The culture of product development in student organisations

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ABSTRACT:

Product development in a multidisciplinary student organisation brings many challenges, such as varying experience, adaptation and involvement of members. This article will discuss how a multidisciplinary student project creates a learning culture for product development and project management. This statement is grounded in the following identified factors for a learning culture; 1) define product specifications, 2) involve alumnis, 3) facilitate an open minded culture for failure and learning and 4) collect experience and adapt an agile framework suitable for the project. These factors should be implemented to increase the chances of facilitating and maintaining a learning culture.

Align Racing UiA, the case of this study, is a student organisation with over 60 engaged students in multi-disciplinary challenges. The common team goal is to produce one race car a year and compete in Formula Student (FS). The rules for the technical aspect of the project are substantial, resulting in concrete boundaries for project realization. However, every piece of the car is designed, produced and assembled by the members. Looking at the first year of Align Racing UiA, the initial project management was not optimal for a student project of this scale. Consequently, it was realized that a strong emphasis on project management, agile development methods and communication would be key to a more efficient product development and project management.

Key words: **Product development, Product management, Multidisciplinary project, Student organisation, Formula Student**

1 INTRODUCTION

To succeed with complex product development, the organisation and its members need to understand and apply suitable methods and tools. Therefore, a learning culture for product development must be present. Align Racing UiA (AR) is a Formula Student (FS) team at University of Agder (UiA) which consist of over 60 engaged students from different disciplines, working voluntarily to achieve the team goal; compete with a race car at Silverstone Circuit, UK. FS is one of the largest student competitions, giving teams the objective of being a real firm, producing one prototype and virtually projecting 1000 mass-produced cars [1].

FS race cars are complex products with more than 5000 parts, which are developed, designed and manufactured by members, ranging from first year bachelor to last year master. The rulebook of FS is complex, detailed and comprehensive. Still, it does not dictate how to perform product development or project management, which are key factors for success. Moreover, the system consists of different assemblies; driving dynamics, frame, body, brakes, safety, powertrain, sensors and electronics, where the development process lasts for less than nine months. The need for project management and practices of product development has been imperative for all project phases, and continuously revised and altered to be as efficient for all members regardless of their experience.

Furthermore, a culture for rapid prototyping based on physical interaction of ideas and concepts increased the number of design-iterations of each individual part, and also the members' motivation to participate. Comparing the first year (Project Ludvig) to the second year (Project Solan), shows how different dimensions within product development are affected by experience in iterative development and product specifications. Hence, members need to be engaged, supportive and open-minded, and rapidly understand how to approach product development. Therefore, developing and maintaining a culture for failing and learning can be crucial. This represents challenges for the leadership of multidisciplinary student projects, and the question is: *How does a multidisciplinary student project maintain a learning culture for product development and management?*

2 AR'S APPROACH TO PRODUCT DEVELOPMENT

The first year of competition, AR had no previous experience, and examined therefore how other FS teams organised their project to secure establishment. In addition, the academic calendar influenced the time-frame of development phases and the milestone plan, since it aimed to adapt toward members' workload. With this in mind, the project was divided into five phases:

1. **Product specifications:** Clarify and define specification regarding; function, production, design, user-interface and safety
2. **Concept:** Brainstorming and evaluation on product concept based on dimensions prepared in product specification
3. **Design:** Designing the parts in Computer Aided Design (CAD) with use of product specifications, and revised in a complete CAD model
4. **Production:** Production and acquisition of parts
5. **Test:** Stress testing and endurance testing of prototype race car to prepare for the competition

Project management made it possible to organise and manage product development during all phases. It enabled members to follow the project plan, phase plans, and weekly plans to continuously adapt their work and maintain progress. To reach the milestones, an agile development model [2] together with reverse-phase scheduling [3] were used. These models emphasized collaboration and daily communication, which provided flexibility and rapid response to uncertainty and challenges the project consisted of.

To ensure progression and updated plans, weekly meetings for every technical group were held. In addition, transparent tools like Microsoft Project, Trello and a physical "brown-paper wall" (scrum board) were contingent to visualise taks, progress and challenges. The meeting agenda and project timeline were set based on these tools, which all members had access to and could influence based on new knowledge. As for the product development, mainly Jakobsen´s toolbox was used to develop the race car as it gave the tools to structure the development process [4]. To summarise, table 1 shows how the project tools were developed from Project Ludvig to Project Solan.

Activities	*Areas*	Project Ludvig	Project Solan
Project management	*Platforms*	Digital	Physical and digital
	Planning	Low visual and physical interactive	Highly visual and interactive
Product specification	*Rule compliance*	Little review of regulations	Thorough review of regulations
	Specifications	Few and set by a small group of department leaders	More defined and set by all technical members, during workshops
Concept phase	*Knowledge*	Minimal and based upon photos from the FSUK-17 competition	Set of concepts transferred, redesigned and improved. Based upon inspiration and designs seen during FSUK -18 and from other teams
	Rule compliance	Low focus	High focus
	Implementation	Researching all solutions. Force product development tools on members	Researching the best solutions
	Review	One final presentation at concept phase-disclosure. Little regard to product specification and production methods	Three presentations were held; 1) general informational preview, 2) problem solving session and 3) final presentation. High regard for product specifications and production methods
Design phase	*Knowledge*	Basic CAD knowledge. Uncompleted CAD model and low quality on CAD model build-up	Experience with CAD and how to administer projects digitally. Completed CAD model. Higher quality on CAD model build-up
	Review	One design presentation for feedback. Little focus on rule compliance, component alignment and product specifications	Three design presentations for feedback. Continuously checking for rule compliance, components fitting together and assemblies to secure individual design
Production phase	*Drawings*	Uncompleted production drawings and unsatisfactory part specifications	Completed production drawings and accepted specifications and designs
	Production	Lack of following up internal and external production	Defined production boundaries and closer follow-up on both internal and external production
	Assembly	Low iterations of scrutineering towards FS regulations	Higher iteration of scrutineering and continuous checking for adherence with the rules
Testing	*Plan*	No test plan and low number of testing hours	Defined test plan and high amount of testing hours
	Repairs and improvement	A lot of extra work was required to finish the car	No extra work needed to finish the car

Table 1: Comparison table for first year (Project Ludvig) and second year (Project Solan)

The projects resulted in the award “Best Newcomer” the 1st competition year, 13th place overall of 81 teams for 2nd competition year in comparison with 59th place overall of 81 teams the first year.

3 CREATION OF A LEARNING CULTURE

A crucial experience from the first year was how to implement project management and development beneficial to members. As a new organisation, all processes need time to be implemented, matured and defined as standards [5]. The experience of failure, improvement and iteration was highly valuable and therefore directly applied in the second year. Here, a self-reflective culture that allowed open-minded feedback was developed. An idea was therefore never too dumb or too bold, and the culture facilitated for interdisiplinary collaboration to find the best fitted solution. The project is dependent upon every part and member, which makes it the team's problem if something fails. This was a factor to motivate the members to work together for reaching the set goals and milestones.

Furthermore, members are self-driven and need to be autonomous to take responsibility for their components [6]. This was experienced the first year. Also, it was crucial that connections and alignments to other components were maintained. Since the team consisted of members with varying levels of technical competence from both academic and vocational backgrounds, the team strengths had to be connected. In team Ludvig, few had experience of project management and product development. Without communicating clearly the need of the first phases before production, the first part of the project would be understood as abstract and ineffective time-usage. By including members during the phase planning, Project Solan had a positive effect on task quality and time consumed, whereas members understood the reason for all these different phases. In addition, to create a holistic picture of the phases, the agile development model with reverse-phase scheduling was introduced so members could visualise and identify tasks earlier and easier. As an example, planning the production phase with reverse planning, created detailed tasks with correct dependencies and time-estimates, compared to the traditional way of planning. The result of members' ability to visualise and understand what is needed for reaching the given milestone, showed an increase in communication across the departments and less time on undefined tasks and misunderstood tasks. In addition, without the understanding of the whole project and its progress, members easily locked their mindset on their own design without taking other parts into account. Therefore, the agile development model was introduced to cope fast with failures and feedback from members, fit the limited time-frame and the high number of parts designed and produced. It also shortened the time on design-iterations, so new solutions were more efficiently implemented. This approach had positive effects on Project Solan, when the experience from the system gave the members greater understanding of the importance of using the different tools from Jakobsen´s (1997) toolbox [4]. These challenges introduced and developed a culture of acceptance for failing fast [7].

4 INTERACTIVE PROJECT MANAGEMENT

For the first year project management aspects, Microsoft Project was used as a task management tool to maintain progress, overview and control. Experience showed that members got distanced caused by lack of the holistic view and physical interactions. By applying a simple tool, using yellow stickers on a physical "brown-paper wall", it created a direct interaction and personal ownership for the members. When the responsible member described the tasks dependencies, time usage and challenges, everyone got a deeper understanding of the component and knew who to contact. Moreover, gathering the whole technical departments around the physical wall instead of digitally, created a social arena. Members' engagement was expressed and spread at a higher level compared to Project Ludvig, which was a result of the developed learning culture. This was crucial for Solan's success.

The importance of practical experience of product management and product development were essential, and increased the quality of Project Solan. In Project Solan the different impression of its necessity between the experienced members and new members, was noticeable. As expected, members had not much time for self-study as full-time students and full-time in this complex project. To solve this challenge, alumnis were used as mentors. Keeping focus on mentors, has brought the extra element for development and knowledge sharing from one year to another. Engaging the alumnis can maintain the experience level for the new team to develop, instead of using time to build the experience to the same level. In addition, to learn from the previous years of AR, the inspiration from other FS teams was crucial. During the FSUK-18 competition, members looked to others for new designs, specifications and solutions. By taking the advantage of copying already tested solutions, gave the team a head start, resulting in a considerably shorter concept phase and a longer design phase. By using existing solutions, Project Solan had the opportunity to focus on more urgent and critical parts. Decreasing the number of unknowns [8], helped to concentrate on fewer areas of development. Learning from others failures and successes, both earlier AR teams and other FS teams, became an essential part of AR culture of product development.

5 CONCLUSION

By using suitable product development and management methods, a multidisciplinary project is more likely to succeed with creating a learning culture. Based on two years of experience, it is important to adapt to the members preferences and facilitate an arena for failing and learning. Facilitating product development and management methods ensures an organisation to increase the likelihood of reaching its goals. Collaboration for new ideas by using simplified methods like the "brown-paper wall" and the experience from alumnis can be key to alleviate stagnation in evolution. Furthermore, these are factors that should be an implemented part to maintain a learning culture. Continuously evolving the product development and project management system can make the project more efficient, regarding time-usage, task handling and planning. Still, building a unified culture of learning has been the greatest key. Based on our experience and reflections, we have four recommendations for maintaining a learning culture in a multidisciplinary student project, prioritised by order:

1. Define product specification and assure members understand the meaning of the concept phase
2. Introduce a alumni program and an introduction session for new members that include the organisation vision, goals and project strategy
3. Build and maintain an open minded culture for continuous improvement and knowledge sharing
4. Collect experience to apply, adapt and standardise the agile development processes and tools to suit the organisation way of working

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