EFFECTIVE INITIATION TO CDIO FRAMEWORK USING DESIGN-THINKING: The D-I-C-O PROCESS

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ABSTRACT

In the context of a changing world, engineering education is stressed to create new learning concepts and delivery modes adapted to the 21st century challenges. Therefore, instructors as the key building blocks of the corresponding education system need to engage in a reform process to develop innovative educational solutions. In this perspective, the CDIO framework has proven its maturity, as a vehicle, for guiding comprehensible and effective reforms in engineering education. Thus, emphasis should be placed on introducing more faculty to this effective framework in a way that captures their interest and stimulates their motivation for change, while experiencing the CDIO standards strengths. Generally, faculty can access CDIO in a self-directed exploration mode by either gaining knowledge in a passive manner from the CDIO approach book, the annual conference proceedings, and the CDIO initiative website, or by participating actively to the annual international conference activities and regional meetings. However, these means require a strong commitment of time, efforts, and resources to be able to gain a working knowledge of CDIO standards necessary for a good implementation. Therefore, to trigger the willingness of prospective collaborating faculty to engage in these solutions, it is convenient to introduce them to CDIO in a practical and pleasant way. Therefore, there is a need to turn CDIO key elements into an actionable activity to let faculty acquire directly active use of CDIO knowledge. This work addresses this need by proposing an educational design workshop for educators based on a new design process, referred as D-I-C-O process, which stands for *Discover-ideate-create-operate*. The D-I-C-O design process leverages on the power of visualization and prototyping of Human-centered design approach to incorporate CDIO standards. The design workshop is intended to plunge faculty in an enjoyable design activity to create or redesign educational solutions. Thus, this work aims to bring a straightforward design process and activities for educators to build new and efficient educational solutions based on the knowledge and practices from the CDIO framework.

KEYWORDS

CDIO; Human-Centered Design; Engineering education; Education reforms; Standards 1, 9, 10.

INTRODUCTION

Implementing the CDIO approach is an opportunity for engineering education institutions to better prepare future engineers to the new job market (Crawley, E. F., et al. 2014). Therefore, there is a need to raise awareness about the strengths of the framework and to motivate faculty from non-collaborating universities to apply the approach. To do so, educators need to be introduced to CDIO in a way that captures their interest in the approach and stimulates their motivation for change.

Practical introductory experiences are the best fit for this purpose. Indeed, hands-on activities are an effective form of engagement in new topics. Through explorations and concrete representations, a practical activity enables the participant to experience the knowledge and foster the acquisition of skills in the topics involved in the experience (Mazini, S. R. et al., 2018). On the other hand, human-centered design (HCD) methodologies provide a comprehensive structure to investigate a topic framed as a problem. The exploration, visualization and prototyping characteristics of the method allow the designer to gain understanding about the problem and provide tangible solutions (IDEO, 2019).

In this view, this work seeks to harness the strengths of human-centered design to develop a hands-on design activity for educators around CDIO key elements. The proposed activity is in form of a local workshop for faculty from non-collaborating institutions. To design the workshop, an adapted design process, named D-I-C-O for *Discover-ideate-create-operate*, was developed based on both CDIO and HCD rational. The proposed process aims to guide faculty in developing solutions -using the CDIO approach knowledge- for a given challenge related to engineering education at their institution.

This paper starts first by giving a short overview of HCD that highlights the strengths of the method in education. Second, a presentation of the D-I-C-O process and its associated workshop is detailed. At last, a summary of the paper is provided.

HUMAN-CENTERED DESIGN

Applying human-centered design to address complex challenges has been widely used during recent years (M. Garreta-Domingo et al. 2018). Different industries, including education, applied the approach to improve the experiences of end-users (Lee, C. H., Lee, L., & Kuptasthien, N. 2018).

The potential of HCD lies in its ability to address the three spaces of a design challenge as shown in Figure 1. It balances the needs of customers -the student in the context of education- in the need space, with the study of possible solutions, taking into account existing resources and eventual limitations in the solution space, while it considers capturing value for both stakeholders and design team in the value space (Brown, T., & Katz, B., 2011). In the context of education, we consider that the need space is composed of both the personal needs of students, that are related to their interactions with the learning environment, and the intended learning outcomes (ILOs) that they are foreseen. Visualization and prototyping are also strength points of the method (Mais, V., 2020). Designers are able to better structure their reasoning through visual representation of information collected with respect to the mentioned three spaces.

Figure 1: The three spaces of a design thinking challenge for education.

THE PROPOSED APPROACH

In this section, an explanation of the process that is developed for the suggested DICO design activity is provided; and a detailed structure of the proposed workshop, for initiation to CDIO, is described.

D-I-C-O Design Process

Building on the rationale of HCD and CDIO processes, we developed the D-I-C-O design process, which stands for *Discover-Ideate-Create-Operate*, to initiate faculty to the CDIO approach in a practical way. Figure 2 illustrates the proposed design process.

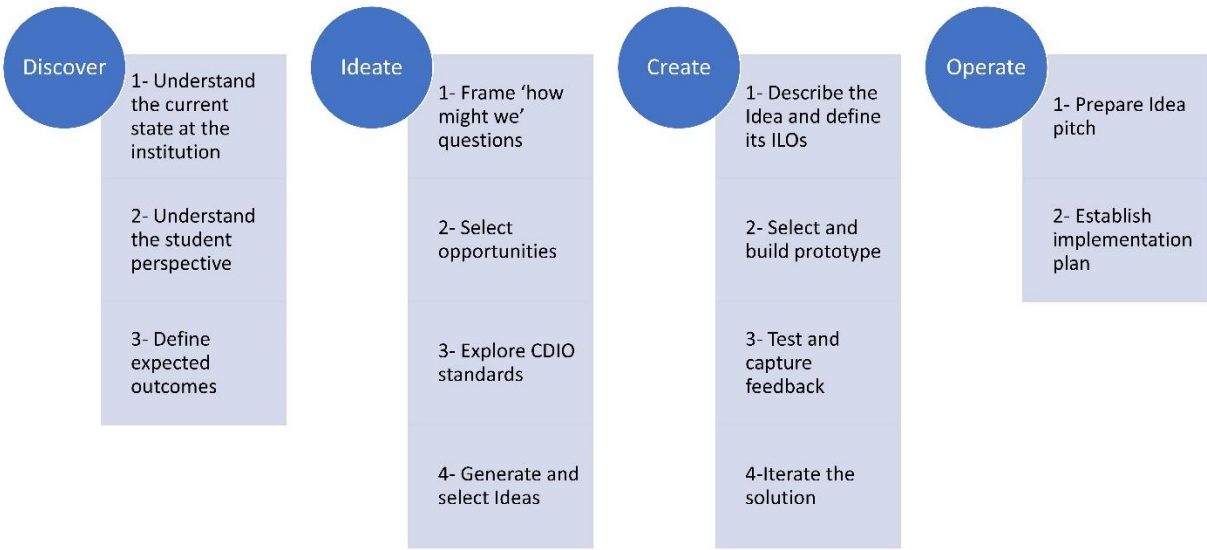

Figure 2: The proposed D-I-C-O process.

In the Discover phase, educators need to understand the current context of the problem. For that, we suggest to make an internal research to identify the existing solutions, the available resources and the constraints. Second, the educators need to capture students' perspective. For that, we suggest conducting interviews with students and potential stakeholders. Educators could also observe the reactions and interactions of the students in the environment related to the challenge. As the critical requirement for developing effective education solutions is to create learning experiences built around student acquisition of knowledge, skills and attributes, we propose exploring the CDIO syllabus (standard 2) to define the learning outcomes that the challenge is intending to achieve (ILOs). This phase is aligned with the Need space of a design challenge (Figure 1).

In the Ideate phase, educators are required to, first, analyze information collected in Discover phase, formulate opportunities in the form of actionable insights using the HCD tool *"how might we + the need"* questions and select interesting opportunities. To generate ideas for selected assumptions, educators need to leverage existing solutions to generate wide range of ideas that might address the new opportunities. For that, we propose exploring the CDIO standards to enable educators gain knowledge on existing solutions with effective practice in engineering education. We recommend providing a visual representation of the standards to facilitate the exploration (Figure 3). Instructors can also benefit from brief presentations of adapted solutions and cases' studies from CDIO collaborating universities. After this step, educators can proceed to generate ideas and select promising ones based on the identified constraints and resources in the previous phase. With reference to the three spaces of a design challenge (Figure 1), this phase aims to combine the Need Space and the Solution Space.

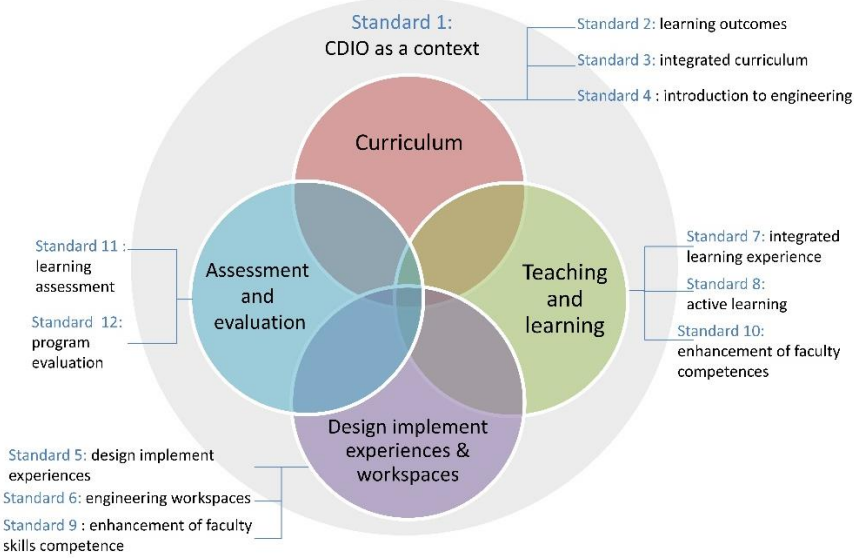

Figure 3: Example of visual representation of CDIO Standards.

In the Create phase, educators are required to make ideas tangible for testing. Different types of prototypes can be built depending on what requirements the instructor is willing to test. Educators need then to test the prototype and capture feedback. After that, designers can reflect back on possible iterations and identify needed resources to fine-tune the solution.

In the Operate phase, educators need to consider engaging external support and building partnership for successful future implementation. To get ready for the transformation of the concept into a deliverable solution, they are required to pitch their solutions to stakeholders

and potential partners, and prepare an implementation plan. This phase is aligned with the Value Space of a design challenge (figure 1).

D-I-C-O Design workshop

To engage faculty in a pleasant design activity around the CDIO approach, this part presents a workshop structure that is based on the proposed DICO process. For this activity, faculty members need to work in teams of 3 to 4 professors to address a certain challenge defined by the workshop facilitator. The proposed workshop is made of 6 phases and is designed for a total duration of 4 days. Figure 4 illustrates the workshop structure and the estimated time for each phase. Participants are provided with two types of material throughout the workshop: visual templates for each phase to facilitate the teamwork, and documentation to support the design activity. In the following, we describe each phase of the workshop (figure 4);

Introduction

In the first phase, participants are briefly introduced to the CDIO approach and teams of educators are created. Afterward, an Icebreaker activity is organized with the aim of facilitating interaction and communication between participants. Workshop facilitators can decide on the icebreaker activity depending on the type of participants. Teams are then introduced to the DICO design process and the challenge that will be addressed. The challenge is presented as an initial problem statement that clearly defines who is involved in the challenge and what is his need. To formulate the challenge statement, we suggest starting the sentence with a verb followed by the opportunity and the target user -student in this case- then the need behind the challenge (e.g. "*Find a way to stimulate the interest in engineering for undergraduate mechanical engineering students so they can use the engineering principles to solve simple problems!")*.

Discover

The application of the design process starts in the second phase; The "Discover" phase require participants to undertake internal research. For that, they have to reflect together as a team and fill out internal research template provided by the facilitator. For the interviews, we suggest that the facilitator prepares a list of contact interviewees beforehand. Participants need to agree on the observation activity and use the provided template. Next, teams are given the CDIO syllabus, at the second level of details, in addition to a template and are required to select the intended learning outcomes depending on the needs identified previously. Given that interviews and observations might require time for getting sufficient results, we propose to introduce participants to interviews during the workshop session, and set extra-hours for conducting further research.

Ideate

In the "Ideate" phase, the new opportunities are formulated using a template for the "How might we" question framing methods. Participants then filter opportunities according to criteria retrieved from the internal research. Afterwards, teams are provided with a CDIO standards map (Figure 3) to explore the CDIO guidance and define where the framed opportunities fit in the CDIO standards sections (i.e., curriculum, teaching and learning, assessment and evaluation, design implement experience and workshops) (Figure 3). Participants are also given documentation about case studies to serve as an inspiration for participants. A SWOT analysis (Strengths, Weaknesses, Opportunities and Threads) for CDIO case study is an optional task that can be conducted in this phase to enable participants understand the strengths of the approach and help towards ideation. The next step is to brainstorm ideas and

select promising ones based on feasibility and relevance. At the end of this phase, teams are required to share their key learnings from the CDIO standards exploration.

Create

In the “Create” phase, selected ideas need to be described in a way that explains how the idea satisfies the intended learning outcomes that were established in the “Discover” phase. A template for idea description can be used for this purpose. Likewise, for prototyping, it is demanded to describe what the prototype is intending to test and how test will take place. The workshop facilitator needs to make prototyping material available. For the test session and iteration, participants can involve people from previous interviews to get their feedback.

Operate

The objective of the Operate phase in the workshop is to initiate participants to first steps of an implementation process. At this level, teams need to present their ideas to guest colleagues as partners for the idea execution. For that, they need to prepare a pitch that explains the idea and highlights the value for the student, the invited colleagues, and the participant himself. To do so, teams are given a documentation to help them prepare the pitch. Later on, they are provided with documentation about the guidelines for successful implementation of new solutions from CDIO approach and resources that are required to prepare an implementation plan based on the CDIO guidelines (i.e., organizational change, Standard 9 and 10) . To facilitate this step, a template for implementation can be provided.

Join CDIO

In the last phase, the workshop facilitator presents successful examples of implementation of the CDIO approach in similar contexts to the host institution. Explanation is also provided to participating faculty about how to join the CDIO initiative.

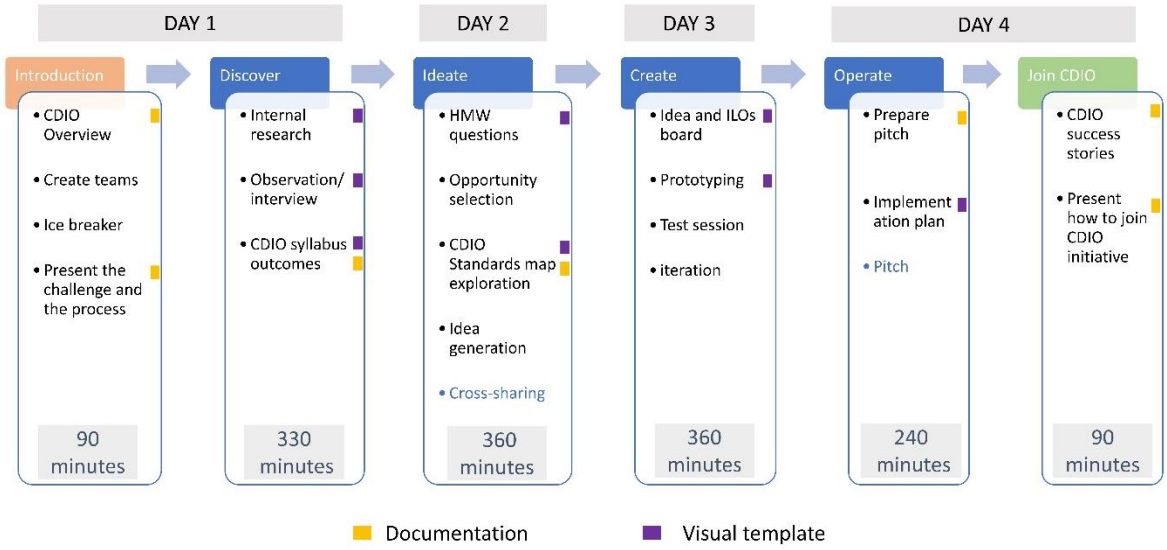

Figure 4: DICO workshop structure.

CONCLUSION

Involving faculty members in the change process for engineering education is an essential key for the intended effective reform. It is therefore necessary to introduce them to innovative transformational initiatives as the CDIO approach. Is this work, we have presented a hands-on design workshop that is proposed based on CDIO elements and Human–centered design rationale to initiate faculty from prospective collaborating universities to the CDIO approach. In perspective, the proposed concept of the workshop and its respective DICO design process will be tested locally with educators from Sidi Mohamed Ben Abdellah University in order to collect qualitative data for further improvement of the concept.

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BIOGRAPHICAL INFORMATION

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