CDIO IN THE DESIGN OF A NON-ENGINEERING PROGRAM

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ABSTRACT

Integrating the core areas of the health, natural, social and management sciences, the Master in Development Practice program P.PORTO will provide students with the substantive knowledge and practical skills required to analyze and diagnose the multi-dimensional challenges of sustainable development such as extreme poverty, climate change and infectious disease. It is part of a global network of similar programs and it involves faculty from all P.PORTO schools, as well as external organizations.
The design of such a multidisciplinary program is a challenge. Though it is not an engineering program, one of its educational objectives is the practice of a problem solving and development process. Thus, it was decided to leverage on ISEP's experience with CDIO and use it to support the MDP program design.
In this paper, it will be provided a short description of the program and its objectives and it will be explained how CDIO was used in the program's design process.

KEYWORDS

Development Practice, Sustainable Development Goals, Program Design, Pedagogical Patterns, Standards: 2, 3, 5, 7, 8

INTRODUCTION

The Polytechnic of Porto (P.PORTO) is a Portuguese public higher education institution created in 1985 by joining several independent higher education institutions, some of them over 100 years old. Instituto Superior de Engenharia do Porto (ISEP) is a 164 years old engineering school and has been a member of the CDIO Initiative since 2008. With over 18500 students P.PORTO is the largest and most highly regarded Polytechnic in Portugal. It stands out for its ability to instruct young people with the knowledge necessary for the working market, able to contribute to economic development with a high sense of social responsibility.
This institution stands out for its interdisciplinarity, covering a wide spectrum of scientific knowledge, such as Engineering, Music and Performing Arts, Education, Accounting and Administration, Management and Technology, Health, and Tourism.
P.PORTO also has a long history of collaboration and support of Non-Governmental Organizations (NGOs), both in Portugal and in Africa.

The Master in Development Practice (MDP) intends to be an interdisciplinary master degree program offered by P.PORTO's that prepares students to better identify and address the challenges of sustainable development. This MDP program consist of two years of coursework in four intersecting macro disciplines areas - health, natural, social, and management sciences -- combined with cross-sectorial field training. The program is scheduled to start in the 2017/2018 school year with a maximum of 25 students.

The MDP program will be a part of the global network of MDP programs offered by universities and collaborating organizations and have been developed according to recommendations outlined in the final report of the International Commission on Education for Sustainable Development Practice (2008). It is led by the Earth Institute of the Columbia University, New York. CDIO members Tsinghua University (China) and Trinity College Dublin (Ireland) already offer MDP programs in this network.

PROGRAM OVERVIEW

The MDP program is designed for: Generalist development practitioners; Specialist development practitioners; Policy administrators and policy professionals; Private-sector professionals and Educators.
Integrating the core areas of the health, natural, social and management sciences, the MDP program will provide students with the substantive knowledge and practical skills required to analyze and diagnose the multi-dimensional challenges of sustainable development such as extreme poverty, climate change and infectious disease.

The two years MDP curriculum includes:

- Core courses in the health sciences, natural sciences, social sciences and management sciences;
- Global Classroom: Foundations of Sustainable Development Practice (FSDP) course that fosters cross-border and cross-disciplinary collaboration;
- Electives or additional credits in the core courses;
- Field training experiences that provide students the opportunity to gain first-hand experience of integrated development approaches within the real-world context;
- Intensive pre-MDP preparation where students may need to take additional courses if they have not fulfilled prerequisite requirements in areas such as chemistry, biology, economics, math or statistics.

Global Classroom: Foundations of Sustainable Development Practice (FSDP) is a blended-learning course that fosters cross-disciplinary collaboration and allows students and teachers from around the world to participate in collective assignments and learning experiences. Global Classroom was initiated at the Earth Institute, Columbia University, in 2008. The first edition addressed a broad range of core issues, including health, economics, policy, agriculture, ethics, and education. Students from around the world are assigned the same readings and then can join their classmates for live sessions with global experts.

CDIO CONTRIBUTION TO PROGRAM DESIGN

It is a challenge to design a program with so many different people involved, so we resorted to CDIO to provide the framework for program design and operation. Though it is not an

engineering program, the core of MDP is a problem solving and project development process, i.e. CDIO. The full stack of CDIO standards was applied in the MDP program design.

Syllabus

The MDP program follows some general guidelines common to all MDP programs in the network, especially covering many of the UN Sustainable Development Goals (SGD). As such, each host HEI's can customize their program to meet local needs and objectives. Since the MDP program it is not an engineering program and has quite broad objectives, more akin to a social sciences one, the extended CDIO Syllabus 2.0 (Crawley et al., 2011) was used as template for the program's syllabus. No major changes were needed in section 2 and 3.

Section one was structured according to UN Sustainable Development Goals, instead of Math, Science and Engineering subjects. The 8 schools delivering the program defined two sets of priorities, i.e. a subset of SGD goals the program should focus on: one short term, to be immediately in the program; and long term, that they expected to start being covered or partially covered in a 5-year time-frame. So, section one has two subsections, one with core SGD goals and one with supplementary goals.

Regarding section 4, subsections 4.3 to 4.7 focus on the Conceive-Design-Implement-Operate in an engineering perspective, thus they had to be adapted to the broader objectives of the MDP program. Direct references to "Engineering" were removed and the content trimmed. Subsections 4.5.2, 4.5.3 and 4.5.4 were eliminated.

Integrated Curriculum

The MDP program-s curriculum is depicted in Figure 1. It includes 3 types of courses:

- Personal and interpersonal skills (blue) – Management Science I, Management Science II, Global Citizenship and Education and Contemporary Global Problems.
- Disciplinary knowledge and its application in professional engineering (red) – Global Health and Development I, Global Health and Development II, Engineering for Sustainable Development I, Engineering for Sustainable Development II, and two elective courses.
- Product, process, and operating skills (orange) – Foundations I, Foundations II, Field Practical and Thesis/Internship.

The program's curriculum is structured so that the student continuously improves its competences and skills in dealing with the challenge of addressing UN SGD's. Following a spiral approach to curriculum design, the first semester is focused on analyzing problems and identifying solutions; the second encompasses designing a plan for action and manage its implementation, including assessment; and the third extends to plan implementation and operation. Each semester builds on the previous ones, fostering curriculum integration.

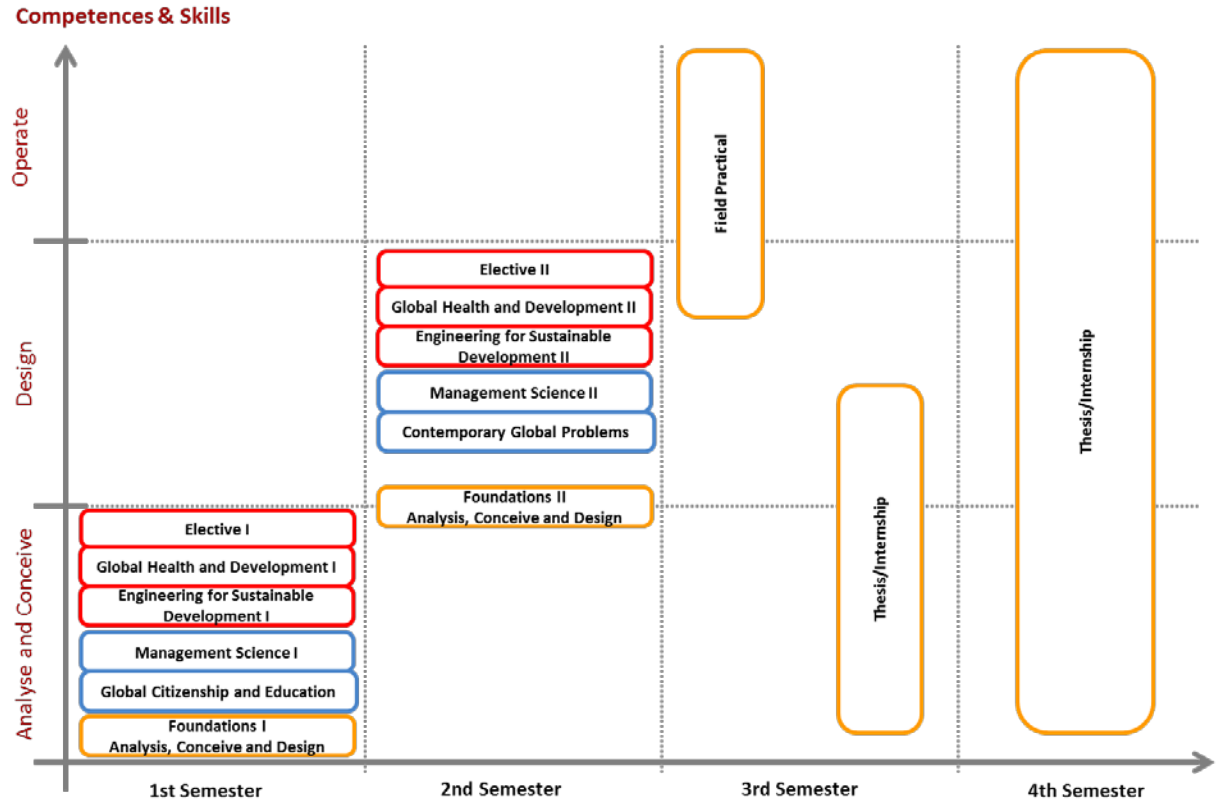

Figure 1. MDP program's curriculum

Design-Implement and Integrated Learning Experiences

The MDP program's learning process uses the experiential learning model (Kolb, 1984). As such, the product, process and operating skills courses are paramount for the learning process, as they provide the student the opportunity to work in real challenges and apply the knowledge and skills acquired in the other courses. The Foundations I and II courses provide two especially interesting design-implement experiences, as there is the possibility that students from multiple MDP programs across the world can create multidisciplinary teams and collaborate in solving a challenge.

Field Practical combines practical work in an organization, where the student will experience firsthand the challenge of implementing a real project in a real organization, with critical assessment and brainstorming. MDP students participate in "hands-on" field-training sessions of up to three months' duration. Beginning after completion of the first academic year, they constitute a structured, "clinical" training program, giving students the opportunity to gain first-hand experience of integrated development approaches in a real-world context. Students may work in Africa, Asia, or Latin America, for example, in teams dedicated to solving development challenges. With careful input from collaborating MDP organizations, appropriate development projects for students to join are identified. Site visits, meetings, lectures, and other academic events are examples of activities that may be organized to complement the students' fieldwork.
Students, on completion of their field training, reflect on their experiences, prepare a consolidated field-training report, and may provide recommendations for addressing the complex development challenges that they encountered in the field. They offer a

comprehensive analysis of local conditions, explain possible measures for reducing poverty, and suggest a roadmap for working toward sustainable development.

The program management is quite aware that the implementation of this integrated learning process is a challenge, but the program is expected to have a maximum of only 25 students per year.

Active Learning

MDP program lacks the strong disciplinary content of a traditional engineering program. The program aims to combine social sciences, management and engineering to provide the student the tools to solve problems in a challenging multicultural environment. In this context, the program aims to have students with diverse backgrounds and regards this as an asset to be exploited in the learning process. Therefore, the learning process is mostly based in active learning methods, but also includes some project based learning.

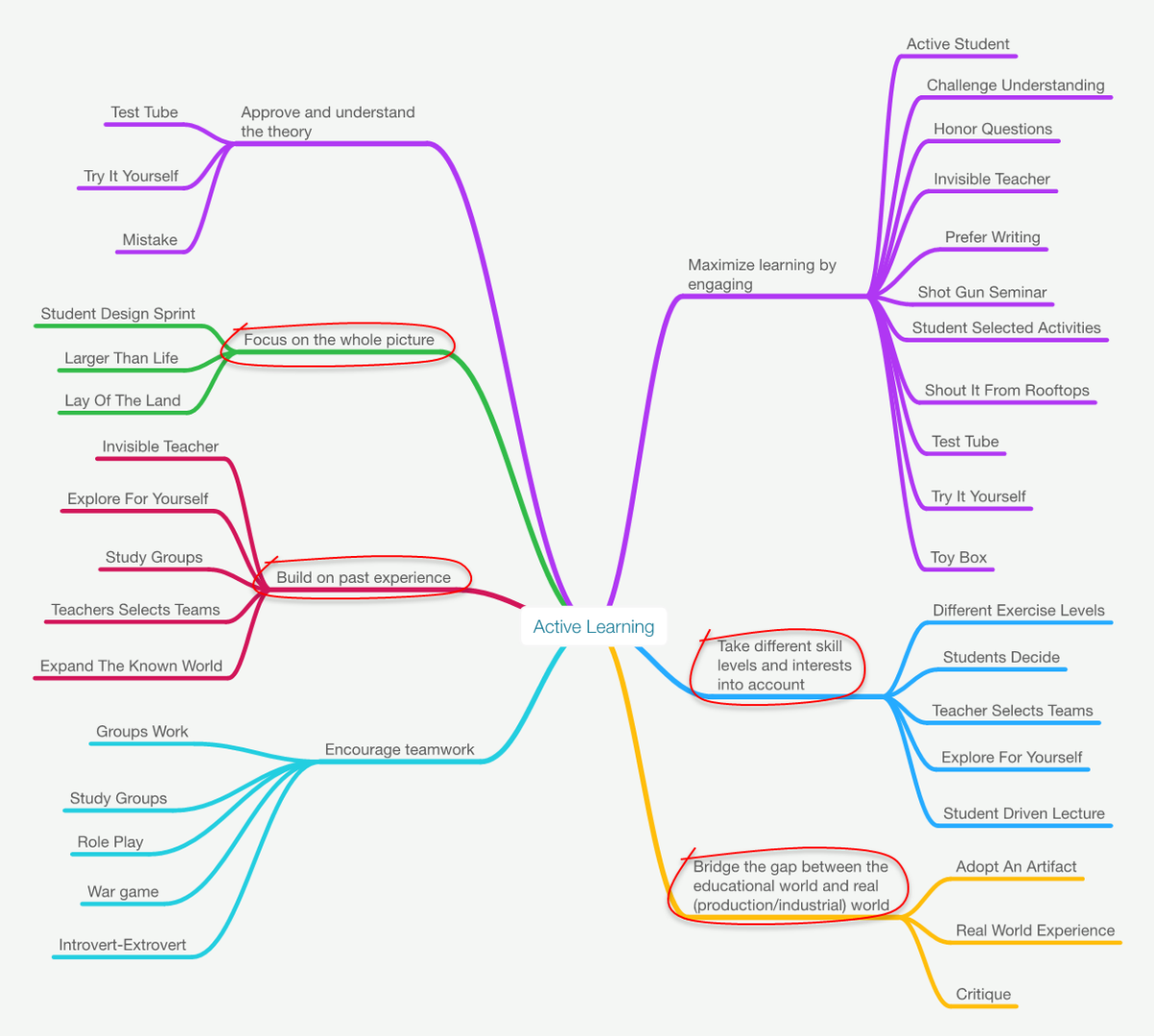

Figure 2. Active learning pedagogical patterns mind map

Active learning means different things to different people, so that it would be useful to have a reference/catalog for active learning methods. The Pedagogical Patterns Project (PPP) has produced the book "Pedagogical Patterns Advice for Educators" (PPEB, 2012) to try to capture the expertise of teaching practice/learning in a compact form that can be easily communicated to those who need the knowledge. Many of the pedagogical patterns in the book are focused on active learning. Figure 2 provides a mind map of the active learning patterns in the book.

The MDP program management used the ISEP framework for pedagogical patterns' use (Martins et al., 2016) to identify pedagogical patterns classes/subclasses and a few wide-ranging patterns (e.g. Embrace Correction**) that should be dominant in the program. They act as pedagogical guidelines the faculty should use when designing the courses' learning processes. The active learning pedagogical patterns classes/subclasses to be promoted in the MDP program are highlighted in Figure 2.
This approach doesn't mean that all patterns in class should be used or that patterns in another class can't be used. These are mere guidelines. The actual set of all patterns to be used in a course may be dependent on a lot of factors (e.g. subject, student background experience and knowledge, project characteristics, etc.) and may even evolve during the course in order to improve learning effectiveness.

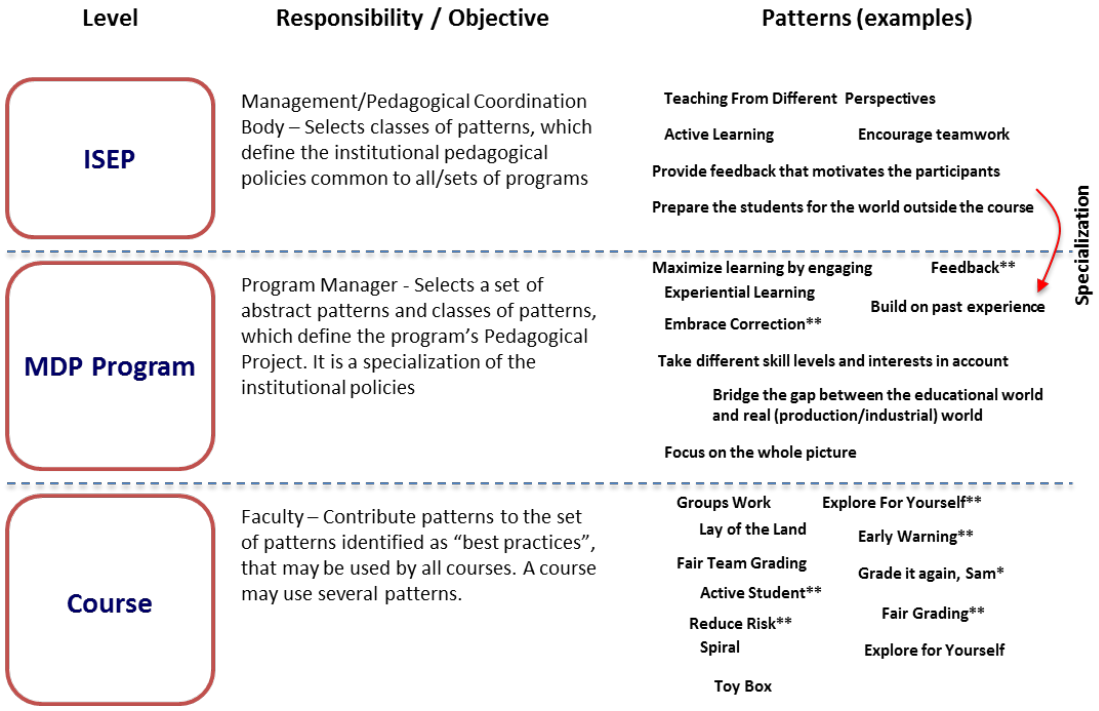

Figure 3. MDP program's pedagogical patterns

The set of reference pedagogical patterns classes/subclasses and pedagogical patterns in the MDP program are depicted in Figure 3. At institution level, the definition of policies for a program or encompassing multiple programs is a key instrument for pedagogical coordination. The indication of pedagogical patterns classes considered "best practices" helps translating the documented policies and objectives into comprehensible implementation goals, but still generic and flexible at the implementation level. A program's pedagogical approach is a specialization of the educational policies of the institution. At this level, one should resort to pedagogical patterns classes/subclasses and, possibly, to a few

wide-ranging patterns. At the course level, pedagogical patterns are used to describe the operational implementation of different types of classes and assessment. Though the set of used patterns may not be restricted the classes of patterns defined for the course and the institution, it is natural that most patterns will fall within these classes.
The pedagogical patterns classes/subclasses and pedagogical patterns in the MDP program reflect the multidisciplinary nature of the program and aims at to leverage the diverse background and aims of the students.

CONCLUSION

We can conclude that it is possible to apply the CDIO framework to support the design of a non-engineering program. Some adaptations were required, especially in sections 1 and 4 of the CDIO Syllabus (v2.0), and standards 4 – Introduction to Engineering - and 6 – Engineering Workspaces - were not used. Standards 9 to 12 were out of the scope of this phase of the project, but they will be used in the operation phase of the program.
Faculty from non-engineering schools had no problem in understanding CDIO and were even eager to use it, especially the Syllabus. Some of them were familiar with active learning and experiential learning, so they found the use of the CDIO framework quite helpful.
ISEP pedagogical patterns framework was also used to foster the design of a coherent learning process involving faculty from so many schools.

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BIOGRAPHICAL INFORMATION

Eduarda Pinto Ferreira, PhD. She is an Auxiliary Professor of Mathematics at ISEP - Instituto Superior de Engenharia do Porto, Portugal. PhD in Optimization. Chairman of 1st CDIO Iberian Workshop (ISEP), March 2011. Chairman of the 3rd ESICUP Meeting (EURO Special Interest Group on Cutting and Packing), international conference in Porto (ISEP), March 2006. Member of the Scientific Committee of JBLE-09 (Jornadas Luso-Brasileiras de Engenharia), Porto (ISEP), February 2009. President of ISEP's Pedagogical Council between 2010 and 2014. President of the NGO IPP Solidário since January 2016. Attended almost all CDIO conferences since 2008 and lead the organization of the 2016 Fall meeting in Porto

Ângelo Martins, PhD. He is an Auxiliary Professor of Computing at ISEP - Instituto Superior de Engenharia do Porto, Portugal. Since 2008 has been the program manager of the Informatics Engineering BScprogram, the largest ICT program in Portugal, which is EUR-ACE accredited. He is the scientific coordinator of the Computer Graphics and Information Systems unit of INESCT TEC, the Portuguese largest research lab on computing and electrical engineering with over 1000 researchers. He is also the national representative on the European Commission Digital Skills and Jobs Sub-Group. He is CDIO enthusiast and has been involved in CDIO since 2008.

José Carlos Quadrado, PhD. He is a full professor with tenure and is currently the immediate past-President of ISEL and the Vice-President of ISEP.
Holds the position of past-President of the International Federation of Engineering Education Societies (IFEES) and the position of past president of the Ibero-American Engineering Education Association (ASIBEI). Currently he is a President of the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI) and a member of the board of the European Society for Engineering Education (SEFI). He is also a past-Vice President of SEFI.
He leads the Portuguese Observatory on European and Latin-American University management strategy best practices (TELESCOPI Portugal) and is the past-President of the Portuguese association of engineering deans (APDI2E).
He was a member of the general assembly of the European Network for Accreditation of Engineering Education (ENAEE), and has been actively supporting the development of accreditation agencies in Central Asia and Latin America.

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