INTEGRATED PRODUCT DEVELOPMENT PROJECT IN A MULTI-CULTURAL AND MULTI-PROFESSIONAL BACKGROUND TEAM: CHALLENGES AND KEY SUCCESS FACTORS

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Abstract

This paper describes the key success factors of an integrated product development project involving several stakeholders from different professional and cultural backgrounds. Based on a summer school project, a detailed case study is described to illustrate the importance of project team commitment and member profile complementarities in achieving the project requirements under time, geographical and cultural constraints. The case study consists in designing a human washing device for elder people to allow them a certain degree of freedom and privacy to wash themselves. Thereby, engineering, manufacturing as well as a business aspects has to be considered in the final concept. After analyzing the case study, challenges as well as opportunities during the project are summarized and described in an adapted approach. At the end, the main influence factors for a successful integrated product development project are analyzed and concluded hierarchically.

Keywords: Integrated product development, Project management, Case study, Design practice

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1 INTRODUCTION

The success of Product Development is reflected by the economic success and acceptance of products by the anticipated target group. The task of successfully designing products however becomes increasingly difficult due to higher technical complexity in products on one side and manifold market requirements in a globalized world on the other side. Designing a successful product thus requires, among other things, the anticipation of all customer needs in all targeted markets. Industries focusing on the healthcare sector, especially those focusing on the design of products suitable for the use by elderly people, face difficulties designing successful products. It is due to the fact that the target group strongly varies in its physical and psychological abilities and often comes from diverse cultural backgrounds. Designing products that meet the needs and requirements for such a diverse target group can be seen as very challenging task in product development and has often led to project failures.

This paper aims for the promotion of an interdisciplinary approach which can resolve the described difficulties by facilitating teamwork and team spirit. The approach presented in this paper was followed within a student project as part of an international summer school on product development. The objective of the project was to design a human washing device suitable for the previously outlined highly diverse target group. With time being very restricted, a very challenging task to solve, and team members spread around the globe the outcome of the project was uncertain but became a great success. In a consequence, the article contributes to describing success factors in the field of virtual teamwork in integrated product development.

Section 2 reflects the current state of the art in the research on team project success. Section 3 describes the case study that focuses on the integrated development of a human washing device. The analysis of this practical project and the applied methodology is summarized in section 4. The article concludes with the overall findings of success factors in international, interdisciplinary virtual projects.

2 SUCCESS FACTORS FOR IPD PROJECTS

A project is a sequence of unique, complex, and connected activities that have one goal or purpose. It is constrained by a specific deadline, allocated resources, and must be completed according to specifications (Wysocki, 2011). Working in a project team implies a group of people with complementary skills and different backgrounds working together and accomplishing complex tasks within a fixed period of time. Usually, the project team works in a cross-functional mode in order to save time and costs. Integrated Product Development (IPD) is holistic product development approach first described by (Olsson, 1985) to work in a cross-functional mode reducing project costs as it is based on the integrated design of products as well as its manufacturing and support processes. In this approach, all aspects of product realization should be considered as early as possible in the phases of product design, resulting in overlapping and iterative development processes (Bramklev, 2007), (Ottosson et al., 2006), (Vajna, 2014). It has been proven that this approach is efficient in terms of a company's profitability and time-to-market (Ottosson et al., 2006), (Vajna, 2014).

The success of a project teamwork has been discussed by many authors. The project team integration was defined by (Baiden, Price and Dainty, 2006) as "where different disciplines or organizations with different goals, needs and cultures merge into a single cohesive and mutually supporting unit" and was highlighted as a mean to improve the effectiveness of a teamwork (Baiden and Price, 2011). Interpersonal relationships such as trust, honesty, and commitment, were also mentioned by several authors as important factors for team project success (Maurer, 2010), (Webber, 2008), (Kozlowski and Ilgen, 2006). Team spirits such as collective emotions, collective attitudes, and behavioural norms may play an important role in a team project success (Aronson, Shenhar and Reilly, 2010), (Peslak, 2005). The project leader can play an important role in making the project successful by focusing the spirits of the project members towards a unique goal and motivating each member to give its best to reach the expected project outcomes (Peslak, 2005) (Yang, Huang and Wu, 2011), (Nixon, Harrington and Parker, 2012), (Turner and Mueller, 2005). However, some challenges may be encountered in a project team especially when working in a multi-cultural environment and when project members are located far from each other. Here, the importance of IT communication emerges as an important means to bring the team members together and facilitates the knowledge diffusion within a project team despite their worldwide dispersion (Verburg, Bosch-sijtsema and Vertiainen, 2013), (Andriessen, 2012), (Andriessen and Vartiainen, 2006), (Montoya, et. al., 2009).

Rules should be settled by the project leader in order to optimize work efficiency in the context of IT communication. These rules and policies include the schedule of communication and the means used to communicate (frequency of meetings, deliverables and next steps, tools of communication available, etc.) should be accepted and used by all team members in order to achieve the expected project performance (Verburg, Bosch-sijtsema and Vertiainen, 2013).
This paper highlights how the team project success criteria combined with optimal use of IT communication lead to achieve interesting results using the IPD approach in order to design a new human washing device helping elders to wash themselves in an autonomous manner.

3 CASE STUDY: DEVELOPMENT OF A HUMAN WASHING DEVICE

The task for the group work presented in this paper was to develop a human washing device for elderly people in context with the aging population. A simple daily activity like having a bath or shower becomes difficult with growing age and accompanying reduced mobility. Such people need aiding means either to wash themselves or to support caregivers when these wash them.
The aim of this project-based learning task was to experience a product development project and to overcome its specific difficulties regarding the organization of an interdisciplinary team under uncertain requirements. To name these difficulties, only rough instructions on the implementation and organization were given and only a few requirements and restrictions regarding the expected product were specified (e.g. modularity, adjustable to tall/small people, usable by standing and sitting, good use of water, positive emotional effect). As stated in e.g. (Ottosson et al., 2006) and (Paetzold, 2011), the importance of creating products that fulfil the demands and expectations of the users (user-centered design), an integrated procedure (IPD), the consideration of the whole product lifecycle, all accompanied by an appropriate business model were emphasized. The project started in the middle of the first week of the Summer School in May 2016 and was finished in the second week in September 2016. In the meantime of 18 weeks the team had to design a product concept with an appropriate manufacturing concept and the business model.

3.1 Project implementation

The biggest challenge of this project was the fact that all team members work in different cities distributed in Germany, Austria, France, and Chile. To have a good basis for further discussions and design of the product details, we used the first week of the Summer School to gain a common understanding of the aimed product in as many face-to-face sessions as possible, because these are much more efficient for idea generation discussions than digital conferences.
At first we specified more detailed requirements by identifying the demands of elderly and immobile people using the “Personas” method (Cooper, 1999). We defined six different personas with specific handicaps and personalities and imagined the issues they would have to deal with during washing. On this basis, which was complemented by literature research and surveys after the first week, we developed initial product ideas using the “635” creativity method, which was adapted immediately to “735”, as we were 7 members, each one generating three ideas in the first round and modifying the initial ideas of the others in the following six rounds each lasting 5 minutes. Then the resulting ideas were clustered and evaluated considering the results from the “Personas” so that six concepts remained. These concepts were not seen as a potential solution yet but as a basis to define the necessary next steps.
After collecting activities and building work packages we allocated them to the individual team members considering the respective disciplines and competences. Before, we defined the project schedule with activities, responsibilities, and milestones. According to the activities we determined the roles of a general manager with mostly coordinating and communicating responsibility, an industrial designer for concept sketches and the design of user experience analyses, two engineering designers for CAD modelling and simulations, an IT-specialist for the design of all communication channels, and two business engineers for the development of the framing business model. Before starting the respective tasks a comprehensive market analysis was divided into researches of patents, existing and failed solutions, and user-needs by literature review and by implementing a survey with 187 respondents from 15 countries to find as much information as possible. Figure 1 depicts several examples of the gained results.

Figure 1. Work progress and results during the first half of the group work

To monitor the project's progress and to discuss results and problems over the period until the second week of the Summer School we arranged a fixed time for a weekly digital meeting. Due to the fact that some of the team members research in institutions where certain communication tools like Skype are blocked, it took some time to finally identify Google Hangouts as the only remaining freeware that was suitable for us. These weekly meetings were used to report the results of each work package. To share files and store our results we used Google Drive, another open and free service.

3.2 The resulting product

The result of our project is the "Shower Buddy" series (Figure 2), a washing aid for people with reduced mobility. By combining its different modules, these people are enabled to wash themselves almost the habitual way.

The Shower Basic Buddy is a wall construction that has two main advantages over conventional shower cabins. Several grab rails provide a safe and ergonomic hold in different standing and seating positions. Furthermore, there are evenly distributed water nozzles in the walls, which enable a fast and pleasant watering of the whole body without big body movements. With the clearly arranged and intuitively operated control panel both water temperature and pressure can be regulated and the height level of the water discharge can be adapted to the individual body height. Also via the control panel shower gel can be added to the discharged water as well as a water discharge from an additional over-head showerhead. In addition, a hand showerhead can be activated. A second control panel at the outside of the cabin allows nursing staff or relatives to regulate water and shower gel if the showered person is handicapped to do it by himself. At the outside there is also the filler aperture for the shower gel with an additional reservoir for a cleaning agent to clean off occasionally the valves and pipes from inside after usage. The standalone Shower Basic Buddy is intended for people who are still able to stand and to wash themselves in the shower, but want to make a provision for advanced age. Due to its modern design and the inconspicuously integrated grab rails, it does not obviously appear as a shower cabin for elderly or disabled people.

The Shower Best Buddy is a chair-shaped bathing aid that is designed for people with highly reduced mobility to sit down and rest during the shower. Its shape allows a comfortable forward and backward sitting position for people of different sizes and weights. The integrated nozzles supply water and shower gel "bottom-up" to the parts of the body that rest on the surface of the Shower Best Buddy by sitting or leaning against the valve-closures that open only when pressed. With slight relative movements a good cleaning result for the contacting body parts can be achieved. There are also additional open nozzles for the legs and arms when sitting backward on the Shower Best Buddy.

Wheels at the bottom allow to move it flexibly in and out of the Shower Basic Buddy. Thus the user can be pulled out to gets her/his back washed by another person and be pushed in again to rinse. Having wheels facilitates the Shower Best Buddy to be easily transported when needed (e.g. to another bath-room).

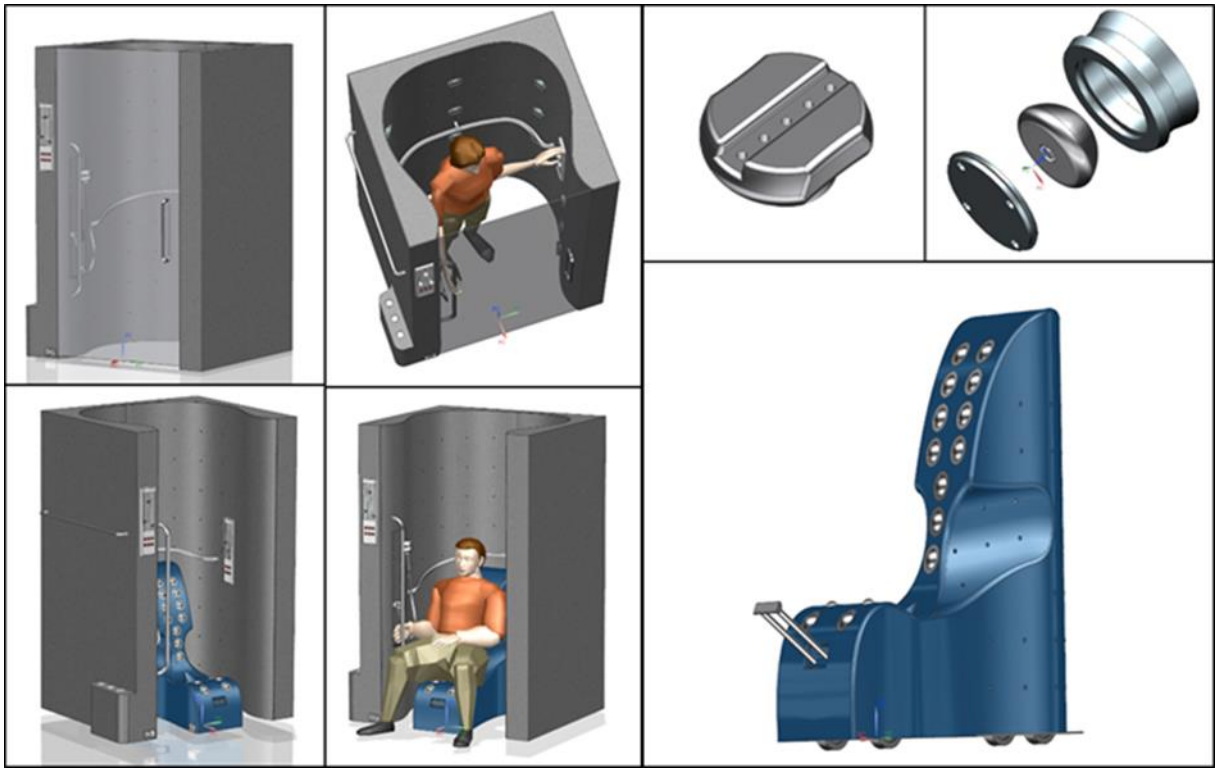

Figure 2. The "Shower Buddy" series consisting of a shower cabin ("Basic Buddy" module) and additional modules for higher comfort and aid (seating system and door), nozzles for water/shower gel supply in the cabin wall and in the seating system ("Best Buddy" module)

The Shower Loose Buddy is comparable to a simple chair and is intended as a cost-saving alternative to the Shower Best Buddy. It is meant for a transitional period and for customers who started with the basic module and don't feel comfortable or safe anymore to stand during the showering.
The Shower Private Buddy is a door system which can be easily mounted to the Shower Basic Buddy. It prevents the water from splashing out of the cabin and wetting the floor and the rest of the bathroom. Also, if multiple Shower Buddies are assembled in one bathroom (e.g. in a hospital), this additional module helps to keep the privacy of each user.
Depending on their level of mobility the Shower Buddy allows a totally autonomous washing experience without help from other people. In a user experience study we identified that this product has a twofold positive effect on the users: being able to wash on their own protects not only their intimacy, but they also feel to keep their dignity.
The capital demand for the first year was estimated to 499.000 € on the basis of around 700 produced modules. To fund this amount we decided to look for private investors via crowd funding in the first year with the goal to gain just enough income to realise the basic equipment and the production to start the business. Here we focus especially on Japanese people who prepare for future days (50+), because they have a very high sense for hygiene and affinity to new sanitary technologies. In the second step the business model (Figure 3) includes complementing services like a free check of the installation place, shipment, installation, and maintenance to fulfil all customer demands. In this phase we also expand to the B2B-market offering full services and support to business clients (diverse hospitals) and private clients. Based on the estimated cost structure and capital demand were shown that the price for the complete product series is below the identified target selling price of 5.000 €.

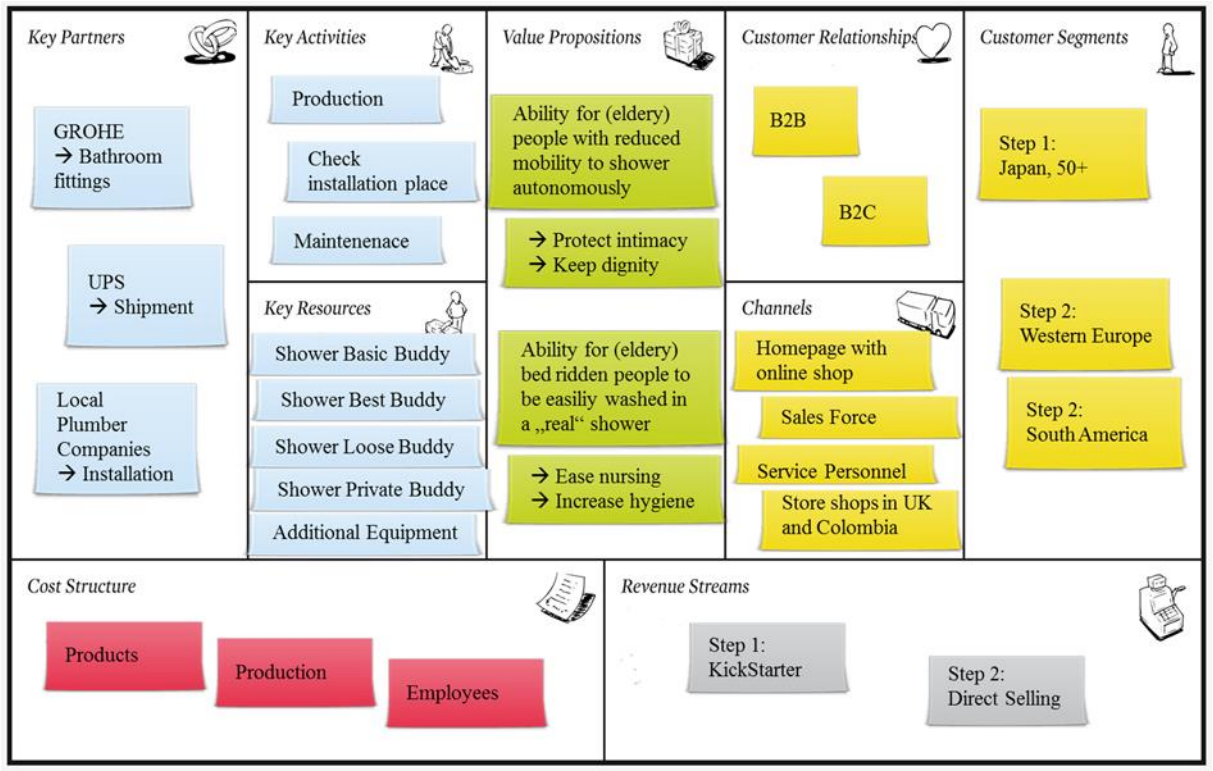

Figure 3. Business model canvas with the developed business elements regarding value proposition, infrastructure, customers, marketing and finance

The operative results from marketing, business, product and manufacturing were developed within 20 weeks. Thereby, the team members cooperated face-to-face only during the first week. In the following 18 weeks of decentralized cooperation, the various work packages were managed by a virtual communication system for project planning in internationally distributed locations.

4 LESSONS LEARNED FOR AN ADAPTED IPD APPROACH

As a strict and rigid development approach like the VDI 2221 guideline (VDI, 1993) wasn't suitable for the described project, an unconventional procedure was used with strong attention on interdisciplinary teamwork considering key IPD aspects like understanding customer needs and requirements management, as well as planning and managing product development. Figure 4 summarize the general approach during the project, as explained in section 3. After the face-to-face cooperation in the first week, the work was distributed according to the expertise of each member. On the 20th week the team had the opportunity to work face-to-face again.

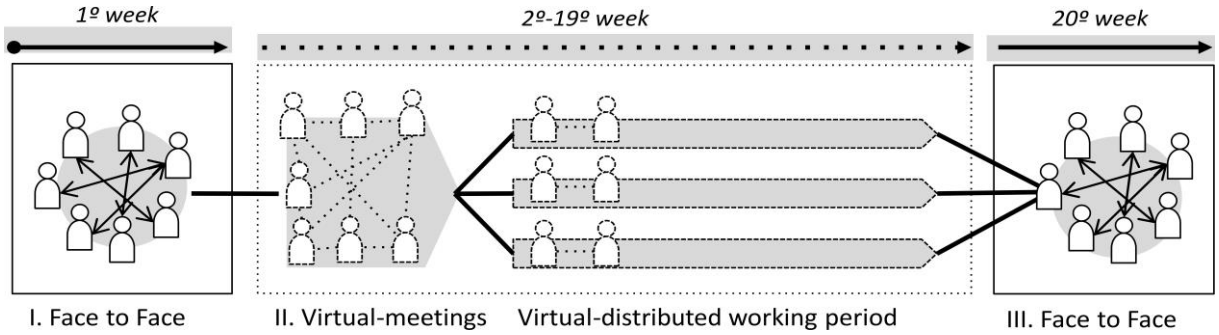

Figure 4. General approach during the project

4.1 Defining the Team

Getting to know the team members face to face allowed to build trust between the members and to have confidence on their ability to develop the project. It also had a motivational impact, generating cohesion and team spirit. Having team members that cover the key expert fields of product development allowed

to define clear roles and to assign tasks to each team member. Not only manufacturing and business aspects were studied but also aesthetics, usability, and their integration. Leadership and management were identified as key dimension for teamwork (Koutsikouri et al., 2008). The previous experience of the project leader allowed for an effective management, based on the processes and the definition of consensual design goals, roles of the team members, and accountability assigned to each member within a defined timeframe. The approach used on this exercise allowed giving responsibility and autonomy to each team member, so that everyone could develop his own potential and integrating his proposals to the final product. Close coordination and decision-making in the early phases of the product development process lead to a common understanding of the major tasks and the main goal of the project. This allowed a relatively quick execution of particular activities with much less coordination between the domains during the main development phase.

4.2 Project organization and management

After the project team was defined, the communication media had to be specified, in this case since the team members work from different countries, a free video chat service was chosen (Google Hangouts). Communication through regular telephone conferences has proven to be highly effective, whereby each conversation with important decisions should be documented. To document and store the data of the project a common database was set up using an online storage site (Google Drive). An essential document in this database has been the list of open points (LOP) that allows organizing tasks, assigning them to members, highlighting priorities, and setting deadlines. As (Ford et al., 2016) stated “Virtual teams depend on having appropriate communication technology to connect and support the members in ways that develop trust”. Multidisciplinary collaboration demonstrates the relevance of the development of skills related to communication, collaboration, and understanding of collaborative processes, while time pressures and cultural background differences may present some disadvantages or problems (Tang and Hsiao, 2013).

4.3 Soft skills

Finally soft skills proved to be helpful for the design process. Working in a multidisciplinary team calls for additional competencies like communication skills, humour, and respect for the others, all of them essential to generate a good working environment, especially in the soft stages of creativity, understanding and highlighting the professional complementarity as a way to success. This generated awareness regarding how the individual part contribution should be put at the service of a common goal in a collective work. The team's commitment allowed it to go beyond disciplinary boundaries and conventions to risk exploring new ways to respond to the requirements and conditions of the project context.

4.4 Retrospective design approach

At the beginning the organization of the project process required considerable efforts, however in the following project phases (e.g. simultaneous group work), considerable advantages were identified. Starting the general project process (Figure 5) the milestones had to be defined, as these were the starting point for the requirements.

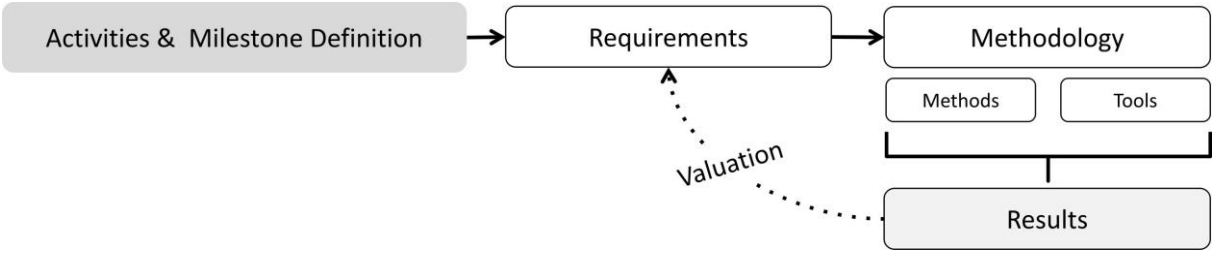

Figure 5. Project Process in general

To meet the needs and requirements defined, existing and proven methodologies were selected and used. After the implementation of methodologies first results could be achieved, which later had to be compared and matched with the requirements under consideration. If the requirements were insufficiently fulfilled, another iteration should be done. This iteration can also be accompanied by the use of first findings or the adoption or change of the methodology.

As shown in Figure 6, all the necessary activities that contribute to the success of the project have to be defined first. In terms of IPD it is recommended to arrange the flow of activities according to the IPD concept of Olsson (Olsson, 1985) in Business & Marketing, Engineering, Manufacturing, and Project Management. The activities are assigned to the project members according to their respective expertise, and are registered in the List of open Points (LOP).

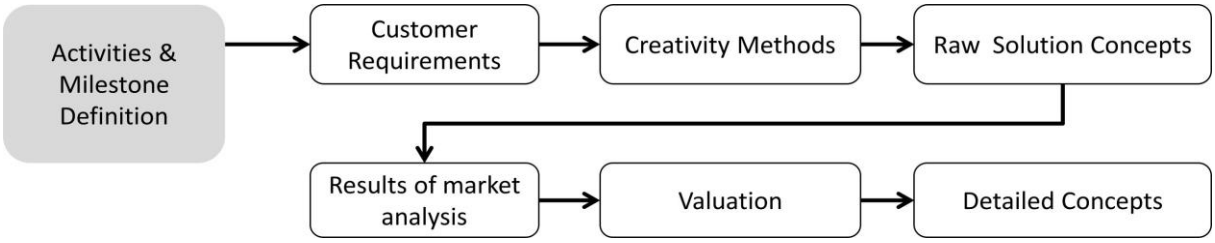

Figure 6. Iteration in preliminary phases of the project process

In a next step creativity methods were applied to develop first raw concepts. These raw concepts can be used as a basis in another iteration through the process (Figure 6). Further requirements were collected by a market analysis, for example, by showing both raw concepts and first ideas to customers during the survey. Thus, a better knowledge of the customer's requirements was ensured, by which the raw concepts could further be developed to get the final concept. All participants with their different expertise could incorporate their interests and ideas in a quite preliminary phase, this may need substantial effort, but in further steps the advantages become visible.

At this point the simultaneous engineering part started. Based on the detailed concept the tasks were split and consequently processed by sub groups from different domains. The division in subgroups is oriented on the approaches of Olsson's IPD concept (Olsson, 1985). Figure 7 shows this organization form, where engineering, manufacturing aspects, and marketing aspects are treated simultaneously. The integration of these three aspects of the project process allowed enormous saving on the development efforts.

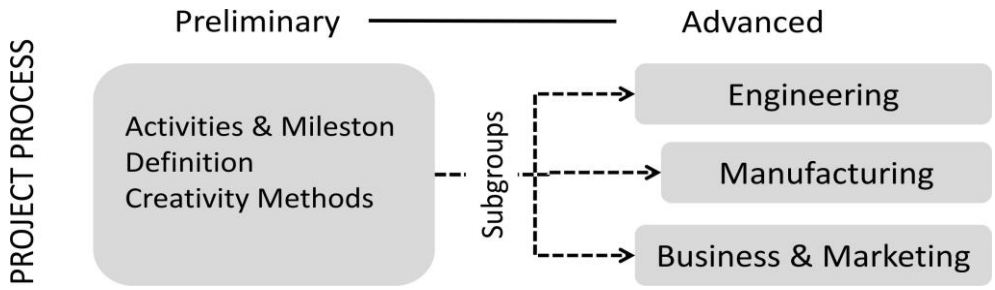

Figure 7. Simultaneous Engineering within product development

5 CONCLUSION

This paper presents an IPD project performed at the IPD Summer School 2016 (ipdISS2016). Thereby, the interdisciplinary team, consisting of 7 members, developed a human washing device. The team worked on planning the different tasks, finding of different concept solutions, elaboration of the selected concept, and both sales aspects and developing a business model. Beside the consideration of the specifications for fulfilling the requirements, both a manufacturing and a procurement concept were developed.

Based on an initial benchmark of the competitors, the final product was evaluated. By considering the target markets, a high degree of fulfilment of the requirements could be achieved. Thanks to the modular design a market niche can be served. The high quality of the Shower Buddy is specifically tailored to the aging population. Concerning other existing solutions, the elaboration of product, manufacturing, business model and marketing has a strong influence from the international team. The various competences as well as different knowledge backgrounds have contributed to the positive development of human washing device.

In general, both project plan and milestones were accomplished and the operating result met the required specifications. However, it was also shown that the specialized tasks do not represent the greatest challenge for achieving the overall objective. Due to the fact that each team member has her or his special competences, which were identified during the first week, each member could focus on the own working packages. Rather, the organization and coordination of the sub-tasks as well as the discipline for a continuous cooperation presented great challenges in the distributed project processing.
Thereby, a periodic virtual meeting once a week was used to set a "social pressure" on the team members, because everybody had to present his developed results. As shown in Figure 8, it was possible to identify that good teamwork is the basis for achieving the target as all other issues rely on a smooth cooperation of the team.

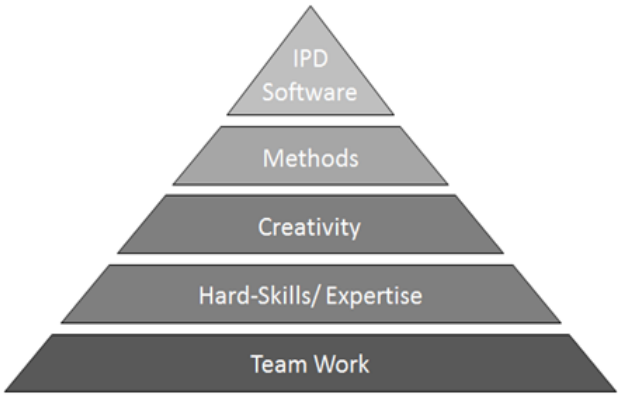

Figure 8. Fundamentals for a successful ipd project

The virtual collaboration of a team is massively fostered by good team spirit. A strong sense of solidarity was at the core of the collaboration. Knowing that the business partners are doing their job seriously and motivated, enabled the cooperation to be object-driven without any kind of confrontation or conflict. Without this basic cohesion, the basis for the project success is not given. For a good team spirit, different influencing factors could be identified during the project, as the evaluation of a participant survey shows:

- The most relevant aspect was the faith in the other members, so that the individual members could concentrate on their respective competences and tasks.
- A relevant influence factor was the "fun" during the work as well as a comprehensive linking of soft and hard skills of the individual team members. Compared to a tight schedule and a high workload, these positive influencing factors outweigh.
- Other important influence factors are the "unlimited" resources (and as well that there was no budget), the team building action during the personal meeting in the first week of the Summer School, a high creativity of the team members as well as an uninhibited interaction, so that members could bring their own ideas without a negative evaluation of the team members.

This IPD project shows that a physical kick-off meeting at the beginning of a project promotes the team spirit so that a good teamwork can result during the processing and the project becomes successful. Furthermore, regular virtual meetings are conducive to maintaining the team spirit as well as a concluding personal meeting, to present the results.

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