DESIGN BY ANALOGY IN ENGINEERING EDUCATION: A METHOD TO IMPROVE CREATIVE IDEAS

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INTRODUCTION

• The so-called analogical reasoning gather several kind of ideation methodologies.

• Analogy is an important approach for creativity and innovation and consist in transfer the knowledge between different domains.

• It enables the generation of new ideas using other ideas taking from another places. Thus, the key point is the similarities between the new problem and the problem taking as similar.

• The knowledge generated in a previous problem is then used (or transferred) to generate a new solution. Both experts and novice designers can use this technique without training because is somewhat evident and intuitive.

• In the literature analogies have been classified based on the distance. Indeed, some similar ideas provide similar solutions to the problem under study. However, sometimes is necessary to explore other solutions that are used in very different applications.
DEFINITIONS

• Design-by-Analogy is a process that can be divided in five steps which are the following:
  • **Identification**, is crucial, and consist in the selection of all possible similar problems. Without good candidates, the subsequent steps may be useless.
  • **Retrieval**, two procedures are generally used to this aim. The first one is semantic-based retrieval where the semantic similarities between different objects are evaluated. The second one is the structural-based retrieval, where the engineering similarity features are compared.
  • **Mapping**
  • **Transference**
METHODOLOGY

• It starts with the source, which is the proposed problem and it is studied, recorded and stored in the memory. This phase requires establishing the main goal of the design, or in other words, the desire or what they really want.

• The next step is to retrieve the appropriate analogy. This step is often the most difficult because it depends on the student experience. Even expert engineers have limited knowledge and that can make the project fail.
WORD-TREE

• The objective of using the Word-tree method is to assist to the student in identifying analogies in other domains.

• The method begins by the definition of the main problem (desire) and their descriptors.

• These descriptors must be condensed by introducing simple words or verbs and they are related with the short phrases describing the desire.

• Brainstorming can be combined with the Word-tree method in some of its many variations (e.g. brainwritting).
CASE STUDY (1)

- The methodology was applied to engineering students in the third year design course during seven lectures of 50 minutes.
- Volunteer students were recruited and they were divided into groups or teams. Each team has between 5 and 8 students.
- They were given extra credits for the participation in the activity.
- A total of six teams were created in one course. A pre-lecture was given to all students before the enrolment.
- In this lecture the main goals and activities to be performed were explained to the students. The decision to follow the activity was taken by the students after the introduction.
CASE STUDY (2)

• In the second lecture, creative thinking and ideation methods are explained to the students.
• The next lecture deals with the Word-tree method and the different projects were assigned to the groups of students.
• This lecture ends with the application of the Word-tree approach to the current work.
CASE STUDY (3)

• The students working in groups represent the key problem descriptors using the Word-tree method. They are encouraged to use brainstorming (or brainwritting) to create sticky notes. The objective is to generate linguistic representation of the problem leading latter to the new ideas.
## RESULTS

<table>
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<th>Team</th>
<th>Analogies</th>
<th>Ideas</th>
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<tbody>
<tr>
<td></td>
<td>Close-domain</td>
<td>Far-domain</td>
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<td>2</td>
</tr>
<tr>
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</table>
CONCLUSIONS

• Understanding creativity and the generation of ideas in the context of education is essential for engineering students.

• Instructors should be able to foster creativity and innovation inside the classroom in order to create an awareness of creativity in the students.

• The instructor should promote the use of creativity techniques that are easily adaptable to the classroom conditions.

• To improve the solution the far-domain should be explored. In this case, Design-by-Analogy is a well-known approach that can be used in engineering. It is intuitive and it is not necessary long periods of training to use the method.

• This work provides an educational experience with engineering students where Word-tree design by analogy approach has been used.

• One of the main advantages of the method is that it can be systematic, and students can follow the step-by-step process. The results show how the method provides solutions in the far-field of creativity.