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Application of Virtual Simulation Experiments in Teaching of Industrial Product Design

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Abstract: The development of virtual simulation experimental technology provides favorable conditions for the cultivation of innovative talents in universities. Initially, this paper describes the disadvantages to the training of students in product design, particularly from a practical point of view, as it can be easily found that traditional education lacks feedback on the validation of product design and the rationality of production processing. The virtual simulation experiments as a platform for design experiments can be used to test and react to students' design solutions through a combination of virtual and real teaching modes, as well as to improve students' practical skills and benefit greatly in terms of product processing techniques and how to reduce production costs. It is a virtual platform that enables practical cases from enterprises, teachers' research projects and disciplinary competitions to be used as experimental projects, advocating independent, collaborative and inquiry-based innovative design practice, thus achieving the aim of improving students' innovative practical skills. Virtual simulation experimental teaching is the practical way of teaching reform model of project-based teaching.

1. Introduction

Virtual simulation experiments focus on the enhancement of students' abilities from a practical point of view. At present, many students of industrial product design at universities and colleges in China have a common problem of having pie-in-the-sky designs that cannot be realized and implemented. It is for this reason that the students lack the experience of being exposed to the mechanized mass production of products, which makes it impossible to design practical products that combine theory with practice. Many products have innovative design concepts, however, which will not be realized if mass-produced because the structure and shape of the product are impractical, or the shape of the product cannot be machined, or even if it can be machined, it cost so much. However, students are unable to measure the realisability of their products by one standard. It aims to cultivate talents and adheres to the basic requirement that virtual experiments are "practice-oriented". Combined with the disciplinary characteristics of the art and design profession, the teaching of design, in particular, focuses only on aesthetic values and lacks production manufacture. In addition to this, the teaching of product experiments for purposes that cannot be achieved by real

experiments and the running costs are far to be met, leaving several contradictions between aesthetics and technology.

1.1. The Production Process is Complex with an Unclear Processing Principle

Product Design is one of the design disciplines that require the interplay of art and technology, making it one of the faster growing and more in-demand disciplines in China at present. However, many art graduates currently lack practical design experience resulting in products that are only aesthetically focused and not commercially viable for mass production, or are too costly to produce and process, increasing the risk to enterprises. The reason for this is that students cannot visually observe the process of design solutions going through mechanized production and material processing to produce the final product, although similar courses such as *Fundamentals of Product Engineering Design* and *Machining Processes for Product Design* are taught in schools. This key process has always been in the “black box” of product design. It directly results in several contradictions between the artistic form of the product and its production and processing:

- The contradiction between product form and processing. For example, many products are designed with a focus on form, but cannot be produced using modern materials and processing techniques.
- The contradiction between product form and material choice. For example, products cannot be realized with suitable materials.
- The contradiction between product form and mold making. For example, problems such as focusing on aesthetics but neglecting mold processing such as demoulding and parting in product design.
- The contradiction between the form and the cost of the product. The cost of the product includes a range of factors such as materials, workmanship, and mold making, so the aesthetics of the product design is at odds with these factors, making it difficult to reconcile them.
- The contradiction between the shape and efficiency of production. A product is designed in a form that is too complex and reduces production efficiency.

As a result of all these contradictions, the products designed by the students are unable to be adopted by the enterprises and accepted by the market and consumers because of the high cost of construction or development and end up as a product "model" or handicraft, which cannot be put into mass production.

1.2. Long Design Development Cycles

In addition to the contradictions mentioned above, there is also the problem of long product development cycles in design teaching. The development of a design requires iterative revision, comparison and discussion, and is an activity that requires close planning and a high degree of economic risk. The design development cycle often exceeds a year, which conflicts with the school's short curriculum time.

1.3. High Cost of Product Experimentation

The aesthetic form of product design, together with production, production cycles, economic value and innovation, constitute the 'force field' of product design. How to balance these elements in the design of a product, art and design cannot just be a 'paper exercise', but needs to be linked to practical processing. However, the reality is that few companies invest in students' 'artistic experimentation' designs. Virtual simulation teaching is thus a great solution to this reality, improving students' design fundamentally.

1.4. Features of Virtual Simulation Experiment Teaching

Feature 1*:* Based on the background of "grand design", the virtual simulation platform of design is constructed to realize the collaborative innovation of "design-practice" by combining the virtual and real. Wang Shouzhi has described the relationship between design and art as "small art, grand design". Design differs from art in its specificity and irreproducibility, especially as industrial product design is for the market, i.e. the general public, and is therefore called "grand design ". The design, therefore, needs to enable the production of products in large quantities by machine as a means of meeting the demands of the mass market and companies. In contrast, current product design education in China is still lagging. In particular, it fails to meet the demand of companies for design, and many recent graduates are not well received by employers, the reason being that design is more craft-oriented. In particular, despite the emphasis on applied education in many institutions, students are not offered the opportunity to participate in school-enterprise cooperation projects. Even if they do, they are not recognized by companies because of their lack of experience, and thus stand even less chance of continuing to work on projects, and end up in a vicious circle. Currently, project-based teaching mechanisms are advocated in the teaching reform of art and design, introducing design projects into the classroom and allowing students to exercise and practice. Furthermore, students will be able to realize the importance of mechanized product production through virtual simulation experiments to "practice". The virtual design and production process is combined with the actual project, which achieves the goal of "combining the virtual with the real "experiment and increases the fault tolerance of the design. In particular, it will be a valuable design experience for students to be aware of the reasons why their designs cannot be mass-produced and to optimize them to better meet the needs of the mass market.

Feature 2*:* It explores the intersection of art and technology, aesthetics and engineering in a way that is based on a vision of a larger discipline. It promotes and guides design aesthetics with manufacturing practices. Currently, so much of art and design education emphasizes only the creative thinking and formal aesthetics of students but is relatively weak on how to realize them rationally and technically. In product design, for example, most students are interested in product modeling but know little about how to open a mold, the CMF (C: color, M: material, F: process) and structural assembly of a product, or they are stuck in theory. Product design is a combination of art and technology, a cross between aesthetics and engineering from a disciplinary point of view, and a focus on formal beauty at the expense of technical grounding is ultimately just a solitary artifact. The construction of a virtual simulation experiment platform can effectively complement and intersect the disciplines of science and technology, such as electronics and machinery, materials science and machining processes, to build a multi-disciplinary and integrated experiment platform.

Feature 3*:* Establish an assessment mechanism to improve students' sense of responsibility and tolerance of product design. As a mass-produced product, any problems with the design will cause problems such as late sales and reworking of the product, resulting in large losses for the company. For students living in ivory towers, it is difficult to think about such issues and thus lack the sense of responsibility that designers should have in their designs. Designers have a level of responsibility that many school students cannot comprehend or appreciate. This is one of the reasons why recent graduates are unable to undertake projects in companies. It is for this reason that the virtual simulation experiments enable students to comprehend that product design is a real balance between rationality and art, and to appreciate that designers do not design products as "functional works of art", but rather as analysis and trade-offs based on rationality. It is the responsibility of the product designer not to pursue self-expression in disregard of the demands of corporate development, but rather to upgrade corporate products and serve society and users through what they have learned. Designers will dance in chains if the factors affecting the product, such as technology, industry and

consumers, are compared to chains. Once the shackles are expressed in the form of data, a more varied "dance" can be performed. Virtual simulation experiments could account for costs, including material, process and tooling costs, using big data and computer algorithms, as a result. Moreover, different results can be obtained by selecting or entering the corresponding parameters, which can be compared and selected, or even optimized. For example, the cost of choosing "metal - aluminum alloy - stamping" and "plastic - PP - injection molding" for the material and process of the mug is completely different in the experimental process. Once a production batch is entered, students can visualize the difference in price between the two materials and processes and appreciate that product design is not an 'art game'. A mistake in the school's choice of experiment could be just a poor result, while it could be a huge loss for the company. Likewise, such simulation experiments can be used as product evaluation and selection for companies to make product design more fault-tolerant. It combines design and virtual processing and production well, facilitating comparative trade-offs and modifications of design solutions through the selection of different materials and processes, establishing a mechanism for product evaluation and reducing commercial risk.

Feature 4*:* Implement the school-enterprise collaborative development to create a virtual simulation teaching resource system that combines the aesthetics of design forms and material processing technology as the theme of independent R&D. Today, it is the lack of funds for the establishment of laboratories that makes the implementation of virtual simulation in most schools difficult. Therefore, the establishment of virtual simulation experiments can be developed jointly by schools and enterprises to train students in this way. Enterprises can optimize and evaluate designs and adjust product development ideas by using experiments to obtain data and parameters, or they can select students with high performance for schools as trainees and designers. From the perspective of education reform, the virtual simulation experiment can truly achieve the purpose of "project teaching" around "student capacity development" and "industrial needs", without making enterprises take risks, thus achieving long-term cooperation and a win-win situation for both education and industry.

Feature 5*:* Set up a teaching management and sharing platform to form a "three-oriented" resource-sharing system, that is, a resource-sharing system for teachers and students on campus, for institutions off-campus and design companies in the industry. The virtual simulation experiment platform is set up to introduce projects from enterprises and train more outstanding students with project experience. It is the rational use and effective utilization of the platform that is the ultimate goal of platform building and management, although effective management and maintenance are required for the platform to be sustainable and maintained. On-campus, the virtual simulation experiment platform should not only be open to product design majors, but also to all majors across the university. In particular, it is the collaboration with product design-related disciplines as a way to promote the development of interdisciplinary interaction to promote the advancement of teaching and educational reform to promote relevant research results. For example, the interaction and cooperation between disciplines such as materials science, mechanical engineering, electronic science and technology, and ergonomics and product design promote the development of a positive discipline within the school.

The maintenance and upgrade of the virtual platform require constant investment and updated data to keep the platform sustainable. It is not sufficient to rely on school funding alone, so it can be shared with other professional institutions, using the professional strength of other institutions to achieve the update of data materials, software upgrades and diversification of experimental projects on the virtual platform, etc., which promotes the exchange among institutions even more.

As mentioned earlier, for the school-enterprise collaboration to build a virtual simulation platform, the school side can introduce more projects from more product design-related enterprises and take advantage of the resources of the experimental platform to complete project-based

teaching and practice. Also, the virtual experiment platform can be conditionally opened to relevant design enterprises and charged a corresponding fee to maintain the platform development and update, feed the construction of the virtual simulation platform and realize the social sharing system of design resources.

2. Conclusion

Virtual simulation experiments are widely used in product design education, not only for the benefit of project-based education models to train students, but also to develop students' design skills and knowledge of their profession in virtual experiments of projects, as well as to cultivate students' sense of responsibility and enthusiasm for learning as future designers. A win-win situation can be achieved through cooperation between the university and the company to be able to build a virtual simulation platform. Meanwhile, the virtual simulation experiment platform is strict in management, as well as the utilization needs to be adequate. It is oriented towards universities and enterprises to form shared resources in order to serve the local community and society and to achieve the purpose of applying education in learning.

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