HOW TO ANALYSE COLLABORATIVE PRACTICES OF ENGINEERING STUDENTS?

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ABSTRACT
In this paper we present two pedagogical experiences to analyse and stimulate the collaborative design activities of products as part of the formation programme for future engineers. The first one is a game based on the adaptation of the Delta Design game developed at M.I.T. The principle of the game is to co-imagine an automotive in Lego® blocks with functions and rules assigned for several students. The software used (MLCad) provides for a shared and distributed use of the game. The core objective is to create a situation that brings the students together in a way that encourages them to experiment with different designs by making compromises, overcoming conflicts, and working within the constraints of the game. The second one is a design contest called “24h for Innovation” based on the challenge to design an industrial product in only 24 hours. The underlying theory of these experiences is that by encouraging collaboration among each other when addressing the different obstacles and variables encountered, the students will have a better understanding of their own behaviour and the behaviour of other members.

Keywords: Pedagogic game, 24h for Innovation, Lego bricks, Innovation contest, collaborative design work,

1 INTRODUCTION

Throughout the competitive character of the market, product design is affected and driven by the constitution of multidisciplinary teams capable of efficient collaboration. The collaboration practices among project stakeholders are an essential catalyst for creative sharing of skills. By its socio-technical characteristic, collaboration is a relatively complex phenomenon to study and to formalize in the organization. The interaction between the individuals themselves, as well as the interaction with the surrounding systems (objects, context, etc.), creates major concern in the academic and industrial world. The study of collaboration is relatively complex in the industrial context. Likewise, the education of individuals is also a major concern for most academic institutions and particularly among engineering institutes. In the end, preparing future engineers with real technical knowledge while allowing them to acquire collaborative competencies remains a challenge for these institutions. Due to this issue, engineering institutes must teach an ever greater number of disciplines to their students. Nowadays, the training of individuals focussed on the development of know-how and aptitudes of collaboration remains a major problem. In fact, it is necessary to recognize the strong contextual character of the collaboration from its numerous “parameters” (personal development, individual and group psychology, enterprise culture, power game, general working habits, etc.). For this reason, the aptitude to collaborate is often perceived as a competence that is essentially learned by experiences and real situations. It is accordingly very difficult to reproduce such a training environment when striving for a pedagogical goal. However, the internships and student projects are the first answers delivered by the academic institutions to encourage their future engineers to act as actors of collaboration in real situations. In this paper we propose in section 1, a design game with the intention that engineering institutes use it as a pedagogical tool for the teaching of collaboration. This game, essentially based on LEGO blocks, was developed to simulate the multi-disciplined design of a technical object. In section 2 we present a second experimentation to stimulate creativity and innovation capacities of engineering students.

2 PROPOSITION OF A LEGO GAME

2.1 Analysis of the Delta Design game

In the Delta Design Game [1] game, the team must design a house by assembling equilateral triangles in either red (heating triangle) or blue (cooling triangle) formations. The design team is composed of a project manager, a structural analysis specialist, a heat engineer, and an architect. Each member of the team receives two documents. The first part presents the team composition and target. This directive also specifies the global task to be undertaken by detailing the design requirements of a house. This first part is the same for all participants. The second part of the document, different for each stakeholder, outlines the essential requirements for the correct execution of the role assigned to the player. Therefore, the team task is to design a house that takes into account and integrates all of the stakeholder’s rules that are sometimes vague or precise and subjective or formal. The main interest of Delta Design game remains the analysis of the collaboration “highlights”. An external viewer or a set of viewer-player can do this analysis for each stakeholder. Analysing the corpus, the pictures and videos of a session with Delta Design allow us several opportunities for insight and observation of individuals in a collaborative situation. In this paper, we will not develop the pedagogical interest of this approach as the reader may consult the paper [2]. Thereby, through reflective analysis [3], he can better understand and analyse his own behaviour during a collective action. However, we have identified some limits of the Delta Design game. First of all, the future design product engineers occasionally have a lack of enthusiasm or concern for the experiment. This is related to the fact that the final objective of the experiment is the design of a house assimilated to the formation of architecture and with characteristics not focused on the mechanical product technology. The representation of the object to be designed (under the triangle assembly) seems to be too abstract to solicit more interaction between the players. Moreover, the 2-D format differs from the 3-D formats (CAD) traditionally used in product design. The game format imposes its utilization at the present moment and does not allow for a test in a distributed environment. Taking these limits into consideration, we designed a different game focused more upon mechanical product design. This aforementioned game is presented below.

2.2 Design a Lego car!

The objective of the proposed game is to design a Lego car (cf. example figure 1) by assembling Lego® blocks while respecting various constraints. The choice of block is essentially based on upon its ease of use, its allowance for building, its resemblance with mechanical products (an airplane, a car), and its functional free software used (ex:

MLCad) to remotely build and share virtual assembling models. It is important to note that numerous pedagogical games (engineering specific, marketing formation, and enterprise coaching) have been designed using these types of blocks (http://www.seriousplay.com/).

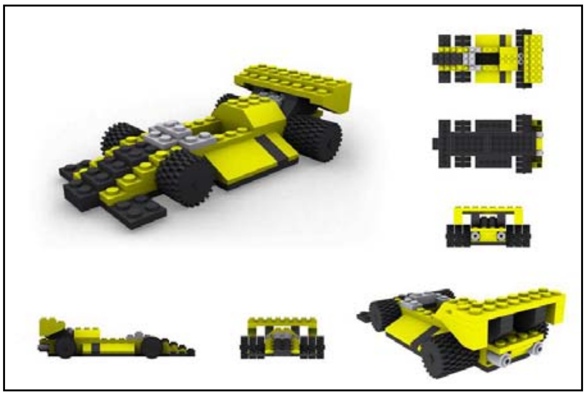

Figure 1 Example of Lego car

The elementary blocks to construct the final product are used by means of a reduced and specific database, obtained from the set of Lego® type blocks. This database can be used virtually with the free software MLCad (http://www.lm-software.com/mlcad/) or in a tangible way in the event in which the Lego® blocks could be purchased. The blocks are differentiated by their attributes (form, type, and color). These attributes also give the blocks special characteristics in terms of weight, cost, mechanics, or aerodynamic resistance. There are several types of blocks that represent mechanical resistance, aerodynamics, ergonomics and aesthetics aspects. There are different types of assemblies that can be made to fix the blocks, motor families with non-proportional power, weight, and heat diffusion parameters are proposed. Each car model has similarities (the “sport” model which is powerful, but not economic; the “family” model which is cheaper; etc.). Within the game, we have a series of rules that belong to each of the implicated disciplines and assigned to each of the design game players. These different disciplines are: the project manager, the motor engineer, the ergonomic responsible, the architect… We have expressed the rules in both a quantitative and subjective manner. This enables us to condition our work habits necessary for the project and avoid our tendency to only cooperate when required to satisfy the constraints. The rules are designed to encourage the actors to cooperate, negotiate, and to converge on an acceptable compromise for everyone.

We are implementing different tests with engineering and Ph.D. students. To this day, two groups have enabled us to experiment with new rules and a new functioning mode. Within its imaginary world, the game that has been proposed permits the users to be placed in an ambiguous environment: pleasant and unnerving at the same time. The appeal of the "CAD utility" of the Lego® game is undeniable compared to the triangle papers of the Delta Design Game. We assist to a true passion on the screens that present the CAD model of the car. However, we observed that the computer strongly restricts the number of manipulations and limits the sharing of the intermediate design object. Moreover, a future improvement could consist in adding physical Lego® blocks in order to construct the first physical prototype of the space shuttle before producing it using MLCad. After the tests and the finalization of our rules, we would like to propose an experience between several institutions (engineering schools, universities) in order to test this game in a distributed way (between several teams) and at distance (at different locations). The goal of our game is to approach socio-technical practices [4] of the engineers that use at the same time i) CAD models (in our case, the MLCad model), ii) proprietary utilities (in our game, the team could prototype the first versions of the car with real physical Lego® blocks). When fulfilling this condition, the young modern engineers [5] could be integrated more easily in the socio-professional networks. The Lego game helps us to analyse engineer student's collaboration. We propose also another pedagogical experimentation in order to stimulate creativity and innovation capacities of engineering students. This experience is described in the following section.

3 "24H FOR INNOVATION"

3.1 The "24h for Innovation" contest

We have initiated an Innovation contest in October 2007. Students formed teams of around 10 members and selected projects which were proposed by industrial companies. SMEs and large companies proposed concepts but no fixed specification book. The aim of the event was to make students experience an innovative design adventure. The issue was for them to explore a design proposition and generate with their engineering knowledge a virtual or physical prototype in only 24 hours.

3.2 Developing an effective and attractive design progress media

As the main objective of the event was to foster innovation it was excluded to propose a step to step guideline for the participants to follow to issue a prototype. As stated by [6] average young students spent less time reading, but more than 10,000 hours on digital media such as games, web, peer to peer programs. Taking into account those elements our focus was to propose a practical means to observe the innovation design development. The adopted solution has been to propose a web based application where participants have to register and login to participate to the design event as in common virtual environment. This proposed media had the advantage to procure a dynamic environment stimulating participants to report their project progress. The application allowed setting rules such as hourly reports by every participating team. Those reports have a double objective. First, they allowed participants to have a strategic overview of activities being operated in their projects. Second, they provided to the pedagogical team an online hourly review of the whole participating teams progress [7]. The application had two main objectives, to offer to the participants an adequate media to report their progress, and provide to the pedagogical team and exploratory observation tool on how participant innovate in 24 hours.

3.3 The web application

Students were asked to depict on an hourly basis activities they were operating so as to reach their project goals. 3 main columns resumed activities being operated in an hour:

Project Step

The steps were represented by a scrolling menu composed of nine possibilities. Each one referring to a project life cycle step, project planning, activity planning, specifications, conceptual analysis, solutions, embodiment, prototype, project costing, other.

Considered product aspect

This dimension describes on which product part the team was focusing in a specific hour, the possibilities were: Overall product, Specific part, Functionality, Design, Emotional factors.

Methods and tools used

On each steps a description of the methods and tools such as software's, specific methods like brain storming, calculations were to be illustrated.

The project step definition was adapted from classical project life cycle development [8]. The aim was to expose to the participants examples of product design phases, from which they can express how they consider the innovation design process. A text field was added so that they could explain what they meant by a specific phase, and how a specific phase contributed to the innovation process. The nine phases were designed to explore how participants manipulate those concepts to reach an innovative product design. One of the phases was "Other" to provide free expression and creation to the teams to describe their innovation project structure. Each adopted design process step was codified by a specific colour. In the web base application, a graphical table illustrated the structure of the design activity hourly, by representing different colour cell in each hour (Fig 2). We will focus on this particular aspect of the innovation design project structure by exploring the student's project configuration.

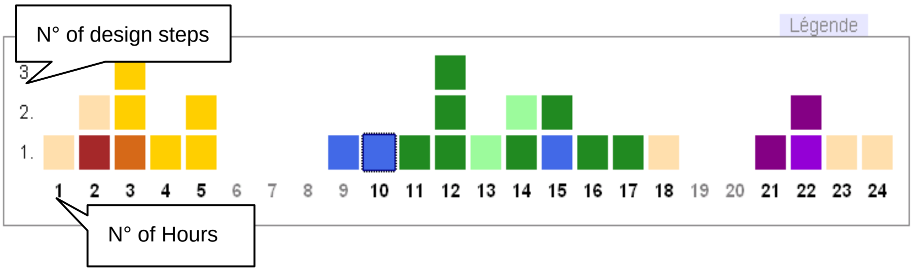

Figure 2 Example of team project steps configuration on 24 hours

3.4 Events results analysis

The general analysis of the 19 participating teams revealed that the most used project step to describe the design activities was "Other" which represented 22% of the total 622 expressed project phases (Table 1). The second most used step was "Solution" 21%, followed by "Concept" 16% and "Prototype" 12%.

Table 1 Total of expressed project phases

Project plan	Activity plan	Specification	Concept	Solutions	Embodiment	Prototype	Costing	Other
37	38	32	104	133	54	73	16	135

Among the 19 teams, 8 of them won specific "prizes". The prizes concerned the following factors being evaluated by an examiners panel composed of industrials and academics. Evaluation was based on the quality of the following aspects of the developed project: Jury trophy, 2 Best prototypes, Best design, Best presentation, best technological project, Best concept, Fun project.

A comparison of the used project steps among the winning teams and the other teams revealed that the most used activities were the same but in different proportions (Table 2). For the winning teams it was "Other" 27%, "Solution" 22%, "Concept" 16% and "Prototype" 10%, these percentages being calculated on the whole used activities 357 for the 1st teams and 265 for the others. The other teams focused more on "Solution" 20%, "Concept" 17%, "Other" 14% and "Prototype" 13%. The obvious difference among those teams is the number of activities launch in 24 hours. We can observe that the winning team structured their design project with other steps than the classical proposed ones. These results provide us with first facts on the behaviour of these teams participating in the "24 hours for innovation" game. Further investigations need to be operated to depict the specific design process configuration used to reach innovation objective. This exploratory tool allowed us to observe how the students interact with the web base application. Functions which stimulated their participation and the way they structured their innovation activity. For the next "24 hours for innovation" event we will update the tool to have a better understanding of the processes categorised as "other" that sustains innovation process.

Table 2 Project phases used by 8 winner teams v/s other teams

	Concept	Solution	Prototype	Other
Winner teams	59	79	38	98
Other teams	45	54	35	37

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