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Gamestorming for the Conceptual Design of Products and Processes in the context of Engineering Education

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Abstract

Creating an ideal environment to develop creativity and innovation in engineering education is a real challenge. One alternative approach can be based in the application of Gamestorming methodology that considers the use of games in the process of brainstorming. Presenting the problem in a game format eludes the conventional lecturing and frees the participants to think creatively to solve problems. In this contribution, the adaptation of the Gamestorming methodology was applied in different Bachelor and Master courses of Chemical Engineering and Environmental Engineering in the University of Santiago de Compostela (Spain). The aim of this initiative was to develop students' creativity and teamwork, where the class divided in working groups propose and assess alternatives in the Conceptual Design of Products and Processes. Specifically, two examples of the application of the methodology are provided: (i) a wood box for wine storage was remodeled according to a number of requisites: functionality, savings of energy consumption and reduction of environmental impact; (ii) the conceptual design of a treatment system for the removal of pollutants present in a gaseous stream to accomplish the targets of wide applicability and efficiency as well as reduced cost and environmental impact. A total of 129 students from 4 different academic years participated and the survey performed after completing the activity rated this methodology as a mechanism to foster their creativity in the progress of teamwork toward decision making process.

Keywords

1. Skills to be developed under the Gamestorming approach

Engineering education must strengthen students’ capabilities in the decision making process in the design and operation of engineering processes, offer more and better instruction in oral and written communication, and provide training in teamwork skills, critical thinking and problem-solving methods (Shook and Kinckrehm, 2017). After the completion of the studies, students must have acquired the so-called business or employability skills (Fletcher et al. 2016; Grant and Dickson, 2006). Therefore, the curriculum of engineering students must include activities that enhance their initiative and versatility and, in this context, the different courses should address simple strategies and practices that allow the development of transversal competencies.

Creating an ideal environment to develop creativity and innovation in engineering teaching is a real challenge. Beyond the traditional lecturing approach for the presentation of principles and concepts, critical thinking must be fostered through specifically designed methodologies. This goal is very important in Product-service systems, motivated to fulfill customers' needs, considered as good strategies to face today's competitive business environment (Vasantha et al., 2012). There are different strategies based on the classic methodology of brainstorming that aim to standardize this process of creation. The Design Thinking process developed by Stanford University is one of the most developed options (Plattner et al., 2011).

The term gamestorming is linked to the process of brainstorming under the perspective of games (Gray et al., 2010). Introducing game dynamics in the teaching practice is nothing new, but many times we find cases of failure where the sessions of "games" are not productive and these dynamics are discarded because the participants have the feeling that it is a loss of time.

Gamestorming applies the theory of games to develop the potential of students in the field of creativity and other general skills. The development of the teaching process starts with the creation of teams, where all participants in a team are aligned towards a goal, everyone
understand what they are doing and their way of working as a team is active and dynamic. They solve problems through games and interactive discussion, avoiding the use of presentations where a single voice monopolizes the presentation of results. This teaching activity also provides information about the skills developed by the students from previous courses but it aims to foster creativity and critical analysis (Bruning et al., 1999). The concepts of teamwork (particularly how to promote creative participation and interaction with fellow group members), critical analysis, time management, and communication skills are also competences to be acquired. Although its application can consider different learning environments, few references are available on the concept of Gamestorming such as its application in a workshop on Data Mining using vision sensors (Kushiro et al., 2017) or the conceptual design of industrial product-service systems (Meuris et al., 2013).

2. Gamestorming methodology

The gamestorming methodology starts with the division of the class into groups of three or four. It is essential that at the beginning of every session all participants of the gamestorming session should be aware of the preliminary statements and principles and the final goal to accomplish. The participation of the different members of the group will also integrate methods of cooperative learning, as one of the most commonly used instructional method used for team work (Johnson et al., 1999; Millis and Cottell, 1998).

There are three main stages in the process: opening, exploration and closure (Gray et al., 2010). The opening consists of bringing together in the same workspace different interest groups to let ideas come up and information flow. In this stage, the different groups should generate as many examples as they can think of in a brief period of time in a brainstorming process, considered as explosion of ideas and opportunities when all ideas are written down. The more ideas generated in this phase, the more efficient the work will be in the next phase. The teacher should give the
groups a fixed allotted time (it can be slightly increased depending on the group dynamics), afterwards, it is time to collect ideas and list them without criticism.

During the exploration phase, participants seek to sift through the ideas described in the opening, so that unexpected and surprising elements emerge. Yang (2009) found statistically significant correlations between the quantity of brainstormed ideas and the design outcomes. At this stage, patterns and analogies should be investigated, initial premises and problems must be evaluated in a different way so ideas can be built and tested. In addition to contributing their own ideas, participants can suggest improvements in others’ ideas, which can be as a stimulus for improvement. Sometimes, changing just one aspect of an impractical solution can make it a great solution.

Closure is the last step that allows us to move towards conclusions and actions from a more critical and realistic point of view, channeling the energy of the organization towards the most promising elements. It is the time to conclude, to make decisions, to define the actions to be carried out, to converge to the final solution. These three stages constitute the basic structure of a session of gamestorming, that can be used sequentially, making that the conclusion of a session of gamestorming is the initial condition of the following one.

This methodology has been implemented in three courses at the University of Santiago de Compostela (Spain): Project Design in the Bachelor of Chemical Engineering and two courses in the Masters in Chemical Engineering and Environmental Engineering: Life Cycle Assessment & Ecological design of products and processes. To be admitted for enrollment in the different courses, the students must have completed a number of basic fundamental topics such as material and energy balances, process analysis and unit operations. Lectures and group problems are also teaching activities developed in the three courses. In the course of Project Design, lectures are dedicated to specific topics on conceptual design of design projects, including mass and energy
balances, but also equipment dimensioning, engineering ethics, financial planning and market study. Students can complete an in-class problem at the end of every lecture to immediately apply the concepts learned. The problems are primarily completed in teams that will also work together in the gamestorming activity. Regarding the Master courses, the fundamentals of Life Cycle & Ecodesign will be presented in a number of examples. Now, it follows a description of the methodological approach, including the analysis of student perception, based on four years of experience.

Among the different games, we selected an opening game named as "The Publication" (Staker, 1997), where from a simple element such as adhesive notes, a set of ideas are obtained, classified and reorganized as function of the objectives sought. There are a number of requisites to be predefined: Common space (the classroom), Time restriction (to be defined in the different stages of the process, a maximum period of 2 h is recommended for the whole session) and Material (internet access, laptops and ordinary classroom materials: papers, colored markers and post-it®).

In this framework, this type of activity can be afforded within the context of a regular class. Additionally, a number of informal rules are recommended to define the dynamics of the whole session to accomplish the different stages: One conversation at a time, Stay focused on the task, Encourage wild ideas, Go for quantity, Be visual, Defer judgment and Build on the ideas of others (Kelley and Littman, 2001).

2.1. Statement of the problem (up to 10 min)

The teacher defines the problem to be solved, establishing the characteristics of the product/process and the targets for improvement: efficiency, yield, environmental impact, etc. (Figure 1). Regardless we focus on product development or process design, the system is subdivided into its main characteristic subsystems and on which the different improvement strategies will be proposed.
With this methodology, the teacher changes the role as lecturer role by a supervisor role, with the objectives of managing the evolution of the learning process and guaranteeing that the interactions among students and students-instructor are productive. It is very important that all team members participate in the development of the bullet points as the proof of the potentiality of the team work.

When designing a session of gamestorming, a balance between creativity, reflection and decision making must be established. There is no standard protocol and depending on the work team, the instructor will have to define the session ad-hoc, handling the group features under the framework of gamestorming. Each team is a world, there are working groups that flow very fast and others that need more time for reflection.

>Figure 1<

### 2.2. Brainstorming (30-45 min)

Brainstorming is a tool for creative problem solving, wherein a group of people come together to contribute ideas spontaneously. It is particularly useful when one wants to break out of out-of-date patterns of thinking, so that new ways of looking at things are developed. When an interdisciplinary team aims to accomplish the same goal under diverse perspectives, the acceptance of the final solution is easier to achieve (Kelley and Littman, 2001).

The definition and presentation of ideas will be placed in a mural in the class. The steps to follow are:

a. Each student should write in a post-it® an idea about each stage/section after a reflection (in silence) of 5 min

b. The ideas are published, which gives name to the game: The Publication

c. The same procedure is repeated for each of the stages or sections in which the product or process is subdivided.
2.3. Classification of ideas (30-45 min)

The classification of the viability of the ideas presented in each stage is performed as follows (Figure 2):

a. Characterization of each of the ideas according to their technological and economic viability with the following grading:
   i. Viable in the short term: VI+
   ii. Viable: VI
   iii. Unviable: IV

b. Grouping of the proposed options with the label "VI +" in a forcefield analysis as a way to visualize the driving force ideas or general lines of action.

At this stage the pros and cons of the VI+ options will be compiled to develop strategies to reduce the restraining forces and strengthen the driving forces.

>Figure 2<

2.4. Decision making (25-30 min)

The driving force ideas of each of the stages or sections for its implementation in a new prototype or process strategy will be integrated. The class acts here as a single team with a common goal: to obtain the best product or process possible.

3.- Case study I: Product Development

This case study was developed in the courses of Life Cycle Assessment (elective) and Ecological design of products and processes (compulsory), subjects from the Master in Chemical Engineering and Bioprocesses and the Master in Environmental Engineering.
3.1. Statement of the problem

The product selected for improvement consisted of a wooden box for wine bottles, and the principles of the final "product" should accomplish the minimization of energy consumption and, therefore, the reduction of the carbon footprint. The stages of the life cycle to act were: concept, materials, production, distribution and end of life.

3.2. Brainstorming

The class participated actively, assuming the role of "designer", with the proposal of large number of ideas: an average value of 150 ideas for a classroom of 25-30 students. It is very important that in this phase there is no break in the process not to limit creativity. Later on, there will be time to evaluate the scope and feasibility of each proposal.

3.3. Classification of ideas

For one of the stages of the life cycle, the teacher guided through the characterization of the options and later definition of the driving force ideas. Thereafter, the class was divided into several groups that performed the activity for the remaining stages of product life cycle (Figure 3), the results were presented to the class. During the process, several ideas whose approach was more appropriate for some other stages were reassigned. A selection of the driving force ideas for each stage of the life cycle are shown in Table I. For example, in the concept stage, one of the ideas force was to develop new uses for the wooden box under the perspective of multi-functionality. Beyond the initial use of transporting bottles from the supermarket to the households and storage, the common impression among students was that a high quality product is used for a short-term single use, and it could have other applications after the initial use.

>Figure 3<

>Table I<
The proposed new "uses" to extend the life cycle of the product were developed from two perspectives:

a) Oriented to the implication of the consumer. Use the product as storage box of common materials in the home: sewing elements, tools, games, etc.

b) Oriented to take actions by the seller/retailer. The proposal of option (a) has a limit of reuse of the boxes by each individual consumer; so, in the medium term, the surplus number of boxes would turn into a waste. Therefore, it is necessary to consider options that assume the availability of the boxes in large quantity. The proposals were characterized by the use of the box as raw material for the manufacture of furniture (shelves) or use it directly as shelter of animals in nature due to its biodegradable features.

3.4. Decision making

A priority was given to the various options for improvement, resulting in new products where the proposed prototypes should maintain the following guidelines:

(i) To develop multi-functionality, using the function of basic storage for chess pieces, socks, underwear, etc. or others such as a pot for home-grown agriculture or as an anthill.

(ii) Single material. Use the wood of a single tree species as the only constructive element (main body, cover and joints), which facilitates their final recycling.

(iii) Renewable. The concept of the "total" renewable product is pursued, by making use of only renewable material (wood) and renewable energy (the company should choose to install wind and solar energy systems in its facilities).

In all cases, the final ideas were compared with the prototypes that an eco-design team carried out for a timber enterprise (González-García et al., 2011), so that students can compare their proposal and evaluate them under the light of the real prototype (Figure 4).
4.- Case study II: Process Design

This case study was developed in one course of the Bachelor in Chemical Engineering (Project Design as mandatory subject).

4.1. Statement of the problem

Conventional end-of-the-pipe technologies for air pollution control are based on the transfer of pollutants from the gas stream to a solid or liquid phase through adsorption or absorption processes, followed by a chemical or biological oxidation of the target compounds (Estrada et al., 2011; Schlegelmilch et al., 2005). The challenge is the consideration of reliable alternatives for the mitigation of odour nuisance associated to the presence of certain pollutants.

4.2. Brainstorming

The students performed the evaluation of a range of technologies, specifically designed and applicable for the treatment of pollutants present in gaseous streams. For this purpose, the concepts developed in previous courses on mass and energy balances and unit operations would be the basis for the calculations for equipment sizing. In this case, the representation of the idea in the post-it® was modified to include a brief summary and description of the process. The proposed alternatives were the following: chemical scrubber, incineration, adsorption system with artificial (ie activated carbon) or natural packing support (ie tree bark), biofilter and biotrickling filter (Figure 5).

4.3. Classification of ideas

When assessing and determining the potential viability of the different strategies, the analysis mural was divided in 4 quadrants according to the following targets: application, efficiency, cost
and operational requirements (Table II). The valuation of each technology was qualitatively performed according to a traffic-lights code.

>Table II<

4.4. Decision making

In this phase, the students investigated the technology that would allow guaranteeing the achievement of all the criteria defined in the previous stage. Assuming that there is no single technology that satisfies all the restrictions imposed, a first line of discussion was focused on the prioritization of the criteria and, therefore, skipping some requirements for the sake of practicality. In this way, they were able to proceed with the process design. A second line of discussion (which might be encouraged by the teacher, but not always necessary) is established when considering the possible integration of alternatives. In this stage, the advantages and disadvantages of each technology are confronted to select a process that accomplishes a balance of the requirements (Alfonsin et al., 2015).

The final choice depends on each class and the creativity in the combination of process units. Normally, they opt for a combination of biotechnological processes and physical-chemical ones, seeking maximum removal yield of the target pollutants at lower cost (Figure 6).

>Figure 6<

5.- Assessment of activity

In order to analyze the results of the activity, a survey was developed to rank several items grouped in three blocks: (A) scope of the competences; (B) qualification of the activity and (C) overall satisfaction with the activity. A detailed analysis of the results obtained in the different blocks will be included in the subsequent sections, analyzing the survey responses from an item and a cohort perspective.
5.1 Scope of the competences

Table III shows the results for block A, where the students evaluate the achievement of various competences associated to the implementation of Gamestorming. The scores considered run from 1 (strongly disagree) to 4 (strongly agree). As it can be seen in Table III, for all items, the highest proportions correspond to score 4.

>Table III<

An equality test for proportions has been run using function prop.test from statistical computing developed as R software (more details in www.R-project.org). The equality test for proportions of “strongly agree” for each item reveals a maintained trend, with no significant increasing or decreasing patterns. The high proportions for score 4 translates into average values higher than 3.5 and mostly over 4, for all items and all years (Figure 7). It is worth highlighting the excellent working atmosphere in the classroom, as well as the identification of the students with the common challenge to propose actions to bring the product or process to the real world.

For each year, it has been also checked if all items were equally highly valued or if there were significant differences between them. This feature was observed for all the groups except for the 2015 cohort. Specifically, it should be noted that the largest differences (comparing proportions of “strongly agree” by items) involve item 4 (the teamwork spirit has been strengthened), which usually gives the lowest (although high) rate.

>Figure 7<

5.2 Qualification of the activity

The second block corresponded to the self-evaluation of the activity by the students, defining the grade (between 1 and 4) that the class should have. This grade would represent 25% of the final grade of the subject. The evaluation criteria to be taken into account were: the development of the activity and the characteristics of the prototype. The concept of “development” implied
evaluating the performance of the class as a "unit" or "team", constructively supporting the search for the best solution. The evaluation of the final solution obtained after completing the gamestorming process consisted in comparing the "driving-force" ideas that its conceptual design had with the one that finally was put into practice.

The grades are in line with the assessments of the competencies analyzed in the first block of the survey (Table IV and Figure 8). There are no significant differences in the grades given by the different groups. Regardless of the students cohort considered, the activity allowed teamwork to be strengthened, and the comparison with the "real" prototypes promoted the positive endorsement of the professional capacities and competences of the students, which finally implied a very positive self-evaluation of the work done.

>Table IV<

>Figure 8<

5.3 Overall satisfaction

The last block of the survey contains a single item: "Indicate the degree of overall satisfaction with the activity", where students score between 1 (very unsatisfied) and 4 (very satisfied). Results are reported in Table V and Figure 9. The students clearly showed a remarkable satisfaction with the implementation of Gamestorming as part of the teaching activity of the subject, and this behavior has been maintained along the years, with no significant differences. As a global result, 23% of the students were "somewhat satisfied" and 70% "very satisfied", being this pattern observed for all the years (Figures 9 and 10).

>Table V<

>Figure 9<

>Figure 10<
6.- Conclusions

Gamestorming can be a working methodology for several reasons: easy to implement, team oriented, inspire commitment and encourage creativity. This teaching methodology emphasizes free discussion and expressions of student opinions, with minimal teacher-centered information. The major goals of the Gamestorming activity are the development of critical thinking and creative problem-solving skills, reinforcement of the students´ self-confidence and teamwork in pursuit of a common goal.

Moreover, the nature and quality of interactions between the students and the professor and among the students had a positive effect on the quality of learning and the motivation and attitudes of students toward the course. The students´ perception considered this methodology as a mechanism to foster their creativity in the progress of teamwork toward decision making process.
References


Kushiro, H., Ehira, T., Kaihara, R., 2017. Aware environment for Workshop with Game Storming. IEEE International Conference on Data Mining Workshops, Article number 7836750, 806-812


https://www.accenture.com/t2017117T110152_w_/us-en/_acnmedia/pdf-40/Accenture-

Strategy-Harnessing-Revolution-POV.pdf (accessed 17.03.11)


Caption to Figures.

**Figure 1.** Definition of the framework for a "new" product or process.

**Figure 2.** Classification of the options of improvement in driving force ideas or lines of action.

**Figure 3.** Stage of brainstorming: reflection and publication

**Figure 4.** Comparison between the actual prototypes considered by the company and those defined by the class in the case study of a wine storage box.

**Figure 5.** Selection of the technologies for the abatement of pollutants from gaseous streams.

**Figure 6.** Combined approach of technologies for the abatement of pollutants from gaseous streams.

**Figure 7.** Results for block A: scope of competences. Bar plots for each item and year with the following legend: strongly disagree in yellow, disagree in red, agree in green and strongly agree in blue. Line plot for average trends, from 2013 to 2016. Note that axis has been reduced to 3-4.

**Figure 8.** Results for block B: qualification of the activity. Bar plots for each item and year with the following legend: strongly disagree in yellow, disagree in red, agree in green and strongly agree in blue.

**Figure 9.** Results for block C: overall satisfaction with the activity. Bar plots for each item and year with the following legend: strongly disagree in yellow, disagree in red, agree in green and strongly agree in blue.

**Figure 10.** Trend lines for average values (± standard deviation) for block B (qualification of the activity, red) and block C (global satisfaction, blue).
Figure 1

- Specific characteristics of product/process
- Less environmental impact
- More efficiency
- Other possibilities

Start

End
Figure 2
PROTOTYPES CONSIDERED BY THE COMPANY

PROTOTYPES PROPOSED BY STUDENTS

FLOWER POT
CHESS
SHELVES

Figure 4
Figure 5
Figure 6
Item 1. The objective of the activity has been clearly defined.
Item 2. You have felt involved in the activity.
Item 3. You have detected that the class has acted as a team.
Item 4. The teamwork spirit has been strengthened.
Item 5. The activity is related to the content and competences of the course.
Item 6. The activity encourages the development of creativity.
Item 7. Critical analysis has been strengthened.

**Trends**

Figure 7
Figure 9
### Table I. Main driving force ideas derived from the phase of brainstorming and subsequent analysis for the wood box.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Materials</th>
<th>Production</th>
<th>Distribution</th>
<th>End of life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-functionality from a seller/retail perspective</td>
<td>Reduce</td>
<td>Reduction of process steps</td>
<td>IKEA model: &quot;detachable&quot;</td>
<td>Enhancing energy recovery</td>
</tr>
<tr>
<td>Minimalist design</td>
<td>Change</td>
<td>Renewable energy</td>
<td>Packing material Green logistics</td>
<td>Extend the end of life with other uses: related to concept</td>
</tr>
</tbody>
</table>
Table II. Classification of the different process diagrams according to selected criteria

<table>
<thead>
<tr>
<th>1. Applicability</th>
<th>2. Efficiency</th>
</tr>
</thead>
</table>
| Range of applicability, considering both the type of the pollutants (more or less recalcitrant) and their concentration in the gas stream:  
- Wide range of compounds and concentrations (VI+)  
- Limited range of compounds or concentrations (VI)  
- Limited range of compounds and concentrations (IV) | Operation versatility that fulfills diverse regulatory standards:  
- The efficiency removal can be extrapolated to other conditions beyond those representative of the system (VI+)  
- Meets the efficiency removal required by current legislation (VI)  
- Does not achieve the required efficiency removal (IV) |

<table>
<thead>
<tr>
<th>3. Cost</th>
<th>4. Operational requirements</th>
</tr>
</thead>
</table>
| Estimation of costs for infrastructure and operation:  
- Affordable cost of equipment and operation (VI+)  
- High cost of equipment or operation (VI)  
- Very high cost of equipment and operation (IV) | Reduced chemicals and energy consumption:  
- No need for chemicals or limited energy consumption (VI+)  
- Requirement of chemicals or high energy consumption (VI)  
- Large consumption of chemicals and energy (IV) |
Table III. Evaluation of the skills developed in the Gamestorming activity.

<table>
<thead>
<tr>
<th>A. On the scope of competences</th>
<th>Year</th>
<th>Total (NR/NK)*</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>Average (StD)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>The objective of the activity has been clearly defined.</td>
<td>2013</td>
<td>29</td>
<td>0.00%</td>
<td>6.90%</td>
<td>13.79%</td>
<td>79.31%</td>
<td>3.72 (0.58)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>35</td>
<td>0.00%</td>
<td>2.86%</td>
<td>11.43%</td>
<td>85.71%</td>
<td>3.83 (0.45)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>35</td>
<td>0.00%</td>
<td>0.00%</td>
<td>11.76%</td>
<td>88.24%</td>
<td>3.88 (0.32)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>31 (1)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>10.00%</td>
<td>90.00%</td>
<td>3.90 (0.30)</td>
</tr>
<tr>
<td>You have felt involved in the activity.</td>
<td>2013</td>
<td>29 (2)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>3.70%</td>
<td>96.30%</td>
<td>3.96 (0.19)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>35 (1)</td>
<td>2.94%</td>
<td>2.94%</td>
<td>5.88%</td>
<td>88.24%</td>
<td>3.79 (0.63)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>34 (1)</td>
<td>0.00%</td>
<td>3.03%</td>
<td>9.09%</td>
<td>87.88%</td>
<td>3.85 (0.43)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>31 (1)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>6.67%</td>
<td>93.33%</td>
<td>3.93 (0.25)</td>
</tr>
<tr>
<td>You have detected that the class has acted as a team.</td>
<td>2013</td>
<td>29 (2)</td>
<td>3.70%</td>
<td>0.00%</td>
<td>14.81%</td>
<td>81.48%</td>
<td>3.74 (0.64)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>35 (1)</td>
<td>0.00%</td>
<td>8.82%</td>
<td>11.76%</td>
<td>79.41%</td>
<td>3.71 (0.62)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>34 (0)</td>
<td>0.00%</td>
<td>2.94%</td>
<td>8.82%</td>
<td>88.24%</td>
<td>3.85 (0.43)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>31 (1)</td>
<td>0.00%</td>
<td>6.67%</td>
<td>23.33%</td>
<td>70.00%</td>
<td>3.63 (0.60)</td>
</tr>
<tr>
<td>The teamwork spirit has been strengthened</td>
<td>2013</td>
<td>29 (1)</td>
<td>3.57%</td>
<td>3.57%</td>
<td>28.57%</td>
<td>64.29%</td>
<td>3.54 (0.73)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>35 (0)</td>
<td>0.00%</td>
<td>5.71%</td>
<td>17.14%</td>
<td>77.14%</td>
<td>3.71 (0.56)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>34 (1)</td>
<td>0.00%</td>
<td>9.09%</td>
<td>15.15%</td>
<td>75.76%</td>
<td>3.67 (0.64)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>31 (1)</td>
<td>0.00%</td>
<td>10.00%</td>
<td>33.33%</td>
<td>56.67%</td>
<td>3.47 (0.67)</td>
</tr>
<tr>
<td>The activity is related to the content and competences of the course.</td>
<td>2013</td>
<td>29 (0)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>100.00%</td>
<td>4.00 (0.00)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>35 (0)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>5.71%</td>
<td>94.29%</td>
<td>3.94 (0.23)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>34 (0)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>8.82%</td>
<td>91.18%</td>
<td>3.91 (0.28)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>31 (1)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>3.33%</td>
<td>96.67%</td>
<td>3.97 (0.18)</td>
</tr>
<tr>
<td>The activity encourages the development of creativity.</td>
<td>2013</td>
<td>29 (0)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>10.34%</td>
<td>89.66%</td>
<td>3.90 (0.30)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>35 (1)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>2.94%</td>
<td>97.06%</td>
<td>3.97 (0.17)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>34 (0)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>5.88%</td>
<td>94.12%</td>
<td>3.94 (0.24)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>31 (1)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>6.67%</td>
<td>93.33%</td>
<td>3.93 (0.25)</td>
</tr>
<tr>
<td>Critical analysis has been strengthened.</td>
<td>2013</td>
<td>29 (0)</td>
<td>0.00%</td>
<td>6.90%</td>
<td>10.34%</td>
<td>82.76%</td>
<td>3.76 (0.57)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>35 (1)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>2.94%</td>
<td>97.06%</td>
<td>3.97 (0.17)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>34 (2)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>12.50%</td>
<td>87.50%</td>
<td>3.88 (0.33)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>31 (1)</td>
<td>3.33%</td>
<td>3.33%</td>
<td>13.33%</td>
<td>80.00%</td>
<td>3.70 (0.69)</td>
</tr>
</tbody>
</table>

*NR/DK: No Response/Don’t Know  **StD: Standard deviation
Table IV. Marks from the self-evaluation of the activity by the students

<table>
<thead>
<tr>
<th>B. Grading of the activity</th>
<th>Year</th>
<th>Total (NR/DK)*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Average (Std)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate the grade that the class deserves considering the development of the activity and the proposal of the prototype</td>
<td>2013</td>
<td>29 (3)</td>
<td>0.00%</td>
<td>6.90%</td>
<td>13.79%</td>
<td>79.31%</td>
<td>3.72 (0.32)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>35 (3)</td>
<td>0.00%</td>
<td>2.86%</td>
<td>11.43%</td>
<td>85.71%</td>
<td>3.83 (0.54)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>34 (4)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>11.76%</td>
<td>88.24%</td>
<td>3.88 (0.37)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>31 (2)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>10.00%</td>
<td>90.00%</td>
<td>3.90 (0.43)</td>
</tr>
</tbody>
</table>

*NR/DK: No Response/Don’t Know  
**Std: Standard deviation
Table V. Overview of global satisfaction by the students

<table>
<thead>
<tr>
<th>C. Overall satisfaction</th>
<th>Year</th>
<th>Total (NR/DK)*</th>
<th>Very unsatisfied</th>
<th>Somewhat unsatisfied</th>
<th>Somewhat satisfied</th>
<th>Very satisfied</th>
<th>Average (StD)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global satisfaction</td>
<td>2013</td>
<td>29 (2)</td>
<td>3.70%</td>
<td>3.70%</td>
<td>25.93%</td>
<td>66.67%</td>
<td>3.56 (0.74)</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>35 (1)</td>
<td>2.94%</td>
<td>2.94%</td>
<td>23.53%</td>
<td>70.59%</td>
<td>3.62 (0.69)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>34 (1)</td>
<td>0.00%</td>
<td>3.03%</td>
<td>27.27%</td>
<td>69.70%</td>
<td>3.67 (0.53)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>31 (1)</td>
<td>3.33%</td>
<td>6.67%</td>
<td>16.67%</td>
<td>73.33%</td>
<td>3.60 (0.76)</td>
</tr>
<tr>
<td></td>
<td>Global</td>
<td>129 (5)</td>
<td>2.42%</td>
<td>4.03%</td>
<td>23.39%</td>
<td>70.16%</td>
<td>3.61 (0.68)</td>
</tr>
</tbody>
</table>

*NR/DK: No Response/Don’t Know  
**StD: Standard deviation