Giving Students a Head Start by Connecting Systems Design with Vertical Studio Teaching

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1. Introduction

As the profession of industrial design is becoming more competitive, designers are expected to embark on the *Right Alliances'* to survive and succeed in a global market where end-customers are getting more demanding. The traditional practice, where industrial design consultants operate as a separate contributor, less-integrated within R&D processes, may soon be obsolete. This indicates the need to revise educational objectives and teaching methods within the field of Industrial design. To offer a more comprehensive curriculum, external collaborators, educators, and students should work more integrated, whereby knowledge is created through the transformation of experience [1]. Based upon the concept of "collaborative learning" within and beyond the studio environment, this paper discusses a three stage approach to prepare students early in their design career for the opportunities and challenges in real-life practice. Reference to a systems and strategic design approach a positive attitude towards mentorship, as well as a well-planned core design curriculum, is being promoted beyond the education program.

2. The Business of Design

A designer's career usually starts with on-the-job training. After normally 1 to 3 years of training, they advance to higher-level positions. In a situation where a fresh graduate opts for setting up a design consultancy, he or she usually capitalizes on the need for further development of the final outcome of the design thesis. For example, Theo Groothuizen has cofounded with Ton Haas and Marcel Vroom Landmark Design & Consult BV and DMD BV Rotterdam (1987–1993), and contributed with a project from PTT telecom (Dutch Telecom); 'Design of a Public Phone.' The project was initiated and conceptualized as part of Groothuizen's master thesis [2]. Another example of a start-up consultancy, where four cofounders graduated in 2004 from the Norwegian University of Science and Technology) NTNU, is Kadabra Design. A recent interview with one of the cofounders Carl-André Nørstebø revealed that the start was financially difficult. Three (3) projects, which were further developed as a continuation from previous thesis projects, proved insufficient to sustain the four member team and other financial resources had to be brought in. In terms of facilities, NTNU Product Design assisted in providing a 'working place' for the initial 2 months. Only 9 months later, Kadabra Design received a start-up fund of 175,000 NOK *(Norwegian Kroner)* by joining an incubator. Presently, the team has the luxury to focus on core industrial design project and select their clients. There is no need anymore to survive on small web, graphic and exhibition design projects. Turn-over has grown exponentially from 70,000–1,200,000 NOK in the first 3 half-years, whereas the past two half-years have shown an increase of respectively 1,600,000 and 1,800,000 NOK.

Unfortunately the business of design consultancy has always been characterized by a narrow and competitive clientele, which keeps the consultants' turnover low, which, in turn, weakens their capacity to seek growth in the international market. Generally, consultants and their clients rarely manage to establish, foster and maintain long-term client relationships, which would benefit both in cost-efficiency and quality, compared to unsystematic, project-based operations, resulting in unsuccessful tryouts to achieve a competitive advantage [3], [4]. Research findings revealed that design consultants are not sufficiently able to package and sell their skills and knowledge, and their challenges seem to culminate in the management of the interface between them and their clients [5]. Inherited from the tradition of low-tech art and craft manufacture, working procedures, do not assist the effective utilization of ID in the field of engineering processes, leading to a situation where the consultant operates too far from the company unable to solve valid problems.

Recent trends have indicated that companies will not construct large inner ID organizations, but need to find new competitive means and challenges of product development in the network. However, industrial design consultancy services are still seen as a separate contributor to R&D processes, where designers operate near the end of the product development sequence of activities, significantly reducing their

potential to contribute to corporate goals and strategies [6], [7]. The above indicates that there is a need to revise consultant- client working relationships to offer a more holistic and integrated approach in the development of products, services and systems. The design consultant should be more proactive in integrating down-stream engineering and manufacturing processes as well as up-front strategic product planning activities in developing and realizing the end product. International corporations, including Acer, Apple, Philips, Sony, etc. have adapted a holistic design program to integrate design into the concept-to-market process and let designers participate in decision-making for product planning and positioning [8].

3. Challenges for Design Education

The scholarship of teaching, 'Mentorship' goes beyond good teaching in terms of mastering the subject and effective delivery. Sachdeva sees mentorship as a more global and long term responsibility for development of the apprentice [9]. For many, the mentoring relationship comprises more personal, closer relationships that demand time, commitment and a level of emotional engagement [10]. Considering the needs of the apprentice, mentoring as a source of learning has become particularly relevant given the boundary-less nature of careers today where changing organizational structures create the need for fast-paced learning [11].

This need for fast-paced learning is becoming more urgent in a transitional and increasingly competitive profession, such as industrial design (ID). The ID profession has experienced significant transformations, which provide new challenges for design education [12]. These challenges incorporate: 1. understanding of other design fields and interaction with other disciplines. 2. advancement of interdisciplinary teamwork, involving user research and lifestyle trends. 3. introduction of systems thinking to solve higher level strategic design problems [13]. Reference to the above challenges, educators need to continuously update their knowledge in order to help students to prepare for the real world [14].

Unfortunately, compared with the development of design practice, design education has developed more slowly over the past decades, and many design schools continue to teach their students with the traditional design skills, knowledge and processes [15]. Within the context of customized and flexible learning, only a few design schools have introduced 'student-centered learning' concepts, emphasizing on self-directed learning, where students are encouraged to determine their future role as a 'designer' in the broader context of product development [16].

Educators should hereby take up the responsibility to elevate students' future career and employment prospects. This can be achieved by training them how to collaborate and learn structurally within a strategic and systems design studio setting through group work as well as externally with industry. For example, Technical University Eindhoven has introduced competency-based learning in their curriculum, since they have started in 2001, Here, under the guidance of a unit leader, a team of consulting experts from the university and from outside business partners, and a number of junior employees, each student customizes his or her academic study career by working mostly on industrial projects, as well as acquiring the knowledge directly relevant for these projects. Similarly ENSCI: Les Ateliers promotes 'customized learning through practice and theory'. Studio projects are developed according to student's capabilities and skills.

At the Norwegian University of Science and Technology (NTNU), an integrated two-stage studio teaching-mentorship program has been adopted to prepare students early in their educational career for the design opportunities and challenges after they have completed their studies. In addition to this, a third stage is under construction, based on experiences at the National University of Singapore (NUS).

3.1. Stage 1: Systems Design in Year 2 Undergraduate Design Studio Teaching: The Norwegian Postal Service (NPS) Project

The most inclusive definition of a *'System'* is a set of interconnected entities, comprising people, processes and technologies, which are dynamic in their behavior and have a purpose or reason for existence [17]. From a system level engineering design approach, complex systems include large products, which comprise of many interacting subsystems and components [18].

In the Norwegian Postal Service (NPS) project, it was obvious that systems thinking exposed 20 undergraduate students to complex design problems at an early stage of their education *(year 2, semester 2 studio)*. It was a challenging task to be clear and detailed in the organization and management of studio teaching, as well as the supervision of students on how to plan and manage their projects. The terms ‘system’ and ‘structure’ were introduced in the project, whereby the system is the collection of subsystems and products that make up the mail distribution service, and the structure is the predetermined logistic framework on which this mail distribution system is based upon [19].

In the first stage of the project, student teams iteratively generated and evaluated a wide range of system concepts. To understand current and to develop new system concepts, students were guided to undertake observational studies, user-scenario development, storytelling, etc. of a wide range of sequential and parallel activities. The challenge for these students was to approach the problem using an increasing number of parallel lines of thought [20].

On one hand, the tighter the boundaries are placed within the system to define activities, the lesser the number of parameters and variables has to be considered explicitly, but the more the crucial interactions will be omitted or simplified. This has led to errors and an unrealistic understanding of the user’s situation. On the other hand, the further the boundaries are placed, the more complex are the set of variables and parameters to be considered, and the more work in systems thinking and management is required [21]. Novice design students experienced difficulties in combining broad boundaries with concrete consequence analysis. However, those who had an aptitude to process information and thought holistically, found it easier to structurally develop the system inclusive of its elements, boundaries, and connections, compared to those who preferred to process information in parts independently and sequentially. In such a situation, customized mentorship was necessary to facilitate segmenting system processes into sub-systems or products and allocating design tasks.

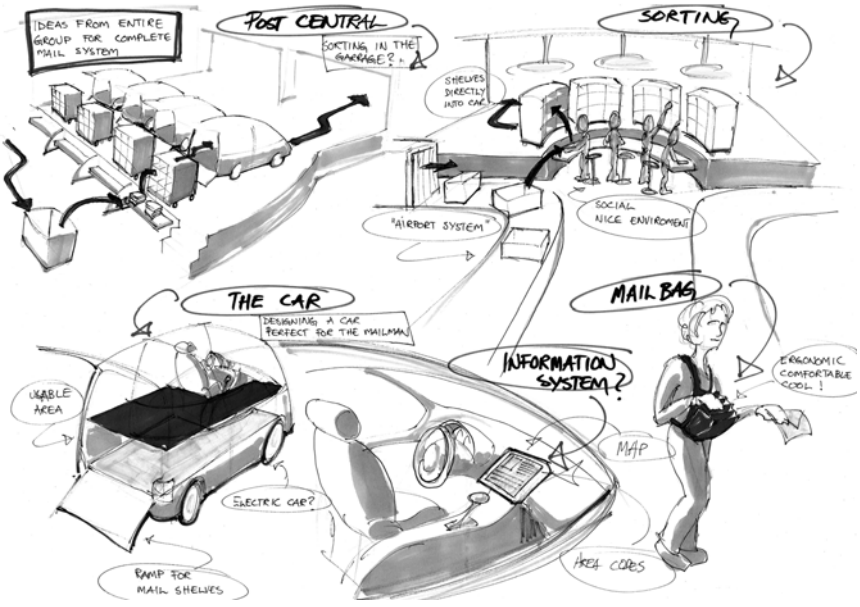
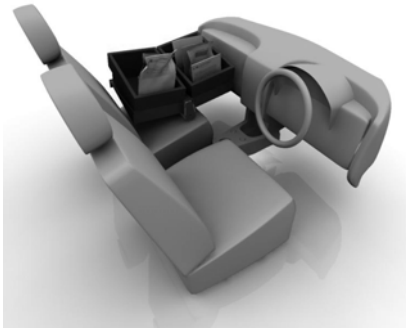


Figure 1. Subsystems and products within the overall system of mail distribution.

In the second phase, these subsystems and products were individually further developed into two or three detailed design concepts. The selected design concept was then subjected to iterative cycles of refinement, user testing and materialization. After completion of the formal studio, selected designs were commissioned by NPS for further development and professional prototyping, providing some students with the experience of a real-life industrial design setting.

The example below shows how a selected design concept has been further developed into series-production after completion of the studio. The design concept refers to a ‘Mail Organizer’, placed in the

front passenger seat, next to the postman. Although the development process after completion of the formal studio was tedious, 1200 pieces, worth 3.5 million NOK have been ordered from contract manufacturer Loyds Industri (Frederikstad, Norway)


Figures 2A, 2B, and 2C. Analysis, concept development, and user testing of a front-seat mail sorter (Bjørn Hembre, during Year 2 design studio).



Figures 3A and 3B. Detailing and prototype development. Figure 3C. Final product as used by Norway Post (Bjørn Hembre, after year 2 design studio).

3.2. Stage 2: Strategic Design in Year 1 Post-graduate Design Studio Teaching

A collaborative studio concept at post-graduate level *(year 4, semester 1 studio),* based on *'Product Planning and Management'* principles was introduced, where each student was allocated a company. Based on two semester rounds of studio teaching over 2 academic years (2005/2006 and 2006/2007), a total of 30 well-known Norwegian companies such as, Stokke, Håg, Jordan, Helly Hansen, Tandberg, Lærdal Medical, Borealis, Vestre, Asono, etc. were involved in the collaboration. Each strategic design studio lasted for 19 weeks and comprised of one collaborative project, supported by lectures, and seminars. The project was divided into two stages: a product planning and management (PPM) and an industrial design stage.

In the PPM stage, students were subjected to a model for integrated product development where they had to follow a systematic innovation-step model, which guided them to determine their design brief, as no other direct applicable models were found in the area of systems engineering, macroergonomics or product service system (PSS). [22], [23]. the industrial design stage emphasized on design, where students iteratively analyzed and redefined the problem fields, as well as developed design solutions using a wide variety of analytical and generative methods.

In line with the student's progression from novice to expert user, whereby the latter is expected to demonstrate strong skills in managing goal-limited strategies and domain-specific knowledge, the project brief was presented at a business rather than a product level [24].

In line with Hakatie's observation of 'Metso's division of labor between external consultants', close collaboration at strategic level during the studio semester led to continuation of selected student-company link-ups after the studio has been completed [25]. Several projects were selected for further development,

detailing and prototype building, demonstrating another avenue of strategically uplifting an educational to a real-life design project.

3.3. Stage 3: Collaboration through Mentorship: A Design Consultancy Service

The third stage elaborates on past collaborative experiences in mentoring freshly graduated Industrial Designers to pursue an own design consultancy, while capitalizing on existing "vendor /supplier – client / end – customer" working relationships.

Previously a faculty member of the National University of Singapore (NUS), the author of this paper decided to involve a promising graduate in his free-lance design activities. Both faculty member and graduate did not have the financial means, but had the support of a contract manufacturer, Valen Technologies Pte., to start up a design consultancy, named 'Design Insight' (DI). The collaborative initiative between Valen Technologies and Design Insight was based on a unique win-win concept. Being strongly involved in the coordination and manufacturing of optoelectronic products, Valen Technologies was able to provide his customers with a one-stop design, development and manufacturing service, even up to the design of the packaging. In return, DI was given considerable help in terms of facilities, start-up assignments and manufacturing expertise. The collaboration proved to be successful as both were able to offer a more complete product development service to their end-customers.

Besides Valen technologies, Design Insight managed to build a network of clients, suppliers and collaborators within a period of 2 years, companies, such as BC2L Pte Ltd, a local OEM dealing with Bluetooth related products, Qbian, a Belgian-based company developing and designing marketing and training materials for Nokia, and Samsung Electronics Co. Ltd in Korea are now part of the network. Presently, the collaboration between DI and Qbian has resulted in 3 business areas: Product Design, Content Development and Visual Communications. The work with Samsung and some local and a US-based ODM, OEMs is still on-going. Overall, the turn-over of DI has doubled on a yearly basis. From 2004 to 2006, turn-over has grown from 70,000–400,000 SGD (Singapore Dollars), and is expected to reach close to 1 million SGD in 2007.

When comparing DI with Kadabra Design, both consultancies did very well for the past 3 years. The case of Kadabra Design is a classical example of how a design consultancy has started, without a formal or informal mentorship to support the initiative. Design Insight had the advantage of having an academic, as well as an industrial mentor, who helped the consultancy with the basic facilities, projects, and contacts to start up.

4. Vertical Studio within the Context of Hierarchical and Collaborative Learning

According to Kvan, collaboration is a deeper, more personal synergistic process, involving consultation, negotiation, agreement and reflection in order to achieve success [26]. In industrial design the difference between conventional learning and teaching versus collaborative learning and scholarship is very much determined on how teaching is being organized and executed in the studio environment. In a situation of collaborative learning, students will be challenged on design practice, methodology and teamwork. In addition to being supervised to solve complex design problems, the student will also be guided to interpret and disassemble holistic systems into manageable design assignments. A systems approach in design education has mooted the idea of organizing studio teaching in a 'vertical' manner, based on the concept of hierarchical learning.

4.1. 'Vertical Studio' at the Norwegian University of Science and Technology (NTNU)

The 'Vertical Studio' is being planned in conjunction with hierarchical and collaborative learning. As the program has a yearly manageable student intake of 20–25 and a teaching faculty to student ratio of approximately 1:20, it would be possible to regroup studio teaching across all levels of the program. Besides this, there is a consistency of studio activities throughout the entire curriculum on a semester basis (see Figure 5, highlighted in grey).

Semester	7.5 Study Points	7.5 Study Points	7.5 Study Points	7.5 Study Points
5. Spring	Final Year Project			
5. Fall	Non-Technology Elective	PD 9 – Research & Design		
4. Spring	Elective (Technology)	Experts in Teams	Packaging & Communication Design	PD 8 –Design Strategies
4. Fall	Elective	Free Elective; LCA, Design in Wood, P&D, Maskindeler	PD 7 – Industrial Project	
3. Spring	Statistics	Eco-Design	Anvendt modellering	PD 6 – Products & Systems
3. Fall	Technology Management 1	User-Centered design	PD 5 – Mechatronic Design	
2. Spring	Physics / Lab	Materials Technology	Man-Machine Interaction	PD 4 – Form & Function
2. Fall	Mathematics 3	Mechanics 2	Form and Colour 2 / Design History	PD 3 – Form Materials & Processes
1. Spring	Mathematics 2	Mechanics 1	Form and Colour 1	PD 2 - IT
1. Fall	Mathematics 1	Ex. Phil. 1	Form and Colour 1	PD 1 - Ex. Fac.

Figure 4. Highlighted in gray are the studio courses at NTNU, Department of Product Design that form the backbone of the program

Instead of having one studio teacher / coordinator responsible for each semester studio, groups of 4–5 students of each year should be working together in one studio class. The teaching load will be similar to teaching a specific year cohort (4 students x 5 years = 20 students), see Figure 6. The advantage of a vertical studio is that the hierarchical master–apprentice relationship is maintained throughout all levels. Besides having classical teaching methods, where the studio tutors instruct, senior students are expected to mentor their juniors.

	Studio A	Studio B		Studio C	Studio D	Studio E
Year 1	(4-5 Students)	(4-5 Students)	Vertical Studio	(4-5 Students)	(4-5 Students)	(4-5 Students)
Year 2				Conventional Studio		
Year 3	(4-5 Students)	(4-5 Students)		(4-5 Students)	(4-5 Students)	(4-5 Students)
Year 4	(4-5 Students)	(4-5 Students)		(4-5 Students)	(4-5 Students)	(4-5 Students)
Year 5	(4-5 Students)	(4-5 Students)		(4-5 Students)	(4-5 Students)	(4-5 Students)

Figure 4. A proposal of regrouping students for ‘Vertical Studio’ teaching.

4.2. Challenges in Managing Vertical Studio Teaching

Two main challenges need to be considered in planning for a ‘Vertical Studio’. These are 1. how to structurally determine the project scope to involve all students from the different levels of the program as well as external collaborators, 2. how to plan the timetable as to avoid conflicting schedules. Unlike the studio concept at ENSCI, where one same project is introduced across all levels of the program, a holistic program should be suggested, which can be broken down into three levels: Strategic, System and Product.

At strategic level, mainly year 4 and 5 (postgraduate) students will be involved, as they should have greater ‘domain knowledge’ to approach the project from a strategic business systems perspective,

providing downstream information and guidance to the year 3's to define the user-system and year 2's to determine its supporting products and hardware components.

The challenge for the studio coordinator is to formulate a project brief, where product, system and strategic design tasks are interconnected, allowing for mentorship and interaction across all levels of the studio.

Concerning timetable planning, arrangements need to be made to find a common studio schedule for all levels of the program to host instructional lectures, group work, presentations and critiques. Although, each study year has their own time table concerning other courses, it would still be feasible to find common timeslots for studio teaching across various levels, as at the most only two subjects in each semester are not within the control of the Product Design department and timetable planning arrangements are easily made between departments.

5. Discussion and Further Research

When preparing design students for the challenges of design practice, it is necessary to consider core-curriculum as well as mentorship aspects in the overall education and grooming of the student or newly graduate. The studio environment forms a platform that is conducive to development of long-term collaborations among companies, students, graduates, and educators. Dependent on how the studio program is managed, these collaborative structures may extent beyond the formal studio, providing students with the opportunity to gain experience in real-life practice, at an early stage of their careers.

From an educational perspective, teaching, and mentoring within and beyond the studio context have revealed the following findings:

- An emphasis should be placed on strategic and systems design to facilitate innovation and the further development of design solutions beyond the studio environment.
- A systems approach in studio teaching will lead to a wide variety of product proposals, which can be interesting for the industrial collaborator to further develop after the completion of the formal studio.
- Within one semester, where the task was presented as a business rather than a design brief, only provide sufficient time for the students to complete their project up to the conceptual stage, giving them ample opportunities for detailing and completion after studio.
- To provide newly graduates with a head start, faculty should consider taking up interest in serious mentorship. For example, facilitating and introducing an industrial mentor or investor in starting up of design initiatives.

In terms of future research, a structured and formalized student / graduate mentorship program should be explored within a 'Vertical Studio' setting, where time and manpower resources are allocated among external collaborators, students and faculty members.

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