Design thinking (DT) for the design and planning education of engineer-architects

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ABSTRACT: Engineers are facing new challenges connected with globalisation, digitisation and the increased complexity of the design process. This calls for new, more interdisciplinary and user-oriented approaches to problem-solving. In this article, the authors analyse design thinking (DT) as a method to support the education of engineers specialising in architecture and urban planning. Identified in this study are the opportunities this method offers to solve design and planning problems, as well as the limitations of the method. It is based on experience gained, while conducting regional and urban planning courses for engineers in the Faculty of Architecture at Gdańsk University of Technology (FA-GUT). Gdańsk, Poland, The design thinking method is not a remedy for all design problems, but the user-centric, iterative and experimental approach that can help to prepare future professionals to conduct participatory design in the changing conditions of the modern world.

INTRODUCTION

The changing conditions and complexity of the modern world require new methods for the education of engineer-architects. There is a need to introduce new approaches to teaching to respond to globalisation and digitisation. Traditional domain-based knowledge and skills, although necessary, are no longer sufficient. Practitioners need to possess skills addressing *collaborative readiness, (…) negotiation of differences* and *management of conflict* [1].

Architecture engineering students at Gdańsk University of Technology (GUT), Gdańsk, Poland, already learn to solve design problems but in this article, the authors introduce the design thinking (DT) method for design problem-solving. The DT method was introduced to solve so-called *wicked problems:* that are so complicated the outcome is uncertain, but so important that they need to be tackled. Urban and regional planning problems often have such characteristics [2]. Consequently, the authors decided to use DT to support the education of engineers specialising in architecture, urban design and planning.

This imperative was analysed from two aspects:

1. the role of urban and regional planner, which is changing due to new challenges connected with complexity and globalisation;

2. the definition of engineers' work formats in these changing conditions.

In both cases, there is a need to build new skills and competencies, which allow future engineers to work in a rapidly changing environment to implement a user-oriented approach.

DESIGN THINKING TO SUPPORT THE EDUCATION OF ENGINEER-ARCHITECTS

Changing conditions call for a new approach to design. The work of the designer is less repeatable, because of new technology and the requirement to solve complex problems associated with the needs of society. But, there is also a need to become familiar with new tools such as artificial intelligence, 3D printing and virtual reality.

Design thinking is a method for defining and solving problems in a user-centric, creative and multidisciplinary way. It defines design as *a certain way of thinking and working.* Meinel and Leifers [3] enunciate four basic principles:

- *the human rule:* to satisfy users' needs;

- *the ambiguity rule:* accept failures (in line with the Ok2Fail principle);
- *the redesign rule:* envision the future by understanding the past (based on iteration back to earlier phases);
- *the tangible rule:* to facilitate communication using prototypes [3].

The main difference between DT and the traditional engineering and scientific approach is that problem-solving starts with a vision-goal definition instead of an investigation of the problem [4] (see Figure 1).

These principles are mapped by the five steps of the DT process as outlined by the Stanford d.school, which are empathy - define - ideate - prototype - test [5].

Figure 1: Identification of users' needs - empathy phase (Source: Authors).

The initial phase addresses users and other stakeholders, their needs, expectations and the context to define the problem from the users' perspective. This investigates how the needs are to be met and the problem solved (Figure 1). The ideation phase stimulates individual and team creativity to find a number of solutions to be prototyped and tested. It allows redefining solutions as further data and information are gathered. The process can be iterative, e.g. prototyping looping back to *ideate* or even *define*. This approach fosters experimentation, which will not always be successful. The DT method regards failure as an integral part of the design process.

The DT method is involves a wide range of tools that support:

- observations, interviews, diagnosis of situations (part of *empathise* and *define* phases);
- workshops and discussions (as a part of *prototype* and *test* phases).

The most important tools applied in the course were:

- *Persona building* - a tool to model, summarise and communicate research about the different users' types, considering not only basic characteristics, but also behavioural patterns, goals, skills and attitudes.
- *Value proposition canvas* - this tool is a part of the business model canvas, which helps to design products and services to answer users' needs. It helps to define value propositions in a more structured and reflective way (developed at Walt Disney Productions during the early 1930s).
- *Story boards* - a tool that displays the thinking process in sequence, in the form of illustrations or images. It is often used for the purpose of pre-visualisation.
- *The lotus blossom technique* - a creative-thinking technique to help produce *outside-the-box* thoughts, but also to organise thinking around significant themes and to explore a number of alternative possibilities and ideas [6].

EDUCATION OF ENGINEER-ARCHITECTS TO FACE NEW CHALLENGES OF THE BUILT ENVIRONMENT

The education of future engineers needs to be based on solid foundations within the discipline of architecture, including both the body of knowledge and the methods used to solve design problems. Such knowledge and skills form the basis

for future professionals to have confidence in their abilities [6]. However, excessive specialisation can lead to a *silo* effect and a closing-off within the discipline [7].

New problems, both in theory and practice often occur at the *edge* of a discipline and require an interdisciplinary approach [8]. Avsec and Ferk Savec stress the value of interdisciplinarity for critical thinking in engineering design, and hence, there is a need to teach students the skills supporting this approach [9]. To do so, the concept of the T-personality is useful.

Introduced by the IDEO (Innovation Design Engineering Organisation) company's Tim Brown, the *T-shaped* individual has *…a depth of skill that allows them to contribute* to the design process, but also has *…the disposition for collaboration across disciplines.* T-shaped competencies possess two kinds of characteristics corresponding to the two parts of the letter *T* (see Figure 2).

The vertical stroke indicates the level of competencies within the person's own discipline, including both knowledge and skills. The horizontal stroke of the *T* represents the disposition for collaboration across disciplines, an approach that allows a problem to be perceived from another person's perspective [10].

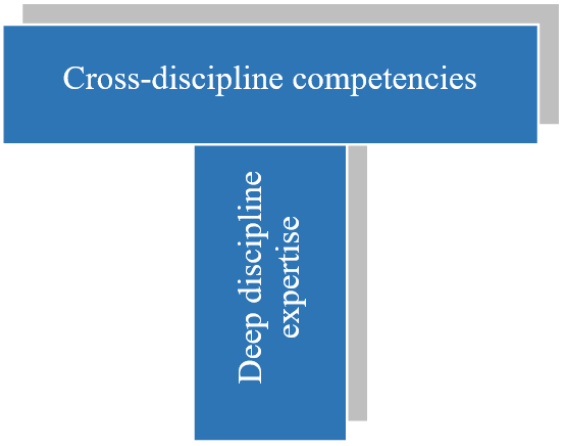

Figure 2: T-personality diagram [5].

At Gdańsk University of Technology, an engineering school, the curriculum is being transformed to respond to *changing* trends and conditions [11]. An example of such an approach is in the regional and urban planning courses, which allow students to work with real-world problems from design praxis and develop the soft skills needed by an urban and regional planner.

STRATEGIC DEVELOPMENT OF KNOWLEDGE DISTRICTS IN GDAŃSK AND PORTLAND

The DT method was introduced at the GUT to teach planning and architectural engineering students to solve metropolitan design problems. It was implemented for regional and urban planning courses for the fifth and sixth semesters of undergraduate studies. This allowed students to see different possible approaches to solving *wicked* design problems. The aim was to teach students design and planning skills allowing them, in future, to work on the creation of spatial strategies responding to societal needs.

Students of the fifth semester of undergraduate studies worked on the creation of a spatial micro-strategy for the University of Gdańsk Baltic campus, treating it as an element of the metropolitan strategic development area and future knowledge district. In the following year, sixth-semester undergraduate students worked on a micro-strategy leading to the transformation of an industrial district in Portland by introducing a knowledge-based economy into the area. There were several goals to the teaching strategy, to:

- develop hard and soft skills and competencies;
- teach students to conduct participatory research to investigate users' needs;
- show and encourage the use of user-centric tools in planning and spatial management.

The teaching format included a four-hour workshop to introduce the DT method. Weekly meetings were held during the semester. The work undertaken included:

- field studies: such as gathering information and data for the empathy phase;
- design work: based on iterative prototyping (Figure 3).

a) b)

Figure 3: Examples of various designs: a) prototyping - Portland Central Eastside District; and b) fast prototyping - students of engineering studies, specialty spatial planning (Source: Authors).

STRENGTH AND LIMITATIONS OF THE DESIGN THINKING METHOD

As this teaching format is based on a student-centred approach, the teacher's role was limited to mentoring. The project was especially challenging for students as teachers were only facilitating the process and not providing solutions. Students needed to leave their comfort zone and embrace uncertainty to become creative in looking for solutions.

The problem-based approach meant that students were given aims to achieve and possible tools but were not given answers. Students needed to define problems, analyse possible tools and find solutions, while the teachers only advised on the scope of the tools [6]. This teaching format allowed the creation of innovative solutions for a better quality built environment (Table 1).

Table 1: Strengths and limitations of the design thinking method.

Strengths of the design thinking method	Limitations of the design thinking method
• Solving problems under rapidly changing conditions. • Solving complex *wicked* problems. • Collaboration, co-operation and consensus building. • Experimental: look for improved, refined solutions (iterations) through being open-minded and accepting failure. • Solutions answering the needs of society (user-oriented), real-life problems. • Facilitating communication using prototypes.	• As a new method, still not fully recognised as a valid way to conduct the design process. • Needs a change of mindset to accept experiments and failures. • Design phases, with possible iterations: usually longer than in the classic design approach. • Demanding for students: leaving comfort zone, embracing uncertainty, creative solutions. • Strongly defined strategy systematising the work-flow; may pose restrictions on the design process, limited flexibility.

As is shown in Figure 1, at the same time there are several limitations of this method. Design thinking is a strongly defined strategy, which systematises workflow, so its implementation poses restrictions on the design process and sometimes does not allow enough flexibility for a specific project. Acceptance of failure and iterative prototyping in DT may be difficult to incorporate into a classic university course, where there is rigid timing and need to distribute workload throughout the semester. Empathy and problem-defining phases, with possible iterations, are usually longer than design phases in the classic design approach.

CONCLUSIONS

In engineering studies, competence building in solving real-life problems is of the utmost importance [12]. Future engineers need to possess domain knowledge - to be competent professionals - but their work also needs to be a response to societal needs [13]. Engineering education should teach future architects and urban designers to conduct planning and design that is:

- informed;
- human-centred;

- based on qualitative values and goals;
- produces a liveable urban environment.

There is a need to transform teaching curricula, so that students gain such skills. Design thinking as an iterative, user-oriented method is a tool to support this process.

This method may be challenging for students who need to learn tools for user-oriented design and to use them to solve real-life problems. They learn not only to answer the needs of users, but to co-design with users, to listen to all stakeholders and also to be aware of their role as an expert [6]. That is why the DT method can produce better solutions to complex technical problems as compared to conventional approaches [14].

The design thinking method, though demanding and lengthy, helps develop solutions that better answer the challenges of today. As such, it is a valid methodology supporting the education of future engineers.

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