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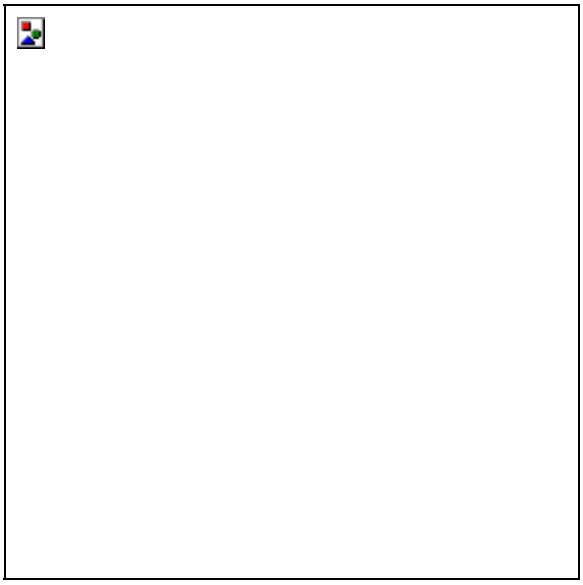

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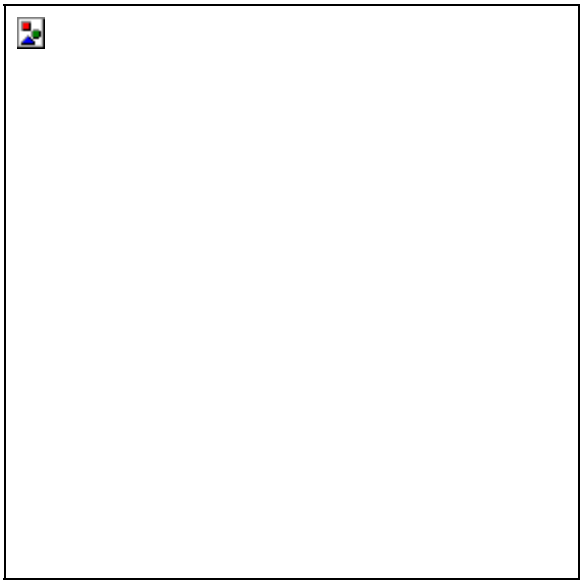

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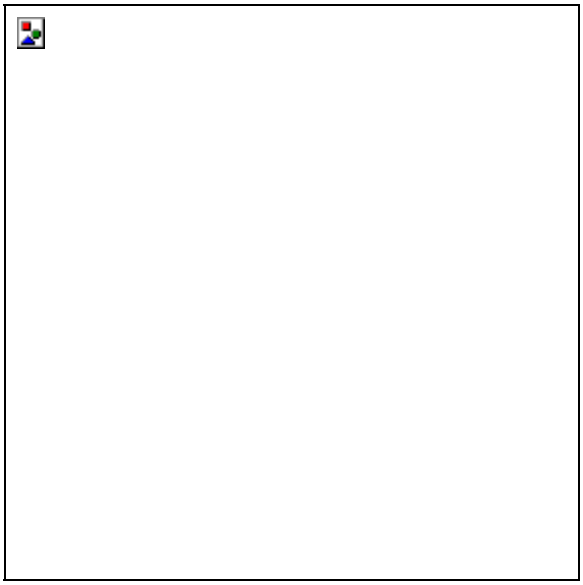
Hartvig

Susanne



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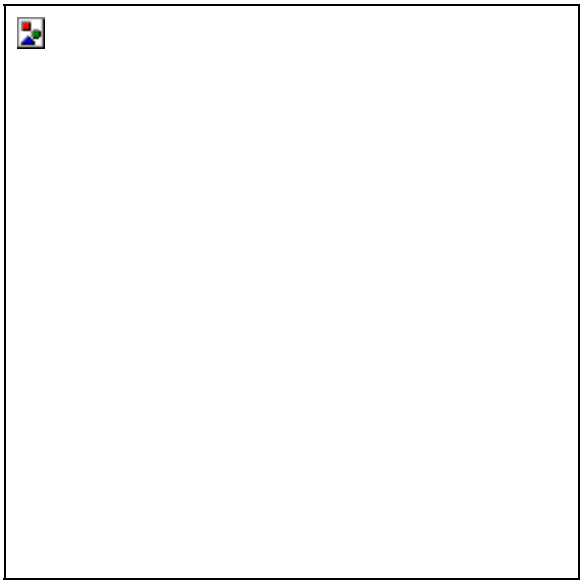
Address : 
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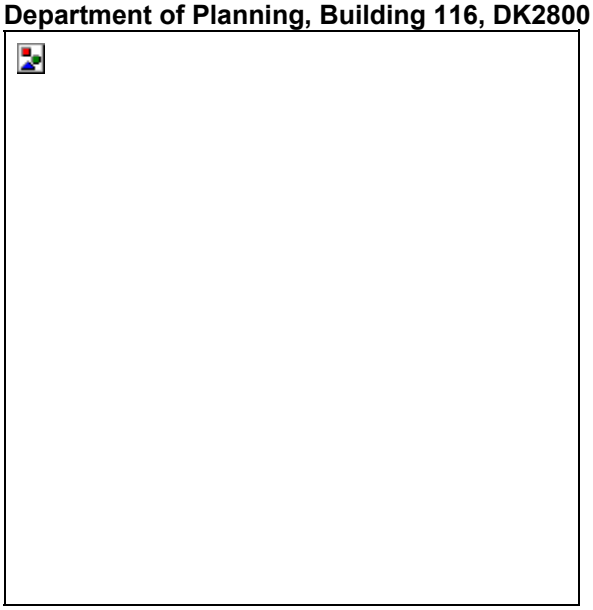
Country : 
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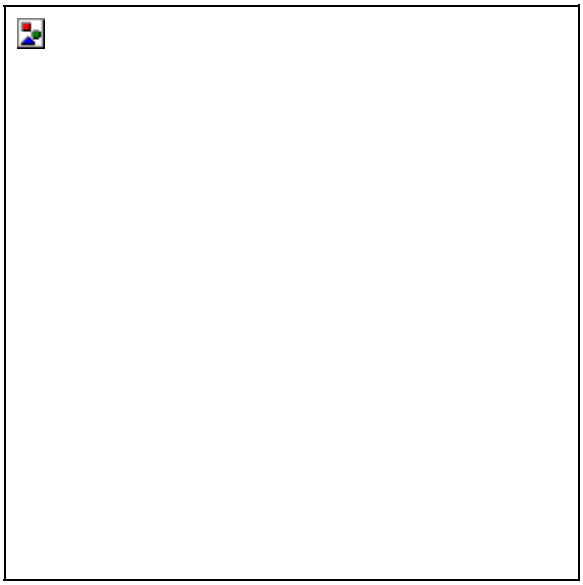
E-Mail : 
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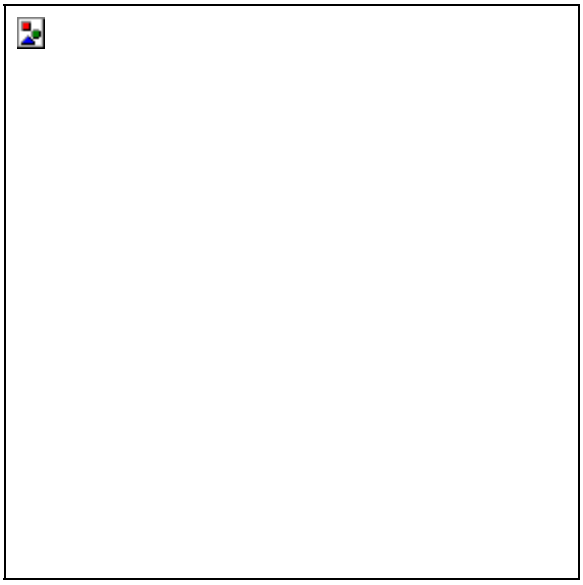

Tel / Fax :

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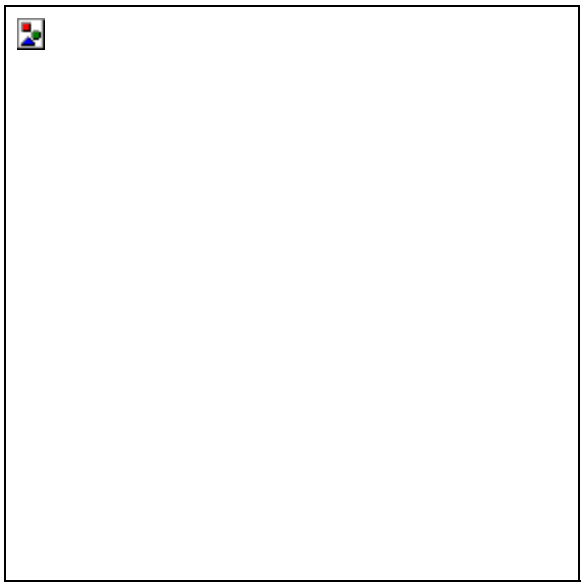
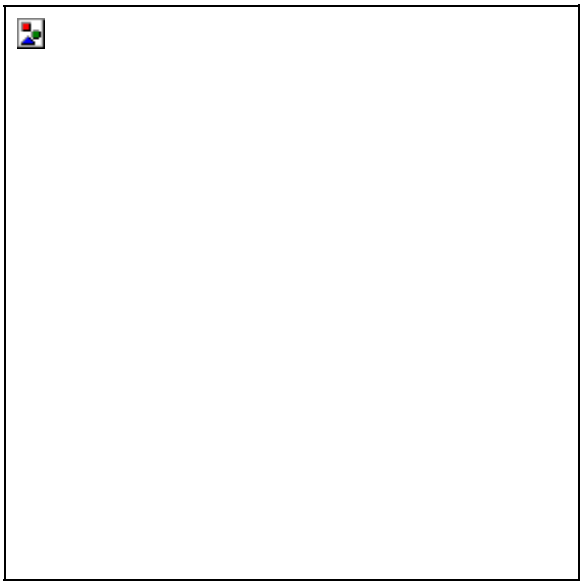




Author ID:

294

Title :
Prof.

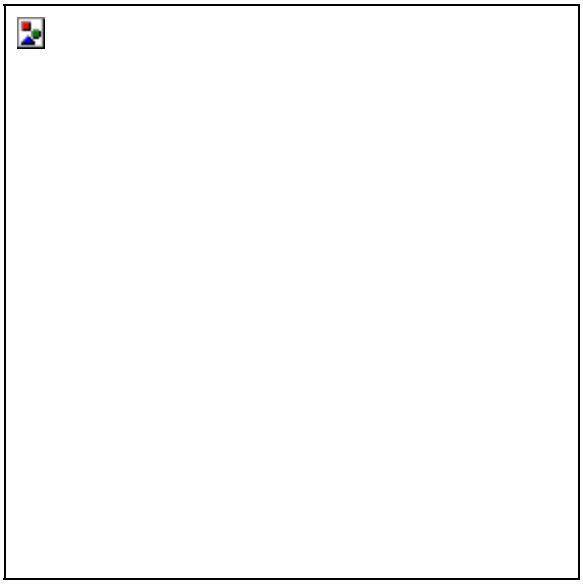
Assoc.

Name :
Andersen

Tom

Organization :
University of Denmark

Technical

Address : 
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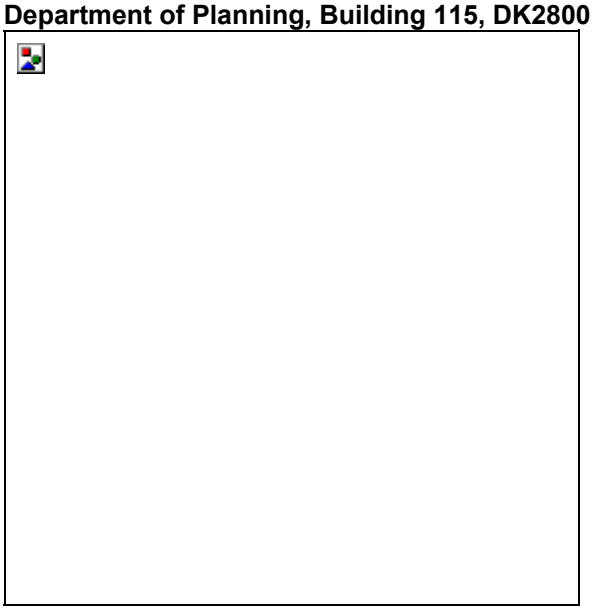
Country : 
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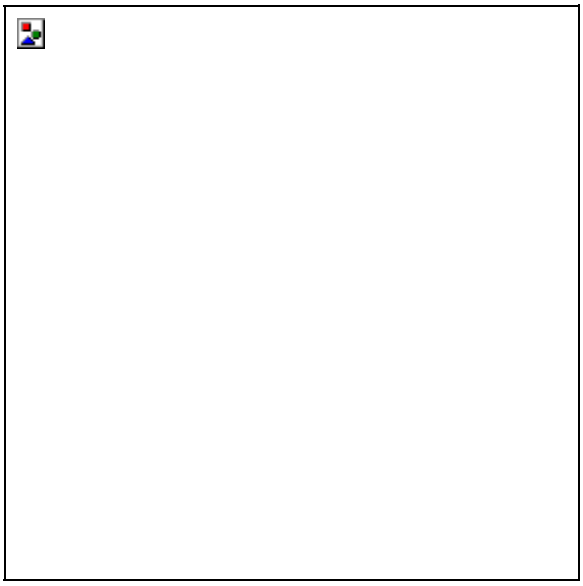
E-Mail : 
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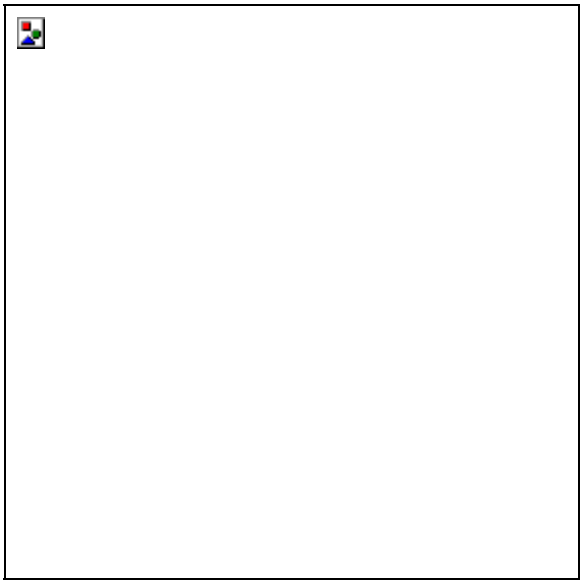

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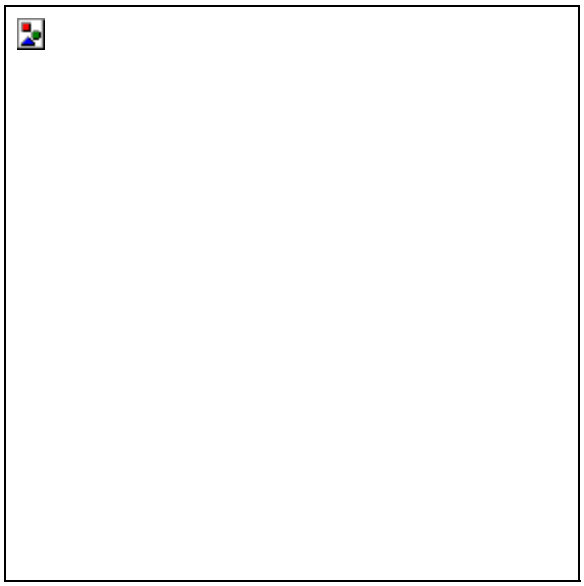

TEACHING COMPUTING IN CIVIL ENGINEERING: KNOWLEDGE SYSTEMS

Susanne C. Hartvig[1], Tom Andersen[1]
1 Department of Planning, Technical University of Denmark

ABSTRACT: After decades of research and development the construction industry is still not taking proper advantages of IT. The authors believe that one reason is a lack in teaching advanced IT to civil and building engineering students. This paper describes a survey performed at DTU which investigates the value of introducing coming civil and building engineers to knowledge based methods/advanced IT and whether it affects their careers towards more IT related tasks. The survey show that teaching advanced IT does have an effect. Graduates that have been taught knowledge based methods work more with IT related tasks than graduates that have not been taught knowledge based methods. Furthermore this paper outlines an agenda for maintaining and improving the teaching of knowledge based methods/advanced IT at the Department of Planning at DTU.

KEYWORDS: Education, Advanced IT, Survey, Knowledge systems

1. INTRODUCTION

After decades of research and development in 'advanced' IT, the picture of IT usage in construction remains the same – industry is not taking proper advantage of commercially available IT-technologies, as for example knowledge systems (Fenves 1997;Howard 1998;Sørensen & Andersen 1996).

We and others (Raphael, Shea, & Smith 1999) think this is caused by the fact that technical universities do not include teaching in advanced computing for civil and building engineers despite an outspoken need for it.

At the Department of Planning at the Technical University of Denmark (DTU), we have acknowledged this need, and we offer an intensive class in knowledge engineering. Experiences from that course have been presented in (Andersen & Hartvig 1998). It is clear to us that this class is valuable, because it enables a fraction of the new generation of professional engineers to cope with 1) knowledge and problem solving and 2) more advanced use of IT. However, it is equally clear that we need to do more; that is: offer teaching in a broader field than just narrow scope expert systems, and just this year two new courses in IT in construction: Management of IT and Applications of advanced IT in construction, have been initiated.

However there has until now been lacking evidence for the real value of introducing coming civil and building engineers to advanced IT, and it has not been throroughly investigated how courses in IT later impact their career.

This paper presents a survey performed in relation to development and improvement of IT courses for civil and building engineers at the Department of Planning at DTU. The survey is based on a small population, but it suggests that introducing students to IT has an effect on their choice of careers and interests. Following the presentation of the survey and its result,s a few suggestions for how to improve teaching in advanced IT based on the replies in the survey are presented.

2. THE SURVEY

The group that formed the primary focus of our investigation comprised students who have at on time or another been subjected to topics related to knowledge engineering, this being through regular courses, individual courses, student projects, or master projects. To establish baseline information with which to compare we collected similar information from a control group, consisting of randomly chosen M.Sc. civil and building engineering graduates from 1990 and forward.

Both groups were sent the same questions, but the primary group were asked 4 additional questions to analyse their use of the learned knowledge and identify possible improvements to teaching in advanced IT in construction.

- Name?
- Year of graduation?
- Companies you have worked for so far?
- Have you been working with IT related tasks
    - As a developer or planner?
    - As an advanced user?
    - Other?
- Do you or have you worked with knowledge based systems (methods) – alternatively other forms of advanced IT, such as neural networks, object orientation, virtual reality etc?
    - If yes, describe the task

The primary group were furthermore asked the following questions:

- Are you interested in knowledge based systems/ methods (and similar for example knowledge management, knowledge acquisition etc)? Four options were given: Yes, very much; Yes; A little; No; Do not know
    - If yes, does this interest spring from your studies within the field?
- Have you tried to get employment within the field? Have you succeed?
- We would like your opinion on whether it is important, that we continue or extend the courses within knowledge based systems/ advanced IT – and preferable a reason (that it is a requirement to future engineers, that it can be learned anytime and such like)
- Comments and suggestions?

As knowledge based systems and advanced IT have only been taught regularly at DTU since 1996, although to an increasing number of students, the number of students who have both been educated in the topic and graduated is low. The primary group comprised a total count of 15 civil and building engineers, out of these 11 returned the questionnaire.

The control group were put together randomly from M.Sc. civil and building engineering graduates from 1990 and forward. The control group comprised 30 engineers out of these 14 returned the questionnaire.

3. RESULTS

The first 3 questions have mainly been used for administration and will not be commented here.

The answers to question 4 “Have you been working with IT related tasks?” shows whether the graduates have had tasks as developer /planner, advanced user or other tasks in working with IT.

In the following we will categorise the answers into groups; those that have worked with IT and those that have not worked with IT. The criteria for having worked with IT is answering question 4 positively, even if the IT related task is only advanced usage of for example scheduling software. Advanced usage is interpreted to mean that the user is capable of minor macro programming, and/or is responsible for supervising others in use of the software.

	Yes IT	No IT	Sum
Primary group	7	4	11
Control group	5	9	14

Question 5 “Do you or have you worked with knowledge based systems (methods) – alternatively other forms of advanced IT, such as neural networks, object orientation, virtual reality etc?” were included as a supplement question to question 4, and the following list shows the answers we got:

Primary group:

- “Development of knowledge database for construction companies to identify the company’s environmental effect on its environment”
- “Expert systems, neural networks, integration of these, knowledge database for acquisition and transferral of experience, simulation of logistics with 3D-VR and 4D-VR, and web based information systems and knowledge banks”
- “Knowledge management: In the management business there is a continuous demand that all tasks end with a resume, template and such like, which can be used by others in the organisation (internationally)

who has to solve a similar task. At Ernst and young this is done in Lotus Notes. Object orientation: for example in the DICom standard which is used for handling medical pictures."

- "The closest is SAP's variant configuration – which is registration and application of knowledge of configurable products to be used for sale projects or maintenance."
- "Yes, but I am not allowed to describe it in any way."
- "ProjectWeb development [an interface and database for designers to exchange and share drawings and documentation on the Internet]"

Control Group:

- "Yes, I am not working as a civil engineer, but as a system developer of database applications, object oriented design, and e-commerce solutions"
- "I work with GIS that registers position and origin on all objects (cables, vents, maps) in the database. Furthermore the system for user consumption is coupled to our technical maps through addresses and numbers. In the future our cable monitoring system will be linked to our digital cable map aswell."
- "Database technology"

If no answer is taken as a an indication that the graduate has not used knowledge based or database technology, the results from question 5 can be summarised in the following table:

	Have used knowledge based or database technology in their work	Have not used knowledge based or database technology in their work
Primary group	6	5
Control group	3	11

Question 6 "Are you interested in knowledge based systems/ methods (and similar for example knowledge management, knowledge acquisition etc)?", was only given to the primary group and gave the following results on the primary groups interest in knowledge based methods:

	Yes, very much	Yes	A little	No	Do not know
Number of answers (only primary group)	1	5	2	1	2

5 indicated that the interest sprung from the course and the topics they had been taught.

In question 7 "Have you tried to get employment within the field? Have you succeed?" only 2 of the 11 answers indicated that to a minor degree they had tried to get work within the field. One mentioned that it was the education within knowledge based systems that secured him the position he has today, and the other states that knowledge based systems are a research field, and that he has gone for the application areas, and has worked with analysing work processes and, with how these are supported by IT.

Question 8 "We would like your opinion on whether it is important, that we continue or extend the courses within knowledge based systems/ advanced IT – and preferable a reason (that it is a requirement to future engineers, that it can be learned anytime and such like)" got the following answers (only primary group):

- "To be a building site engineer/ contractor, as I am, it is completely irrelevant to learn about advanced IT/ knowledge management"
- "Working as a contractor I have special focus on knowledge on planning a building site and scheduling, and it is obvious that by systemising knowledge in this area advantages could be achieved. Specific use of IT-tools is not how I would characterise my working day, but I think it is a relevant supplement in the curriculum."
- "Traditionally the contracting business is low-technology, and with my knowledge of IT I am not able to offer any suggestions within this area. (The program 'Microsoft project' is used weekly, and it is relevant to be able to use this.)"
- "It is absolutely important and becoming more and more so, because application of these methods is increasing. The principles can furthermore be used in connection with development of advanced internet solutions such as 'virtual marketplace' and so on."
- "It is indeed important to continue teaching knowledge based systems/ advanced IT. The next big step in IT (after 'data gathering' and structuring has been solved) is to sort the data and use it intelligently. This has to be done with knowledge based systems and neural networks. The interest has to be started

during the education (I think most will find it interesting and be able to see the advantages in the information age). Object oriented models is something everybody has to use sooner or later – it should be obligatory."

- "Generally few companies can see the advantages of this form of IT. It is the practical problems, which are interesting. Handling of knowledge is most interesting in relation to effective registration and application of the employees' knowledge. Focus on making the employees' knowledge into the organisation's knowledge. The starting point is that knowledge is a dynamic size. Fixation of knowledge in systems which are difficult to maintain is therefore seldom interesting."
- "I very much think that application of knowledge based systems/ methods are relevant, and should be strengthen through courses, because this field will become more important for the future work processes and it is an important part of 'learning' and developing 'intelligent' systems"
- "It is important that knowledge based systems/ advanced IT are used in the real life."
- "Yes, it is important that engineers not only know that problems can be solved through application of IT based knowledge systems – BUT it is central that they also know where the limits are – not only for what is possible and what is profitable, but also for what one can develop, what is to be functionally described, and what one should let others develop."
- "The knowledge based systems that I have seen have not been practically applicable, therefor I think that the effort primarily should be in research and development of systems that are used by 'end-users'."

Several of the graduates used the opportunity to give comments and suggestions in question 9, and these are listed below:

- "If department of Planning [at the Technical University of Denmark] wants to educate engineers for contractors others more concrete and practical oriented topics should be addressed."
- "Continue focus and development in the field."
- "Knowledge based systems is something that all engineers need to know about – not only civil engineers. It is important that engineers also understand the areas where the systems can be applied (limits/ potentials)."
- "Focus on disciplines within analysis of business processes in relation to better application of IT. There is enough scientific content in these disciplines that will give the graduates far better job options than the 'long-haired' IT."
- "If the construction industry wants an innovation based development, IT and knowledge based systems are central. Thus innovation and creativity just as technology management should be part of topics taught in IT."

4. DISCUSSION

The discussion of the results can be divided into three topics. First, it is possible with the data collected to compare the percentage of civil and building engineering graduates that work with IT with the number of courses that teach advanced IT. The second topic is confirmation or refusal of the hypothesis that students who have been taught knowledge systems are more prone to choose a career with IT related tasks and to use knowledge based or database technology. The last topic is to outline a suggestion of how to teach advanced IT to civil and building engineers at DTU, based on the estimated effect of the previously taught courses, especially the course in knowledge systems, and based on the suggestions given on the returned questionnaires.

4.1 Is IT taught enough?

At DTU an investigation, into how many of the civil and building engineering courses that teach use of IT and advanced IT, has identified 9% out of 180 courses as having their main focus on advanced IT, 15% teach the use of IT either as an introduction to specific software or as a tool for doing exercises, the resulting 76% do not teach or use IT.

This data can be compared to the percentage of civil and engineering graduates that work with IT. In this test we did not include the graduates that have been taught knowledge based systems, but only used the questionnaires from the control group. As indicated above 5 out of 14 in the control group worked with IT, and if compared to the fact that 25% of the courses for civil engineers address IT, the conclusion seems to be that IT is taught almost adequately. However, it can be discussed if more courses should address advanced IT, because the questionnaires showed that the graduates, which have worked with IT, have actually worked with advanced IT (database design, system development, and ad-hoc software, hardware and ISDN tasks). Hence, the amount

of IT taught to civil engineers at DTU seems to be appropriate, but the focus could perhaps be moved from using IT towards more advanced IT.

4.2 Does teaching advanced IT have an effect?

4.2.1 Career effect

It was a goal of this survey to investigate if the fact that the graduates have been subjected to education in knowledge based methods has affected their career, making them more prone to choose careers in IT than students who have not had education in knowledge based methods/ advanced IT.

Question 4 showed that 7 out of 11 in the primary group had or worked with IT, and only 5 out of 14 in the control worked with IT. Hence there seems to be a slight indication that the primary group work more with IT than the control group. The significance of the result can be calculated using the formula and the χ^2 distribution given in appendix A.

$$\chi^2 = \frac{25(7 \cdot 9 - 5 \cdot 4)^2}{11 \cdot 14 \cdot 12 \cdot 13} = 1{,}92 \quad \chi^2 = 1{,}92 \Rightarrow \alpha = 18\%$$

According to the χ^2 distribution there is about 18% probability that the observations are a statistical coincidence, thus the results show that graduates that have been educated in advanced IT have a tendency to choose careers where they work with IT. The teaching of advanced IT and knowledge based methods seems to have effect.

One problem that we encountered in collecting the results is that it is difficult to get people to answer questionnaires especially if they have little interest for the topic. Hence, the numbers that have answered may actually give a slightly faulty picture of the situation, because graduates that are not interested in IT, who probably do not think that IT is important, and who have no or little contact with IT will not return their questionnaires. If the results are looked at in that perspective, the effect of teaching IT may in reality be more significant.

Another issue that has to be mentioned is that the choice of courses at DTU is flexible and totally op to the students, hence the students that choose to take a course in knowledge based methods can be expected to be interested in advanced IT, thus it is not that surprising that the graduates who have been taught knowledge based methods choose careers in IT. However, what can be said is that the students have not been scared off by the topic, and chosen totally different careers. If the results had shown that graduates from the primary group worked equally or less with IT than the control group, then we should consider serious restructuring and revision of the IT courses.

4.2.2 Method effect

Question 5 is basically a supplement to question 4, and the answers can be used to give a more detailed picture of the advanced IT that graduates use.

The hypothesis that we have been especially interested in investigating is whether the fact that they have been taught knowledge systems makes them more prone to use knowledge base methods, than graduates from the control group.

In question 5, 6 of the graduates in the primary group answered that they have used knowledge based or database technology in their work, only 3 out of 14 in the control group answered that they had used knowledge based or database technology. Using the same formula and χ^2 distribution as above the significance of the result is found:

$$\chi^2 = \frac{25(6 \cdot 11 - 3 \cdot 5)^2}{11 \cdot 14 \cdot 9 \cdot 16} = 2{,}93 \qquad \chi^2 = 2{,}93 \Rightarrow \alpha = 9\%$$

In this case there is only 9% probability that the distribution is a statistical coincidence, hence the result shows that teaching knowledge based methods has an effect on the technologies that the graduates use.

The graduates were asked to describe the work they had done, and the results show a few that actually have used the knowledge based methods, but more indicated that they have used database technology. If this is held against the fact that 8 out of the 11 graduates in the primary group answered that they are interested in knowledge based systems and methods (question 6), it shows (what might have been expected) that the interest in knowledge based methods is there, they are just not being used for the tasks. We take this as an indication that the course in knowledge based methods for construction is very important in order to make the knowledge based methods a real tool for the graduates, and enable them to apply the methods in their tasks. We need to continue teaching knowledge based methods and should continuously improve the course.

4.3 How do we improve teaching in advanced IT?

The results show that teaching knowledge based methods and advanced IT has an effect. The primary group work more with IT and they use knowledge based and database technology more than the control group. Hence, this is taken as a sign that the courses in particular in knowledge base methods and in general in advanced IT should continue and perhaps be extended. The question is how do we continue, change, or improve the courses?

With regards to this we have asked the graduates to indicate whether they think that having courses that addresses knowledge based methods and advanced IT is important and to write suggestions if they had any. As mentioned earlier the number of courses that address advanced IT has been increased the last year through the introduction of two new courses: one in management of IT and one in application of advanced IT, thus there is already an increasing focus on IT for construction at DTU (the graduates we sent questionnaires are probably not aware of these new courses). A number of comments were received, as shown in results, and with these in mind we can put forth a tentative agenda for our courses in knowledge based methods and advanced IT.

- Teach knowledge based methods as a tool, not only as a step in developing a knowledge based system
- Include realistic and practical topics (this is already part of the current knowledge course (Andersen & Hartvig 1998))
- Teach limitations and potentials of technologies
- Put focus on analysis and support of processes in construction e.g. turning employees' knowledge into organisational knowledge, supporting design processes and information flow, and implementing IT in construction organisations.

Generally the comments and the agenda can be summarised into a paradigm where it is the organisational, process, and knowledge oriented approach that is dominant instead of a more technical, programming, and hard core IT oriented approach.

5. CONCLUSIVE REMARKS

It can be tentatively concluded that the primary group in our test do work more extensively with advanced IT compared to the group of engineers who did not include knowledge engineering in their studies.

Supported by the constructive feedback we got from the questionnaires, and the growing interest for our teaching among the students we think that we are on the right track when expanding our teaching in advanced IT. At the same time we must realise that the test is somewhat weak because the population to test on still is very limited, and there is an obvious need for carrying out similar test in the future, hence enabling us to adjust and possibly improve our courses on a more solid statistical basis.

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APPENDIX A

If results are given on a nominal scale (Yes or No) then the significance of the result can be found by using a χ^2- test (Pedersen 1979):

Results:

	Yes, effect	No, effect	Total
Primary group	a	b	a+b
Control group	c	d	c+d
Total	a+c	b+d	a+b+c+d=n

χ^2 is calculated using the following formula

$$\chi^2 = \frac{n(a \cdot d - b \cdot c)^2}{(a+b)(c+d)(a+c)(b+d)}$$

with χ^2 and the following table the significance can be found:

α	2,5%	5%	10%	25%	50%	75%
χ^2	5,02	3,84	2,71	1,32	0,455	0,102

α is the significance and it indicates the probability of observing values that does not follow the pattern given in the results, or said in other words it gives the probability for the result just being a statistical coincidence. For example if α is 5% there is a 5% risk that the results are a statistical coincidence, and we can be 95% sure that what ever was done for/ to the primary group had an effect.