Assessing Creativity Aspects in Engineering Students’ Project Work

Authors:
Wakes Shlomo and Merdler Moti, Department of Education in Technology & Science Technion - Israel Institute of Technology, Haifa 32000, Israel  waks@tx.technion.ac.il Phone number: (972) 04 – 8293110/ 3842, Fax (office): (972) 04 - 8325445

Abstract — Qualitative research methodologies have become more commonly applied in science and engineering education. There may be different reasons for implementing qualitative instruments of inquiry, ranging from ideological factors, up to practical necessities whenever quantitative tools are inadequate. This article illustrates an array of both quantitative and qualitative methods for exploring creativity aspects, following students’ activity on a comprehensive project and producing a worthy artifact.

The study has been carried out in three disciplines, electronics, software engineering and marketing. Findings indicate that “Originality” is correlated to “system thinking” or “system approach” in the sense of using knowledge from other disciplines, while “Innovation” depends on the extend to which the application of a new idea is adequate and effective. Nevertheless, both “Originality” and “Innovation” require sufficient disciplinary knowledge to work upon.

Qualitative and quantitative methods of inquiry indicate similar and complementary explanatory factors related to creativity in engineering design.

Index Terms — creativity, project, innovation, methodology.

INTRODUCTION

Complexity of creativity and research methodology

Creativity research, or rather the search for creativity, extends beyond content domains and disciplines and as such it is more commonly studied in the latest decade. Competition and availability of advanced software and hardware have deployed a platform upon which creativity, in engineering design, could take place on a daily base. Perhaps it is not surprising that creativity research emerged in engineering education, since patterns of creative behavior resembles to that of developing an artifact. Nevertheless, profound methodological means of inquiry, regarding the phenomena of creativity and its complexity, have not yet been established.

Since the early sixties, as the necessity for creativity emerged as a major issue on the background of space exploration and the ‘cold war’, psychology researchers began to develop assumptions and theories about the nature of creativity. Normative means and tools for measuring creativity, especially creative ‘personality’ and creative ‘thinking’, were constructed and tested with extensive application in education. At the late seventies, creativity research had been divided into four categories: personality, process, product and place or environment. This categorization has since then been referred as the 4- P’s. Although creativity research in any category is essential for understanding creative behavior, still there is a call for investigating the relationship between the 4- P’s.

While manifested elements of the first two categories can be estimated by quantitative instruments and tests, still quantitative measurement of the creative “product” has no such way of estimation. Therefore a reasonably approach had been established that the assessment of a creative product should be performed by experts in their field [1]. Methodologically, this observation is important since the evaluation of a product or an artifact has ecological validity [4] and not only in engineering [6]. Consequently product’s embodied creativity and the expressed creativity of its producers is assessed by qualitative tools. Such observations and interviews often have a phenomenological meaning. Still, it is essential to raise the question of what are the appropriate circumstances in which it is more probable that creativity would take its course and should be assessed? (Or as Csikszentmihalyi suggests “where is creativity and not what?”). Since the essence of engineering is to design a useful product, therefore creativity should be evaluated during working on a project. Design has multifarious aspects that could contribute to understanding how creativity may be fostered. Factors such as motivation and personality, curricular and non-curricular knowledge, dependence on the instructor, divergent or lateral thinking during projects’ various stages and encountering time and resources limitation are in fact major factors which their influence could shed light on the ability to perform creatively.

Engineering projects may have different scopes and purposes. A certain group of high school students could engage a selected topic during which creativity fostering model, such as De-Bono’s Cort model, can be examined for its usefulness [2].
Students could work on a series of projects that become less and less constraint [7], and a project could have the scope and freedom of a summative engineering project during which various creativity aspects could be analyzed for their effect [9].

As we deal with many students that are engaged in wider projects, there is a greater importance as to which case should be deeply examined, presumably by qualitative in-depth interviews, so as to reveal more about the nature of creativity in engineering.

**Conceptual originality and engineering innovation**

Creative thinking that may pave the way to original ideas or solutions is insufficient in engineering design. Although an original solution to an engineering problem needs primarily sensitivity to gaps in information and knowledge, still it must be applicable and useful. This applicability is usually referred to as innovation and as such it could be evaluated only when the designed product is done and presented.

Riple [8] identified a consensus that creative expression in a technological society is acknowledged by novelty and adaptability. Kirscheaum [5], while describing a classification system to creativity components, estimates that a creative product is one that reflects originality and that is useful. Busmer and Traffinger (1993), after reviewing research literature and referencing criterions of a creative product, concludes that there are 3 major ones: novelty, resolution and elaboration with synthesis. Dither [3] even suggest two alternative patterns of a creative product evolvement. The first and somewhat the rarest is a sudden enlightenment and the more common – an aimed and gradual one, which according to Dither, demands well-based knowledge and precise thinking.

If we refer to working on a design project and producing an artifact, as the occurrence during which creativity most likely to be expressed, then we should evaluate two aspects. The first is whether the idea or solution is original in the sense that it expresses a new and unique necessity or approach to a problem. The second is whether the solution is efficient and applicable.

**THE STUDY**

**Comprehensive study**

The study examined aspects of creativity, within the advancement of a summative project work of practical engineering students in three disciplines: electronics, software and marketing. The study was conducted without any intervention of the researchers. From that point of view it has explored the nature of creativity as it is reflected in the field. The study examines the assumption that originality could be obtained by a system approach to the topic or problem at hand and that innovation requires compatibility and effectiveness. Findings indicate some bounds and conditions in which those assumptions are based.

Students that participated in the study, learned practical engineering between 1998 to 2001 in a college that is located in the northern region of Israel. Since the main goal of their study is application, they have to accomplish a major project work. Choosing the instructor and the actual project activities begun at the last semester and prolonged for approximately one year. After producing the product, which may be an artifact, instrument, applicable software or a marketing plan, they presented it to evaluators. Usually the presentation was carried out in front of students, teachers and instructors. Though none of them could ask or comment during the presentation, still the scene could be stressful for the presenter. The process of working on the project was assessed for creativity aspects through qualitative and quantitative methods of inquiry as described in table I.

**Experts’ assessment**

In particular, in this paper we describe the process of two experts evaluating the originality and innovation as it is reflected in projects’ product presentations in the fields of electronics and marketing, as well as presumed insights about the relationship between system approach and creativity.

Video recorded presentations were displayed to two experts in every field. The experts filled in an 8-questions questionnaire (see Appendix) for every presentation. The questionnaire included 3 taxonomic questions regarding the extent to which non-disciplinary knowledge was involved in the project (mentioning, using and successfully integrating non-disciplinary knowledge). Inter-correlations were examined between the experts (tables II, III). A Wilcoxon signed ranks test was performed in order to establish the concordance between the two experts (tables IV, V). During the evaluation, the experts were interviewed to determine reliability. After the evaluation, cluster analysis was conducted in order to decide upon which projects were most original and innovative. Based on this distinction. students’ presentations were analyzed and preliminary interviews had been conducted with both students and their instructors.

In addition, linear regression and multi-variance analysis have been conducted in order to identify factors that had influenced originality and innovation (tables VI - IX).
RESULTS

Electronics

According to Wilcoxon signed ranks test both experts concur up to the degree that there were not any statistically significant disagreement between them. Nevertheless, they disagreed upon the role of disciplinary knowledge to originality. According to the multi-variance analysis, this may be explained by a ‘threshold’ effect suggesting that disciplinary knowledge should be high enough to generate originality (figures I, II). Furthermore, this condition is an essential one but not sufficient and as seen in the analysis, successfully integrating non-disciplinary knowledge must be accompanied by high disciplinary knowledge (var2*var3*var4).

As to innovative ideas (var6), the experts hold the opinion that only an effective application of the project’s idea (var7) will cause novelty.

Observations’ analysis indicate supportive and complementary explanations.

Supportive explanations:
• The project examiners tend to refer to the complexity and challenging task that was taken by those who were identified as creative performers.
• Those students expressed their need for major non-curricular knowledge.

Complementary explanations:
• Those students were anxious to tell about the ways in which they had overcome problems during the project work while others (less creative) tend to blur their ways of problem encountering.
• The creative performing students declared their intention to work on unique and new ideas. This observation is important in the light of their disapproval from working on ‘recycled’ issues.

Marketing

Surprisingly, the lack of agreement upon the role of disciplinary knowledge to evoking originality had also emerged between the two marketing experts.

According to the linear regression, it seems that while originality (var5) relates to merely mentioning the need for knowledge (var1), still innovation in marketing is a rather composite goal. In addition to some, rather low but yet significant, need for non-disciplinary knowledge, innovative marketing plans demand profound disciplinary knowledge (var4) and need to be usefully applied (var7).

Observations’ analysis indicated similar students–examiners interaction.

Discussion

One of the main assumptions regarding this research was that a system approach to a problem or to an aimed product, would in fact facilitate opportunities to evoke original ideas and solutions. Although this assumption is reinforced by the analysis of the results, it still raises a picture that links system approach to innovation in engineering design. First, it does not only substitutes the need for disciplinary knowledge, it even aggravates that necessity. Secondly, it seems that there are some differences between disciplines as to the factors that could trigger innovation. While in the field of electronics innovation should be concerned only with the usefulness application of the artifact, in marketing innovation requires also a comprehensive view involving sensitivity to other fields interfacing with the marketing plane.

In order to establish a profound model and its nuances in different fields of design further research should be done.

REFERENCES


