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PROJECT ORIENTED LEARNING ENVIRONMENT, BRIDGING ACADEMIA AND INDUSTRY

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1. Introduction

The efficacy of project-based learning in design education has gained broad acceptance. Moreover, when project-based learning is performed in teams, it mirrors professional design practice more closely, and offers an attractive proposition to educational institutions to produce highly employable graduates. Therefore, most state of the art design curricula employ project-based learning principles within the context of student teams.
Innovative curricula designers clearly recognize the significance of interdisciplinary practice and organize student teams in such a way that the different functions associated with key disciplines of design projects are represented. However, the reality is that the majority of students usually belong to a single educational discipline, and some are simply asked to "wear" another discipline's hat for the duration of projects. There have been very few consistent attempts at recruiting students who actually belong to different educational disciplines so that a true interdisciplinary make-up is achieved.
Project Oriented Learning Environment (POLE) is one such educational paradigm. This paper describes the POLE platform, discusses insights gained during the ten years of its existence and the resulting methodological improvements and presents key findings of POLE's assessments. Finally, the recently implemented web-accessible data base (Libraries for Advanced Knowledge Environments, LAKE) is described which allows the analysis of the decision taking process of internationally distributed (student) teams. This is based on the recordings of the teams' meetings by video conference and their processing by a speech recognition software. With these two columns POLE puts emphasis on the design process as well as on the final product.

2. Philosophical and pedagogic background

There have been many attempts to establish the theory of design education [Eris 2006], [Dym 2005], [Haselrigg 1999]. But nonetheless, we recognize a pluralist paradigm in this field. One such paradigm is the "distributed trans-disciplinary project-based design methodology" that is gaining growing acceptance [Eris 2005]. Nowadays, students are not only increasingly challenged within their specific core disciplines, they are also supposed to develop the necessary skills to apply this particular knowledge in practice. Ideally, this goes hand in hand with mature understanding displayed by the individual of a social, cultural, and economic environment. The practical application of theoretical knowledge can, thus, only be implemented successfully, if these three basic elements are taken into account [Faste 1993]. It is in this field where the Project Oriented Learning Environment (POLE) has its position, i.e. where knowledge and skills are combined to accumulate professional competence.
In addition to students' disciplinary knowledge, the ability to work efficiently within multicultural environments has become increasingly important. Universities are, therefore, looking to expand and

deepen this particular aspect in order to provide the necessary expertise in this field. This has led universities to becoming more proactive with regards to networking and offering collaborative courses.
POLE sees itself as a learning system cooperating within a network of universities and industry partners. It does so within a reflexive context, taking into account the various cultures involved in order to create new methods of resolution regarding teaching and learning. The students are at the core of this concept, and are given the option to develop process-oriented expert knowledge through trans-disciplinary teamwork. Simultaneously, they learn to work independently and to deal with current problem cases through the use of modern information and communication tools. In the course of this joint activity, it has become apparent that this complementary aspect has gained in importance.
The rapid technological development and the need to cope with an increasing amount of information generate a challenging situation for both: professional courses at universities and industry. University teachers and researchers have to constantly update their knowledge on newly available technologies and products. The same happens to professionals working in industry. The research done at universities increasingly necessitates the support of industry, not just financially, but also to test ideas in practice. Conversely, industries can also benefit from receiving creative concepts originating from unbiased out-of-the-box ideas and having the opportunity to present their strategies to students, who will be future professional employees and probably work in their design teams. Therefore, the potential which a collaborative networked learning environment can offer to both, universities and industry is obvious.
Design innovation, which essentially means the definition, development and creation of new concepts and their successful launching to the market, is the driving factor for a powerful, competitive economy and the prosperity of society [Feyerabend 1975], [Freire 1985], [Pugh 1996]. Therefore, the education of creative individuals at universities and the continuous professional development of architects, engineers, industrial designers, etc. in the wide field of design innovation are of central importance. POLE's philosophy is committed to fostering trans-disciplinary design thinking and creating an awareness for sustainable solutions that are not only economically viable, environmentally sound and socially equitable today, but also allow future generations to do the same.

2.1 International and multi-disciplinary setting

POLE is a learning system developed in cooperation with several international universities, such as University of Applied Sciences Northwestern Switzerland, ETH Zürich, EPF Lausanne, Aalborg University, Tecnológico de Monterrey, NTNU Trondheim, TU Delft, Politecnico di Milano, Olin College Boston and Stanford University. It operates within a reflexive context, taking into account the various cultures involved in order to create new teaching and learning methods. Students are given the opportunity to develop process-oriented expert knowledge through interdisciplinary teamwork, to deal with current practical problem cases and get accustomed to use modern information and communication tools. Depending on the task, the participating can be comprised from fields such as architecture, urban planning, construction management, mechanical engineering, mechatronics, computer science, industrial design and economics. Each individual student is given the opportunity to comprehend different disciplinary processes and acknowledge their relation to social, economic, and political dimensions of design projects.
The POLE setting shows similarities with the European Global Product Realisation course (EGPR) with respect to multi-disciplinarity and the distributed team aspect but gives stronger emphasis on the team- and trust-building exercises during the physical kick-off. Furthermore, it draws from experiences of the international, but more mono-disciplinary course offerings "Architecture, Engineering and Construction" and "ME310" at Stanford University.

2.2 Structure of POLE courses

Depending on the task, students from a subset of the mentioned partner universities are selected to attract the appropriate graduate (or last year undergraduate) students for the project. Based on a Curriculum Vitae and a letter of motivation the most qualified students are selected. In an elaborate process respecting disciplinary proficiency, cultural background, gender and personality (assessed by

Jungian typology) they are then put together in 6 teams (with five to six students each) in the most heterogeneous way possible. The second main pillar of the project is formed by a group of approximately 5 to 10 academic coaches who not only take responsibility for the local disciplinary guidance of their own students, but are also accessible during the entire project for all participants. Finally, and most importantly, the outermost circle visualizes the integration of the industry partners who have to commit themselves to actively participate as mentors in the design process (Figure 1).

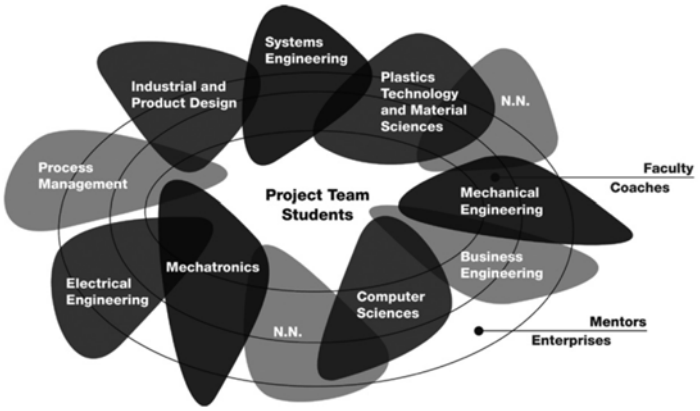

Figure 1. Human resources

POLE courses generally last for one academic semester. Originally, they used to start with a physical kick-off week at the site of the industry partner. However, this experience has shown, that the students were usually overwhelmed and could not react appropriately to the inputs received. Therefore, the new structure (see Figure 2) initiates the project with a virtual session by video conference in which the students and their coaches introduce themselves, get a rough introduction into the task and are asked to start their disciplinary analysis and research phase. After two weeks the students then physically come together for team building and trustbuilding exercises. The new scheme has shown to be very successful in so far as the students arrive prepared and already full of questions. The main task during the kick-off phase is to define a meaningful process planning per team with a shared goal statement and milestones as a deliverable. This physical gathering has proven to be eminently valuable because it is this phase that creates the "glue" and the commitment to be able to work together afterwards in a distributed fashion using video conferencing tools.

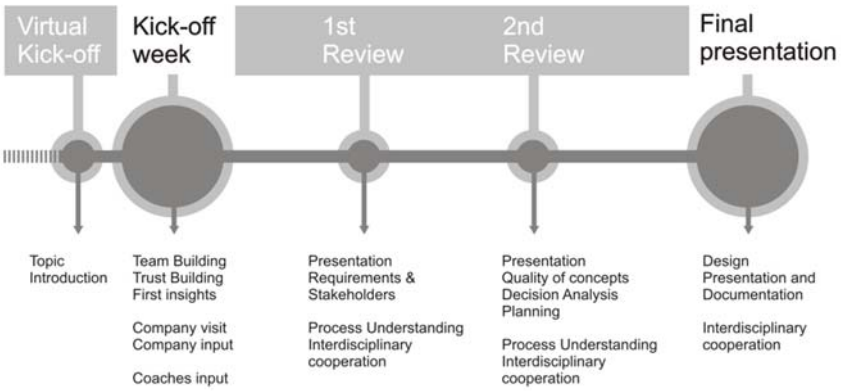

Figure 2. Time structure of project

2.3 History and results

Since 2001, twenty projects, all originating from and funded by industry or government partners, have been completed using the POLE platform. To name a few examples:

- "SnowDive": Design of Novel Sports Equipment for Use in Snow and Sand

- "Architecture and the Body": Planning of a Sports Facility in a Historical Heritage Sensitive Area
- "CanPlus": Novel Packaging Systems (Nestlé)
- "Driven Driver": Navigation System for the Car of the Future (Volkswagen)
- "High Light": Controllable Head Torch for Mountaineers (Mammut Sports)
- "Move!": Multi-Sensory System, Recording Sports Activities (Actismile)

The assessment methodology that was used to monitor and measure key aspects of student experience relied on a mixed set of techniques:

- Ethnographic observations during project kick-off and product presentation meetings.
- Students interviewed throughout the course.
- Structured feedback sessions held with students during project kick-off and product presentation meetings.
- Interviews and discussions held with the instructors.
- On-line surveys administered two and ten weeks into the projects, and four week after the projects.

Some key findings are:

- Throughout the course, students appreciated the interdisciplinary and international nature of the teamwork which POLE promotes.
- Students' appreciation of the realistic nature of projects increased a month after the projects ended.
- Communication and interdisciplinary teamwork were clearly perceived to be two major learning outcomes.
- Distributed students spent slightly more time on group work than individual work when compared to local students although both groups spent about the same amount of total time per week.
- The co-location of the kick-off week is of central importance to the performance of distributed design teams.
- Re-evaluation of video-taped team and/or review sessions proved to be a welcome source for a better process understanding and for personal awareness.

3. Understanding decision taking process by dynamic knowledge data bases

There is a saying that "you can only step into the same river once". This applies to learning processes, too. But the fact that the POLE teams are using video conferencing systems for their design process, allows for fostering the consciousness among students of the team dynamics in retrospect when they watch the recorded team sessions again. It not only helps them to get more aware of their individual blind spots but also to evaluate their way of interaction in their team. This feature is eminently important when students from different cultures and different disciplinary backgrounds are brought together in one team to work together in a constructive way, which means not to split the task into disciplinary slices but actually finding a common vocabulary, reducing prejudices, explaining his/her own professional view and (often) proceeding by using an amalgamation of methodologies that often is different from what one had learnt to like. It is this aspect of POLE projects that creates a different mind set in graduates, making them better prepared to bring about more sustainable solutions since they integrate more facets - technically, economically, ecologically as well as socially.

In addition – and for academia even more important – the recorded video sessions allow a subsequent analysis of the decision taking process. And it is these many bifurcations in a process that are often more valuable than the final product; in other words, the final circuit diagram of a product does not show the many decisions that were necessary and crucial for the final result. But it's these decisions that bear important information for later re-design or new product innovation. [Wood 2004], [Smith 2004]. This said, it is obvious that no one can watch hundreds of hours of video recordings to – hopefully – find a discourse on a specific topic of interest. Therefore, POLE's research group established a tool that allows not only to synchronize the video recordings with the slides shown and to add annotations to augment the content, but passes the audio track through a speech recognition

software that creates a text string which can then be searched through for segments where special key words appear more frequently and, thus creating a higher probability to finding useful information on a given topic. The access to the data base on which all the mentioned information is stored is done over a web application. At the present time the accuracy of recognition of non-english native speakers is the challenge to continue working on. It is anticipated that an adaptive system that can be trained and fed by the participating team members way of talking will improve this obstacle in the near future. Figure 3 shows the technical set-up of the methodology described above which is called "Libraries for Advanced Knowledge Environments" (LAKE) as a working title. In the farther future these dynamic libraries shall also be made accessible for non-academic partners in practice; but problems of personal data protection need to be cautiously addressed before this step.

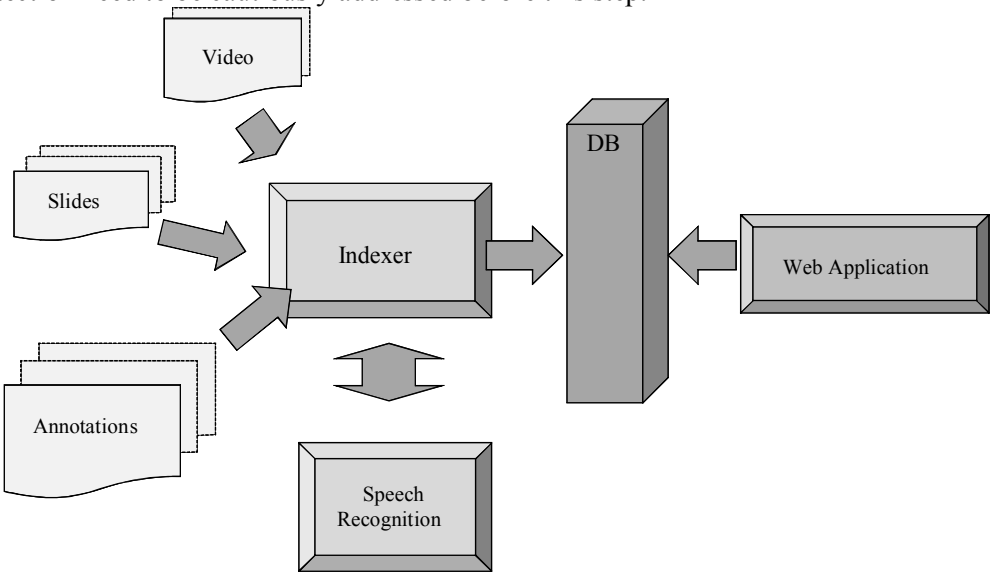

Figure 3. Structure of knowledge data base: A web application allows access to data base

4. Strategic partnerships between industry and academia

Today's challenges are complex in nature. Meaningful solutions can only be found by bringing all the necessary team players together, i.e. the different disciplines at universities and the partners in industrial enterprises and/or in the public sector. The methodology of trans-disciplinary co-operation practiced in POLE has the following five core strategic focuses: a) bringing together international academic partners to share their methodological knowledge, b) establishing an atmosphere of trust between universities and industry, c) bringing a user-orientation to academic projects, d) breaking down disciplinary blinders and reducing prejudices, e) tackling real-world problems and, thus, making sustainable contributions to today's global challenges. In summary: to create a new broader minded type of graduates. In addition to this vital contribution to education POLE's methodology has been explicitly appreciated by internationally active partner companies such as Nestlé, CEMEX, elica and others due to its know-how in the co-operation of globally distributed partners – a field in which the companies often fail. E.g. CEMEX has initiated virtual sub-companies in their consortium using the team-building method and co-operation strategies experienced in POLE. The following statement by elica's product manager, Fabrizio Bigatti, may illustrate this finding: "*The collaboration between elica and POLE has been a great and complete success. Not only because during the AIR® project the teams have developed new product concepts and prepared physical as well as functional prototypes, but also because the students with their working attitude reminded us how important it is to work and think as a whole team with all heading in the same direction. All of them had the challenging task in mind and then worked with passion, devotion and determination to achieve it. Elica is currently working to refine the ideas received during the project to let some of them become real products. Elica thanks once again POLE teachers and students for their strong commitment and initiative - underlining, how the collaboration between business companies and the academic world is essential and crucial for coping with the new challenges and to touching the future.*" Trans-disciplinary co-operation combined with design thinking can be a powerful fuel for innovation.

5. Conclusions

When asked to summarize the weaknesses and strengths of POLE projects carried out with culturally distributed and multi-disciplinary teams from an academic point of view, the following aspects are the prevailing ones: During the ten years of its existence, POLE has created a network of partner universities with a core crew of faculty members who are committed to trans-disciplinary design thinking; it is also them who select the most qualified students at the local campuses. This guarantees a highly motivated group of students to participate. Nevertheless, it is always an immense challenge to bridge the disciplines by developing a shared vocabulary. This latter process takes a considerable amount of time and often irritates students (especially from the engineering disciplines) who wish to start "doing something" rather than taking ambiguity as an opportunity to explore a broader spectrum of options. Another challenge arises when the team members were taught different methodologies at their home universities to tackle a problem. The pros and cons have to be discussed and a selection or compromise have to be found; this process forces the students to clearly formulate and defend "their method" and by doing so becoming more aware of its relativity and own idiosyncrasies. A further important aspect is the a-synchronous mode of working due to time zone differences. This forces students to formulate their ideas and contributions in writing rather than discussing them real time with the other team members. This situation necessitates a much clearer formulation of ones own thoughts - especially when team colleagues from another discipline must understand the contribution. What might have been self-explanatory in one's own discipline, needs a more detailed description in a multi-disciplinary context in which the respect for and the integration of the other profession is a key for success. It is POLE's belief that in particular this aspect - despite of often being considered an irritation and extra work - reflects the real life co-operation scenarios in design studios and engineering firms in which the graduates will be employed in the future - or, as it has been the case, that POLE graduates establish start-up companies across cultural and disciplinary borders.

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