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THE USER INNOVATION TOOLKIT: PROJECT-BASED LEARNING FOR NON-DESIGNERS

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ABSTRACT
Increasingly, higher education is turning towards project-based learning as part of its curricula. Concurrently, there has been increasing attention given to the ways in which designers typically solve problems, popularized under the term 'Design Thinking' with several commercial and educational efforts to present non-experts with tools to apply design thinking in their own organizations. Yet, as a review of these tools illustrates, while comprehensive in nature, they provide novices with an overwhelming number of tools and techniques, making it hard for non-experts to apply. To this end, we have developed an online wizard, intended for use by novice non-design students that provides a curated selection of tools to support students in project-based learning, with an emphasis on end-user involvement. The toolkit follows an iterative approach, with checks on whether intermediate requirements are met (i.e.: problem definition, knowledge of the user or stakeholders). Our article will present this toolkit and its use among a group of students who did not follow a traditional design education (n=18). We expand on the rationale for the toolkit and reflect on the results of the evaluation.

Keywords: User innovation toolkit, project-based education

1 INTRODUCTION AND BACKGROUND

Recent years has seen the proliferation of project and problem-based education (PBL) [2, 12]. While the terms *problem* or *project*-based learning are often used interchangeably under the acronym PBL and nuanced differences exist between these two approaches, they also align by virtue of a focus on achieving concrete outcomes. Specifically, project-based learning aims at the development of an artefact (i.e.: the design of something) while emphasizing integration of theory and practice [17]. Given the emphasis on materialization, project-based and problem-based learning has often been the focus of engineering and design related fields (i.e.: computer science [10]). For engineering education specifically Peschges and Reindel [15] argue that project-based learning (or project oriented education) is an effective way for students to amass the skills demanded by industry. Nonetheless, this philosophy has seen broader adoption, including in healthcare education [20] or entrepreneurship [8].

Concurrent to the rise of interest in project-based learning, there has been increased attention given to the ways in which designers solve problems, popularized under the term "Design Thinking" [1]. While the term and its application has come under scrutiny and criticism in recent years [11], there remains an interest from traditional non-design disciplines to apply tools used by designers in their respective domains. Most specifically, there is an interest in using more iterative, experimental or prototype focused modes of work to achieve innovation goals [7]. Central to this idea is the need to be more empathic towards users, while abstaining from a stage-based or waterfall decision taking model, to iteratively prototyping and testing solutions [11]. Design thinking's close association with project-based learning can be partly ascribed to its adherence to practice and the associated emphasis on concrete outcomes [9, 14].

As part of this flourishing of design thinking, several (online) toolkits have been developed and released to present non-experts with tools to apply design thinking in their own organizations or projects, or at least offer ways of emphasising with end users through the application of a variety of tools commonly used by designers. To illustrate, Roy and Warren performed a systematic review of card-based design

tools and identified 155 different offers of toolsets [16]. Specific examples include IBM's Enterprise Design Thinking Toolkit [6] or the Design Thinking Bootleg by Stanford d.school [5]. Other examples do not necessarily invoke the term design thinking. These include IDEO's Design Kit [3], Service Design Tools [18] or the Design Method Toolkit [4] but they contain broadly similar tools. These range from cultural probes, "A Day in the Life", paper prototyping or personas.
Often available both as online index of tools, pdf booklets or real printed books, these toolkits offer a broad range of tools, throughout different phases of the innovation or design process. While thus presenting a wealth of information and comprehensive in nature, they simultaneously suffer from being broad in scope. To illustrate, Service Design Tools [18] offers 32 distinct tools across four categories, while the Design Method Toolkit [4] contains 60, with each tool falling in two categories. For a non-expert population, this broad array of tools is a challenge, given that students lack the prerequisite knowledge to pick the appropriate method at the right time.

2 TOOL REQUIREMENTS

Given the above mentioned rise in interest for project-based learning in university education, with an accompanying interest in tools that facilitate this process, we set out to develop a toolkit that offers students an essential point of departure for realising their project-goals, with a specific emphasis on involving end-users.
To do so, we had informal interviews (n=5) with staff from several non-design departments, including computer science and mechanical engineering. These interviews support the assertion made previously that project-based learning is more frequent. A typical example might be developing the layout for the necessary IT infrastructure for an elderly care facility. While most of the work relies on theoretical and technical knowledge about network infrastructure, this project also involves real stakeholders and end users (i.e.: nurses, inhabitants, maintenance workers, visitors).
They might thus have to rely on generating user requirements and subsequent prototyping or visualisation of ideas within a domain that traditionally focused much more explicitly only on technical requirements. For students who are not accustomed to involving users, this often poses a challenge. Beyond this, lecturers have limited scope as part of their existing curriculum to teach additional skills.
Furthermore, concerns for staff ranged between the lack of time in the current curricula to expand their course to discuss – for example – persona development. Simultaneously, they emphasize the need for more codified structures to assist students in their innovation goals, while having a low threshold of use. In relation to this low threshold of use, lectures emphasise the need for practical tools that are self-contained (i.e.: there is little need to consult external literature).
Based on these interviews, we thus identified a few key requirements. First, the proposed toolkit should focus on novices. This constitutes most of the user-group, while more advanced students are best served by more advanced tools. A second related requirement was that the toolkit and accompanying tools need to be self-contained, needing to further explanation and guide them through their project.

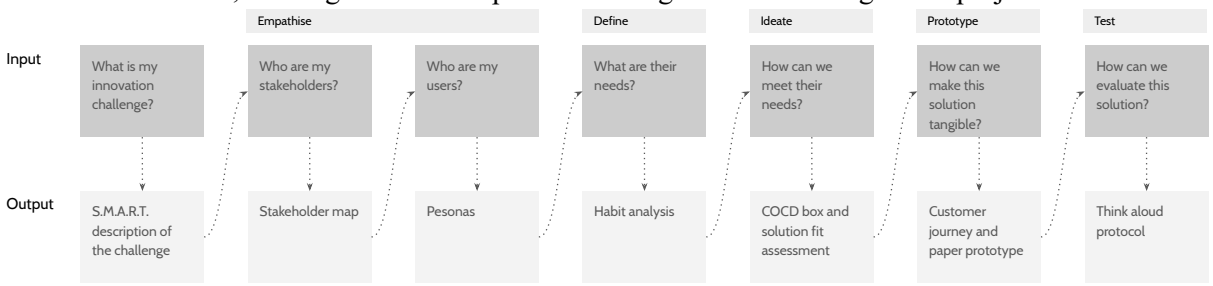

Figure 1. Overview of tools

Using an existing set of circa 70 tools [13], a selection of 9 essential methods were made. The selection of these tools was based on both their ease of use for novices and their flexibility of use. They were:

1. S.M.A.R.T. description of their challenge
2. Stakeholder mapping
3. Personas
4. Habit analysis of persona
5. COCD box to generate ideas
6. Must Should Could Won't (MoSCoW) evaluation to assess the fit solutions
7. Customer journey to further explore ideas

8. Paper prototype to materialise ideas
9. Think aloud protocol to evaluate their paper prototype

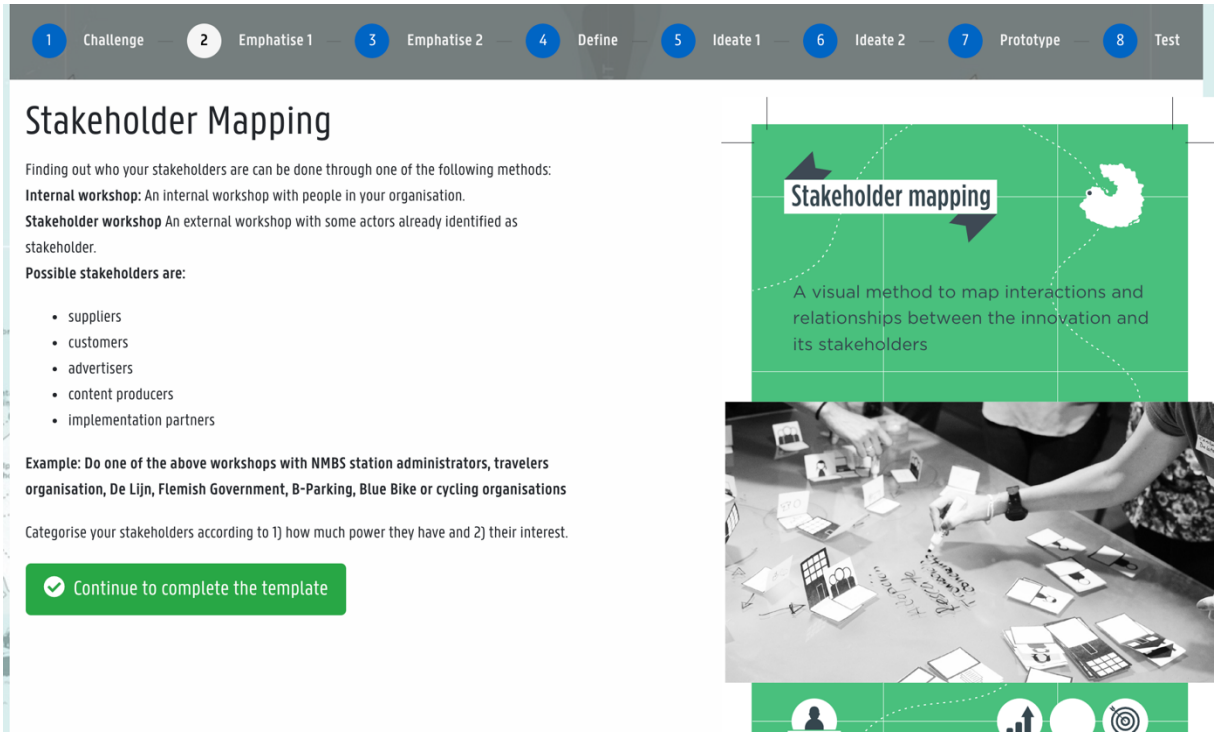

Figure 2. Stakeholder mapping as tool

Following this selection, we proceeded with an online wizard containing the selected tools. As noted, the emphasis was on end-user involvement and the toolkit follows an iterative approach, with checks on whether intermediate requirements are met (i.e.: problem definition, knowledge of the user or stakeholders).

More specifically, at each step participants are asked to confirm whether they have the prerequisite knowledge to answer the questions related to the relevant step or tool, giving them more detailed information if this is not case, while offering them a PDF template if they are confident in their ability to answer the questions related to the task (see Figure 1). The rationale for this somewhat waterfall-based approach is that it allows students to start using the tool from anywhere in their design process, while still allowing them to repeat steps, if necessary.

For example, to create a persona, knowledge is needed about the types of stakeholders involved in the project, while ideation is a prerequisite for prototype development.

3 TOOLKIT EVALUATION

To assess this tool, it was integrated as part of a module for a management and leadership course for (early or mid-career) engineers. Attended by eighteen students, the module focused on the development of a new product or service for an existing shoe-brand, incorporating current technological or societal trends. Participants were thus all professionally employed, with a background in civil or industrial engineering, with ages ranging from late 20s to early 50s. None had traditional industrial design education.

Concretely, during a one-day workshop, participants were presented with several existing technological or social trends (i.e.: 3d manufacturing, one day delivery, on demand manufacturing and personalization, sensor integration into various consumer products). Participants were randomly assigned to one of five groups and asked to develop an idea for a new product or service for a specific target audience, while incorporating one or more of these technological or societal trends. Groups ranged between 3 and 4 participants.

In a regular university course, students would have more time to gather data about their target audience. In our case limited time made this a challenge. To alleviate this, participants were given existing data for their personas, consisting of five distinct profiles of Flemish digital consumption, derived from yearly

report on technology and media consumption in Flanders [21]. This data could be used to develop their persona with each team being assigned one media consumption profile. While profiles were assigned, groups were free to choose a technological or societal trend.
Time constraints also limited the steps to 1) stakeholder mapping, 2) personas, 3) habit analysis, 4) COCD to generate ideas, 5) problem solution fit and 6) customer journey, with actual prototyping and testing falling outside the scope. After completing their assessment of user needs and ideation fit, teams could present their results.

4 DISCUSSION

Before we discuss our experience of using the tools, we note a few limitations. While the selection of tools for this toolkit was derived through a combination of interviews with lecturers and own experience, they were not subjected to any quantitative or objective criteria (i.e.: ease of use). Furthermore, we present a severely limited set of tools to students. This limitation – while being an essential component of the toolkit – thus also limits its use for more complex projects. In its current iteration it also does not provide information on more fundamental skills such as performing interviews or contextual observations.
Additionally, through its evaluation as part of an intensive module, the toolkit was not used for an extended time-period and no pronouncements can be made about its longer-term usefulness or its value for persons who are not novices. In relation, while our evaluation was useful to understand the general value of the developed toolkit, it is not a quantitative evaluation of the toolkit's effectiveness. As a result, it is unclear what (if any) longitudinal effects about its use is present, while the sample size of both the groups (n=5) and students (n=18) precludes any quantitative assessments of the effectiveness, including comparisons between groups.
Recall that students were introduced to several existing technological trends (3d manufacturing, one day delivery, on demand manufacturing and personalization, sensor integration into various consumer products) and tasked with developing a service for an existing shoe brand to using one of these trends and for a specific type of user. An example case was the development of a buy-on-demand personalised shoe, specifically for persons with some technological scepticism. Specifically, feet measurement was performed in-store and given the persona's limited willingness to engage in technology (i.e.: limited smartphone use) the emphasis was placed on the store experience as opposed to a digital only customer journey.
Looking first at the selection of tools, personas were viewed particularly positively, allowing participants to ground assumptions about their product or service around a narrative derived from their specific persona. However, this might also be the result of providing students with rich data to complete their persona. Nonetheless, using personas was especially helpful, since they were often relied on throughout the proceeding steps, acting as check for assumptions. This highlighted the importance of establishing an empirical basis for decision-making, which in our case was the data provided to craft the persona.
Beyond this, the assessment of user needs and ideation fit was also received well. Specifically, we applied the MoSCoW categorisation [19], whereby features or user requirements are individually rated as either Musts, Should, Could or Won't, thus forcing a prioritisation of different features, using the personas as basis for this decision. This step was additionally helpful, given that it facilitated discussion within teams about how important various features are in relation to their earlier research.
Finally, the customer journey was similarly helpful in visualising ideas, while also reflecting on how users will interact with different touchpoints and through different stages of interaction with the service (i.e.: awareness, delivery, etc.). Specifically, it helped students to specify the actions of users throughout each stage of their interaction with product, but also to assist their thinking of how users might encounter a product before and after a purchasing decision.
While these experiences of using each individual tool is valuable, our main aim was to introduce a simplified toolkit for novices. Based on the experience during the course we found that in time constrained contexts it was helpful that the toolkit itself avoids discussions about which methodological approach might be the most appropriate or fitting. For novices this was additionally helpful since they were confronted with several new challenges simultaneously and not knowing exactly what type outcomes they might expect from a tool. By removing that uncertainty, students could focus more on the content of their challenge as opposed to getting impeded by discussions about which tools will be most appropriate. We noted no dissatisfaction to adherence to the prescribed flow or selection of tools,

however, this might be the result of students first encounter with tools such as personas or stakeholder analysis, with students having a limited capacity to compare tools.
A further noted benefit, beyond the limited tool selection, was the linear-like process flow with options to take a step back if assumptions are not met, or new information became available. This allowed students to build on derived insights, but as before, guiding them towards which specific tool to apply next, as opposed to offering a variety of options across different steps in the design process. As illustrated in Figure 1, there is a clear sequentially of the tools, which makes it clear how different insights build on each other, finally reaching the prototype phase.

5 CONCLUSIONS

To conclude, in this article we described the rationale, development and evaluation of a simplified toolkit for use within project-based education, with a special emphasis on user involvement. Our rationale was that existing tools, while thorough and comprehensive, are often a challenge to use for novice students. Following interviews with lecturers, we made a selection of 9 tools, which could be used in a wizard-like process flow, while still enabling iterations, in case certain assumptions (i.e.: who is the target audience) are not met.
Overall, our qualitative assessment (n=18) was positive. Given the simplicity of the flow, students could easily complete the templates, especially since a single tool was suggested for each step in the innovation process, without being able to deviate.
Nonetheless, while the current toolkit was explicitly designed for use by a novice audience, further development could focus on expanding the selection of tools, but as initial step asks participants what their experience level is. Furthermore, we currently provided only printable PDF templates to complete the challenge. This could be augmented by digital templates, so knowledge can be more easily captured. Finally, as noted earlier, the core of the toolkit current exists of 7 tools. Further evaluation could point out whether this current selection was appropriate, or whether a different combination of tools offer more flexibility.

REFERENCES

[1] Buchanan, R. 1992. Thinking Wicked Problems in Design Thinking. *Design Issues*. 8, 2 (1992), 5–21.
[2] Conradie, P.D. et al. 2016. Prototyping Tangible User Interfaces: Case Study of the Collaboration between Academia and Industry. *International Journal of Engineering Education*. 32, 2 (2016), 1–12.
[3] Design Kit: The Human-Centered Design Toolkit: 2018. *https://www.ideo.com/post/design-kit*. Accessed: 2018-06-12.
[4] Design Method Toolkit: 2020. *https://toolkits.dss.cloud/design/*. Accessed: 2020-02-12.
[5] Design Thinking Bootleg: 2020. *https://dschool.stanford.edu/resources/the-bootcamp-bootleg*. Accessed: 2020-02-09.
[6] Design Thinking Toolkit: 2020. *https://www.ibm.com/design/thinking/page/toolkit*. Accessed: 2020-02-10.
[7] Glen, R. et al. 2014. The Need for Design Thinking in Business Schools. *Academy of Management Learning & Education*. 13, 4 (Dec. 2014), 653–667. DOI:https://doi.org/10.5465/amle.2012.0308.
[8] Hynes, B. et al. 2010. Practice-based learning in entrepreneurship education. *Higher Education, Skills and Work-Based Learning*. 1, 1 (Oct. 2010), 16–28. DOI:https://doi.org/10.1108/20423891111085366.
[9] Johansson-Sköldberg, U. et al. 2013. Design Thinking: Past, Present and Possible Futures. *Creativity and Innovation Management*. 22, 2 (Jun. 2013), 121–146. DOI:https://doi.org/10.1111/caim.12023.
[10] Kay, J. et al. 2000. Problem-Based Learning for Foundation Computer Science Courses. *Computer Science Education*. 10, 2 (Aug. 2000), 109–128. DOI:https://doi.org/10.1076/0899-3408(200008)10:2;1-C;FT109.
[11] Kolko, J. 2018. The divisiveness of design thinking. *Interactions*. 25, 3 (Apr. 2018), 28–34. DOI:https://doi.org/10.1145/3194313.
[12] Lehmann, M. et al. 2008. Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education. *European Journal of*

Engineering Education. 33, 3 (Jun. 2008), 283–295. DOI:https://doi.org/10.1080/03043790802088566.
[13] De Marez, L. 2018. *User Innovation Toolbox*. Pelckmans.
[14] Parmar, A.J. 2014. Bridging gaps in engineering education: Design thinking a critical factor for project based learning. *2014 IEEE Frontiers in Education Conference (FIE) Proceedings* (Oct. 2014), 1–8.
[15] Peschges, K.-J. and Reindel, E. 1998. Project-Oriented Engineering Education to Improve Key Competencies. *Global Journal of Engineering Education*. 2, 2 (1998), 181–186.
[16] Roy, R. and Warren, J.P. 2019. Card-based design tools: A review and analysis of 155 card decks for designers and designing. *Design Studies*. 63, (2019), 125–154. DOI:https://doi.org/10.1016/j.destud.2019.04.002.
[17] Savery, J.R. 2006. Overview of Problem-based Learning: Definitions and Distinctions. *Interdisciplinary Journal of Problem-Based Learning*. 1, 1 (May 2006). DOI:https://doi.org/10.7771/1541-5015.1002.
[18] Service Design Tools: 2019. *https://servicedesigntools.org/*. Accessed: 2020-02-23.
[19] Stapleton, J. 1997. *DSDM: Dynamic Systems Development Method: The Method in Practice*.
[20] Tiwari, A. et al. 2006. A comparison of the effects of problem-based learning and lecturing on the development of students' critical thinking. *Medical Education*. 40, 6 (Jun. 2006), 547–554. DOI:https://doi.org/10.1111/j.1365-2929.2006.02481.x.
[21] Vanhaelewyn, B. and Marez, L. De 2018. *DIgimeter 2018: Digitale Mediatrends in Vlaanderen*.