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Procedia Engineering 2 (2010) 2575–2580

Procedia Engineering

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8th Conference of the International Sports Engineering Association (ISEA)

Verification of the effectiveness of the Integrated Product Development paradigm for the development of sports equipment – A case study

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Received 31 January 2010; revised 7 March 2010; accepted 21 March 2010

Abstract

The sporting goods companies face significant challenges. To be successful on the market it is essential to follow a structured systematic product development process. A potential approach is the Integrated Product Development (IPD) paradigm. In this paper Insider Action Research (IAR) is used to verify the effectiveness of the IPD in a case study. It is shown that IPD is a potential development paradigm for the sporting goods industry to support a systematic development process for a successful product development in sports.

Keywords: sporting goods industry; product development; Integrated Producted Development; paradigm; Insider Action Research; snowboard binding; snowboarding injuries;

1. Introduction

The sporting goods companies face significant challenges: 1. Regarding the economic framework the global recession seems to be having a severe impact on the sporting goods market. The global market remained flat and was valued in 2008 at 219 billion € (284 billion USD) [1]. “This was a tough year, as evidenced by the first decline in manufacturer shipments since 2003. And given the overwhelming economic uncertainty at present, it’s hard to say 2009 will be better.” said Tom Cove, president of the Sporting Goods Manufacturers Association (SGMA) [2]. Further on, high-technology companies enter the sporting goods market [3], which additionally intensifies the competitive market situation. 2. Besides the economic framework, the increasing use of new technologies (e.g. IT,

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1877-7058
doi:10.1016/j.proeng.2010.04.034

new materials), the growing complexity of products (e.g. # of product parts), the importance of product aesthetics, and the shortening the cycles of innovation and product life are further factors [4,5], which influence the product development process of sports equipment.

To be successful in such a market environment it is essential to follow a structured systematic product development process [5, 6]. A systematic R&D process is related to product success, product cost, and product quality [7, 8, 9].

However, a deficit can be observed with respect to a systematic development paradigm for the product development of sports equipment both in research and practice [10]. Approaches discussed in literature [11, 12, 13, 14] are partly insufficient with respect to the requirements in sport or are not validated with respect to the effectiveness for the development of sports equipment. A closer look on the industry reveals that the "trial and error" method is often used by the sporting goods companies [4]. In contrast, interviews with the heads of R&D departments of 18 national and international companies show that there is a demand for offering a systematic product development approach for sporting goods.

A potential solution can be seen in the Integrated Product Development (IPD). IPD is one of the most important product development paradigms and is well established. According to Gerwin & Barrowman [15] IPD is *the* paradigm in new product development. In this paper, the so-called "Magdeburg Model" of IPD is used as paradigm. The Magdeburg Model is not considered as an idealistic model of the development process, but rather as a holistic development philosophy. It consists of four views: Planning and organization, methods, technology, and, dominating the other views, the human user (Figure 1).

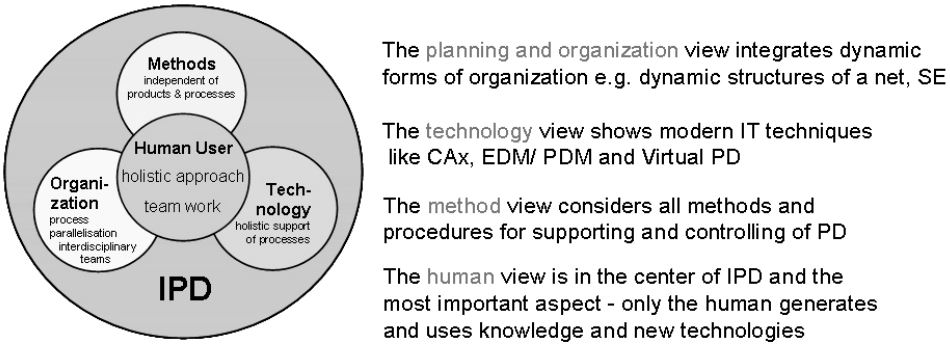

Fig. 1. The four views on IPD (Magdeburg Model) [16]

In this human-centered approach the human is seen as the driving force in the development process. He forms the most important part of the IPD [9]. Other important characteristics of this model are the overlap of certain activities in the development process (which leads to a partly or completely parallel execution) and the usage of interdisciplinary teams [15]. Several studies show the application of IPD for a successful development of sport equipment [17, 18]. However, an analysis and proof of the effectiveness of IPD for the development of sport equipment has not been conducted so far.

The aim of this study is the verification of the effectiveness of the IPD (Magdeburg Model) for the development of sports equipment, using the development of a new snowboard binding. This case study is analysed.

2. Methods

The specific task of the case study was the development of a safety snowboard binding concept applying the Magdeburg Model of IPD. Literature calls for the development of enhanced snowboard equipment to reduce the risk of equipment related injuries [19, 20, 21, 22]. With respect to the anatomic location of injuries several investigations show that 5% to 28% of all injuries relate to the ankle joint complex [19, 23, 24, 25]. Furthermore, correlations between the type of equipment used and the injury were found. The usage of soft boots increases the risk of ankle

injuries compared to hard boots [19, 20, 21, 24]. Most snowboarders prefer the use of soft boots [21, 26]. Following this, the aim of the case study was the development of a new soft boot binding concept protecting in particular the snowboarder's ankle.

The project was conducted within the context of an IPD graduate student course at the Otto-von-Guericke University Magdeburg, Germany. Three supervisors and five students from different disciplines (sports engineering, mechanical engineering, product development, computer science) were involved in the project. The base of the project work was the generic IPD process, which provides four project phases: 1. a detailed definition of the task, 2. conception, 3. going into detail and 4. designing a prototype [9].

Due to the complexity of the product development process [27] Insider Action Research (IAR) as a qualitative research approach was selected. In contrast to "traditional" research, IAR integrates the researcher in the project to guarantee a holistic view on the development process (Figure 2). Due to the involvement of the researcher in the project a frequent point of criticism is the issue of objectivity [28]. However, IAR is a unique approach to realize a general, holistic understanding of the development process [8, 28].

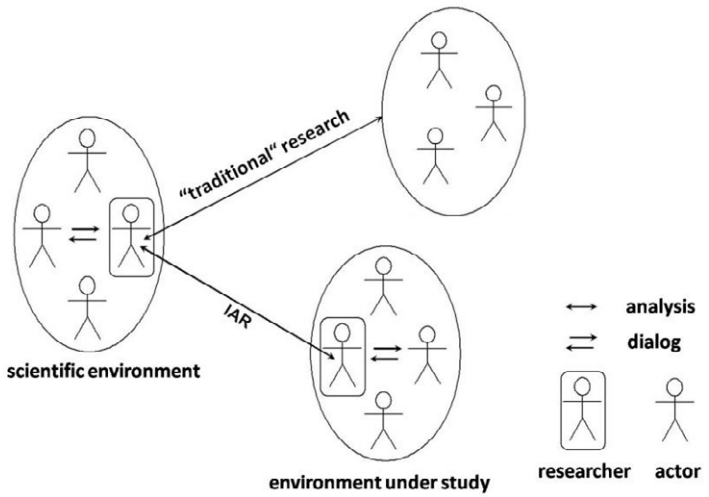

Fig. 2. Basic concept of IAR [29]

To objectify the results, assessment criteria were defined. In accordance to Ehrlenspiel [30] and Moritz [10] the effectiveness of a development paradigm can be assessed by objective and subjective criteria. Defined objective criteria of this project were product performance (O1), product quality (O2), expert rating (O3), # of patents applied for (O4), product costs (O5), and development time (O6). Subjective criteria were learnability (S1) and subjective impression of the effectiveness of the development paradigm (S2).

The learnability and the subjective impression of the effectiveness of the Magdeburg model of IPD were assessed by expert evaluation (three supervisors) of the project progress during milestone meetings and by the analysis of written feedbacks describing the subjective impressions of each team member at the end of the project.

The objective assessment criterion product performance (O1) was assessed in reference to a conventional snowboard binding (Atomic Zombie) in a laboratory environment [31] and in an on snow field test [32]. In the laboratory, critical forces [33, 34] were applied to the new snowboard binding concept and the conventional binding. Ground reaction forces were measured using a force plate (Kistler). In the field test, biomechanical parameters of five snowboarders using a bilateral insole measurement system (T&T medilogic) and a full body inertial measurement system (Xsens) were collected. Additionally, subjective impressions of the conventional snowboard binding and the new binding concept of 12 snowboarders applying a questionnaire were collected. In addition to the conventional reference binding, the subjective impressions were assessed in reference to a new binding concept developed at the Institute of Technology Orientated Design Innovation (ITD) at the Polytechnic Offenbach am Main, which aimed at the protection of the ankle joint complex, too. This enabled a direct assessment of the IPD

approach. In contrast to applying IPD at Otto-von-Guericke University Magdeburg (OvGU), product development at ITD was mainly conducted without a specific product development paradigm.

3. Results

Concerning the verification of the IPD effectiveness the results show a positive evaluation of the criteria in the performed sports equipment development project (Table 1).

Table. 1. Assessment of the objective (O) and subjective (S) criteria (+ positive; 0 neutral; - negative)

Criteria	OvGU binding concept
product performance (O1)	+
product quality (O2)	+
expert rating (O3)	+
# of patents applied for (O4)	+
product costs (O5)	+
development time (O6)	0
learnability (S1)	+
subjective impression (S2)	+

At the end of the IPD development project at the OvGU a new safety binding concept with a semi release function was developed (Figure 3). The concept has been applied for a patent (O4) [35].

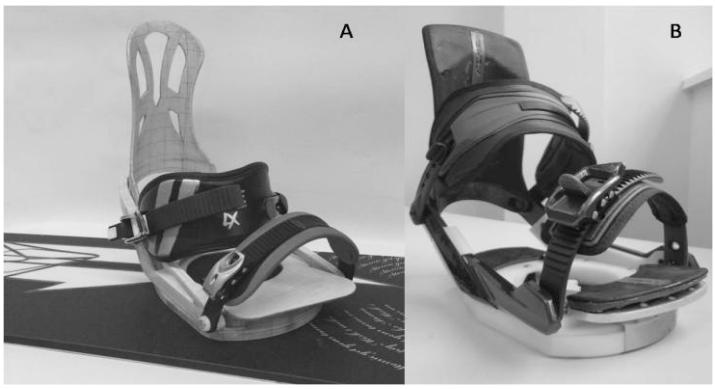

Fig. 3. Rapid design prototype (A) and functional prototype (B) of the OvGU binding concept

The positive assessment of the product performance (O1) (Table 1) is based on the results of the laboratory and of the on-snow tests. Compared to a conventional binding system the developed prototype reduces critical forces up to 28% [31]. Thus, the main requirement “reducing the risk of equipment related injuries in snowboarding in particular for the snowboarder´s ankle” has been fulfilled. With regard to this main requirement, the ITD binding concept does not reduce the risk of equipment related injuries at the snowboarder´s ankle, since no satisfactory protection function for typical injury mechanisms [33, 34] has been developed.

The results of the on-snow tests reveal positive results, too: The analysis of the questionnaires (n=12) shows a good overall impression of the new OvGU binding concept. However, compared to the conventional binding a significantly ($p=0.025$) worse assessment can be seen, which is mainly caused by the additional weight (+82%) of

the used functional prototype [32]. Compared to the snowboard binding concept developed at the ITD a significantly better assessment was given (p=0.006).

The assessments of the other objective criteria are positive, too. Although the product quality (O2) can only be evaluated for the functional prototype, a positive assessment was given. This was due to the fact that the prototype did not show any mechanical weakness during the performed tests. Further on, the concept has been presented at the 2009 congress of the International Society for Skiing Safety [31, 32]. Several renowned experts (O3) gave a very good feedback on the concept. Beside these points, product cost (O5) is another important assessment criterion. According to a local manufacturer, manufacturing costs are realizable, which allow an introduction of the product in the mid-market segment. This is an important requirement, which was defined in the 1st phase of the generic IPD process. The assessment of the criterion development time (O6) is "neutral". The prototype development took 16 month. Still, further tasks need to be completed until the series-production readiness. In contrast, according to a R&D manager of a leading ski manufacturer the time to market in the industry for an alpine ski binding with a similar complexity is approx. 14-20 month.

Beside the objective criteria, the learnability (S1) and the subjective impressions of each team member concerning the effectiveness of the IPD (S2) are further important aspects [10, 30]. Both criteria were positively evaluated. The analysis of the learnability based on the assessment of the three supervisors (completeness, accuracy, independence, quality of the project- and process management etc.) showed good results (67-100%). In addition, the written feedbacks of each team member reveal a positive subjective impression, too. E.g. one team member stated "I have been skeptic at the beginning of the project. How should five students develop a product, which leading manufacturers were not able to? At the end of the project I was convinced".

4. Discussion

The effectiveness of IPD for the development of sports equipment was proofed in the context of a case study. Almost all assessment criteria were positively evaluated. However, the lack of product development experience of most of the team members has to be considered critically with respect to the subjective impressions (S2). Experiences with other development paradigms might have resulted in different assessments. With regard to the product performance, the advantages of IPD are shown in comparison to a reference project (ITD) conducted without a specific development paradigm. In particular the holistic product view, the interdisciplinary teamwork, the consumer orientation, the information and communication flow, the application of modern technologies (e.g. rapid prototyping, CAx tools etc.) as well as the dynamic work flow supported by IPD are important aspects of a successful product development in sports. Critical aspects of IPD, such as "burnout of team members" [36] and "too many meetings" [37] are not observed. A reason for this can be seen in the "semi-technical character" of sports equipment [38], which limits the number of team members to an effective team size. Two further case studies were conducted at OvGU studying the application of IPD for the development of a professional roller ski and a fun sport device. Similar results were found in these case studies. However, a much greater number of studies, in particular in an industrial context, are required.

To sum up, the effectiveness of IPD for the development of sports equipment was successfully shown in the context of a case study. Therefore, a potential development paradigm can be offered to the sporting goods industry, which asked for a model of systematic product development. A stepwise procedure for a successful implementation of IPD in an industrial context is suggested [30].

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