PLANNING AND EARLY IMPLEMENTATION OF VERTICAL STUDIO TEACHING BASED ON A SYSTEMS DESIGN APPROACH

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ABSTRACT
At the Norwegian University of Science and Technology, Department of Product Design (NTNU/IPD), a concept of 'Vertical Learning' within a studio environment was planned and implemented in conjunction with systems design. Systems Design, as a course planning and design process management studio teaching concept, is to provide students with an understanding about different levels of design complexities. Social learning was introduced to expose students to interdependent teamwork.
This paper discusses challenges to be considered in the planning and implementation of 'Vertical Studio Teaching'. Intermediate results showed that students were subjected to a steep learning curve, when it concerned teamwork, problem solving and design thinking. The "social learning" environment, built upon a systems approach, has proven to be a tough but useful learning experience for the students. Aspects, which were considered in the planning and early implementation, were:

- How to structure "Vertical Studio teaching" involving students from both year 2 and 3, as well as external collaborators.
- How to formulate a project brief, where the overall system and its elements are identifiable.
- How to guide student groups in developing a concrete, but interconnected system, where product and system design tasks are clearly defined and distributed among group members
- How to inculcate teamwork among students from different levels through social learning

Keywords: Industrial collaboration, vertical studio teaching, systems design, social learning

1 INTRODUCTION

In the field of 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 a studio environment. In the conventional situation, students receive a design assignment in the form of an ill-defined problem and are guided to solve this problem through classical engineering design processes [1].
Within the context of social learning [18, 19], students are encouraged to interact and collaborate across different levels on design projects, and where possible incorporating external (Industrial) collaborators. This complex studio setting is most suitable for a "Vertical Studio Teaching" approach.
A systems approach in "Vertical Studio Teaching" challenges both students and teachers to solve complex design problems by adopting a different way of design practice, methodology and teamwork based on the concept of hierarchical learning. In addition, the student will also be guided to interpret and disassemble holistic systems into manageable design assignments.
Within the framework of customized and flexible learning, several architecture and design schools have implemented their own programs. For example, from an architectural design perspective, "Vertical Studio teaching" is widely practised as to expose novice students to holistic and contextual thinking approaches, which is inherent for architectural design education.
Mentioning examples from an Industrial Design perspective, the Technical University Eindhoven has introduced Competency-Based Learning in their curriculum, since they have started in 2001. Hereby, students are grouped according to project and interest instead of education level. Similarly ENSCI: Les Ateliers promotes 'customised learning through practice and theory'. However, studio projects

were developed according to themes of interest to the studio teacher, rather then to expose students to a structured design methodology and various levels of prescribed design complexities.

At the Norwegian University of Science and Technology, ”Vertical Studio” teaching is being introduced among a total of 41 year 2 and year 3 Industrial Design students. Six groups of 6 to 7 students *(2/3 year 3 and 4 year 2 students)* will be working on contextual system design problems with an industrial collaborator.

2 THEORETICAL BACKGROUND

The motivation behind “Vertical Studio Teaching” is not only to train design students to solve complex design problems, but also expose them to team work, where by each group members are interdependent of each other performance. The systems approach forms an appropriate platform to implement this interdependent form of learning and working. In addition, new learning styles will be inculcated among design students to challenge them to learn and practice in a reflective and accelerated manner.

2.1 A systems approach in design

The most inclusive definition of a *‘System’* is an integrated set of interoperable elements, comprising people, processes and technologies, which are dynamic in their behaviour and have a purpose or reason for existence [2]. Each element is explicitly specified and share bounded capabilities, working synergistically to perform value-added processing to enable a user to satisfy mission-oriented operational needs in a prescribed operating environment with a specified outcome and probability of success [3].

According to Jones, the traditional design process could no longer support the complexity of problems [4]. This indicates that the design process should be extended from its concerns with products to include the design of systems [5]. An emphasis should be placed on the whole system rather than the product as a self-contained object [6]. For several years now, corporate business has begun to shift attention from product manufacturing to the provision of a set of systemic solutions with a high cultural and social content [7, 8]. In such a new context the design and development of new products and service systems became a strategic priority [9, 10].

When considering users' interaction with systems, Jung and Sato classified mental models into several categories in order to provide more elaborated and systematic explanations [11].

Most commonly these mental models are classified into two categories: structural models and functional models. DiSessa argues that structural models are involved in users' in-depth understanding of a system, and are not restricted to particular tasks, while functional models represent system's functional properties involved in performing a particular task [12]. Preece et al. also categorizes mental models into structural and functional models, where structural models represent the mechanisms of system's component parts, whereas functional models represent the procedures of how to use a system [13].

2.2 Learning approaches

Three types of learning approaches are applicable to “vertical Studio Learning” within the context of systems design.

Learning through confusion

> “The path of learning goes through the swamp of confusion. The only way you can get to the mountain peak of understanding without going through the swamp is if you already understood the idea. The real unfortunate thing is that students rarely see the swamp. Too many of their courses have a path that takes through a quick tour of the rose garden. Sure, it smells nice - but did you get anywhere?” [14]
>
> *Rhett Allain, Associate Professor of Physics at South-eastern Louisiana University.*

From a philosophical perspective, trying to get clear about whatever question we are up against we are at the same time trying to get clear about what a philosophical treatment of the question would amount to. Indeed once we are clear about that, we are done with the question, more or less. If this is so, that means that in philosophy there is no “method” in the sense of a procedure taking you from where you are to where you want to go. Once you know where you are, the rest is easy [15].

Single versus double loop learning

Single-loop learning seems to be present when goals, values, frameworks and, to a significant extent, strategies are taken for granted. Double-loop learning, in contrast, 'involves questioning the role of the framing and learning systems which underlie actual goals and strategies [16]. Within the notions of reflection-in-action, the practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behaviour [17].

Social learning and the "Master-Apprenticeship" model

Social learning theory focuses on the learning that occurs within a social context. It considers that people learn from one another, including such concepts as observational learning, imitation, and modelling [18]. According to Wenger, learning is defined as an inter-play between social competence and personal experience. It is a dynamic, two-way relationship between people and the social learning systems in which they participate [19].

In the field of Industrial Design, social learning is embodied through project-based learning and master/apprentice relationships. Design educators both consciously and unconsciously instil fundamental value-systems into students, especially through critiques [20].

3 PLANNING AND STRUCTURING "VERTICAL STUDIO TEACHING"

The most prominent challenge in planning and structuring the "Vertical Studio" curriculum was to establish a suitable platform where both level 2 and 3 students, define their collective as well as individual project scopes and design goals. Collective work was very much related to defining the system, whereas individual work emphasised the design of the elements / products, which supported the system. Issues to be dealt with were complexity of the design assignment, possibility for students to engage in interdependent teamwork and engagement of industrial collaborators.

3.1 Developing the project brief from a systems perspective

Developing a project brief where complexities are introduced and managed through a systems perspective is essential for the structuring of the "Vertical Studio". From a system level engineering design approach, complex systems include large products, such as automobiles and airplanes, which comprise of many interacting subsystems and components [21]. However, in NTNU/IPD's context of systems design, the emphasis has been placed more on the intangible activities of "Systems Thinking", where students were expected to approach the problem using an increasing number of parallel lines of thought [22]. The project brief was formulated as broadly as possible within selected Strategic Business Units (SBU) of the collaborating companies in the form of metaphors, visions or context-based real-life system, or a combination of the three.

3.2 Involving Industrial Collaborators

Three industrial collaborators were involved in this "Vertical Studio". They were an established Norwegian ship building and design company, a manufacturer of interior wall systems for the office environment and the 4^{th} largest European research centre, section Fisheries and Aquaculture.

The ship building and design company's brief was formulated referenced to their existing system of control units on a vessel's bridge. The manufacturer of interior wall systems introduced the metaphorical design brief "Flexible Workplaces" within the context of an office and school environment. One group addressed the office environment, whereas the other group worked on the school environment with a focus on effective and efficient learning at primary level. The Fisheries and Aqua Culture research centre left much to the students to think visionary based on what situation could be in 20-years time from now with respect to fish farming.

3.3 Course outline for planning and structuring "Vertical Studio" Teaching

To develop a common course outline which communicates to both level 2 and 3 students was a challenging experience, especially when it concerned determining clear learning objectives and finding common timeslots for lectures, tutoring and critiques. Hereby, the aim is to avoid overlap and repetition in design pedagogy between the two levels. Table 1 shows the learning focus between level 2 and 3 students.

Incorporating the participation and availability of guest lecturers and industrial representatives was another factor, which increased the planning and scheduling complexity. Level 3 students perceived the course outline as being more directed to level 2 students, whereas level 2 students were concerned about the delays in reflection to the course outline.

Table 1. Learning objectives, level 2 and 3 - NTNU/IPD design students

Learning objectives /focus level 2 design students	*Learning objectives / focus level 3 design students*
• Plan and manage the Industrial Design process • Integrate and manage usability, technical and form elements in the generation of innovative design solutions • Understand and appreciate the role of industry as a client in an Industrial Design project • Iteratively generate ideas, design concepts and detail solutions through a process of extensive convergence and divergence • Conduct basic usability studies and tests based on functional models • Visualise and communicate the product in the form of convincing renderings, physical models and / or prototypes.	• Understand the concept of collaborative and hierarchical learning within a studio environment • Analyse information, draw conclusions and propose systems and product design solutions • Identify and describe design problems within the broader context of system and product • Mentor level 2 students in conjunction with overall management of the system and / or sub-system.

4 EARLY IMPLEMENTATION OF “VERTICAL STUDIO” TEACHING

4.1 Managing complex systems

Previous studies, showed that those who had an aptitude towards process information and holistic thinking found it easier to structurally develop the system inclusive of its elements, boundaries and connections, compared to those who prefer to process information in parts independently and sequentially [23]. In addition, a visually creative approach towards the idea generation of future systems was considered complementary to achieve a higher level of innovative output.

4.2 Learning experiences

In general, students experienced a high level of uncertainty and confusion in the first 6 weeks of the project, while they were trying to grasp with their systems. The reasons were:

- Students were initially not able to internalize the meaning and understanding of “Systems Design” and “Systems Thinking”.
- Students working with the manufacturer of interior wall systems misunderstood the metaphorical intent of “Flexible Workplaces”. They tried to introduce the overarching system at a technological / constructive rather than at a user-centred level
- Studio tutors acted as advisors, sharing their views and design philosophies from purposely contradictive angles, capitalizing on the concept of “Learning through Confusion”. This was found indeed confusing and stressful among students, especially when the two tutors were respectively perceived as “Facilitator” and “Master”.
- Level 2 students were worried as they were eager to move on to the product designing stages, developing concrete elements.

In the transition from group to individual work students encountered significant problems in determining intermediate boundaries and interface connectivity between the elements of the system, concerning overlapping scenarios and products [23]. However, a diagram inventorying linkages between activities and elements assisted the distribution of design tasks among its group members, based on the decision whether the system should be structurally or functionally modelled.

Generally, division of design tasks and responsibilities among students within the context of social learning has proven to be easier than expected. Based upon theories of communities-of-practice, and Legitimate Peripheral Participation (LPP), group members were able to learn from and communicate with each other, because they share the same subjective viewpoints and speak the same language. In short they were acculturated [24].

This has resulted in a favourable learning situation, where level 3 students understood their mentoring and project management roles and level 2 students accepted their roles as “Product Designers”.

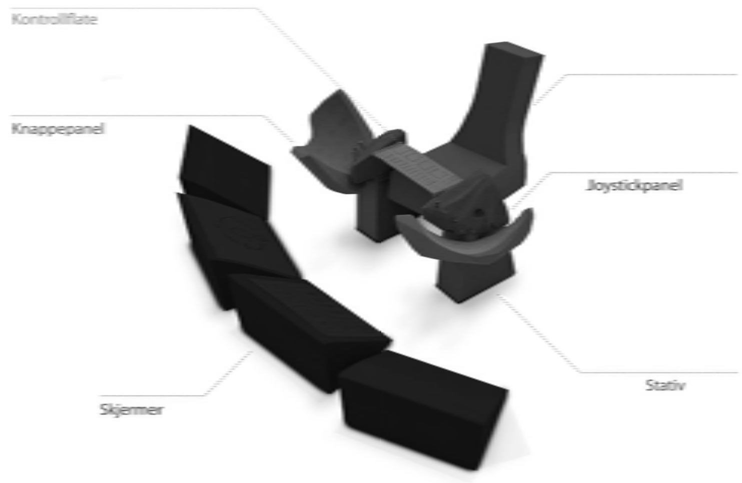

Figure 1. A structurally modelled vessel navigation system, whereby allocation of design tasks among group members is component driven

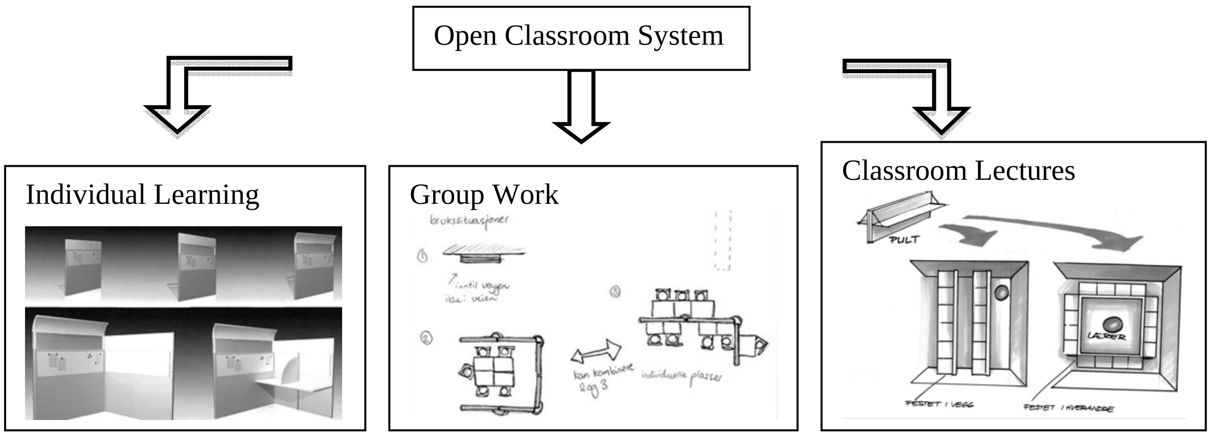

Figure 2. A functionally modelled “Open Classroom” interior system, whereby allocation of design tasks among group members is based upon methods of learning and teacher – student interaction

5 DISCUSSION

With respect to “Vertical Learning” in design, cognitive apprenticeship deliberately brings the thinking to the surface, to make problem solving visible. The teacher's thinking is being made visible to the students and vice versa [25]. In addition, the Master-Apprentice relationship is being extended among students from different levels. In most cases, the design assignments were developed according to themes of interest to the studio teacher, rather then to expose students to various levels of prescribed design complexities. However, by introducing design complexities in the form of a systems design approach, students were challenged to elevate their thinking activities, from a creative as well as analytical perspective, and engage in closer teamwork, considering not only the interest and performance of the group, but also of its individual group members. This has resulted in confusion and to a certain extent frustration among students in the first six (out of the 16) weeks of the project.

However, this purposely created situation of confusion and frustration is being perceived as a favourable learning experience for the students from the educators’ point of view. Once the confusion is overcome, students were able to deepen and communicate their design thinking activities, which led to interesting and innovative systems. In most cases underlying problems, system boundaries and scenarios were questioned and redefined as part of “Double Loop” learning. Industrial collaborators were supportive of “Vertical Studio Teaching” as they saw the benefits of efficient distribution of design task in the pursuit of realising a well-defined system of interconnected entities.

6 CONCLUSION

The implementation of systems design in conjunction with social learning within the context of “Vertical Studio Teaching” accelerates and deepens the learning experience among Industrial Design students.

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