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Creative experience in engineering design: the island exercise
Experiencia creativa en ingeniería en diseño: el ejercicio de la isla

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Abstract
This work addresses the challenge of stimulating creative thought in higher education. With this aim in mind, the article describes the development of a collaborative creativity exercise designed to improve students' creative skills through self-perception of their strong and weak points. In this work the exercise is set out as a five-step methodology, which includes the determination of personality profiles using the Herrmann Brain Dominance Instrument and the design of an island, to be carried out by groups of students in the classroom. In this study, the exercise, which has been applied to first-year Technical Engineering in Industrial Design students for the last five years, is undertaken by different groups of students in five different sessions. Observations performed in the classroom and the results of the exercises, that is, both the islands that were designed and the choices made by the students, are used to draw the conclusions about the validity of the study. Moreover, the paper also compares the perceptions of the students who took part in the experiment this year and those who had done the exercise in previous years. The conclusions concern the style of working of each group of dominances, and highlight the effectiveness of the tool for enhancing students' creativity through self-reflection. The students' positive perceptions, even several years after doing the exercise, are good proof of this.

Keywords: Creativity; design; brain dominances; teaching tool.

Resumen
El presente trabajo aborda el reto de la estimulación del pensamiento creativo en la educación superior. Para ello se muestra el desarrollo de un ejercicio de creatividad colaborativo diseñado para mejorar las aptitudes creativas de los alumnos a través de la auto-percepción de sus puntos fuertes y débiles. En el presente trabajo el ejercicio se plantea como una metodología de cinco pasos, que incluye la determinación de los perfiles de personalidad mediante Test de Dominancias Cerebrales de Herrmann y el diseño grupal de una isla, para ser realizado en una clase docente. El ejercicio, que lleva aplicándose durante cinco años sobre alumnos de primer curso de Ingeniería Técnica en Diseño Industrial, se plantea para el presente trabajo a grupos diferentes de alumnos en cinco sesiones diferentes.
Results Las observaciones en el aula y los resultados de los ejercicios, tanto las islas diseñadas como las elecciones de los alumnos, sirven para extraer las conclusiones necesarias sobre la validez del estudio. Además, se muestra la comparativa de las percepciones de los alumnos que han realizado la experiencia en el presente curso con aquellos que realizaron el ejercicio en años posteriores. Las conclusiones comprenden el estilo de trabajo de cada grupo de dominancias y resalta la efectividad de la herramienta para potenciar la creatividad de los alumnos a través de la autorreflexión. Las percepciones positivas de los alumnos incluso después de varios años de haber realizado el ejercicio son una buena prueba de ello.

Palabras clave: creatividad; diseño; dominancias cerebrales; herramienta educativa

1. Introduction

The importance of stimulating creative thought in order to achieve original, competent ideas is a challenge in education that is currently being tackled with the creative skills training process [1][2]. On the one hand we have a wide range of tools with which to evaluate students' level of creativity or creative potential, such as those developed by Guildford [3], Torrance [4], Otis [5], Corbalán-Berná [6] or Runco [7]. On the other hand there is also a set of techniques aimed at improving or enhancing the degree of creativity of students, which has initially been measured using the aforementioned tools [8- 12].

The problem within the area of education lies in the fact that if students obtain poor results when their creative potential is evaluated with the first group of tools, this will lead to frustration and a negative attitude when it comes to using the creative techniques. To solve this problem, the main purpose of this work is to present a tool for improving students' creativity through the perception of their capacities in a qualitative, rather than quantitative, manner. This technique has been applied to first-year Technical Engineering in Industrial Design undergraduates for five consecutive years.

One of the most important elements of this method is the Herrmann Brain Dominance Instrument [13-14], which describes people's thinking preferences or modes and thus does not use quantitative scales. This instrument has already proved its validity in a number of studies in which it was applied to students [15-17] and teachers [18-19].

This paper describes the development of a collaborative creativity exercise designed to improve students' creative skills through the self-perception of their strong and weak points. In the exercise, the Herrmann Brain Dominance Instrument is used to establish the teams. The work describes the application of the exercise, which was designed to be carried out in five different sessions, with the aim of eliminating possible dispersions and verifying the conclusions in a more consistent way. Furthermore, the paper also offers the results of a satisfaction survey that was administered to the students who carried out the exercise described here and to others who had done it in previous years. By so doing researchers aimed to evaluate students' perception of the exercise both in their recent memory and some years after the experience.

2. The Herrmann Brain Dominance Instrument

As stated earlier, the Herrmann Brain Dominance Instrument (HBDI) [14, 20] is a tool for measuring and describing people's preferences or modes of thinking that was developed by Herrmann in 1979 and later validated by Bunderson [21]. It must be stressed that the purpose of this tool is not to determine the level of intelligence, but rather it is limited to defining styles of thinking in a qualitative way. Hence, there are no good or bad profiles.

In his model of brain dominance, Herrmann identifies four different modes of thinking (Fig. 1), i.e. A. analytical thinking, B. sequential thinking, C. interpersonal thinking and D. imaginative thinking. A person's brain dominance is determined by applying a 120-item questionnaire [13]. The result appears as a score for each quadrant which, taken together, allow us to determine the person's cognitive preference. That is to say, it becomes possible to see which profile is more prominent than the others in the person's normal performance and therefore which traits they present in their interaction with the environment and with other individuals.

It should be noted that many individuals do not present one single dominance, and may be dominant in two styles, where their preferences are defined by a left-right or cortical-limbic hemisphere. In addition, there are even cases of triple or quadruple dominance (the latter being known as "total brain dominance").

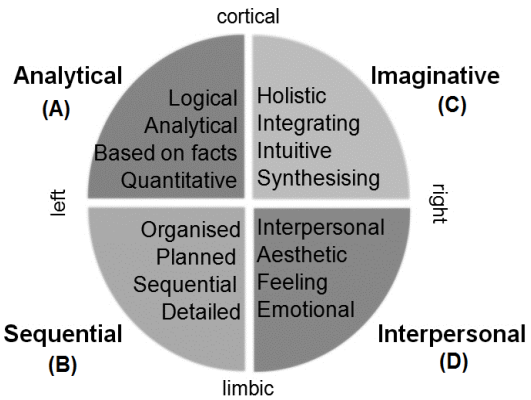

Figure 1. The Herrmann Brain Dominances model

3. Method design

The questionnaire used in the exercise was the reduced version for students produced by Jiménez-Vélez [22], based on Herrmann's original instrument. This test is made up of 40 items, which allow the preferential style of thinking to be identified like the full version, but it is faster and simpler both to answer and to evaluate – a fundamental requirement for it to be used in a practical teaching situation.

The methodology proposed for carrying out the exercise is as follows:

1. The Jiménez-Vélez reduced questionnaire is administered to the students individually in the actual classroom, and it is made clear to them that they are not doing a test or an exam and so there are no right or wrong answers, only personal preferences. At the end of the questionnaire there are instructions on how to score it, so that the students themselves can determine their own dominance.
2. Once the dominances have been determined, the main traits in each quadrant are explained to the students and they are asked to form groups of between four and six members, bearing in mind their main dominance. Only the quadrant in which they obtained the highest score is considered and cases of double, treble or quadruple dominances are ignored.
3. The task that the groups must solve is explained to them as follows: "You have an unlimited budget with which to design an island concept" (Fig. 2). They are not given any further information or restrictions of any kind. They are given handicraft materials for them to use in the design, consisting of one DIN-A1 sheet of lightweight cardboard to be used as the base, sheets of coloured card, wax crayons and coloured pencils, glue, scissors and plasticine in different colours. They are allowed about an hour to produce their design.
4. Once the design time is up, each group chooses one of its members to give a one-minute presentation of the island they have designed to the other students. The students then vote for the design that they consider to be the best out of all those proposed by their classmates.
5. The rest of the session is devoted to getting the students think about the results and to developing self-awareness of their own dominance and that of the people around them.

Figure 2. Instructions for the exercise

Table 1. The dominances found in each session (numbers betwen brackets indicate the number of formed groups)

Number of students with	Session 1	Session 2	Session 3	Session 4	Session 5
Dominance A	5 (1)	2 (0)	4 (1)	5 (1)	5 (1)
Dominance B	11 (2)	10 (2)	9 (2)	10 (2)	7 (1)
Dominance C	10 (2)	6 (1)	6 (1)	6 (1)	6 (1)
Dominance D	6 (1)	10 (2)	13 (3)	6 (1)	6 (1)

4. Carrying out the experiment with students

The experiment was conducted with first-year Technical Engineering in Industrial Design undergraduates. The same experiment was carried out in five sessions with different students, so that the different results could be compared and the conclusions would be more robust. Between 24 and 32 students took part in each session.

Step 1. In the first step of the experiment, students were given the Jiménez-Vélez reduced questionnaire to complete, in order to determine their dominances. The results of the dominances for each session can be seen in Table 1.

Step 2. The second step consisted in making up groups of between four and six students (see numbers between brackets in Table 1).

In the second session, since there were only two students whose main dominance was A, there were not enough to form a group. They were therefore allocated according to their secondary dominance, which in these two cases were B and D. In the fifth session, the number of students with dominance B exceeded the upper limit for the number of members of the group by one, but on forming a group with dominance A, it was found to be one short. Thus, the student with dominance B that had the highest score in A was placed in group A.Step 3. In step 3, they were shown the transparency of the statement of the problem (Fig. 2) and then given the materials and asked to start the exercise, without offering them any further Information.

Figure 3. Different students working in their groups

Throughout the exercise, notes were taken about the attitudes and behaviours of each of the groups so that conclusions could later be reached. Photos were also taken and parts of the experiment were recorded so that they could be consulted after it had finished. The photographs in Fig. 3 show several different instances of the students working in their groups.

Figure 4. A student presenting the group's island concept

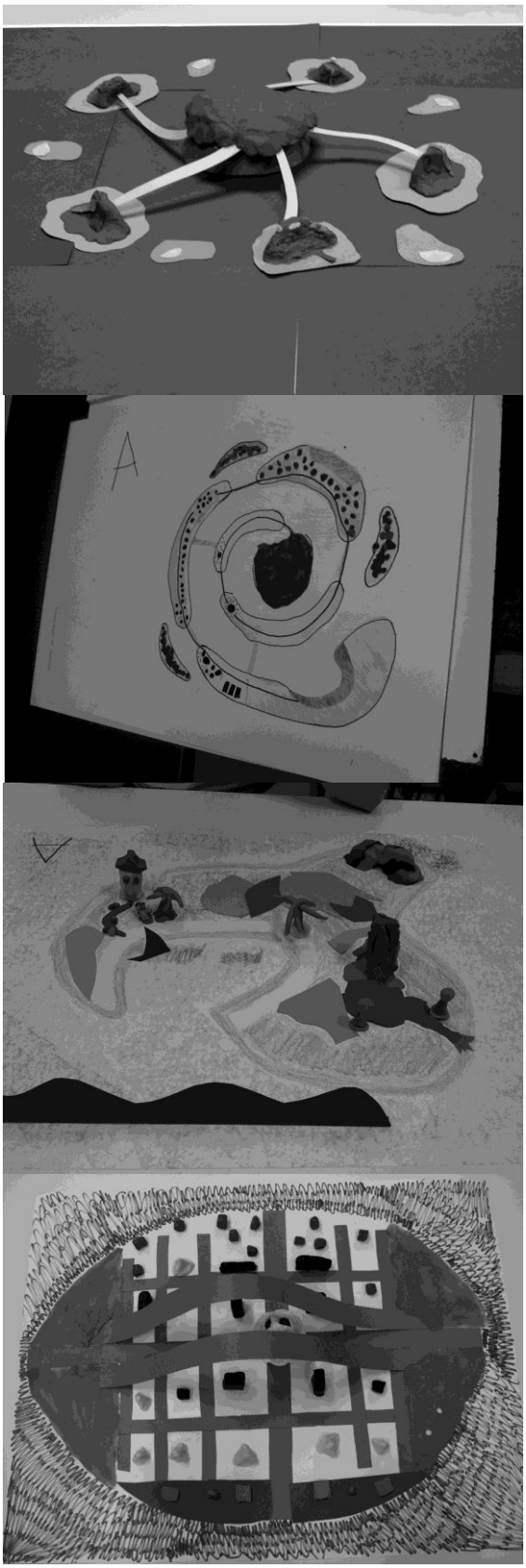

Figure 5. Several island designs produced by groups with dominance A

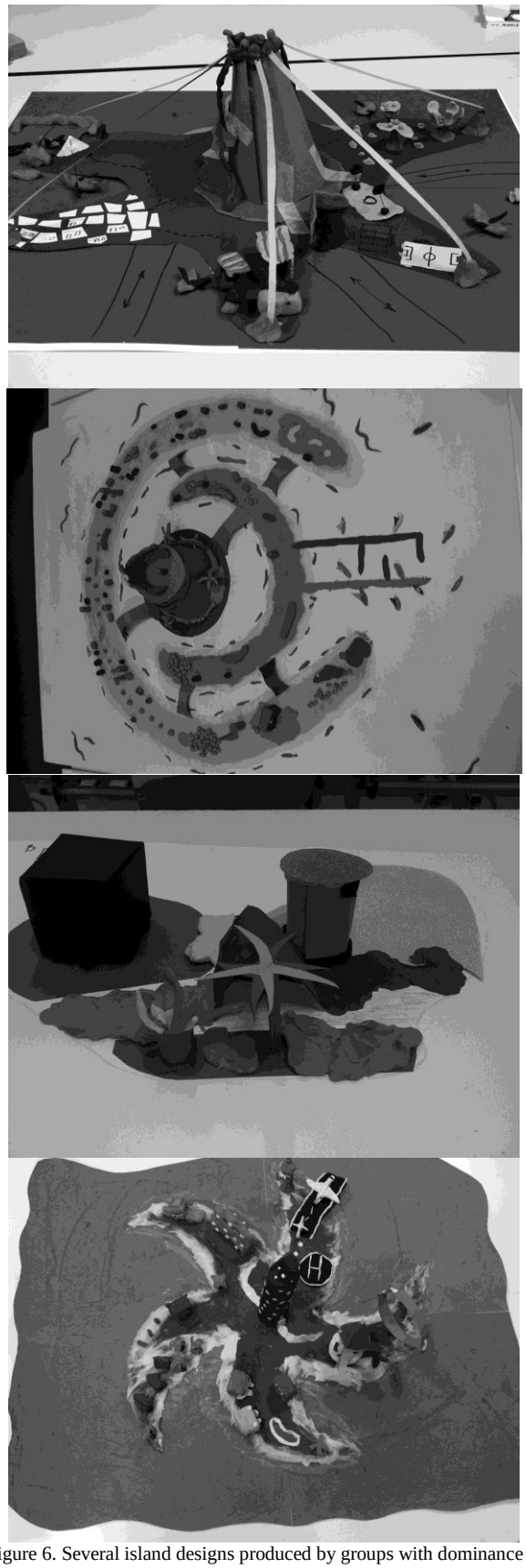

Figure 6. Several island designs produced by groups with dominance B

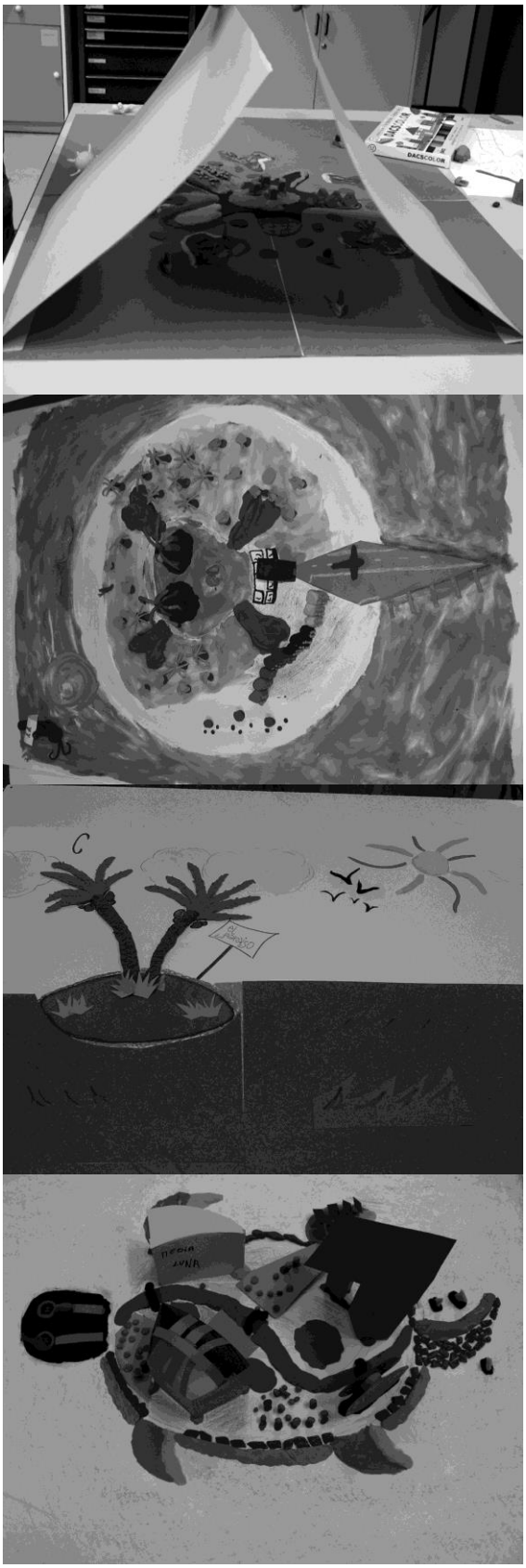

Figure 7. Several island designs produced by groups with dominance C

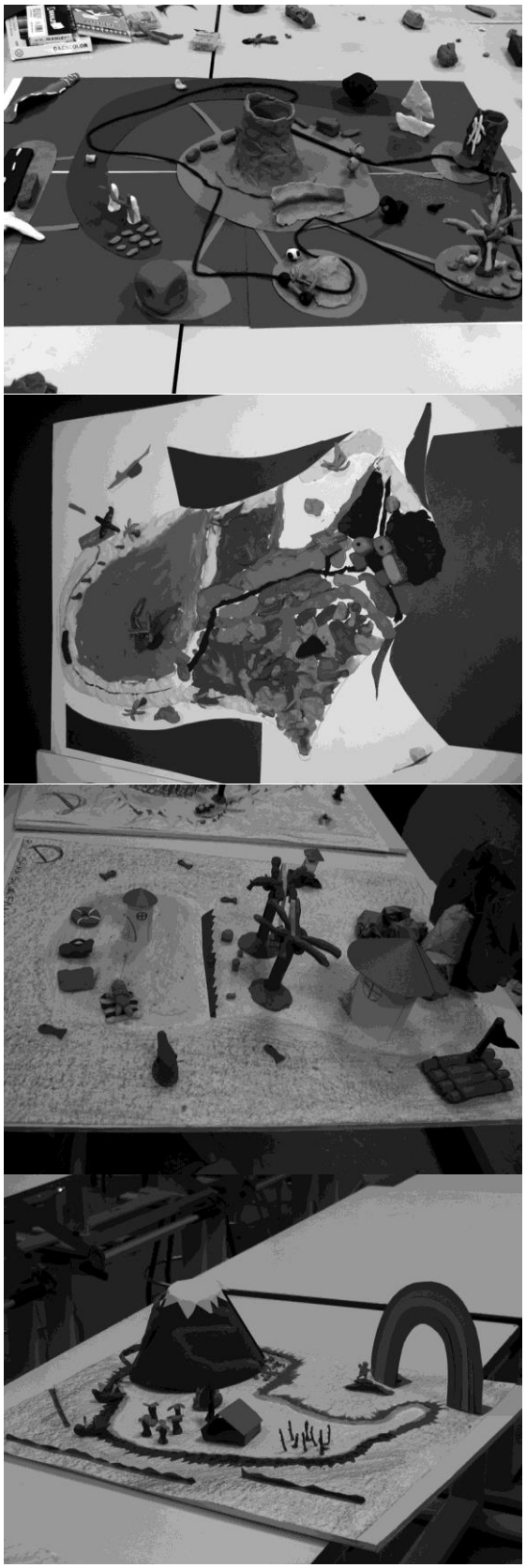

Figure 8. Several island designs produced by groups with dominance D

Step 4. In the fourth step the spokesperson from each group presented their final island concepts (Fig. 4). Fig. 5, 6, 7 and 8 show several final designs for islands produced by the dominance A, B, C and D groups, respectively. The students then voted for what they considered to be the best island concept. The results were as follows: dominance B was the winner in sessions 1 and 5, C won in session 2 and dominance D was the most voted in sessions 3 and 4; dominance A was not chosen as the winner in any of the sessions.

Step 5. In the rest of the session the students are encouraged to discuss the experiment and the results obtained, and to further develop their self-awareness of their creative typology.

5. Results of the satisfaction survey

The survey was administered to a sample of students who participated in the experiment in the current year and also students who had taken part in the experiment in previous years. Altogether answers were collected from 49 students, of whom 23 were from the current year and 26 from previous years. Of the sample of students who answered, 20% were from group A, 24% from group B, another 24% from group C and the remaining 32% were from group D.

The parameters that were taken into account in the survey referred to personal satisfaction, academic skills and professional competencies. Their responses can be seen in the graphs in Fig. 9, 10 and 11, which show the separate perceptions of students who have just done the experiment and that of those who remember it from previous years.

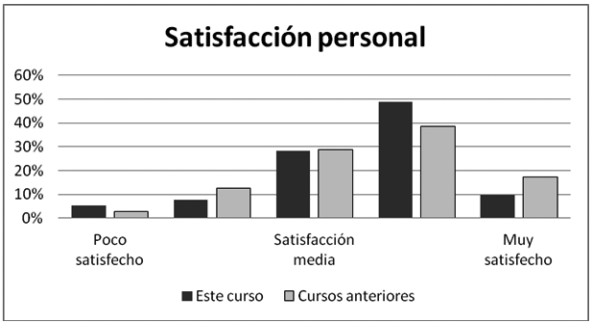

Figure 9. Students' evaluation of their personal satisfaction with the exercise

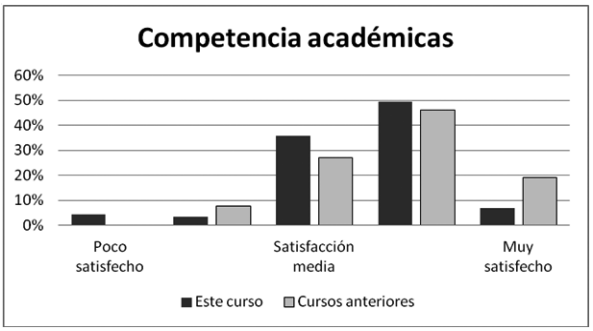

Figure 10. Students' evaluation of the degree of academic skills acquired by doing the exercise

Figure 11. Students' evaluation of the degree of professional competencies acquired by doing the exercise

6. Discussion

Observation of the five sessions allowed the following issues to be deduced:

Dominance A group: the main motivation driving this kind of group is winning. It is usually a controversial group. All the members of the team each want to impose their own decisions. In all five sessions there were always at least a couple of members who argued and in two cases the teacher had to remind them to keep their voices down.

Dominance B group: at first the group is lost. Its members need clear instructions and the first few minutes of the session are wasted by calling the teacher and trying to get answers to questions like "But… what exactly do we have to do?" "An island? How?" "What is the island going to be used for?" Once they give up trying to get instructions out of the teacher, the group agrees on what they are going to do and they set about working in an organised and fairly quiet way.

Dominance C group: The groups of this type spent most of the session talking and discussing their ideas for island concepts. In this case the dialogue is sociable and friendly. Although they spend a lot of time on talking and reaching agreements, this does not stop them from going about the physical construction of the model of the island at the same time. Nevertheless, in comparison to the spokespersons from the other groups, the spokesperson of this group is the one who displays most enthusiasm when it comes to "selling" their island to their companions.

Dominance D group: this group is the first to begin the manual work on building the island, often even before they start discussing the design that they are going to develop. They frequently make changes to the initial concept and do so in a rather chaotic way. The members of these groups display lively behaviour and laugh a lot.

From the resulting islands and the students' votes, the following observations can be made:

The island produced by groups A, despite taking into account all the functional necessities of the island, is not altogether convincing, since the model is designed in a short time and after several arguments, and therefore members' motivation is not very high. Moreover, the spokesperson is often interrupted by a companion from his or her own team, which breaks the flow of information to the audience.

The island designed by groups B, despite sometimes not being very original, is nevertheless the most elaborate and detailed. The team works efficiently and thinks about all the details, which means that their island is always ranked among the best. The solutions they use are usually very rational and methodical; they take into account all the necessary functions and these are clearly differentiated in their design.

The model built by groups C is usually the most original, but sometimes it is so original that it borders on irrationality and this lowers the number of votes they receive because they incorporate concepts that are not very highly valued by the members of the other groups. Their idea is well developed, however, and they stand out in the presentation, which is the group's strong point.

The islands designed by groups D range from the most original to the most chaotic. The disorganised way in which the group works results in a model that is difficult

to understand or which is finally left unfinished. Yet, quite often the actual design is attractive from the aesthetic point of view of the solution or it is amusing for the audience and this can capture quite a lot of votes for them. Hence, these groups usually come either first or last in the voting, but rarely finish halfway up the ranking.

Lastly, from the answers to the satisfaction survey, it can be deduced that students' evaluations of the levels of personal satisfaction and the degree of academic skills and professional competencies acquired are, overall, positive. On the other hand, it is also interesting to note that students who participated in the experiment in previous years rate it higher than those who have just done it.

7. Conclusions

The main aim of this practical exercise is to get students to perceive the way they work within a team and to think about how they can take advantage of their strong points and improve their shortcomings. This is what makes it essential to carry out the fifth step of the session, the discussion of the results, in order to explain to them, the reasons behind their results and their attitudes.

As the work was being carried out, it became clear that a group made up only of leaders (dominance A) cannot advance, because a work team really must have only one clearly-defined person in charge.

It has also been seen how a group made up exclusively of persons with dominance B, despite being more organised and harder working, needs a dominant voice to guide the group and give instructions. In the same way, such excessive organisation sometimes has a detrimental effect on the originality of the work.

It has also been observed how a group made up of just dominance C spends too much time on discussion. Although this results in more creative concepts, they often get stuck on a holistic level and develop a concept that is frequently unfeasible.

Lastly, the workgroups made up only of dominance D display a remarkable lack of control and organisation, which often turns what could be a good idea into a dismal failure. Yet, it seems to be the group that enjoys the experiment most.

Students are then made to think about these observations so that, by themselves, they come to the conclusion that a good work team must be made up of people with several dominances. There are no good or bad dominances; instead they must work together in order to obtain the best results. In other words, a team must have: leadership, to control and make decisions quickly when needed; organisation and effectiveness, so that the concepts are materialised in good designs; interpersonal dealings, so that communication flows and ideas can circulate freely from some members of the team to others; and a creative part, to give the projects an original touch that makes them stand out from the rest.

The most positive point of the study is the positive perception that students have of the experiment. The fact that their perception of the exercise gets better as time goes by indicates that they consider that all the thinking they did during and after the experiment has yielded some benefit for them, both in their academic progress and later in their career.

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