Board 124: Work in Progress: A Framework to Develop Project-based Platforms to Support Engineering and Technology Education: Project Development Canvas

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Motivation

It has been well established that using hands-on projects in a class, connecting course concepts with real-world applications, provides experiential learning that greatly benefits the students in the course [1], [2], [3]. With the increasing use of projects in engineering and technology courses and previous work that was established to design a course structure around the use of an in-class project [4], the need now is to have a structure in place that helps instructors through the process of designing the project itself. Historically though, some potential adopters of in-class projects are reluctant to go through the development process for that project. Studies have identified specific barriers, reported by these potential adopters, that keep them from wanting to take on this process [5]. Those barriers include:

- Lack of resources from administration
- Not valued by administration
- Non-positive student response
- Lack of evidence
- Too much prep time
- Too much class time

The framework outlined in this paper is intended to not only describe the process of developing a course project but also give those who are interested in a course project the tools and guidance to overcome any potential barriers, thus increasing the chance of more instructors implementing a course-associated project.

BMC As a Template

In order to develop a framework that gives a detailed description of the project development process for an engineering or technology course, the Business Model Canvas was used as a base structure. The Business Model Canvas (or BMC) is a tool used by industries worldwide to create an initial business model [6]. It is a blank framework that is comprised of nine individual "blocks." The nine blocks include:

- Customer Segments - The customer(s) the company is trying to reach.
- Value Proposition - The product for that customer(s).
- Customer Channels - Ways in which they will connect with the customer(s).
- Customer Relationships - Focuses on the processes of getting, keeping, and growing the customer base.
- Key Activities - Essential actions needed to make the BMC operate successfully.
- Key Resources - Most important assets required to make the BMC operate successfully.
- Partners - Other companies or groups that help make the BMC operate successfully.
- Cost Structure - All costs incurred while executing the business model.
- Revenue Streams - How the company will make money from the customer segments.

By going through the process of filling out the blocks, the user iterates and refines the details in each block to converge on a complete and sturdy business model.

Project Development Canvas

The Project Development Canvas, or PDC for short, is the method created to detail the various steps required to develop a project for a course. Like the Business Model Canvas, the PDC is a visual framework comprising nine distinct blocks, each detailing a different portion of the process. Unlike the Business Model Canvas, however, the PDC is pre-populated with all the information on each respective section to be used as a reference guide, or a "roadmap", to guide the user through the process instead of a blank form that is filled out iteratively. The PDC framework is shown in Figure 1. The intent of the PDC is to provide the user with all the information necessary to navigate the process and, in doing so, help them overcome the possible barriers by removing the uncertainty and intimidation of an unknown process. The PDC not only covers developing a brand-new project from the ground up, but also updating or replacing existing projects. The process is mainly geared towards creating a project "kit," where every student (or group of students, depending on the needs and limitations of the class) is provided with all the necessary parts and components, and then as part of the course is required to build and use the project. However, in addition to class kits, the PDC can be used to develop other systems for a course, like testing demonstration devices. Below are short descriptions of each of the blocks in the PDC.

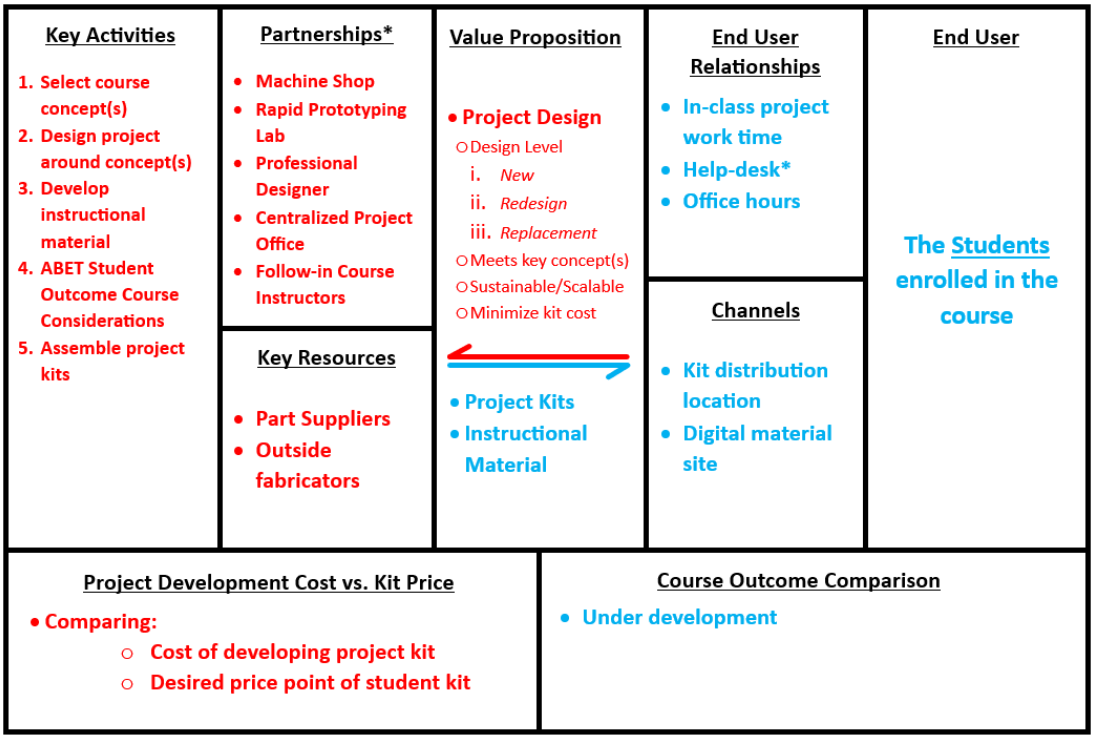

Figure 1. PDC Visualization

End User. Since this process deals with creating a project for a university course and not creating a commercial product, the end users (or "customers" in the case of the BMC) are the students who will be taking the course and interacting with the project.

Value Proposition. This block, like the corresponding block in the BMC, is the product that the user of the model is producing. For the PDC, the product is the project being developed through

the process defined in this model. As stated above, there are three possible versions of a project design discussed in this process: a new project design or a redesign or replacement of a current project.

In addition to the project itself, the individual (or individuals) developing the project will need to also develop the associate learning and instructional material that goes along with the project. This includes instruction on assembly, usage, and testing. More detail on the instructional material is covered in a later block.

Channels. The channels for the PDC, like that of the BMC, are the methods by which the products are provided to the end user. This includes the manner in which the kits are distributed to the students, in the case that a project kit is used, as well as how the instructional material is provided to the students. In most cases, the instructional material distribution is already established for a course. Based on the number of students and the size and complexity of the project being developed, special consideration may need to be given to how the parts and projects are stored, managed, and distributed.

End User Relationships. This is one block that deviates significantly from the BMC. In the BMC, this block is mainly concerned with the methods by which the company will get, keep, and grow its customer base. However, that is not a concern with a university course where the "customer" is the students. In this case, this block in the PDC will provide details about how the instructor interacts with the students. This covers how the students will get assistance with the building, troubleshooting, and usage of their projects. This includes in-class project work time, options for help outside of class time, and instructor office hours.

Key Activities. This block of the PDC is the main description of the steps needed in order to develop the project. The details included are what serves as the main informative portion of the model and what acts as the "roadmap" to guide the developer. This block describes each of the following processes in detail and guides the developer through each step. This block includes:

- Selection of course concept(s)
- Design of a project around the selected course concept(s)
- Developing instructional material
- Assembly of project kits
- Incorporating ABET student outcomes

The last bullet in this list can be performed as a parallel path to this process. In this step, the developer has the opportunity to incorporate student learning outcomes listed in Criterion 3 of the ABET Criteria for Accrediting Engineering Programs by designing the project and course lab around the applicable ABET criteria [7].

Key Resources. Like the BMC, this block of the model describes in detail the possible resources that may be required to successfully develop and implement a project in a course. Most likely any project being developed for a course, whether it is a kit, testing device, or demo unit, will need some level or quantity of commercial parts. This could include raw materials, screws, sensors, motors, etc. This will require the developer to select some outside parts vendor to supply what is

necessary to develop and implement a project. At this point in the development, mindful selection of vendors and parts can result in cost savings.

Another resource that may need to be selected, again based on the scale and complexity of the project design, is an outside fabricator. This can include services like machine shop services (CNC, laser cutting, etc.) or additive manufacturing like 3D printing. Again, cost needs to be carefully considered when selecting one of these services.

Partners. This block identifies some possible partnerships that can be used during the development process, to help design, fabricate, or manage the projects. At this point it's very important to mention that, while the partnerships described below can help the process, limited access to these sources should not be prohibitive to going through the process of developing a project for a course. When dealing with a project that is more complex or distributed on a larger scale, these partners may be beneficial or necessary, but that may not be the case for every situation. Even a small-scale, simple project can be extremely beneficial for the students.

While it may seem very similar to the previous block, the partners differ from the resources in one key aspect. Where the resource is simply a source from which parts or components are purchased, the partners are the people or groups that one would work with to assist in the development process. Some examples of possible partnerships are:

- Machine shop
- Rapid prototyping lab
- Professional designer
- Follow-on course instructors
- Centralized project office

Project Development Cost Analysis. This is the first of two blocks that are suggested methods to assess the success of the development process and determine if any adjustments need to be made. This block simply looks at the comparison of the cost of development, fabrication, and distribution of the project and compares that to a desired or pre-determined cost limit.

In the case of a project kit, the cost of developing each kit is compared to the desired price that the students will be charged for the kit, which should generally be kept to a minimum to make it accessible to all students. Comparing that price point to the development cost of the kit will determine if the design of the project or the selection of certain parts and components needs to be revisited. The kit cost should be determined by combining all the development costs (which will include design, fabrication, and parts costs) and dividing that out by the number of kits required for the course.

Course Outcome Analysis. This section is still in development. This section aims to provide an assessment method that looks at the project's impact, developed through the PDC, on the students' understanding of the pre-defined course outcomes. Some measures being considered for assessment are course-specific student learning objectives and/or ABET student learning outcomes.

Future Work

The PDC will continue to be developed and assessed for its effectiveness. Specifically, assessing the impact of the PDC in reducing perceived barriers to implementing projects in courses by faculty. Additionally, plans for evaluating the PDC's effectiveness in helping to develop projects are planned. To disseminate the PDC process to the larger STEM education community, workshops will be developed to train faculty on using the canvas.

References

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