UTILIZATION OF THE DESIGN PROCESS FOR DEVELOPMENT OF A NEW PROGRAM CURRICULUM

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ABSTRACT

Program curriculum development is a pivotal undertaking to ensure program relevance in a dynamic world. This paper focuses on utilizing a product development methodology to shape the next generation of the Industrial Design Engineering program. The methodology has emphasis on understanding the user and stakeholder needs to develop innovative program curriculum both efficiently and effectively. The primary research question addressed is: " How can a Product Development process be used for developing a new program syllabus?". Given the novelty of applying this methodology to university programs, our exploration sought to identify the most effective methods from the product development process. Initial steps involved gathering information about anticipated future scenarios to ensure the program's relevance, currency, and adaptability to changing landscapes. The program structure needed to accommodate dual-degree variants, allowing students to choose their major initially and later decide their degree path. This flexibility aimed to prepare students for the workforce or further studies, depending on their chosen path, after three years. Following the pre-study, iterations occurred through idea generation, evaluation, and cross-fertilization of drafts outlining the new design program's potential structure. Employed methods included surveys, trend analysis, brainstorming, brainwriting, Pugh's decision matrix, and PNI. The result was three distinct program structures, each offering students the option to complete their studies in three years or pursue a master's program. The final concept that was created after the final phase was completed is designed to not only keep students in sync with societal changes. The academic year and course structure is also organized to clarify each course's purpose and its relationship to others, fostering a cohesive learning experience. The adoption of a product development methodology for crafting a new program curriculum did not only prove to be successful but it also remained effective throughout the entire process. Last but not least the methodology also provided many new ideas on how a program curriculum could be structured.

KEYWORDS

Product Development, Programme syllabus design, Standards: 1, 3, 4, 5.

INTRODUCTION

To meet the ever-changing need from both students and society, including companies, our programmes at universities regularly need development. Chalmers University of Technology currently offers two variants of engineering education in industrial Design. Students have the option to pursue a Master of Science (MSc) in industrial Design Engineering (IDE) degree after five years of study after fist completed a three-year Bachelor of Science (BS) degree, or a Bachelor of Science in Engineering (BSE) degree after three years and the option to take a MSc in Industrial Design Engineering master's degree. At Chalmers, it should be noted that a vast majority of the students from the BSE program continue with studies in a master in the same field, which basically creates two different routes to the 5-year MSc degree.

Since the first three years at the BS and BSE programs in IDE are very similar and the students should have the opportunity to choose whether to continue for a Master during their studies or exit after three years, we want to investigate how a new Industrial Design Engineering program can look like and we want to use a modern approach to develop this. The flexibility that the students can exit the program after 3 years will be a possible game changer for both the students as well as for the industry to adapt to the fast-changing world.

This development endeavour is considered crucial not only in ensuring the successful integration of the combined program, equipping students for both industry roles and advanced studies, but also in maintaining relevance and adaptability to evolving societal and technological trends.

Design methodologies have been used in different forms for product development in industry for many decades. The area is being researched e.g (Ulrich and Eppinger 2016). The methodology or Product development process compromise the following steps:

1. Customer needs identification and
2. Concept generation
3. Concept evaluation and selection
4. System and detailed design.

One of the most crucial things to include is the investigation of the customer needs (sometimes user) in this loop. Bringing all aspects to the table, keep an open mind and finally rather reduce the solutions which have many drawbacks than nominate one winning too early. The idea here is that this engineering principles could be used also for program curricula development.

Scope

The purpose of the study is to explore, analyse, compare, and evaluate how the design program at Chalmers University of Technology, in the event of potential changes, can undergo the most positive development possible regarding program structure, content, collaboration, and adaptation to the constant evolution of the future. Additionally, it aims to provide results that can be utilized in similar endeavours for other subject specializations.

Research question

The research question that has been in focus for the research is posted below.

- How can a Product Development process be used for developing a new program syllabus?

THEORY

There are many papers describing new or partial program curricula, not at least in the CDIO context, e.g. Enelund, M. et al. 2012), but also with an IDE connection (Voûte, E. et. al. 2020), there are not many describing the recipe for a successful process to develop or reform a program. This might be because it is not of common interest to describe the process and the result is more important than the route. A program must of course fulfill national degree requirements but also local ones as well as fulfilling societal and industrial needs. The CDIO standards give good insight on what the result should look like and what the university wants with the program. On a high level, the principles for this are described by Malmqvist et. al. (2006). In this paper we apply a form of Product Development Process (PDP), described by many, e.g. (Ulrich and Eppinger (2016), as a means when developing a program syllabus and reflecting on its usability.

At Chalmers University of Technology, it is a standard to use the CDIO principles when designing programmes as well as courses Malmqvist et. al. (2010). In this case this means the standard 1 The Context is met by a clear Industrial Design Context throughout the programme taking the CDIO principles back to its roots. Standard 3: Integrated Curriculum even though we have not defined this specific course for each interpersonal skill we work with them on an overall level to have them in a course where the belong naturally. This is how we want the students to work in real life but also and not let them think these are separate subjects but rather integrated and therefore best taught in connection with other subjects. In accordance to Standard 4, there is an Introduction to Engineering course given as the first course at the program. In accordance to Standard 5 The curriculum includes two or more design-implement experiences, including one at a basic level and one at an advanced level.

Product Development

Product development is the process of designing, creating, and marketing new products or services to meet the needs of customers. It involves several stages, including idea generation, product design, prototyping, testing, and launch. The goal of product development is to create products that are innovative, high-quality, and meet customer needs. There are several books and proposals for how to carry out product development. Ulrich and Eppinger (2016), provides a comprehensive overview of the product development process. It covers contemporary design and development issues, such as identifying customer needs, design for manufacturing, prototyping, and industrial design. It presents a set of step-by-step product development methodologies aimed at bringing together the marketing, design, and manufacturing functions of an enterprise. Cross (2023), provides an overview of the design thinking process and its application in product development. It covers topics such as design methods, creativity, and innovation. He presents a set of design thinking principles aimed at improving the effectiveness of product development

Ullman (2003) presents a comprehensive overview of the mechanical design process. It covers topics such as design methodology, conceptual design, and design for manufacturing. It presents a set of mechanical design principles aimed at improving the efficiency and effectiveness of product development

In this paper a general product development methodology has been proposed and used to create and evaluate different curriculum concepts. The strength of the product development methodology is that it starts with identifying the user needs (in this case the student, society, industry need) and then creates and evaluates concepts upon these to come up with a final solution.

CONDUCTED METHODOLOGY

In the following section the conducted methodology will be presented. The group that has carried out this work in line with the co-creation process, consisting of two design students, the head of Industrial design engineering and Mechanical engineering as well as the dean of education. This project setup afforded us the advantage of involving diverse stakeholders, thereby enhancing the relevance and accuracy of our outcomes. This approach also minimised the risk of overlooking crucial stakeholder perspectives during the initial phases where the prospect of adaptability persists (Ind, 2013).

Process Initiation

The project began by creating two drafts of how a curriculum for the design program could be structured, see Figure 1 below. The initial draft was prepared the head of Industrial design engineering and Mechanical engineering as well as the dean of education, while the second draft was created by two design students. The decision to do this early in the project were because the student group members had not yet been influenced by various requirements and criteria that needed to be met. Another reason why these two drafts were created were due the fact that these later could be used to compare and evaluate the upcoming drafts (which you can read more about under "*evaluation and development of more realizable concepts")*. These drafts were also intended to highlight the differences before and after the implementation of the product development methodology.

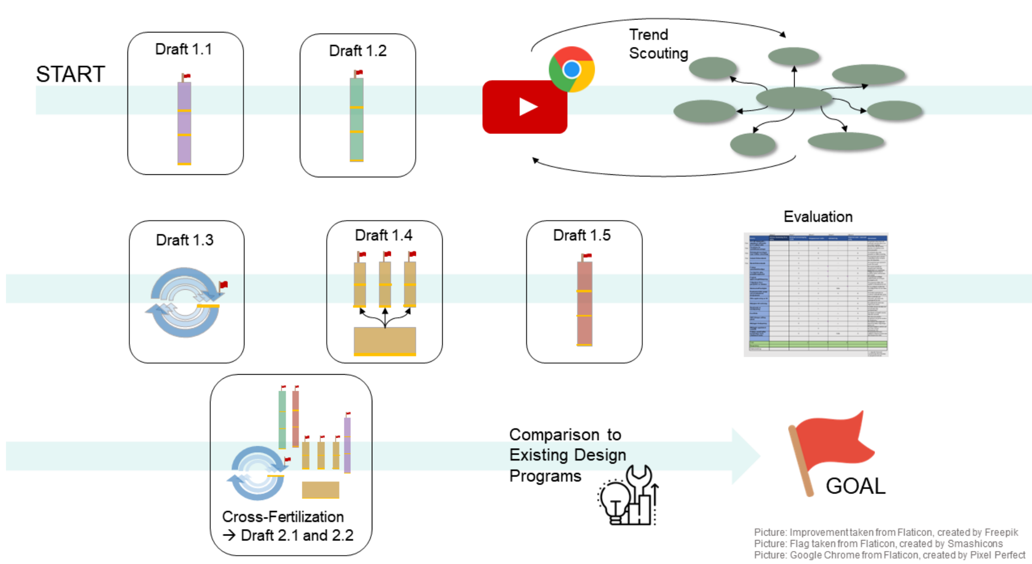

Figure 1. General overview of how the process unfolded.

Preliminary Study

After the initial drafts were completed, an extensive trend scouting was conducted. The goal of the trend scouting was to formulate a foundation showing roughly the direction the future could take (within 20-30 years), thereby increasing the possibility of generating well-adapted program drafts later on. Areas explored during the trend scouting included future society, new technology, sustainability, social and economic aspects, the automotive industry, and more.

Based on the trend scouting, seven pillars were identified as the most significant for the potential lifestyle in 20-30 years. These were: sustainability, user perspective, distance and closeness, the ability to get what we ask for, digitalization, a greener society, and change.

To gain a deeper understanding of how the future development of the design and engineering profession could unfold, the decision was made to conduct additional information gathering, which was done in the same way as the earlier trend scouting. This new information would be used to formulate the foundational pillars for a future design program, serving as a valuable resource for the upcoming ideation. Through previous iterations, five pillars were formulated for a complete design program. All the pillars formulated during the preliminary study, would later form the basis for drafts 1.3, 1.4, and 1.5. In parallel with the trend scouting and information gathering, we used ChatGPT to investigate whether the conclusions that were drawn were somewhat consistent with the information compiled by ChatGPT.

During the same period, a survey was created and later distributed to the newly admitted students to the "design and product development (BSE)" and "industrial design engineering (BS)" programs at Chalmers in 2023. The survey questions were formulated to assess students' interest in technology and design, specific subjects they look forward to studying, and their attitude toward the titles "civilingenjör" and "högskoleingenjör". The results of the survey responses were then considered in the evaluation of the drafted proposals. Through the survey, the group could also identify students whose choices might have been different if they disregarded the titles ("högskoleingenjör," "civilingenjör"). Looking at the survey answers, we saw that the job title really matters when people choose their education. In fact, 92% said they picked their degree because of the title.

Idea Generation - Visionary Concepts

After the information gathering and trend scouting were completed, and the information was compiled, the second phase where the actual ideation process began to develop more visionary concepts on how a new program plan could look was initiated. During this process, methods such as brainwriting and brainstorming were used to stimulate creativity and start sketching new concepts. Through the ideation process and discussions with the head of program for BSE and BS, three visionary drafts were formulated, drafts 1.3, 1.4, and 1.5 see figure 2 below.

Draft 1.3, which came to be called “The Design Process” was developed with inspiration from the structure of the design process and was built on four main areas: preliminary study, realisation, presentation, and context. The main purpose of the draft was for students to go through the entire design process in one year and then specialize in each element the following year.

Draft 1.4, which came to be called "Individual Path" was created through brainstorming and inspiration from the trend analysis and the structure of vocational colleges. The reason for the influence of the structure of vocational colleges was due to the aspect that in some areas, such as CAD, according to the trend scout, it will become more challenging to compete. This suggests that a thorough specialization in a subject can help students in the industry.

The final draft, draft 1.5, called "Integrated Mathematics" was developed based on draft 1.1 with the idea of dividing mathematics into smaller courses that naturally relate to other subjects. In this way, it can act as a tool for increased understanding while simultaneously highlighting its own purpose. To observe the structure of the different concepts, see figure 2 below.

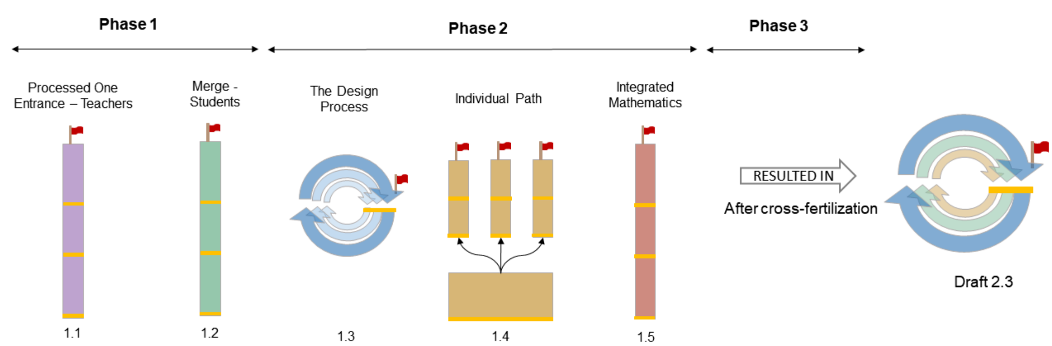

Figure 2. Displays the structure of the different program plans.

Evaluation and Development of More Realizable Concepts

After the three more visionary drafts were created, the decision to begin the development of more achievable drafts was made. The first step to achieve this was to initiate the evaluation phase and formulate requirements that the upcoming drafts must meet and criteria that it is desirable for the drafts to meet. To know which criteria were more important and/or more desirable to be met, the group conducted a weighting of the various criteria through pairwise comparison. After the weighting was completed, Pugh's decision matrix was used to evaluate the different drafts with draft 1.1, as the reference draft. Pugh's matrix is a method commonly used for the evaluation and comparison of developed concepts. The purpose of the method is to facilitate decision-making and promote objective assessments in more complex choices. The process involves comparing the different concepts to a reference, and depending on whether the concepts meet the criteria better, worse, or equally well, which results in a total score in the end. By using this method, one can also more easily identify the strengths and weaknesses of each concept.

To complement the Pugh matrix, a PNI, which stands for "Positive Negative Interesting", was also performed, highlighting more of the drafts' own characteristics rather than in relation to the reference. PNI, is also a method used to evaluate concepts. The purpose of the method is to identify positive, negative, and interesting aspects of each concept, serving as a basis for the development of new concepts. After the methods of Pugh's matrix and PNI were used to evaluate the concept, all materials were compiled together with a requirement list, which together formed a good foundation for the third and final phase of the process, which involved cross-fertilization of drafts 1.1–1.5. The purpose of cross-fertilization was to generate new, more achievable concepts, which were accomplished by combining ideas from previously developed concepts. It was at this stage that thoughts previously formulated during the use of Pugh's matrix and PNI came into play, forming the basis for the development of more realizable drafts.

The cross-fertilization resulted in two more achievable drafts, 2.1 and 2.2 (second generation), which were later evaluated by us. As these were generated with consideration for values and requirements, they were deemed sufficiently developed to be compared with the existing design programs at Chalmers.

Therefore, this comparison between the second generation and the existing programs was made to ensure that nothing essential or successful had been lost during the process, and if so, it could be brought back. An investigation was also conducted on whether the second-generation drafts still provided eligibility for the master's programs that currently follow BS. After this comparison, drafts that were created in the second generation were further refined into a final program draft, which came to be called draft 2.3, see Figure 2.

RESULTS

The use of the product development process as a method for the creation of new university programs curriculum is proved to yield positive results, as the developed programs were considered sufficiently elaborated and well-formulated to proceed to the next stage of implementation. The process structure, involving a preliminary study, iteration between idea generation and information gathering, as well as evaluation and cross-fertilization, demonstrated a systematic and logical progression of work.

The foundation laid during the initial studies provided a basis for the essential components of the program, influencing subsequent ideation towards program aims. Iterations between ideation and information gathering expanded perspectives and gave natural feedback to fill in gaps where information was lacking, without regressing in the process. The evaluation phase in the program development process identified areas where changes were needed in the more visionary programs, guiding the refinement and adjustment of the approach.

As mentioned earlier, each program was consciously endowed with distinct strengths and selling points to broaden the range of solutions. The cross-fertilization of program structures initiated towards the end of the process ensured that these diverse attributes were leveraged. The outcome was that programs with different themes broadened the perspective, and during the finalization of the last draft through cross-fertilization, all aspects could be considered. This resulted in a program customized from its parent programs—a thoroughly and accurately assembled outcome well-aligned with the goal.

DISCUSSION

The utilization of a product development methodology for developing a university program curriculum felt intuitive and natural, yet this may not be applicable for individuals from different fields who wish to implement this approach. The cyclical nature of product development, with its feedback loops and emphasis on user experience, seamlessly aligned with the dynamic nature of academia. Each stage of the curriculum development process became a prototype, subject to evaluation and enhancement, mirroring the iterative testing and improvement characteristic of successful product development cycles. The methodology's emphasis on adaptability and responsiveness to evolving trends and demands in education proved invaluable, resulting in a curriculum that felt not only comprehensive but also agile and well-suited to the ever-changing landscape of higher education.

Selection of Methods

The methods chosen for the process included trend scouting for pre-studies, dividing ideation into three phases (initiation, visionary and realizable), and employing PNI and a Pugh matrix for evaluation. The decision to initiate trend scouting was based on the program's goal of aligning with future changes in education and society. Acknowledging the unknown nature of the future, our approach needed to rely on well-formulated guesses derived from past events and future predictions.

Employing the trend scouting method enabled us to investigate current trends not only in industrial design engineering but also in related fields such as AI, technology, future cities, and evolving living standards. To maximize information within a brief timeframe, we consulted diverse sources, including YouTube, podcasts, and articles. Subsequently, ChatGPT was utilized, due to its time-efficiency, to validate our perspective and identify potential information gaps post-gathering. Highlighting these gaps allowed us to iterate the information gathering around these elements for a more detailed picture. This approach proved invaluable as the easily accessible platforms offered diverse search results, encompassing various perspectives, depths, angles, and expertise. The efficiency of this method likely allowed us to gather more information with different viewpoints and focuses than if we had relied solely on reading articles and papers. Overall, this method together with AI played a fundamental role in enhancing our understanding of potential crucial pillars for the future work of design engineers and the general human lifestyle.

Regarding the credibility of our primary source, YouTube, we recognise its challenges in terms of trust compared to other sources, as most channels lack transparency about personal perspectives, expertise, and sometimes even their own sources. Consequently, all information derived from our information gathering results is compiled based on consistent information from multiple videos, avoiding reliance on a single source. Prioritizing a broad information gathering approach, we considered this more significant than the sophistication of the sources' content.

The ideation part in the process was divided into three phases that each had different directions in the generation of programs. The first phase was centred around refinement and ideation on the own experience, while the second was more visionary and the third more focused on realisation. The methods mainly used was brainstorming, brainwriting and cross-fertilization.

The pivotal role in this project was played by the second ideation phase, where it was sought to craft more visionary and adventurous drafts. Here, brainstorming was fundamental, while brainwriting did not serve as well as with product development. Yet brainwriting was instead used to draw the general shape of the programs, for example as in figure 2. Employing this approach allowed for the exploration and expansion of potential solutions for varied program structures, a critical aspect in achieving a more futuristic orientation for the developed program. This phase involved a continuous questioning of "what if…?". Consequently, this stage served as the bridge linking the formulated pillars from the pre-studies to the generation of well-defined program drafts.

Prior to the final ideation phase, the visionary concepts underwent evaluation using pairwise comparison, the Pugh matrix, and PNI methods. Conducting these assessments proved crucial, aiding in pinpointing strengths and weaknesses, as well as identifying shared and distinct traits among the drafts. This understanding was valuable as it enabled us to outline aims and necessary outcomes for the impending cross-fertilization method, proving to be a vital step in realising the programs.

The cross-fertilization, the primarily used method during the last phase for a more realistic combination of programs, complemented the prepared formulation of strengths and weaknesses for each program derived from the evaluation. The programs generated from this method ensured the fulfilment of all criteria in the outcome while retaining the essence of the visionary ideas. These traits confirmed that this could be the concluding phase of the process, giving us candidates to advance into a new selection process.

Encountered Challenges and Recommendations

Regarding elements and methods chosen that turned out unhelpful or less suitable for the process, the focus on specific courses during ideation as well as the Pugh matrix as an evaluation method shall be discussed.

Mathematics is considered fundamental and characteristic of engineering programs. One of the visionary program proposals aimed to explore how mathematics courses could be designed in the program to be more motivating for students. The team was inspired by how this was done for a mechanical engineering program where the mathematics courses were reformed to support the parallel mechanics and strength of material courses (Enelund & Larsson, 2006). In our project, mathematics would instead support the design subject. Such a proposal was made in this project, but one of the lessons learned is that a multifaceted competent group is needed to work further with it.

The Pugh matrix that was used for evaluation produced a very useful result for the process, but not in the usual form of ranking the drafts. Due to the weighting of criteria, different perspectives, and addressing significant issues, the assessment was not so black and white that a "+" or "-" could be unequivocally assigned. Therefore, the most valuable result was the comments and reflections that emerged during the method's implementation, which were carried forward into the subsequent steps.

For future implementations of the Pugh matrix in the execution of this methodology, a very detailed definition of the criteria should be conducted before the method is carried out. Other alternatives could have been to choose another method to support a systematic discussion, or to conduct a weighted matrix, such as a Kesselring matrix.

Conducting user testing in the development of a program curriculum presents challenges due to its intricate nature concerning time and scope. This was no exception when employing the product development methodology in crafting the program plan. Nevertheless, a survey was conducted during the process, and responses from students offered valuable insights into their anticipated needs, preferences, and expectations, thereby enriching the scope of considerations.

Research Contributions

Regarding the research questions outlined in the introduction, the project addresses them through the presented results and the generated final draft of a program curriculum. The outcome of this study gives a first answer to the question of how a product development process can be applied to program development. Due to the multi-faceted nature of this inquiry, the answer may not be comprehensive, yet it enhances our understanding of the subject in whole. These results can therefore serve as a reference for future investigations into potential enhancements to this methodology and approach. The output, which is the framework of the new design program, will undergo further refinement and evaluation to determine its suitability for the flexible program scenario that is aimed for.

CONCLUSION

Utilizing a product development methodology to the creation of a new program curriculum proved successful and remained effective throughout the entire process. A particularly beneficial aspect, recommended for retention, involves introducing a method early in the process that broadens perspectives, allowing ideas to stay expansive for a significant period. Following this, the use of a defined method to narrow down ideas facilitates visionary solutions in the early stages without overlooking crucial aspects, as there is ample time for refinement in later phases. Another successful element was the inclusion of a forward-thinking trend scouting in the pre-studies, bringing diverse perspectives and proving vital for the project's foundation.

Drawing lessons from this project, suggested modifications for the next implementation primarily involve refining method selection to enhance results further. This includes ensuring precise and well-arranged criteria for the program, such as sufficient credits, included subjects, and alignment with university aims and values. This precision is essential for the chosen evaluation methods and plays a crucial role in refining the programs into more realizable drafts. Equally important is planning and defining the goals for each step throughout the entire upcoming process, providing all members with the necessary knowledge early on to execute the methods properly and achieve the desired outcomes.

In conclusion, the successful application of a product development methodology in creating a new program curriculum emphasizes the significance of early broadening perspectives, defined approaches for focused development, and maintaining a close connection to the initial aims and purpose.

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