Creative Education
2013. Vol.4, No.7A2, 130-136
Published Online July 2013 in SciRes (http://www.scirp.org/journal/ce)
http://dx.doi.org/10.4236/ce.2013.47A2016

Higher Education for Complex Real-World Problems and Innovation: A Tribute to Heufler's Industrial Design Approach

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Received May 31st, 2013; revised June 30th, 2013; accepted July 7th, 2013

This article appraises an internationally top ranked higher education program in industrial design, whose stated mission is to enhance students' ability to deal with complex real-world problems and thereby develop (sustainable) innovation. At the outset, we discuss in general terms—in our view—the indispensable essentials of a higher education program that specifically aims to equip students with the competences needed to successfully deal with such complex real-world problems. In the second part, we specifically examine Heufler's School of Industrial Design in Graz (Austria), its development and characteristics. A summary of general implications for higher education and lessons learnt from this top industrial design program concludes the article. Our analysis suggests that the school's success is based on a few key cornerstones: 1) The program has a clear mission, which has been communicated early on, internally and externally; 2) Strong leadership, which enables continuity and high-quality output (e.g., attracts high-quality input reflected in the profile of applicants to the program); 3) Real-world projects with co-leadership from industry; 4) Provision of a supportive learning environment which extends beyond lecture times and which is conducive for collaborative creativity; and 5) Faculty are professional experts who focus on problem- and project based learning approaches which aim at the joint development of personal, professional domain, systemic, creativity, and sociocultural (collaborative) competence of the students. The authors of this article have been involved with Heufler's School of Industrial Design since its establishment in 1995; they speak on behalf of Gerhard Heufler, the founder and head of this program, who unexpectedly passed away in April 2013. His remarkable leadership has enabled an extraordinary program in higher education with the explicit aim to provide students with competences needed to successfully deal with complex real-world problems.

Keywords: Gerhard Heufler; Industrial Design; Complex Real-World Problems; Collaborative Creativity; Sustainable Innovation; Higher Education

Introduction

The world needs to mobilize human capital, knowledge capital, and creativity as their main assets in order to cope with its "unprecedented challenges" (OECD, 2012: p. 13). Yet these assets cannot be taken for granted: they require growth and training via appropriate primary, secondary, and tertiary education (i.e., higher education). Today's educational systems are embedded within a highly dynamic world and require constant adaptation in order to adequately respond to the need for training and supply of competences needed in such a complex environment. Great strides towards student mobility have been made in recent years in Europe via attempts for standardization within international education policy, most notably the Bologna process, which enables comparisons between country specific educational standards, raises basic qualities of education, and consequently, increases international mobility of students; however, such standardization processes also have their shortcomings and certainly do not automatically provide for excellence within education. Rather, there is a need to leave certain flexibility to the individual educational systems, allowing them to creatively establish outstanding programs, which are suited for their particular purpose and mission in a highly complex world. For example, the Bologna process provides a framework, which distinguishes between Bachelor's degree programs and Master's degree programs; such a framework supports clarity and comparability of educational systems within Europe (European Commission, 2012). However, the specific content and objectives of a particular educational program, such as in industrial design, might require a different structure, perhaps something simple as a more extensive program which reaches beyond a Bachelor program, and requires an integrated Master program in fulfillment of its educational goals (to attune all modules of the whole program to each other, from the first term of the bachelor's degree program to the last term of the master's degree program). Depending on these objectives, three years of undergraduate training towards a Bachelor's degree (as is currently the standard in Europe) might not do justice to an education with interdisciplinary, real-world, and innovation-based orientation.

We believe that the Industrial Design School of Graz (http://www.fh-joanneum.at/aw/home/Studienangebot_Uebersicht/department_medien_design/~cyi/ide/?lan=en) can be regarded as an excellent role model for future higher education for several reasons. One of them is the unprecedented success of its alumni in "the real world" of industry, non-profit organizations, and as entrepreneurs, which provides testimony and practical evidence that the competences they acquired during their training are useful in succeeding within modern society. Due to this success, the program is currently ranked within the top 60 best design schools in Europe, Asia, and North America (citation: Business Week) and has been classified as a "high standing educational institution" by the Bureau of European Designers Associations (BEDA). Moreover, graduates succeed in design studios such as IDEO, Designworks, Kiska, Frog, or in corporate design or development departments, for instance at Apple, Audi, BMW, Mercedes, Lamborghini, KTM, Kärcher, Lego, Nokia, or Philips. As entrepreneurs, they have successfully founded their own companies, serve in management functions based on their systemic and strategic orientation, or—after having gained appropriate work experiences, have become teachers themselves.

Although this particular educational program is embedded with the theme of Industrial Design, we argue that it has more general implications for higher education. For example, the problem-based approach of this study program is not only directed towards training in industrial design; it also trains the general competences needed to understand complex real-world problems and affiliated stakeholders in their broader environment. After completion of the program, students are able to analyze potential development paths of the underlying systems, to generate creative solutions, which ultimately may lead to successful innovations, to evaluate their effects on the system and the broader environment, and more generally speaking, to actively shape the future based on a clear value system such as related to sustainable development. We argue that these competences are not only characteristics of successful industrial designers, but that anyone concerned with solving complex real-world problems innovatively (Steiner, 2013a) would benefit from acquiring these competences. Consequently, the program in Graz could act as role model for any education and training program focused on providing competences for complex real-world problems. In the following, we will first lay out why competences for solving real-world problems matter, and then describe Heufler's School of Industrial Design, including its mission, specific style of leadership, organization and curricula, and very specific learning environments. We conclude with a chapter describing the specific measures within the industrial design study program which support the development of personal, professional domain, systemic, creativity, and sociocultural (collaborative) competence.

Why Competences for Solving Complex Real-World Problems Matter

Complex problems accompany mankind since its existence and shape our professional and private lives. However, globalization and increasing interrelatedness are the main reasons why complex problems have multiplied in numbers.

In order to cope with complex real-world problems, standard solutions are usually insufficient; instead, they require innovations along a scale from incremental to radical. Within such complex challenges, innovation will usually not occur as a single form of either product, process, structural, social, or political innovation, but will rather encompass various innovations along those dimensions. Therefore, innovations as potential solutions to complex real-world problems themselves possess complex characteristics.

Theoretical Basis

In this article the "2P2SC Framework of Competences for Complex Real-World Problems" (Steiner, 2013a) serves as theoretical foundation for investigating the educational characteristics of the School of Industrial Design Graz.

As outlined in this competence framework (see **Figure 1**), problem solving competence consists of several individual, not interchangeable competences: personal competence, professional domain competence, systemic competence, creativity competence, sociocultural (collaborative) competence (see the detailed descriptions in the case related analysis).

The rationale for choosing the C2P2S competence framework is based on the following argument: The project- and problem-based approach of the School of Industrial Design Graz aims at the generation of innovation embedded within complex real-world systems. This requires specific competences, which are grounded in professional excellence, personal fitness, creativity, systems thinking, and collaborative problem solving capabilities (in an interdisciplinary manner, i.e. across various disciplines, and in a transdiscplinary manner, i.e. together with stakeholders of various levels of society). For a detailed evaluation of existing competence frameworks and their fitness to accommodate the challenges imposed by complex real-world problems, see Wiek et al., (2011) and Steiner (2013a).

Heufler's School of Industrial Design

Gerhard Heufler co-founded the School of Industrial Design Graz in 1995 and headed the program until April 2013. Born in 1944, Gerhard Heufler studied architecture at the University of Technology in Graz, then began his international career as a product designer with Siemens in Munich in 1970. Since 1975 he worked as a freelance industrial designer in Graz, and between 1979-1995 taught design analysis and ergonomics at the

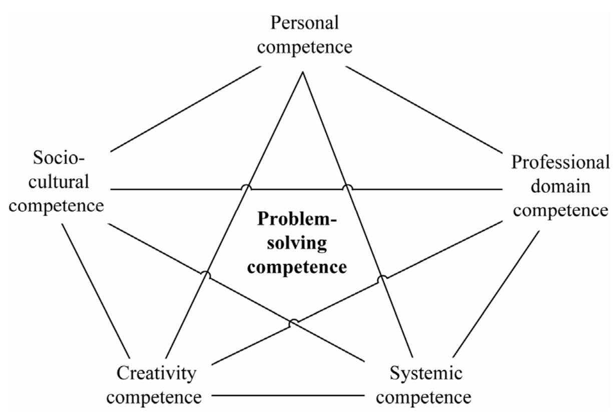

Figure 1.
Problem Solving Competence: The C2P2S Framework of Problem Solving Competence (Source: Steiner, 2013a).

Mozarteum University in Salzburg and the Graz University of Technology. Gerhard Heufler received numerous national and international awards for his work, which spanned from the world's smallest mine detector to an unmanned helicopter, both of which are at permanent display in the Museum of Modern Art in New York. In 2005, he was awarded the USA Industrial Design Excellence Design Award Gold. Being a professional designer and educator provided the basis for his three widely-used text books in industrial design and industrial design education, Design Basics: From Ideas to Products, Design Products (Heufler, 2012), Design Impulse (Heufler, 2010), and Design Impulse No. 2: Bikes Cars Colours More Smart Ideas (Heufler, 2011). One of his chief principles, which comprehensively shaped his work as "designer of an educational system", was that design has to go beyond making a product simply more appealing. Rather, he looked at design as a problem solving process, which (besides aesthetics) should be aimed at providing functionality and value to society. In addition to his numerous professional and educational accomplishments, Gerhard Heufler was a key force and advocate for Graz to be selected the "UNESCO City of Design" in 2011.

Other design schools might be categorized according to their focus on either aesthetic or functional dimensions. Heufler decided to break this paradigm by symbiotically connecting both, requiring students to develop both their aesthetic and functional capabilities.

Mission

A good mission is reflected in the system's members and their actions. In other words, a mission defines the system's fundamental purpose and values. Ideally, it provides a realistic foundation and orientation for current and future actions to be taken within this system (i.e. an organization, such as a School of Industrial Design). Furthermore, the mission should guide a system's vision. Although adaptations may be necessary due to changes of the system and its environment over time, a mission should provide stability and orientation along the system's development.

The core of the School of Industrial Design Graz' mission extends well beyond the school's curriculum, and also provides a more general mission for industrial design as a discipline: As Heufler stresses, industrial design is more than an artist's ego trip or a simple marketing tool to enhance sales figures; in his view, the degree to which the changing needs of society can wisely be incorporated into our cultural, economic, and ecological environment largely depends on sensitivity, intelligence, creativity, and phantasy; consequently, industrial design must be viewed as a holistic problem solving process which aspires to develop technically functional, aesthetic products and meets the needs of the customers and industry by increasing life quality of society (Heufler, 2012: pp. 7, 17).

The School's unique profile centers around its motivation: 1) to develop a joint aesthetic and technically functional orientation; 2) to educate and train industrial designers who are capable to understand and speak the language of various stakeholders and problem solvers (including designers, engineers, marketing or ergonomics experts); 3) to provide graduates with the competences needed to deal with complex real-world problems, and consequently; 4) to educate and train these graduates so that they are fit for immediate integration into real-world projects.

Leadership

Peter Drucker's understanding of good leadership could have been a perfect description of Gerhard Heufler. "For Leadership is not magnetic personality—that can just as well be a glib tongue. It is not 'making friends and influencing people'—that is flattery. Leadership is lifting a person's vision to higher sights, the raising of a person's performance to a higher standard, the building of a personality beyond its normal limitations (Drucker, 1999: pp. 370-371)." Or, as Cohen (2010) synthesizes some of the core ideas of Drucker on effective leadership: 1) strategic planning is the first priority of a leader, 2) ethics and personal integrity are crucial, 3) a good leader needs to take care of his/her people (with military as an example), 4) the capability to motivate others is essential (e.g., one conclusion of Drucker was to treat employees as if they were volunteers), and 4) it is more appropriate to persuade instead of bossing your "partners" around (as an extension of 3)).

A core aspect of Heufler's leadership philosophy was that co-leadership within applied real-world projects is essential. This implies that projects of the School of Industrial Design are done in collaboration with a specific company, which is working on a real-world challenge and is open to fresh approaches and concepts. These fresh approaches and new concepts necessarily have to be tied to the company, its philosophy, values, mission, vision, and strategy. In partnership with the academic leadership provided by the School of Industrial Design, experts from the company may act as additional external facilitators (sometimes as external lecturers) and co-leaders (e.g., Scholz & Tietje, 2002), to further strengthen this collaboration.

It is of significance for programs of higher education that a variety of different leadership styles can lead to success. For example, it would be impossible to simply copy a particular successful leadership style i.e., certain attributes of the leader, given that successful leadership largely also depends on the specifics of the respective educational program, its stakeholders, objectives, projects, and how well it is embedded into its environment (i.e., along environmental dimensions such as political, legal, & institutional; sociocultural; economic & financial; technological; infrastructural & architectural; ecological (Steiner, 2013a, 2013b)). However, role models such as Gerhard Heufler or Drucker's lessons can provide a good basis for further refinement or adaptations of one's own leadership style.

Organization and Curricula

A full-time educational program in product and transportation design at the School of Industrial Design Graz is structured into a five-year Master's degree program with an integrated three-year Bachelor's program (originating from a four-year diploma program before the Bologna process). Upon graduation from this integrated program, students are awarded a Bachelor of Arts (BA) and Master of Arts (MA) in Arts and Design. Courses are taught in German and/or English. Following its principle, namely to provide best possible supervision and guidance to its students, the school strictly limits admission to a maximum of 16 students per class. Consequently, approximately 80 students (including international exchange students) are simultaneously trained by roughly 27 professors and additional supervisors from cooperating companies.

As outlined in **Figure 2**, even though the curriculum comprises both a Bachelor's and a Master's degree block, it is the

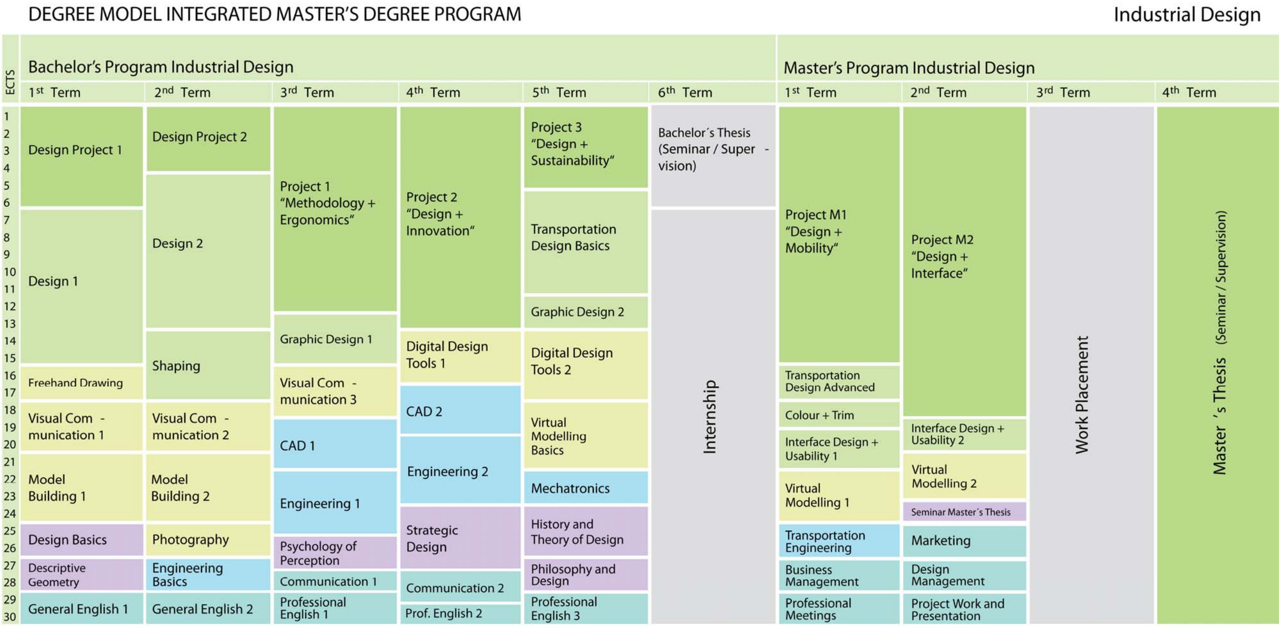

Figure 2.
Curriculum integrated master's degree program (Source: www.fh-joanneum.at/ide).

Industrial School's explicit objective that students participate in the entire 5-year integrated program. This will guarantee that graduates are equipped with the comprehensive set of competences needed to self-assuredly deal with complex real-world problems in industrial design or affiliated fields.

Importantly, the school's curriculum is based on a problem and project based educational approach. Each term, students work on a different core project. Course work is, to the largest extent possible, integrated into term-specific core projects. This allows students to focus on one comprehensive real-world problem, with co-leadership from the industry, while simultaneously applying the knowledge they gain in parallel course sessions. By contrast, the Harvard case-study approach is mainly centered on paper-based cases, whereas the School of Industrial Design's real-world cases require students to apply a transdisciplinary approach in which they have to deal with real-world stakeholders (either as customers, companies, or other groups of society) (Scholz & Tietje, 2002; Steiner & Laws, 2007; Scholz, 2011).

Throughout the entire curriculum, individual projects account for more credits than any other given course. Related to targeted competence(s), the projects require to develop all five competences of the underlying "2P2SC Framework of Competences for Complex Real-World Problems."

Learning Environment

The learning environment—and in particular, the physical and social work environment (e.g., Isaksen, Dorval, & Treffinger, 2000; Steiner, 2011: pp. 146-154)—critically influences students in their acquisition of competences, either within individual or collaborative learning processes. A learning environment which enables students to acquire the competences needed to successfully deal with complex real-world problems—such as the applied project work at the School of Industrial Design Graz, which is done in close cooperation with industry—combines several sets of environments:

- The studio is the center-piece of learning—here, project work takes place, but it is also the space where most project-related and other social activities (e.g., shared dinner or engaging in a game during late working hours) take place and where students spend most of their time. Hence, the studio represents a social arena, which provides the trusting and safe environment needed to deepen collaboration among students on an emotional and social level. As the "mother ship" throughout all 10 terms of the program (with the exception of company internships, which take place in the sixth term of the Bachelor program and the third term of the Master program), it is crucial that the studio allows to create a supportive and comfortable working space which fits both individual needs but also those of working groups. The only restriction for students in creating their own work areas is that each class must have their own working zone within a single top floor studio. Within these class-specific working zones, students are encouraged to creatively and individualistically establish working spaces, which fit their specific needs and requirements. In order to stimulate communication between students of different classes, no static walls divide the various work zones: instead, half-transparent mobile room dividers are used, which simultaneously serve as working walls for e.g., storyboarding, research results, sketching, and idea collections. To keep the creative spirit flowing, visual presence of every working step is emphasized in the studio.
- The internal manufacturing laboratory gives students the opportunity to build physical models (e.g., clay-, wood-, composite models) of their concepts. Here, under the supervision of professional model makers and technicians, students are trained to work with different machinery. The models, which students create as part of a rapid-prototyping process, assist them in obtaining feedback from potential users already at very early stages of the innovation process

or students use them for self-experiments.
- Class rooms and computer labs provide additional space for specific course work, including computer-aided design (CAD) for developing virtual models.
- Besides these school-related working environments, further real-world environments are part of the learning environment. This includes locations of the cooperating industry, their internal design and production facilities but also real-world scenarios for future application (e.g., a rehabilitation center or a hospital for new sport equipment for physically handicapped people). External locations, which are especially stimulating for new perspectives and creative problem solving processes (e.g., outdoor spaces in nature), complete the set of learning environments.

Competence Development

The quality of an educational program depends on the program and its faculty. Heufler's philosophy was that a good teacher is a teacher who is a professional expert in their field, and not simply a professional teacher. The objective behind this educational philosophy is that, by tying in professional experts, students could also benefit from the practical experience of these professional experts. In addition, the quality of an educational program depends on the quality of prospective students the program is able to attract. Contrary to most other Austrian programs in higher education, which are mandated to provide open access for students who fulfill the general higher education entrance qualification, the School of Industrial Design Graz limits the number of admitted students to a total of 16 per year for the entire Integrated Master's Degree Program (which includes the Bachelor program as well). A highly selective admission process is based on a multi-step procedure which extends far beyond the regular higher education entrance qualification and which also requires a comprehensive application package with all relevant documents, a written assessment test (for the Bachelor program), an aptitude test (for the Master program), and a portfolio which contains samples of previous works related to industrial design. For Heufler, a student's portfolio was of utmost importance since it exposes personality, motivation, goal orientation, skills, creativity, and artistic talent of the student. The quality of applications has continuously risen since the beginning of the program in 1995, paralleled by increasing popularity of the program (i.e. even though the quality of applications has improved continuously over the years, still only about 10 % of applications are accepted). The program's increasing popularity stems primarily from word-of-mouth recommendations within the fields of industry and industrial design and the international awards the program and its faculty received. Over the years, a form of branding of the School of Industrial Design Graz took place, with a strong reputation for educating a highly talented pool of graduates who, at the end of the program, have problem solving competences that encompass functional and aesthetic dimensions, enabling them to solve complex real-world problems by generating innovations which are aimed to provide value to society beyond economic purpose. Hence, graduates from the School of Industrial Design are highly sought-after fresh entities of the job market

Criteria which inform the highly selective admission process are not only based on professional domain competence in the field of industrial design, but also include personal, sociocultural, creativity, and systemic competences. By applying such stringent selection criteria, drop-out rates are extremely low.

Although design thinking has become of special interest in literature and practice (e.g., Brown, 2009; Lupton, 2011), it only describes a single component of competences provided within this educational program. Industrial design is not an end in itself, but as source of innovation it is aimed at providing comprehensive solutions for complex real-world problems which serve economic purposes and contribute to sustainable development and, more broadly, advancement of society (e.g., Heufler, 2012: pp. 5-7).

In the following we outline specific measures within the industrial design study program which support the development of personal, professional domain, systemic, creativity, and sociocultural (collaborative) competence (Steiner, 2013a).

Personal Competence

Personal competence means to be aware of oneself and, more specifically, to manage oneself for example within the problem solving process. It includes the capability for self-reflection as part of personality development, to comprehend mental models that underlie one's own thinking, to think in a goal- and future-oriented manner, to be self-motivated, to act self-dependent, and to be able to apply supportive methods. Further, personal competence is a precondition for collaborating with others, especially when these collaborators have different professional and sociocultural background (e.g., as different stakeholders are involved within the collaborative problem solving process).

Within the study program of the School of Industrial Design Graz, personal competence is specifically addressed in courses such as "Psychology of perception" and various communication related courses. Furthermore, personal competence is trained during participation in projects, internships, and work placement.

Professional Domain Competence

A project- and problem-based learning approach depends, among others, on domain-specific knowledge, methods, and skills. For example, when working on mobility innovations, domain-specific competence related to transport systems is required; or, when working on product innovations by using rapid-prototyping or modeling, industrial design specific knowledge, methods, and skills are required. In contrast to all other four competence dimensions, this competence focuses on specific disciplines or domains.

It is professional domain competence, which is ultimately the competence dimension most specific to industrial design. However, from an industrial design perspective, other classifications are also possible; they might include, e.g., design, visual, and engineering competences. Nonetheless, these dimensions can also be summarized as professional domain competence. The industrial design study program addresses professional domain competence in various individual courses, in addition to continuously working on projects: Design basics, design, freehand drawing, graphic design, digital design, transportation design, CAD (computer-aided design), interface design & usability, color & trim, shaping, visual communication, modeling, photography, engineering basics, and mechatronics are some of these individual courses (see **Figure 2**). Another philosophy of our school is that little things can have a big impact. For example, Heufler suggested that providing each student with a sketch-book at the beginning of their studies would stimulate their visual curiosity and professionalism.

Systemic Competence

Systems competence empowers an individual to understand core characteristics and general patterns of a complex system (i.e., its borders, the interrelatedness of its elements, its interaction with its environment, and its dynamic behavior over time, based on the peculiarities of the underlying mental models that are being employed). This incorporates also the capability to choose and apply appropriate methods for modeling a current complex system and its potential future paths of development.

Systemic competence is more than systems thinking and additionally comprises the necessary skills to accomplish either more qualitative or quantitative forms of system modeling. Training system competence tremendously depends on learning by doing. For this purpose, case-based learning and, particularly, real-world projects (such as the project on "design and innovation" in the fourth term) give students the opportunity to self-responsibly deepen their system understanding by broadening their knowledge basis through secondary and primary research, developing first graphical system models (such as causal-loop diagrams), and future scenarios for the relevant environments (e.g., sociocultural, economic and financial, ecological, and technological) and the system of focus (e.g., the product or service).

Creativity Competence

Within the underlying competence framework (Steiner, 2013a), creativity is not considered an ability or personality trait, but rather a competence that can be developed and trained through the application of creativity techniques and other problem solving methods within the applied projects (Brown, 2009; Steiner, 2011). Such techniques include individual and group-specific methods for creative problem solving and team analysis, amongst others. Creativity is a competence needed to generate original outcomes (e.g., solutions for a specific problem or process related improvements) that go beyond routine problem solving and already known solutions as basis for successful innovations (Epstein et al., 2008; Steiner, 2011: p. 17).

The acquisition of creativity competence, similar to systemic competence, is strongly related to project-based learning which occurs during every term of the study program (especially as part of the project "methodology and ergonomics" in the third term and the project "design and innovation" in the fourth term).

Sociocultural (Collaborative) Competence

Collaborations provide an opportunity to develop a more comprehensive set of competences to solve complex real-world problems as an entity (these problems tend to have ill-defined properties and cannot easily be solved by routine, straight-line problem solving for which one explicit solution is available and for which a system pattern relies on a well-defined algorithm). Such collaborations include not only the involvement of additional experts from various disciplines, but also stakeholders form different parts of society. Therefore, sociocultural competence is a prerequisite.

To improve sociocultural (collaborative) competence, interdisciplinary projects are crucial in both the Bachelor's and the Master's program. Measures to support the development of this competence include shared leadership, group composition, and architectural measures (e.g., open floor plans). Collaboration is not restricted to occur within each specific class only, but—as a distinctive feature of the school—is also aimed to occur across all five classes. This is supported by architectural means such as the previously described studio, which accommodates students of all five classes accomplished by providing a supportive architectural framework in one shared space. This enables an immersion of knowledge across students of all stages of training and development. The internship in the third term of the Bachelor program and the work placement in the sixth term of the Master program complement the comprehensive learning experiences of this educational program.

Conclusion

In the outset of this article, we claim that the educational model applied by the School of Industrial Design Graz may provide fruitful lessons for programs of higher education which are not related to design or industrial design. This educational model does not only provide training in—what is known as—design thinking and which is mostly limited to visual capabilities; it also aims to develop a comprehensive set of competences which, as problem solving competence, consist of personal competence, professional domain competence, systemic competence, creativity competence, sociocultural (collaborative) competence as a requirement for being able to solve complex real-world problems. Within this portfolio of competences, no individual dimension can be substituted by the other; rather, they need to be considered as complementary in order to successfully deal with complex real-world systems. Consequently, as exemplified by various applied projects of the School of Industrial Design Graz, neither creativity, nor disciplinary profoundness alone are sufficient means to successfully develop innovation which may also account for sustainable development—systemic, personal, and sociocultural competences are equally essential as well.

All authors of this article have—either as teachers or as students—been involved with the School of Industrial Design in Graz since it's establishment in 1995.

Acknowledgements

This article is dedicated to Professor Gerhard Heufler as the founder of the School of Industrial Design at the University of Applied Sciences in Graz. Gerhard Heufler, a great innovator, teacher, and designer, unexpectedly passed away on April 29, 2013.

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