Experience with WINDS Virtual University

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Abstract: In the WINDS project the consortium partners have experimented with the Virtual University for Architecture and Engineering Design. University professors and their colleagues have created 21 online courses in this field. Their specific requirements have been taken into account in the implementation of the ALE system that integrates the functionality of a complex e-learning system with adaptive educational hypermedia on the Web. In this paper we present the results of several evaluation studies. They imply that suitable innovations, like the concept map, can help us to overcome the "no significant difference phenomenon".

Introduction

Five years ago 28 partners have started the WINDS (Web based intelligent design tutoring system) project aiming at development of a suitable e-learning solution for university students and teachers in the area of architecture and engineering design. Most of the partners were universities with a lot of experience in design education, so they have specified their fundamental requirements for a supporting software system to achieve the objectives. These rather heterogeneous requirements were elicited due to a variety of pedagogical models and didactical approaches applied in the different universities and by the different professors. This was the basis for the design of a highly flexible and innovative environment that allows supporting those different pedagogical models. As one of the key ideas we identified the structuring of the domain knowledge in two different layers: the learning object layer and the index (semantic) layer. This is very similar to current approaches for connecting semantic web and adaptive hypermedia for learning and knowledge management. The result of this cooperation between end users and software developers includes an effective methodology for e-learning in the area of design and architecture, a learning management system called Advanced Learning Environment (ALE), and more than 20 online courses. ALE integrates the functionality of web based e-learning systems and adaptive educational hypermedia systems with special support for the design learning processes.

Today, there are many web based educational systems, both commercial and free ones (e.g. WebCT, BlackBoard, Moodle). Typical e-learning includes document management, cooperative tools, progress monitoring, but usually not real personalized adaptive learning. On the other hand several applications for developing adaptive courseware (e.g. InterBook, AHA!) exist just as academic developments. Just a few tools focus primarily on the simplification of the authoring process, without the necessity of programming skills – NetCoach (Weber et al. 2001) is one of them. But it is not easy to find a solution for ordinary teachers that would integrate the functionality of a complex e-learning system with adaptive educational hypermedia on the Web. And this is the objective we try to address via the ALE system. Additionally ALE (Kravcik et al. 2004, Kravcik & Specht 2004) provides template based user interface to make the authoring process more intuitive and innovations are implemented also in the learning environment, for instance interactive concept maps. To reach our goals we have taken into account several of the existing standards and semi standards on learning objects, learner models and their storage and exchange (including SCORM). The ALE authoring tool is distributed by bureau42 GmbH as author42™.

What makes WINDS unique is the integration of web-based e-learning with adaptive educational hypermedia, combined with the amount of learning materials for this specific area of architecture and design that have been created in this project by authors without programming skills. ALE is designed to support various learning strategies and their combinations. Paragraphs contain materials for expository (explanatory) education. Discovery learning is encouraged not only by hyperlinks but also by index terms and their interconnection with learning objects and external documents. Collaboration facilities promote constructivistic learning approaches. In this paper we briefly introduce the ALE system and present the results of its several different evaluations – quantitative, qualitative, and summative.

WINDS Learning

The idea of individualized learning is centuries old, but new are the circumstances available for this challenging achievement. And they are really important to change the current educational system for the requirements of the knowledge age to support individual strengths and creativity, as solutions of complex issues necessitate multidisciplinary and collaborative approaches. The rapid development of information technologies might be sometimes confusing, but their suitable integration can bring synergetic effects and new quality, e.g. WWW with publication opportunities for all. Major changes in learning are still to come and certainly a high potential is hidden in mobile technologies.

One of the key objectives in WINDS was support for various learning approaches. *Meaningful learning* (Novak 1998) is based on the belief that the best way to teach is to build on what the student already knows. Interactive *concept maps* provide a technique to aid meaningful learning by representing knowledge in graphs. The explicitly represented conceptual framework that is behind each course enables active acquisition of knowledge. The framework can be also used as a network for navigation, allowing for *discovery learning* (Papert 1980). The explicit references to the course conceptual framework made by the tutor during homework design revision enable *learning by doing*, i.e. the acquisition of skills strongly referenced or related to knowledge. In the design area *case-based reasoning* (CBR) is extremely important, as an approach to learning and problem solving based on previous experience (Kolodner 1993). A past experience is stored in the form of solved problems ("cases") in a so-called case base. A new problem is solved based on adapting solutions of known similar problems. This kind of inference is necessary for addressing ill-defined or complex problems. Our most natural and powerful learning strategies are the automatic ones that situate learning in real-world experience. Key to such reasoning is a memory that can access the right experiences (cases) at the times they are needed. ALE supports CBR by a coaching strategy, recommending cases related to the current content object via concepts. As design teaching passes through daily practice and long revision processes, protocol analysis studies of students' revision activities have demonstrated that these activities consist principally in the construction of reasons that have lead to solutions (design rational). ALE enables controlling of the homework workflow by means of the learning element *Exercise*.

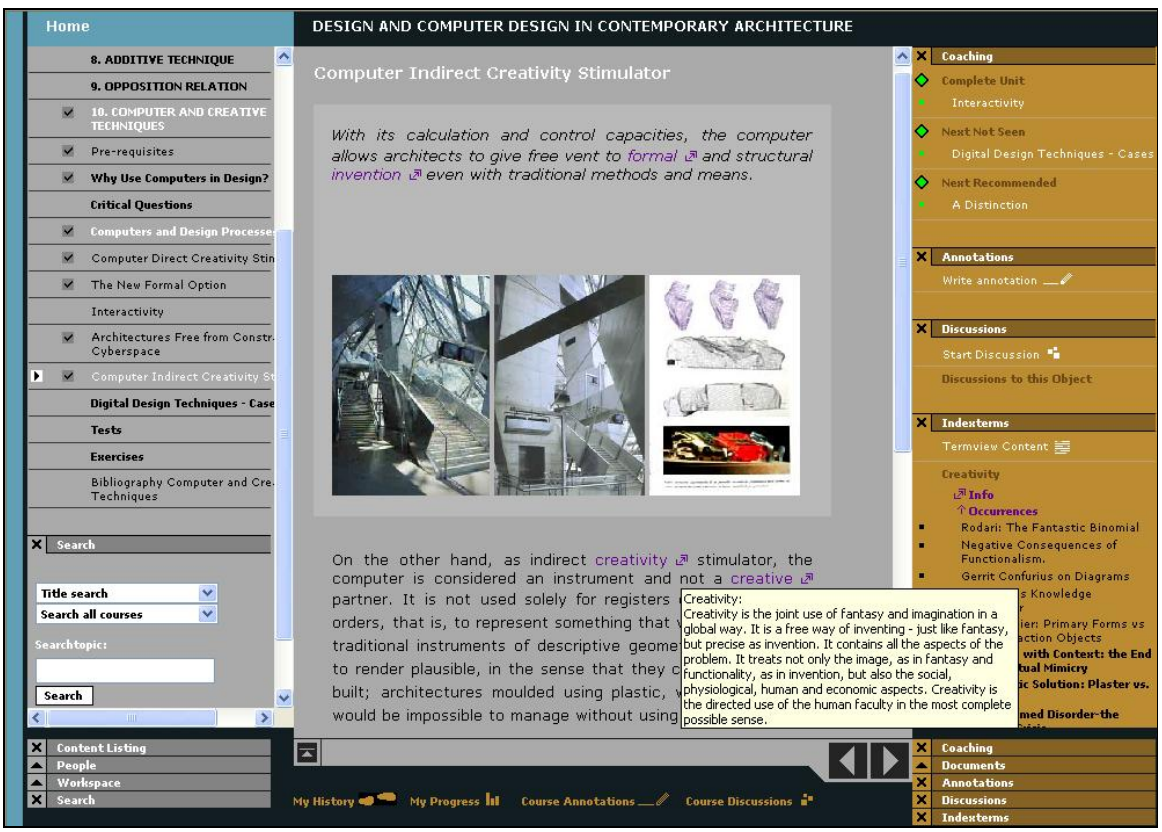

Figure 1: ALE course player

ALE Learning Environment

The ALE learning environment is both *adaptive* and *adaptable* – the system can automatically adapt to the learner given a user model and the learner can influence the adaptation by means of such preferences like language and learning style (access to the related questionnaires is provided). The learning environment allows users to present course materials in an individualized way and get personalized recommendations. The *course player* was implemented in a modular way to be easily adapted to the individual needs. A variety of needs for different navigation support in course materials was reflected in various navigational metaphors. The interface is based on the visualization of the navigation structure, presenting the course content and in parallel displaying the index terms of the semantic layer related to the current learning context (Fig. 1). Context exploration is supported by enhanced *concept based navigation* in ALE. The learner can easily access a wide spectrum of propositions involving the concept of interest. This fosters an inductive way of learning relationships among concepts. Navigation in the semantic space (Fig. 2) can start from an occurrence of a concept, then the concept map is accessed which allows finding the paragraphs related to the concept, and therefore to define its meaning limit, or to navigate towards co-related concepts.

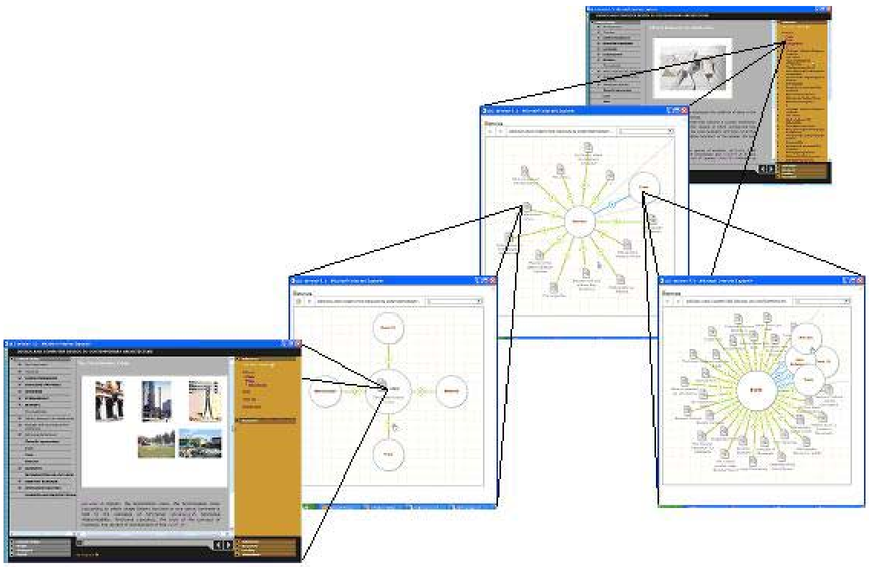

Figure 2: Navigation in semantic space

The coaching strategies can be clustered in *history based navigation support*, *adaptive learning style guidance*, *cooperation support* (to find a suitable peer) and *case based navigation support* (cases are emphasized in concept occurrences). The implemented *history based coaching strategies* include the following ones:

- *Missing Prerequisite:* if the current learning object has missing prerequisites (specified in LOM based metadata)
- *Next Not Seen Learning Object:* the next learning object that has not yet been visited by the learner
- *Complete Current Learning Unit:* in the current learning unit another learning object that has not been visited

Learning style strategies follow the principle that each student will see content in a different way and has individual likes, dislikes and preferences for certain content. Students can take the Felder-Silverman Test for finding out what their individual learning style is. The test consists of 44 questions; the results of these questions are condensed into the preferences of the student. If the student is not satisfied with the test outcome, these preferences can also be set manually in the *Preferences module*. Depending on the student preferences the system then scans through the content and looks for the best matching materials.

The *Next Best Learning Object* is based on the results of the learning style questionnaire available from the ALE portal. The results are stored in the user model indicating whether the user has significant preferences in four dimensions: Sensitive – Intuitive, Verbal – Visual, Active – Reflective and Sequential – Global. Taking into account the types of learning objects and their metadata the system tries to find the best next learning object for the user. It uses a classification schema of the learning objects from the LOM Metadata for the educational metadata *Learning Object Type* and *Interactivity Type*.

Quantitative Evaluation

The WINDS authors have created 21 *courses* (Tab. 1). Each *course* is a part of the curriculum at the university where its authors come from. The total number of 5519 *learning objects* means 262.8 learning objects per course in average. The differences between individual courses are rather essential, with 53 as the minimum and 974 as the maximum value. This shows the freedom of the authors to construct the online course according to their needs and opportunities. 3521 (63.8%) learning objects contain some kind of *metadata*, thus the average number per course is 167.7. It has been strongly recommended to specify metadata and many authors have accepted it, though it required additional work for them. But future authors will certainly benefit from this effort, especially when the WINDS repository becomes a part of a distributed network of learning resources with brokerage facilities. The courses contain 889 *categories* (average 42.3), 3637 *materials* (average 173.2) and 993 *tests* (average 47.3). This gives in average 3.7 materials per test. Almost one third of the courses have no online tests. The relatively big differences between some courses suggest that authors consider rather different structures for their courses what can also reflect the educational methodology employed, e.g. in blending learning the amount of online materials can vary according to the specific demands. As the repository has been built from scratch the authors could not exploit reusability at the beginning when they were looking for suitable materials. Later on they have preferred copying facility instead of more loosely referencing.

Courses	21	Average
Learning objects	5519	262.8
Metadata	3521	167.7
Categories	889	42.3
Materials	3637	173.2
Tests	993	47.3
Content blocks	10542	502.1
Index terms	1744	83

Table 1: Different types of learning objects in WINDS – quantitative overview

The average number of learning objects per *category* (folder) is 7 and almost all the courses have this value in the interval 7±2. The authors did not often use the opportunity to group individual tests into the *quiz* aggregates and the *questionnaires* have not been used virtually at all. This can be explained by the fact that these types were not available at the beginning but have been introduced later according to the authors' demands. The feedback from students is probably supposed to be received in a different way, e.g. face to face or by e-mail. The course content itself is stored in paragraphs offered to authors as *materials*. ALE provides templates for specific types of paragraphs selected according to the CISCO specification. These can help in structuring the materials properly, but we have learned that in this field authors prefer flexibility instead of fixed structure. *Materials* with the flexible structure represent 88.6% of all paragraphs. Having 186 *materials* per course and their average depth 3 suggest that the course structure is well balanced. To assess the learner automatically by the system authors have created various types of *tests*. Although design and architecture depend on pictures there are mostly such types of tests where the alternative answers do not include pictures. The figure showing approximately one test per *category* in average looks relatively low when we realize that a test is typically just one question with alternative answers. However, as has been already mentioned the WINDS courses are not intended to be used exclusively online – they complement the more traditional educational approaches at universities. The WINDS courses include 10542 *content blocks* what means more than 500 atomic units per course. One third of them come from two courses. The materials contain slightly more than 3 assets in average. Almost two thirds of content blocks are in text format, images represent more than one third of them. Java applets, Flash components and other applications occur occasionally, video very rarely and audio virtually absents. This distribution reflects the development effort necessary for individual media as well as their need in this domain. WINDS courses contain 1744 *index terms* and 1121 relations between them. Per course there are approximately 90 synonyms and 850 occurrences in materials, what makes almost 5 concept occurrences per material. This is quite a rich interconnection between the two alternative structures that can provide a good base for concept based navigation and explorative learning. *External documents* are seldom referenced.

Usability Evaluation

At the beginning of the year 2004 we have performed a usability evaluation (Oppermann & Reiterer 1997) of the ALE authoring and learning environments. In both cases the users were observed in a lab through video and after finishing the tasks they have filled prepared questionnaires. Usability experts found (Nielsen 2004) that as formative evaluation is concerned a few users can help to find most of the significant weaknesses. In our case, an evaluation of the ALE authoring environment with 4 lecturers has been performed. Every lecturer was to solve 4 basis tasks, each of them within 30-40 minutes. These tasks include:

- Create course structure (hierarchy)
- Create course content
- Create a test
- Process the feedback from learners

All the lecturers were able to create a basic course in the WINDS system without external support. In open-ended questionnaires they reported that the authoring environment was unobtrusive and inspiring for self-exploration if no external introduction is available. Observations of the test sessions revealed that some particular improvements could increase the efficiency of the authoring environment. It concerns dialogue criteria (ISO 9241, part 10) and information presentation (ISO 9241, part 12): self-descriptiveness (the meaning of icons was not always clear), conformity to user expectations, error tolerance, personalization (specification of colours, font type and size), novice learner support as well as simplicity, clarity, consistency, detectability and comprehensibility.

Our usability evaluation of the ALE learning environment has been performed with 15 students. Every student was to solve 4 basis tasks:

- Find a specified learning unit
- Learn the learning unit
- Contact the tutor
- Enter a contribution (annotation or discussion)

13 students completed the tasks, 5 of them worked efficiently, 6 moderately and 2 students reported problems. Concerning the usability of the system 3 students considered the user interface as good, 4 found it also good, but preferred traditional media, 4 learners regarded the ALE interface not yet good and 2 persons were principally negative. The evaluation has shown that most of the students were able to complete the given tasks. In open ended questionnaires the students replied that the system was unobtrusive and inspiring for self exploration if no external introduction is available. The test sessions have shown that improvements in terms of self descriptiveness, conformity to user expectations and detectability (ISO 9241 standard) can increase the efficiency of the learning environment.

Summative Evaluation

The experimentation conducted on WINDS courses has been evaluated independently by another project partner (CNR) and tried to give an answer especially to two main questions:

- Comparing our web courses with traditional ones
- Understanding what WINDS users feel about the new learning environment

Learning in WINDS

The basic requirement was to couple several WINDS course with traditional ones, so that in each case one group of students has received the same instruction content (topics, goals, if possible also materials) without any WINDS based support, in a traditional way. Both groups have been selected in a random way that should ensure a good homogeneity between them. This evaluation has focused on devising facilities which could enable investigation of both the formal (theoretical) knowledge, and the outcome of a more “learning by doing” oriented approach. To meet these requirements two types of tools have been used:

- *Multiple choice test* (MCT): to check theoretical knowledge; they are easy to construct, deliver and score
- *Design tasks* (DT): to investigate users’ abilities; easy to conceive and deliver, but their evaluation is based on the evaluator’s interpretation

86 students took part in this experimentation, 44 in the experimental group (WINDS students) and 42 in the control group (traditional students). The students came from 7 different universities and were systematically matched in order to obtain the maximal homogeneity in the composition of the 2 groups.

Each teacher has chosen at least two consecutive course units that cover approximately two weeks of work on behalf of the student. During this period the WINDS groups have used only the WINDS system and communicated with teachers only remotely. The teacher has identified a colleague to evaluate the design elaborates of both groups.

To investigate the differences between the two groups of students an analysis of variance has been performed. The main result was that no significant difference emerged (DOF 1.84, F=1.18, p=0.28). Students of both groups found the MCT easier than the DT, obtaining a mean score of 8.42 in the first case and 7.91 in the second; this difference was significant (DOF 1.84, F=7.47, p=0.008). The interaction between groups and tasks approximates significance (DOF 1.94, F=3.34, p=0.07): it is evident (Fig. 3) that WINDS students show a tendency to get better scores on MCT than their colleagues of traditional course (8.70 vs. 8.13), while in the design task there is a slight advantage for traditional students (7.96 vs. 7.87).

Comparing students' performance with their log data describing their interaction with the WINDS system we can see that the performance on MCT has a positive significant correlation with the mean time each student spend on the system ($r=0.43$, $p<0.05$), but the performance on DT has surprisingly a negative one ($r=-0.44$, $p<0.05$). The same result emerges when the mean number of learning objects requested per session is considered instead of the time. This suggests an interesting finding: students who dedicate more time to studying on WINDS tend to reach a better performance on MCT tasks, but surprisingly not in the design activities. Some indication seems to emerge from the analysis of short questionnaires showing that the students were deeply unsatisfied by the design tool and quite enthusiastic of the concept map. One of the main reasons was that the design tool was not very intuitive and required some time to get familiar with it at the beginning.

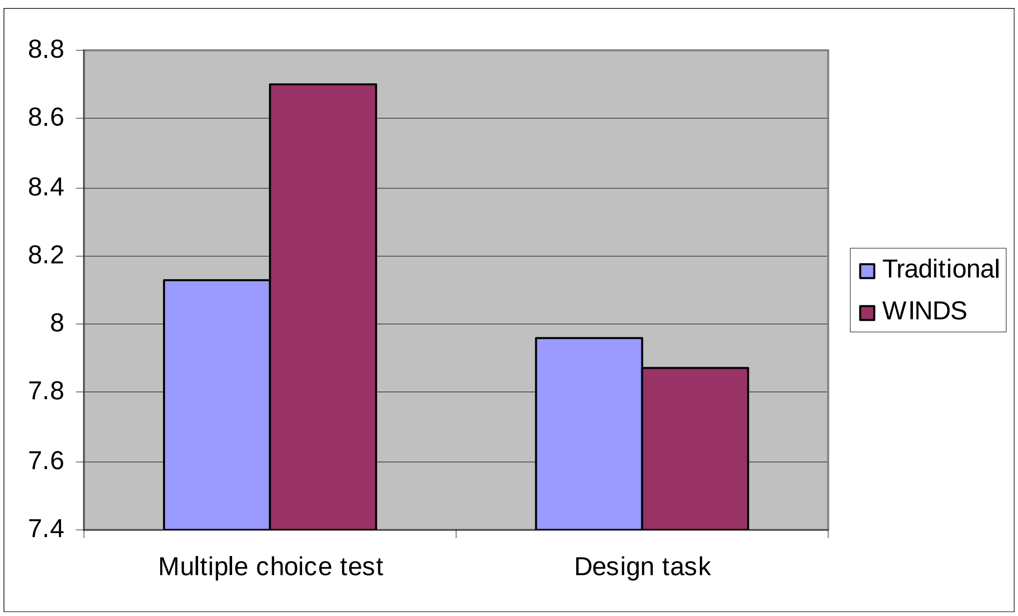

Figure 3: Learning performance

Questionnaires

The model adopted for the questionnaire was based on 5 basic features describing the quality of a web site (Fig. 4): communication, content, functionality, usability, and accessibility. Each of these dimensions has been evaluated on a 5-point-scale through the E-questionnaire, a scale based on 29 items investigating the quality of WINDS as perceived by each end-user. This model enables a comparison between the students and teachers in WINDS. Results reported below are based on the answers from 51 students and 23 teachers or instructors, all well experienced with WINDS.

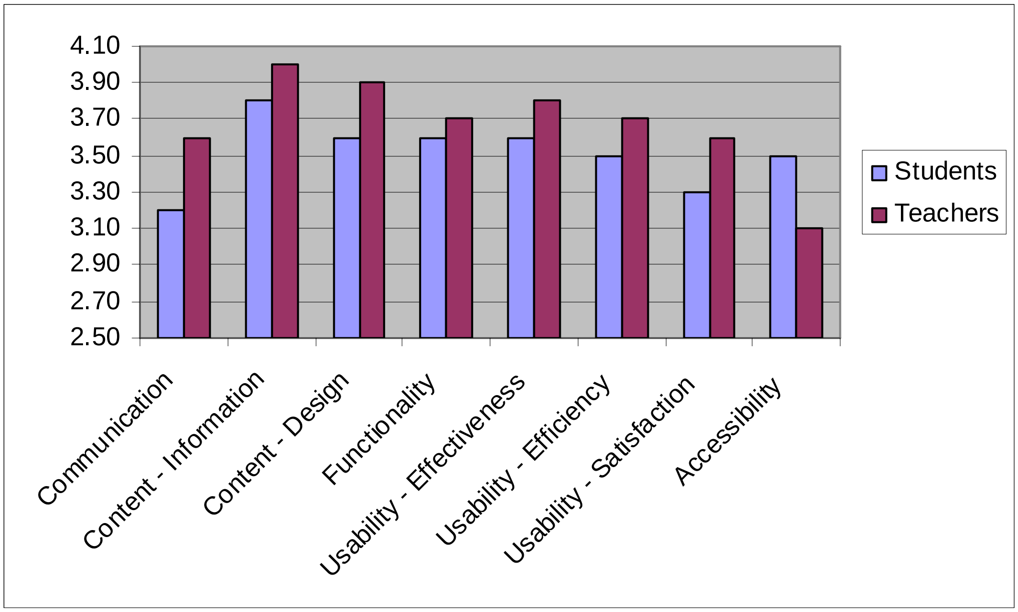

Figure 4: Results of questionnaires

It is evident that teachers appreciate the WINDS environment more than their students. The only exception is accessibility (this can be influence by the fact that accessibility problems at the beginning when just authors were using the system have been solved later on). These findings are confirmed also by the frequency and distribution of "extreme scores": rejections (individual scores below the 3 value) are by far more frequent among students then among teachers (17.6% vs. 8.7%); on the other side "clean acceptance" (individual scores higher than 4) shows an opposite trend: 21.8% among teachers and 17.6% among students. The short questionnaire has shown that the concept map ranges between 3.5 and 4.1 in the above mentioned features; 9.8% users score less than 3 with concept map, on the other hand, "clean acceptance" was 19.5% with concept map.

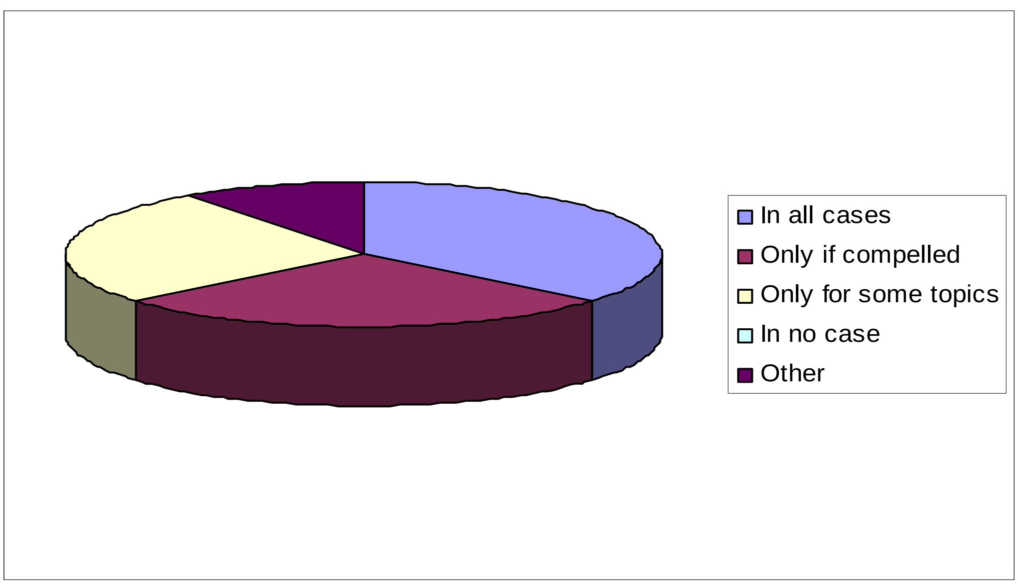

Figure 5: Can a WINDS course substitute a traditional one?

Another goal was to find whether and to what extent WINDS is perceived as a plausible alternative to traditional teaching. 25 teachers and instructors answered the questionnaire. 36% teachers answered that WINDS can substitute traditional course in all cases, 28% judged this only in special cases (Fig. 5). None of the teachers thinks that WINDS cannot substitute a traditional course in any circumstances and none denied the possibility of using WINDS in their future courses; in fact 36% positively asserted that they would certainly do so, 32% probably, and 32% did not know. Most frequent reasons for using WINDS include reduction of workload to save time for more valuable activities with the students, interactivity of the system, advantages offered by network access in terms of space and time, and possibility of a student centered learning. The mostly indicated reason for not using WINDS has been limitations deriving from lack of physical contact with students. More than 50% denied that evaluating WINDS students is harder than evaluating traditional ones. Interaction effectiveness with students based on e-mail appears to be judged moderately positive. In the majority of cases the interaction contents are requests for further explanations (48%) and proposals how to organize the work (28%). Teachers seem to have no problems in following students' progress in design work (64% state no difficulty). WINDS is judged adequate for communication by 76%, while only 20% give negative answer. 88% of the teachers find the WINDS content adequate, none of them finds it inadequate. In summary, WINDS approach to developing design activity is judged to be good.

Conclusions

In this paper we gave an overview of the WINDS system and its evaluation. Our objective was to overcome the gap between pedagogues and technicians by considering the instructional requirements in the design and implementation of the ALE platform. The WINDS experience shows that teachers, even without programming skills, can create web-based adaptive courses (via separation of declarative and procedural knowledge) and students can benefit from the usage of these courses (especially if they complement traditional teaching). The concept map is a good example which kind of opportunity web instruction provides to enhance learning because information can be represented and accessed in different ways. Students and teachers appreciate in the web environment what they cannot find in traditional classroom. According to the evaluation it seems that WINDS environment succeeds in fostering general learning. If we want to go beyond the "no significant difference phenomenon" more attention must be paid to innovative approaches and new opportunities enabled by online instruction.

References

Kolodner, J. L. (1993). *Case-Based Reasoning*. San Mateo, CA: Morgan Kaufmann.

Kravcik, M., Specht, M., Oppermann, R. (2004). Evaluation of WINDS Authoring Environment. *Adaptive Hypermedia and Adaptive Web-Based Systems, 2004*. Springer. 166-175.

Kravcik, M., & Specht, M. (2004). Flexible Navigation Support in the WINDS Learning Environment for Architecture and Design. *Adaptive Hypermedia and Adaptive Web-Based Systems, 2004*. Springer. 156-165.

Nielsen, J. (2004). Risks of Quantitative Studies. *Jakob Nielsen's Alertbox*. http://www.useit.com/alertbox/

Novak, J. (1998) *Learning, Creating, and Using Knowledge - Concept Maps as Facilitative Tools in Schools and Corporations*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Oppermann, R., & Reiterer, H. (1997). Software Evaluation using the 9241 Evaluator. *Behaviour & Information Technology*, 4/5, 232 – 245.

Papert, S. (1980) *Mindstorms: Children, computers, and powerful ideas*. New York: Basic Books.

Weber, G., Kuhl, H.-C., Weibelzahl, S. (2001). Developing Adaptive Internet Based Courses with the Authoring System NetCoach. In: Reich, S., Tzagarakis, M.M., De Bra, P. (eds.) *Hypermedia: Openness, Structural Awareness, and Adaptivity*. Springer, 226-238.

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