INNOVATION IN SPORTS EQUIPMENT – BRIDGING IDEAS, EXPERTISE, AND APPLICATION BY UTILIZING SYSTEMATIC DESIGN APPROACHES

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Today many developments in sports equipment appear to be driven by the interests and processes of individual disciplines or departments. The resulting products consequently often show strengths in some aspects and shortfalls in others. In this contribution it is claimed that the application of systematic approaches would lead to more balanced and more relevant innovations in this field. The basic procedure and some core organizational requirements of a design process suitable for sports equipment are introduced, and illustrated with examples from selected projects. Wherever appropriate or applicable, the consequences for the work of biomechanists involved in product development projects will be specifically highlighted.

KEY WORDS: sports equipment, innovation, design processes, prototyping

INTRODUCTION: Introductions often use exaggerated fiction to get right to the point. Our "story" can start with a real life example – which we are not unambiguously happy about.

It happened a few months ago at a rehab fair in central Europe. "Strength training equipment for the disabled" was promoted at one of the booths; definitely a worth-while product objective. "Wheel-chair drivers are having a hard time getting into most of the existing training equipment," was the main argument in introducing a lat pulldown machine with a swiveling seat allowing easy access. "Over here is our new leg press using the same principle…" A leg press for wheel-chair drivers? With easy access, to add an even more macabre notion to this "new" development?

What had gone wrong? The hostess couldn´t, the CEO didn´t like to explain ("no time…") and never sent the material promised. Likely, the situation was as simple as this: Starting from a good idea and a first successful product, the "winning principle" was transferred to a similar product without much further reflection. In engineering words: It was not a need driven development but an opportunity driven variant – in all probability not a good approach to successful designs. But the reader shouldn´t be too eager with malignancy. It is more than likely that developments resulting from a similar blinker mentality, maybe a little less obvious, can be traced right there in his own home or work-place.

Even more so than the transfer of solutions to unadequate problems, the most prominent reason for "unbalanced developments" in sports equipment are disciplinary or institutional fixations. Engineers, for example, at times unreflectedly apply their methods to the area of sports, often much more for the sake of maintaining or proving these procedures than improving usability, fun-factor, or performance of the resulting product. Athletes can usually not envision the potentials of new technologies and hence tinker with comparatively simple and unsatisfactory solutions. And some experts in biomechanics, as we dare to say, appear to interpret a sportsperson as a biomechanic machine and neglect the psychological and sensual aspects of sports and movement.

The claim this paper makes, now, is that many of these problems regarding development and research in sports equipment could be avoided if the protagonists would apply relevant systematic approaches rather than disciplin-specific or haphazardly evolving procedures.

METHODS: But how to arrive at a "relevant systematic approach" to generate innovation in sports equipment? The obvious solution sounds simple: "Just" apply existing procedures, such as innovation processes and design methodologies, to the area of sports equipment. But even if this platitude points into the right direction, its realization is not quite as self-settling: Sports equipment has a number of features that are distinctly different from almost any other product group.

The most lucid characteristic of sports equipment is certainly that, unlike a coffee maker, a washing machine or a computer in general it does not have any function of its own. Thus the human interface is not one more or less mildly important product feature that maybe left to experts in biomechanics or ergonomics, but the very justification and main purpose of sports equipment at all. It does not prepare espresso, clean underpants or calculate tax refunds, but offers easy and manifold access to thrill, fun, excitement, training, communication, or other functions associated with the performance of sports.

As a first consequence, most of the demands and objectives in the design of sports equipment are non-technical, at least in the traditional understanding of technology. Therefore it must not be the engineer alone who is in charge of concept development, but a large variety of expertise is needed. But there is good news as well. While sports equipment is demanding product development teams of a very heterogeneous composition, it also offers plenty of opportunities that facilitate cooperation and integration. In creativity workshops the intellectual accessability and the often fun-related experimental connotations usually make it rather easy to break fixations, establish a common understanding of the target corridor, let team members play with ideas and gadgets, and have them produce unusual concept proposals. During the development process itself the most effective means of disciplinary integration, the production and joint testing of prototypes, can usually be realized almost as a matter of course. And last but not least joint (related) physical activities do not only help to generate a common understanding of the project contents, but also foster the social coherence of the project team.

The following proposal of a “methodology for the systematic development of sports equipment” (Fig. 1) has thus been developed by transfering the essence of existing methodologies for product development (for a more market oriented approach see e.g. Ulrich and Eppinger 1995, for a more technology oriented approach Pahl and Beitz 1996) onto the field of sports equipment; with emphasis on enhancing interdisciplinary and inter-institutional cooperation. Admittedly, the practical application of this procedure needs more explanation than can be allowed here. To at least make it better accessable to the participants of the conference, we like to briefly exemplify its utility and utilization for experts in biomechanics.

In the *definition of the development task* and the *determination of the project setting* it is important to acknowledge which disciplines (e.g. ergonomics, psychology, material science), institutions (e.g. associations, standardization committees), and expertise (e.g. trainers) are needed besides biomechanic qualifications, and how these may be integrated. In the *definition of the main functions* the biomechanists, using their competences in analyzing movements and stresses of (parts of) the human body, should supply accompanying studies and measurements to quantify the human-related specifications as well. In the *generation of a prototype* it must again be made clear to the engineers that it is not only the functioning of the mechanism and the bearable loads on the mechanical joints that have to be validated but also the useability by the athletes and the loads on the human joints – which obviously are most important contributions of biomechanists in the design of sports equipment.

RESULTS AND DISCUSSION: During the last few years we could validate the general applicability and optimize details of the proposed procedure in a number of projects (see also Moritz 2000). As just one example, Fig.1 also shows the respective results of selected stages in the development of a carving sled.

The idea for the project was developed in one of our creativity workshops by students of engineering and sports science in a joint effort. The further development of the carving sled has been conducted by a team similarly assembled by students of both departments, and been supervised by professors or senior researchers from five different institutes. To cope with the heterogeneity of this “team,” the generation, testing, and evaluation of different prototypes played a most dominant role in the development process, as has been reasoned above.

To demonstrate that the whole idea of a carving sled is workable at all, we first produced an explorative prototype. Due to time constraints caused by the availability of testing opportunities this first edition of the sled was rather quickly thrown together, grossly oversized, and broke down after just a few hours of operation. Nevertheless it still demonstrated that it is possible to steer a sled by simply shifting one´s center of gravity and thus via a parallelogram mechanism tilt the carved runners - which led the whole sled carve curves on the eges of the runners, as had been predicted. Furthermore, as a by-product of the tinkering process we developed what should become one of the highlights of the product: the interface to regular ski bindings. Thus eventually the sled did not become a big monster, but a light and easily transportable "accessory" to ones existing carving skis.

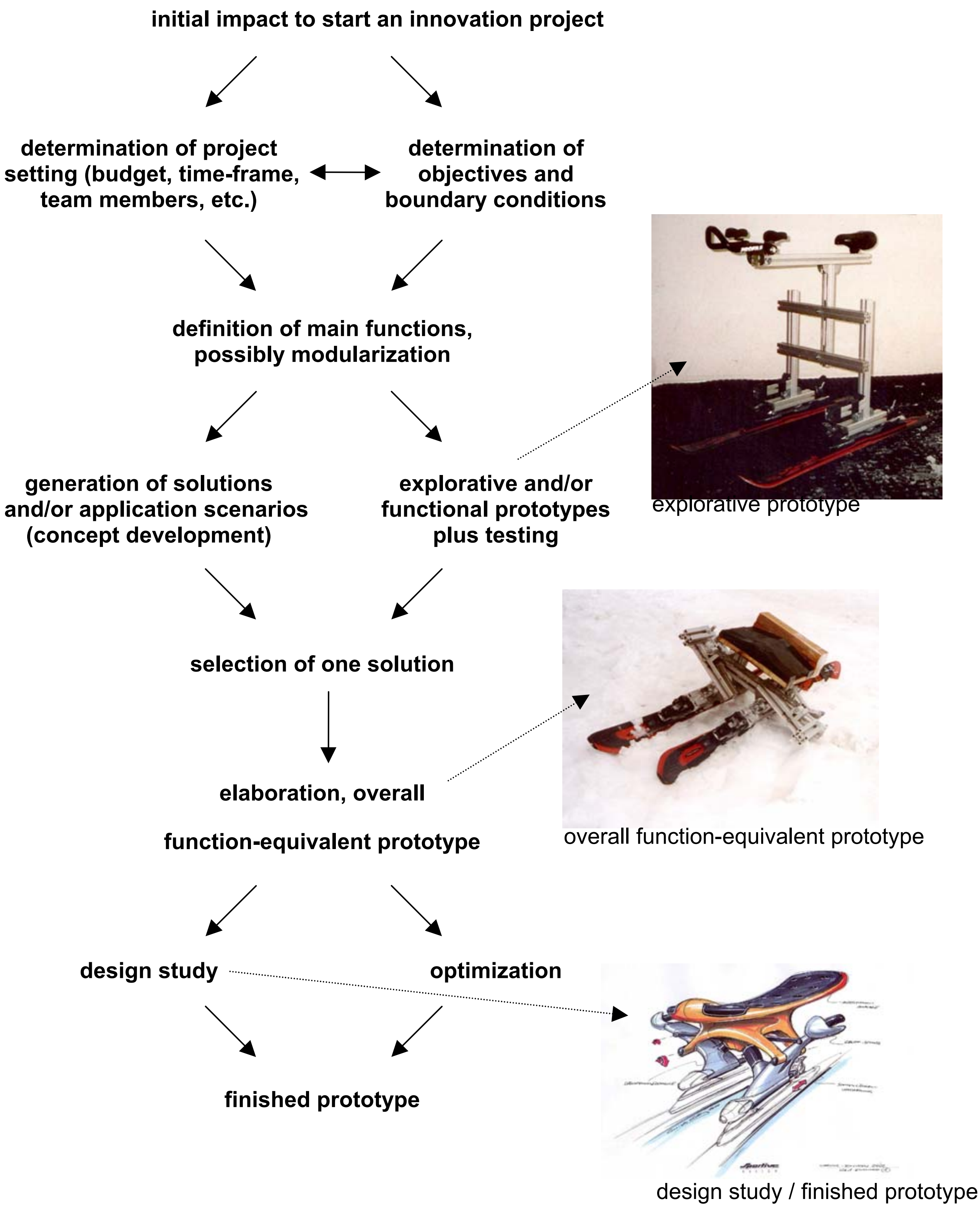

Figure 1 - Systematic development of sports equipment.

For the subsequent optimization of the kinematics we did not need full sized prototypes but experimented with construction-kits. Of course computer models may also serve as "modular functional prototypes" (Fig.1) for certain purposes. Their advantages are manifold: They are quickly generated, modified, and allow all sorts of simulations. On the other hand they require a much larger abstraction in the necessary three-dimensional perception, and lack the integrative abilitites of physical prototypes, as has been outlined above.
A return to full-size was necessary in the generation of the function-equivalent prototype, the term function-equivalent here referring to the functioning of the eventual finished product. Even though by then we knew how to arrange the main parts of the sled, especially the kinematically relevant mechanisms, it was still necessary to optimize steering qualities and driving fun – which by all means has to be experimented "live." The prototype we built therefore had to allow easy variation of track, camber, and similar parameters; a complexity which could later be reduced in the finished product. Test results and subsequent adjustments were jointly discussed by the whole team, respectively.
Just for the sake of enjoying a novel gliding experience among the team this prototype, after some improvements regarding safety and corrosion, would certainly have been satisfactorily. However, as we had become convinced that this product should be of great interest for a larger user-group and should therefore be converted to mass production we did not stop here. The next step was consequently to produce an appealing design while maintaining the functions of the yet ugly and heavy prototype (Fig.1). This was done in collaboration with an experienced designer of sports equipment; we are grateful to Guido Golling for his cooperation. Furthermore we have been working on increasing safety and decreasing loads especially on the knee joints (if steered by drifting); here the biomechanic expertise of Andreas Huber proved to be most helpful.

CONCLUSION: The development of a carving sled was not the only application of systematic design approaches we have been pursuing: A training device for snowboard jumps, a new concept for a SnowCart and a health-sustaining training machine for manned space-flight are other examples of similar design projects. The main conclusions of all these projects can once more be summarized as follows:

1. In the generation of really new and innovative designs, it always makes sense to follow some sort of methodology or other systematic procedures.
2. In the development of sports equipment it is imperative to include athletes as well as experts from different fields of sports science into at least the extended product development team.
3. To improve cooperation and integration and thus lay the groundwork for synergy in these heterogeneously assembled teams, it is important to use physical prototypes of the whole product or parts hereof as early as possible.
4. Biomechanists should highlight their competences in analyzing the consequences of innovations in sports equipment onto the human body, and should support these projects especially by determining human-related specifications and enabling related measurements in the testing of the prototypes.

As a final word, we would greatly appreciate any sort of cooperation or scientific or practical discourse with other teams dedicated to similar projects as the ones outlined above. Please contact us directly under fozzy@ibu.de.

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