineering methodologies that could be useful in the development of the proposal?</p> |
| <p>3. Clear identification of the problem: Does the group have a proper knowledge of the problem and its context?</p> | <p>6. Innovation: Does the group have differentiating characteristics that set them apart from current products/services?</p> |

Week 4: First entrepreneurs evaluation (Entrepreneurs and professors). Evaluation results:

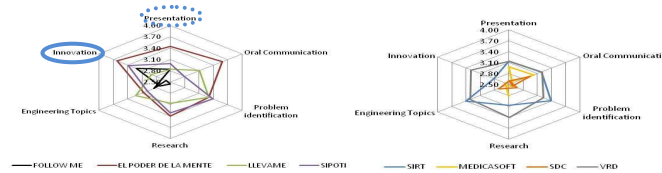


Figure 3

Week 9: Professors evaluation (Professors). Evaluation results:

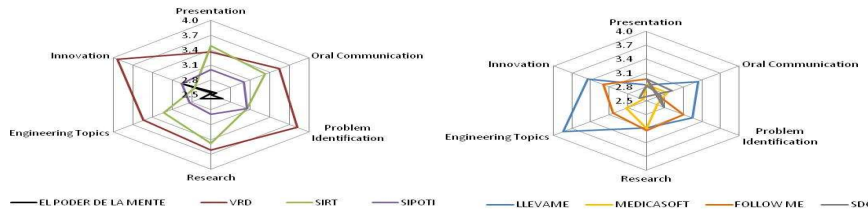
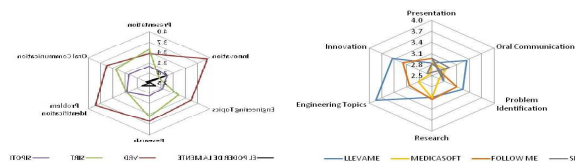


Figure 4

Week 9: Professors evaluation (Entrepreneurs, Professors and Students)- Evaluation results:



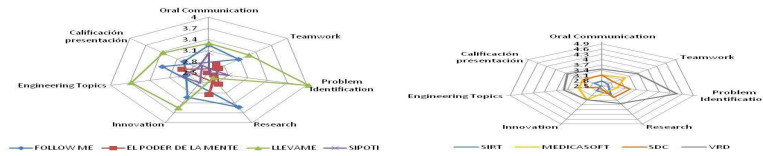
Graph 4

Week 13: Showcase: Innovation with informatics Technology (Entrepreneurs, professors and students)- Evaluation Results:



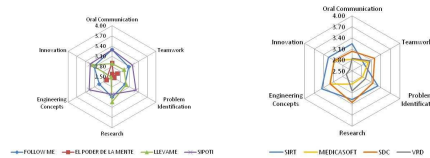
Graph 5

Week 18: Presentation Session 1 (Entrepreneurs and professors)- Evaluation Results



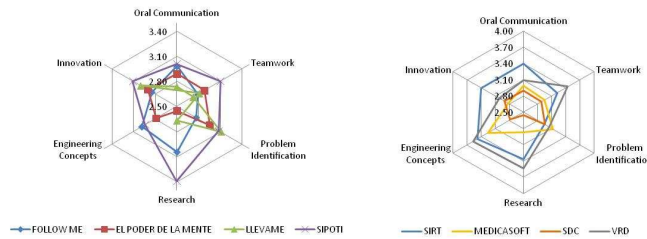
Graph 6

Week 20: Presentation Session 2 (Professors)- Evaluation results:



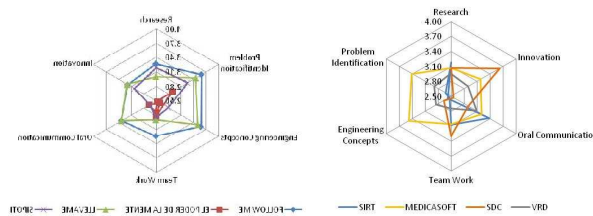
Graph 7

Week 27: Pre- showcase presentation (Students)- Evaluation Results:



Graph 8

Week 28: Informatics Technology showcase- Evaluation Results:



Graph 9

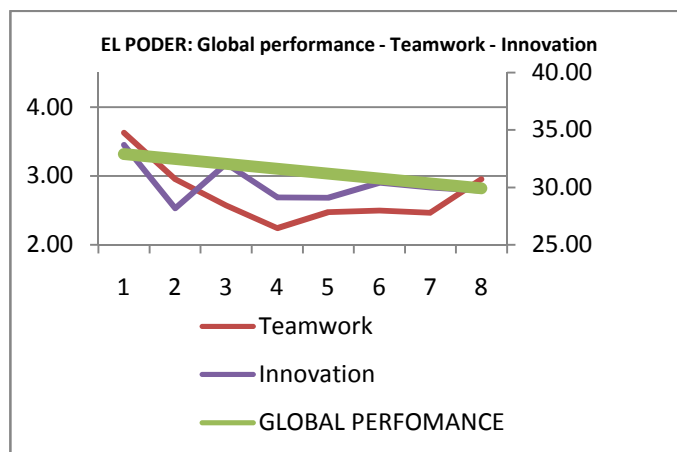
5. ANALYSIS RESULTS

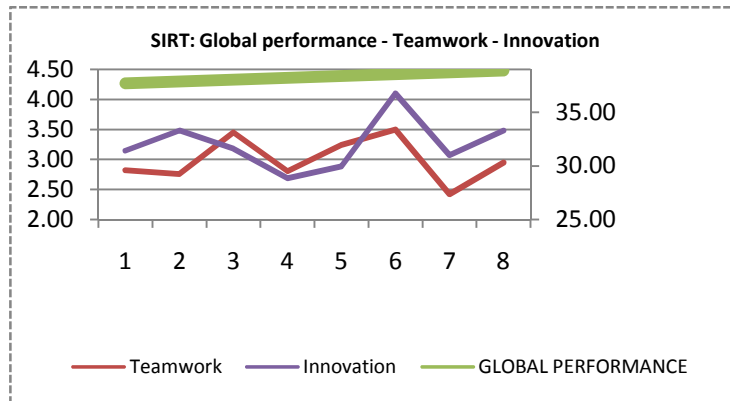
The analysis incorporated thoroughly all the variables measured in the 8 different stages wherein teamwork and innovation were evaluated. Even though in each stage the evaluators were different (a weakness of the process), the data analysis methodology intends to observe the evolution of the work teams. The used methodology was i) To Normalize the data for each stage; ii) To Observe and analyze such data for each group in a relative non absolute way and iii) To Observe and analyze the area of the that constitutes the relative performance of a pair of groups at each stage. Table 5 shows the results of two groups that, according to the team, had notorious differences between themselves. Highlighted in green are the evaluations related to innovation for each stage and in yellow the ones related to teamwork. In bold (last column) are the areas of the polygons formed by the following criteria: innovation, teamwork, research capacity, oral communication, problem identification capacity.

Table 5

| Momento | SIRT | | | | | | | | Área | EL PODER | | | | | | | | Área |
|---------|--------|-------|------|------|------|------|------|--------------|------|----------|------|------|------|------|------|--------------|--|------|
| | a | b | c | d | e | f | a | a | | b | c | d | e | f | a | | | |
| 1 | 3.14 | 3.19 | 3.38 | 3.06 | 3.40 | 2.82 | 3.14 | 37.55 | 3.45 | 3.59 | 3.30 | 3.40 | 3.06 | 3.62 | 3.45 | 40.38 | | |
| 2 | 3.4794 | 3.333 | 3.05 | 3.48 | 3.23 | 2.75 | 3.48 | 38.20 | 2.5 | 2.33 | 2.67 | 2.51 | 2.43 | 2.95 | 2.53 | 30.48 | | |
| 3 | 3.6425 | 3.177 | 2.95 | 3.49 | 3.65 | 3.45 | 3.64 | 40.24 | 1.4 | 3.18 | 2.93 | 1.77 | 1.75 | 2.57 | 1.40 | 26.88 | | |
| 4 | 2.7793 | 2.688 | 2.68 | 3.03 | 2.81 | 2.52 | 2.78 | 32.63 | 1.9 | 2.69 | 2.09 | 2.84 | 2.24 | 2.52 | 1.91 | 28.25 | | |
| 5 | 3.2425 | 2.886 | 3.31 | 3.27 | 3.46 | 3.24 | 3.24 | 38.37 | 2.6 | 2.68 | 2.57 | 2.1 | 2.7 | 2.48 | 2.58 | 29.84 | | |
| 6 | 4.1 | 4 | 4.2 | 3.6 | 4 | 3.5 | 4.10 | 46.24 | 2.9 | 2.9 | 2.9 | 3 | 2.6 | 2.5 | 2.90 | 33.20 | | |
| 7 | 3.1861 | 2.419 | 3.38 | 3.07 | 2.54 | 2.63 | 3.19 | 34.05 | 2.25 | 2.47 | 2.10 | 2.83 | 2.59 | 2.33 | 2.25 | 28.80 | | |
| 8 | 3.4016 | 3.222 | 2.95 | 3.37 | 3.48 | 3.4 | 3.40 | 39.16 | 2.9 | 2.88 | 2.95 | 2.55 | 2.78 | 2.9 | 2.89 | 33.54 | | |

For the SIRT group, the relative area for the 8 stages tends to grow as time goes by. For the Poder de la Mente group, the relative area for the 8 stages tends to reduce. SIRT shows a higher average of the 8 stages in innovation and teamwork (inn=3,25; t/work=3) than Poder de la Mente (inn=2,88; t/work=2,72). It can be seen that the evaluations related to teamwork and innovation are highly correlated between them, and also with the global area of evaluation of the polygon formed by the 6 criteria of interest.





6. CONCLUSIONS

The process of evaluation of a course such as this includes the design of tools that allow a systematic measurement of the performance related to all the criteria of active learning in engineering, such as: innovation, teamwork, research capacity, oral communication and problem identification capacity. Each of the instruments designed sought to measure the groups' performance in each of the phases defined as Observe, Conceive, Design, Implement, and Operate during the development of the project (8 stages in 28 weeks).

For this process different evaluators were included (entrepreneurs, professors and student peers –even though the latter were not evident in the paper-). The fact that the evaluators vary from week to week imposes certain restrictions on the model. Similarly, due to the differences in the conceptualization of the different criteria, the comparison is only possible after the normalization of the data obtained in the 8 stages.

The performance of each group, in each moment and globally in terms of the 6 selected criteria, evidences the evolution of the groups in the active learning process. For this purpose, the indicators are the increase or decrease of the areas of the polygons formed by the selected criteria. What's interesting of this evaluation process is how the preliminary evolution of the criteria can be appreciated, whether it is globally or each criterion individually. For example, for the two selected group, the teamwork performance is associated to the innovation performance; likewise, the performance of both groups in these two criteria is related with all the other selected criteria.

Even though, this is an initial pilot test to measure teamwork and innovation, the objective in the future is that the entrepreneurs and professors evaluating team can replicate this evaluating methodology, not only with the new groups, but also with those who continue with their TIC innovation project through 28 more weeks.

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