Knowledge Integration in Architectural Education; The Development of a Dynamic E-Learning Environment.

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Abstract

Both the integration of knowledge from different domains and the use of knowledge integration in problem solving are classic issues for all types of education. This is especially the case in architectural education, as a huge amount of specialized knowledge on several levels and form several domains – varying form material sciences and structural engineering, to architectural history, city planning, infrastructure and spatial policy – has to be integrated in design studio projects. Developments within IT technology offer the possibility to design interactive content-based knowledge environments for education. This paper describes the development of a Dynamic E-learning Environment (DEE). DEE was developed as a pilot study directed at e-learning innovation within the Faculty of Architecture, at the Delft University of Technology. The aim of the project was to provide students with both an institutional and a personal knowledge base, directed at providing possibilities for the active production and use knowledge in a consistent way throughout the curriculum. In addition, the DEE project aims at representing knowledge in such a way that it provides insights into knowledge levels (basic knowledge, domain specific professional knowledge, abstract scientific knowledge), and the relationships between knowledge domains as offered in a specific educational setting. This interactive knowledge environment is intended to enable students to actively explore and integrate knowledge into their designs. The results of the DEE pilot were evaluated with a small group of students. Based on this evaluation it was concluded that special didactical tools have to be incorporated in order realize the benefits of the DEE work as an activating learning and knowledge environment. For the development of these didactical tools the concept of blended learning was chosen. Blended learning is an approach in which face-to-face activities are mixed with online activities. It is assumed in blended learning that each educational situation has to be a balanced setting (blend) according to four dimensions: structured/unstructured; group/individual; online/offline and teacher directed/student directed. The DEE has been developed further as part of an EU funded Blend-XL project in collaboration with 5 European universities. This second version of the DEE has been used with large cohorts of students. User evaluations were solicited from students as part of the Blend-XL project, and these evaluations have been positive.

Keywords: design, knowledge integration, design education, blended learning, e-learning.
1. Introduction

Especially in the Netherlands, governments have stipulated a great deal of educational renewal. A shift was encouraged from traditional teacher oriented models to student-oriented models. The focus of education has shifted from the classic learning aims as for instance described by Bloom [2] – Knowledge, Insight, Skills/Application, Analysis, Synthesis, Evaluation – to so called competencies as in today’s constructivist approaches. The new approaches were based on a type of thinking in which learning is no longer seen as a knowledge transfer process from teacher to students, but as a discovery process of the student in which he/she discovers his/her own personal learning needs, and acquires competencies with the guidance of a teacher or coach. Although these renewals can be seen principally in terms of new pedagogical and didactical insights in primary and secondary schools they have also had an influence on university education.

A Dutch parliamentary research committee found that the government translated the above new concepts into a series of renewals for primary and secondary education, mostly ideologically driven and weakly grounded in research [7]. The committee views the results of this initiative rather negatively based on the educational effect as measured by government research over the last few decades. The biggest complaint is that the educational system, in its broadest sense, now delivers students who have acquired too little knowledge, especially of language and mathematics.

In the Netherlands at the university level, Problem Directed Education first was promoted by the Faculty of Medicine at the new Maastricht University at the end of the eighties. The theoretical principles mainly were related back to Wijnen et al [27]. In Problem Directed Education students are working in groups on practice related problem situations, defining and acquiring their own knowledge and skills while solving their problems.

During the last decades of the previous century, the authors of this paper were involved in educational renewal at both of the faculties of architecture in the Netherlands. It’s remarkable that both faculties each at their own manner has chosen for a blended mix of traditional face to face learning and new types of learning (as the movement is called in the Netherlands). Education at the polytechnics has been reformed primarily around the new learning methodologies. The Bloom taxonomy [2] is still being used in some faculties of the Dutch University system, while describing their learning goals, while most polytechnics nowadays are working with competencies.

It has to be noted, however, that the concept of competencies is often misunderstood, and is frequently used as an equivalent for skills [17]. Actually competencies are meant as a limited series of keywords together describing the core of a profession [25b]. They are not a series of behaviors but points of reference including knowledge, insight, skills and personal attitudes [18]. In their basic form competencies can be related back to the idea of Spencer and Spencer [22] in which a firm has to describe its core competency (that what distinguishes it in the market) before it can define the needed competency to contribute to the mission of functional groups and employees. Projecting this thinking to education, incorporates the danger that learning outcomes can be measured simply by developing checklists in form of an assessment.
of what has achieved at the end of the educational process. In the educational interpretation of Vreugdenhil competencies open up the possibility to combine academic and professional education while using the concept to develop so called knowledge grammars in which the knowledge oriented fundamentals and grounded structures of a domain are combined with professionally oriented profiles. Realizing this is of essential importance for engineering studies at the university level. Unlike in the Anglo Saxon world, in the Netherlands professional university education is not controlled or accredited by the relevant professional bodies. Instead, the ministry of education (however delegated to the Association of United Dutch Universities VSNU) reviews educational programs periodically. Nevertheless the engineering sciences can take advantage of the concept of competencies as a basis for their educational programs as they are intrinsically based on a blend of science, applied technology and professionalism. The educational program of the department of Real Estate and Housing at the Faculty of Architecture of Delft University of Technology is an example of how this type of thinking can be translated into a curriculum which a rich blend of didactical forms.

Alongside the above developments, a kind of technology push towards the concept of e-learning has emerged. Often it was thought that classroom teaching would disappear and education would go online, using digital learning environments, without face-to-face contact. In practice, a blended approach is usually chosen, combining online and offline activities. Verkroost et.al. [25] have extended this definition by adding three dimensions: structured/unstructured, group/individual, and teacher/student directed. In each educational setting these dimensions will be balanced differently because of different preconditions. It is a challenge to balance these dimensions in such a way that an optimal learning situation is established.

E-learning started in the early nineties with names as ‘computer based learning’ ‘tele-learning’ or ‘online learning’ simply by putting learning material (information) on the web. Today e-learning is often oriented toward interactive and collaborative learning. Portfolios and learning material can be stored in Content Management Systems (CMS’s) while the students behavior (which learning object is loaded, which training activities are done) can be tracked in so called Learning Management Systems (LMS).

E-learning aims to make education faster, more efficient and more interactive, with powerful, flexible and so called authentic learning environments [8]. As e-learning is still developing rapidly no consistent well accepted definition exists [19]. In its most widely used sense e-learning compromises individual and group learning processes, the development and management of learning processes and learning material as well as the organization of learning activities [18]. Some authors, such as Cobb [4], even assume that new technologies like Web 2.0 are the drivers behind a move to student-centric rather than teacher-centric learning bypassing decades of developments in didactics and learning psychology.

2. Design Education in Architecture

Despite all the developments in learning approaches, design education in the narrow sense seems still to be tied to traditional design studio training in which the master designer coaches the novices in learning while doing. Using Sfard’s [20] distinction between Acquisition and Participation we can describe the design studio as a participation situation in which the
student becomes a member of a community, learns to speak a community based language, and participates in discourse and cooperative learning. On the other hand, lecture courses typically conform to the acquisition model, and are directed towards conveying pre-specified knowledge and developing pre-defined concepts. Sfard’s concept comes close to what Jonassen Peck and Wilson [13] describe as meaningful learning, which they define as active, constructive, intentional, authentic and cooperative. Collins and Moonen [5, 6] develop this further in what they call ‘the contributing student approach’. In this approach students can contribute to the learning material based upon their own experience, can draw on each other’s experiences, and can use material that they can obtain via the Web, or from their workplaces. Other similar approaches include Kearsley and Sheinderman’s Engagement Theory and Action Learning [9, 21]. Although there seems to be a lot of similarities between modern didactical approaches to learning, and the traditional design studio, one can ask if this is a merely superficial similarity or a more fundamental likeness. One might be tempted to say that the design studio is modern didactics avant la lettre. However within the design studio the personal social interaction between novice and master remains central to the instruction method, and the emphasis on the teacher is not consistent with modern student-centered developments in learning.

3. Knowledge Integration in Design

The integration of knowledge from different domains, and the use of knowledge integration while problem solving, are both issues in all types of education. This is especially the case in architectural education, as a huge amount of specialized knowledge on several levels, and forms several domains varying form material sciences and structural engineering, to architectural history, city planning, infrastructure and spatial policy, has to be integrated in the design studio projects. Knowledge integration is an essential feature of design activity and is traditionally regarded as one of the key tasks of the architect [26]. This is particularly important now, as the spatial, functional, and technical aspects of building design and construction becomes increasingly complex and the number of parties involved increases. Little is known about the actual course of the integration process during design activity, though this is a source of many possible errors. Improved design integration may be expected to lead to a faster building process, fewer building errors and higher architectural quality. Within this context, knowledge integration is considered in terms of the integration of all building aspects within an architectural design into a single complete and coherent building design.

In their classic work on knowledge management Takeuchi and Nonaka [24] distinguish between knowledge and information in the following manner: “First, knowledge, unlike information, is about beliefs and commitment. Knowledge is a function of a particular stance, perspective, or intention. Second, knowledge, unlike information, is about action. It is always knowledge ‘to some end’. And third, knowledge like information, is about meaning. It is context-specific and relational.” The essential notion in the reasoning here is that information becomes knowledge within a meaningful context. In the context of design processes in educational settings, this means that unless educational information becomes meaningful in terms of being part of a coherent body of knowledge, it will not be integrated in the design.
For the purposes of this paper information is defined as the data provided to the student within different curriculum elements. Data are not the tools with which the design students make decisions, either collectively or individually. Takeuchi and Nonaka [24] put it this way: “Thus information is a flow of messages, while knowledge is created by that very flow of information, anchored in the beliefs and commitment of its holder.” In the context of design Wamelink & Heintz [26] associate knowledge, as it is understood by Takeuchi and Nonaka, with design reasoning:

“The grounds, the conditions pertaining at the current stage of design (the current design itself, and the physical and regulatory environment surrounding it) and the performance expectations outlined in the architectural program form the basis for a claim, a new design decision. This is the information on the basis of which design decisions will be made. But the crucial knowledge which allows designers to choose a course of action (make a design choice) lies in their tacit and explicit domain knowledge, and their reservoir of experience and beliefs. In making design decisions designers generate new information – the design – and also new knowledge – the belief that this design will serve the clients needs (functionally, or in terms of buildability, cost, or other determining criteria), and more general beliefs about the relationships between construction, form, and use. The normal expectation is that effective knowledge integration will enhance the generation of this new knowledge – that it will occur more quickly and that the knowledge generated will be more valuable, more insightful.”

Zeisel [28] states: “Information used in designing tends to be useful in two ways: as a heuristic catalyst for imaging and as a body of knowledge for testing.” According to Zeisel research and design are ‘surprisingly similar activities’. Although designers are not directed to obtain objective scientific knowledge, they execute research based type of activities to generate knowledge as a basis for design decisions in terms of imaging and testing.

This implies that it’s typical for the design studio that students ought to learn to create a meaningful body of coherent knowledge to be used in integrated designs from a fragmented body of information presented in the curriculum. When they acquire more experience and are faced with more complex design tasks, students must be able to acquire additional design knowledge apart from what’s offered within the curriculum by executing research activities. It might be stated that one of the main differences between novice and experienced designers is the availability of a personal knowledge base, which is continuously and actively explored and which can be used to deliver integrated designs.

4. DEE preliminary idea

Between 1999 and 2001 Delft University of Technology (TUD) implemented the so-called Bachelors-Masters structure to its curriculum in order to harmonize with European standards in university education. The Faculty of Architecture used ‘required’ change for a complete redesign of the curriculum. The Faculty of Architecture at TUD is distinct in having a Department of Real Estate, Housing and Design & Construction Management (RE&H) in addition to the departments of Architecture, Building Technology and Urban Planning and
Design. The faculty provides a broad integrated building engineering and design curriculum at undergraduate level, while offering four opportunities for specializations (similar to the four departments) at MSc. level. The new BSc. curriculum is built around design projects in each semester with so called ‘knowledge lines’ providing the knowledge to be integrated within the design by means of a range didactical methodologies. The instructors, including both authors) in RE&H, with their process and management oriented scope, often face the problem that the knowledge offered in their courses is rarely integrated in the students designs. Although officially the students’ designs ought to be judged on all educational information provided within a semester, in practice the criteria of judgment remain vague and are dominated by considerations of architectural composition. As a result, confirmed by systematic student evaluations, carried out by the Faculty of Architecture, TU Delft, students perceive the knowledge provided outside the design studio as fragmented, and less relevant compared to the design studio training. As the development of the new curriculum of the Faculty also implied new courses and new learning material, the Design and Construction Management group (DCM) within the of RE&H department formulated a pilot project called Dynamic E-Learning Environment (DEE). The DEE project originally started with the following aims:

- Providing the content of the DCM undergraduate program on a web-based repository.
- Providing insight in the interrelation of the parts of the curriculum by structuring the knowledge within the DEE.
- Providing insights in the way the curriculum content of DCM can have its influence in design projects as well as on the level of the design studio projects as in practice cases.
- Making clear how the DCM content is related to the other parts of the semester, to the previous and following parts provided by DCM and how it is embedded in the whole of the Faculty’s curriculum.
- Providing the students with opportunities for further research by means of providing links within the repository from course material, to practice based literature, text books and advanced research material, websites etc., and advancing the Faculty’s concept of research based education.
- Providing instructors with the opportunity to actualize, on a frequent basis, the content of the educational material.
- Making education for large groups of students more efficient.
- Providing instructors with the opportunity to put their lectures (streaming video) and ppt’s connected to the study material in the DEE.
- Providing the students with the opportunity to assemble their own personal knowledge base within the DEE throughout the curriculum.
- Giving students the opportunity to share their knowledge with fellow students and the staff, and to form self-producing and self-learning teams.
- Stimulating students to actively explore their own knowledge base with all relevant knowledge produced by themselves as part of curriculum activities, as result of the work they do in the design studio as well as individually found and created knowledge, this complementary to their design portfolio.

The project was funded by the faculty of Architecture and had to be completed within three months. Because the project had to be fast tracked an external project manager, experienced
within ICT projects was hired to facilitate the development process. He provided a detailed project plan and used PRINCE II methodology to manage the team. Further the team consisted of two instructors from DCM both involved in undergraduate teaching, a didactical expert, a librarian experienced in developing repositories and a software developer. The first author of this paper initiated this project and was responsible for project management.

5. The Development and structure of the DEE

The main research questions confronted in the development of the DEE were: How to structure the content? How to make it accessible on a variety of manners as described above? And how to manage its content? Other questions were related to didactics and the support of desired independent study behavior. Sub-question concerned the effects on study efficiency and teaching efficiency. At the same time initiatives were undertaken to revise the way students are to be evaluated throughout their study career. The aim within the DEE was to judge students in terms of the quality of the content added to the DEE, rather than their ability to reproduce knowledge.

The difficulty developing the DEE appeared to be that its concept includes aspects of several different approaches to e-learning (active learning), Learning Management Systems (LMS) as well as Content Management Systems (CMS). The type of software functionalities needed to develop a full function DEE is given in figure 1.

![Software functionalities needed for a DEE](image)

Figure 1: Software functionalities needed for a DEE.
Several existing packages varying from SAP, Stellent, QuestionMark, Canvas, MM Base, Hive, to Blackboard CS were evaluated. The team studied the possibilities of these packages through a literature review, interviews and site visits to a range of universities and other schools for higher education using e-learning tools. None of the existing packages on the market (in the versions available at that time) met our requirements.

Given the available time for development (3 months) and the available resources the group decided to use a beta release of Blackboard CS. From the existing software packages this provided the team with the greatest range of the desired functionalities, and the students for which the team liked to develop the DEE were already used to this system. The concept behind DEE requires that the learning content be structured along a number of dimensions:

The learning community, owner and position within the curriculum:
- Educational unit
- Responsible department and group
- Semester
- Teachers
- Guest lecturers
- Student
- Group

Didactical use:
- Course material
- Students’ own work
- Contextual content

Taxonomical nature:
- Basic knowledge previously acquired
- Required learning content
- Followed learning content
- Recommended linked content

Level of content:
- Required learning content
- Content related to students’ work (content provided by other students)
- Content related to practice (handbooks, project documentation, case documentation, business documentation)
- Related references (literature, source material)
- Related basic content and research (proceedings, textbooks, MSc. projects)
- Related advanced research (journals, scientific books, PhD projects)
While trying to build a knowledge base structured according to this scheme for two small (3 and 4 ects) courses in the BSc curriculum provided by the DCM group several difficulties were encountered. First, it appeared rather difficult for the teachers to provide enough structured material to fully populate the knowledge resource trees implied by the categories laid out above. Second, structuring the material according to taxonomical and level related principles appeared to be difficult. Third, it appeared to be time consuming to design and program the associated graphic-interfaces for each of the above structures. The team therefore decided relatively early on to develop a pilot DEE for the smaller course.

6. Testing the DEE

The DEE was initially tested by the development team. This test was limited to a simulation involving structuring, presenting, storing and retrieving knowledge. The pilot DEE developed for one part of the DCM curriculum was tested, in two rounds with a small group of 10 volunteer students. The students in this case had already followed the course the pilot DEE was developed for. After having introduced the concept of the DEE the students were asked to start exploring the developed system for a period of one hour. The research team assisted them while observing the use of the new tool. Afterwards the students completed a questionnaire and members of the team held open interviews with them. In both cases all students were enthusiastic about the pilot DEE. They all enjoyed working with it, were rather enthusiastic about the possibilities for independent study and a personal knowledge base. However it appeared to be already in the first round that active use of the DEE requires more than simply supplying and structuring content. Based on our questionnaire, the open
interviews and a literature review on e-learning didactics the team identified the following means to enrich the DEE didactically:

- Activated learning; learning by means of interaction, participation and collaboration with peer groups [15].
- Producing learning: students themselves add relevant learning objects and content to the system on a variety of levels within the resource tree [11],
- Authentic contexts: students have to learn and execute tasks concerning relevant, realistic subjects and contexts. A learning experience becomes meaningful if the students environment is part of the learning process [3,14].
- Complex tasks: students have to work on exercises and tasks with multiple layered answers for which they need a variety of sources, experts, peers and meetings (this is based on social constructivism [10] and is an essential prerequisite of competence based education and for the active use of DEE).
- Learning portfolio: students have a clear insight in and record of their acquired competences [23].

7. Reflections and conclusions

Although provided with sufficient budget the three months time allotted to develop the DEE actually appeared to be too short. However the research team provided a positively evaluated pilot project which was further developed as part of an EU funded research project Blend-XL [12].

It appeared to be that none of the existing e-learning software packages on the market was able to meet the specifications outlined in the paper to develop a fully functional DEE. Blackboard CS was chosen as one of the best alternatives, but as expected it was difficult to build our DEE within it and the team was dependent on IT experts to implement (program) their ideas. Although examples were provided of how to structure learning content, for the instructors involved structuring their content appeared to be difficult especially defining the content in domain bound taxonomical structures, and according to learning levels. The development of structured content was to a large extent hindered by software complexity.

The DEE was intended for use with large groups of students. Several issues concerning large groups as access rights, quality of student learning content, and the management of the system were not resolved. Other issues, such as peer group assessment, hot seats, easy user interfaces have been addressed in later developments [12]. Although the two teachers involved were rather enthusiastic, for one of them the complexity of the developed e-learning environment appeared to be too high. One of the instructors (the second author) has continued to develop the DEE, using it initially with groups of volunteer students and currently with a cohort of over 400, and getting remarkably positive responses in the course and research evaluations. This was done as part of the Blend-XL project, and is more fully described elsewhere [12]. The Blend-XL project used action research methodology, employing a several cycles of improvement. Student evaluations of the DEE were done using a questionnaire developed by
the Blend-XL team members at RWTH Aachen University. These evaluations indicated that
the DEE was readily accepted, and students found the system satisfactory. Although all those
involved in the project whether as developers or as evaluators believed in the value of the
DEE as a vehicle for better knowledge integration in design due to it’s pilot status the project
scope did not allow for the production of empirical evidence this conclusion.

References


http://blog.missiontolearn.com/resources/ (last checked April 15 2008).

and expectations, Routledge, London.

Workbench, TUT, Twente.

onderzoekscommissie Onderwijsvernieuwingen, SDU Uitgevers, ’s Gravenhage.

364.


Krachtige leeromgevingen. Studiehuis reeks nr. 36. MesoConsult BV, Tilberg.

Construction Management. Second International Conference of Construction Project
Management, Delft, Netherlands.


