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IMPROVING STUDENTS' LEARNING OUTCOMES THROUGH INNOVATIVE TEACHING PRACTICES WITHIN INFORMATION SYSTEMS EDUCATION

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Abstract:

This article analyses a number of innovative teaching and study practices within information systems education at Copenhagen Business School. Discussing such teaching and study practices including their particular relations to students' learning outcomes, the article offers an applications-oriented approach, which can inspire information systems educators in both their curriculum development and their teaching practices. All with the aim of improving students' learning outcomes through innovative teaching and study practices. We seek to inspire, raise the outcome, and lift the quality or IS teaching with this article.

Keywords: Innovative teaching practices, interdisciplinary teaching, improving students' learning outcomes, Lego Mindstorms

I. INTRODUCTION AND CHALLENGE

There is a general understanding and acceptance that Higher Education (HE) is now in a necessary transition from input based to output based curricula (Jarvis et al., 1998; Rassow, 1998; Nygaard et al., 2009). This transition means leaving behind pure discipline oriented programs, now focusing more on subject based programs, where interdisciplinary paradigms and methods are integrated to link together students' learning at universities with the knowledge, skills, and competencies required at their future job market. Overall HE has become a matter of aligning three audiences' expectations of learning outcomes: 1) universities; 2) students; and 3) future employers. HE today is not about "giving the right knowledge to students" but to provide students with possibilities to develop the "right" competencies (Nygaard et al., 2009). "Right" in the sense that they are transformative and relevant for the job market (Harvey et al, 1992; Harvey & Green, 1994; Harvey & Knight, 1996; Falconer & Pettigrew, 2003).

Being an educational manager, curriculum developer and/or teacher, one is faced with at least three central challenges by this move from input to output based HE: 1) the academic discipline itself has to be actively linked with current professional practices (within private, public or non-profit organizations); 2) students' knowledge, skills, and competencies need to be defined, assessed and linked to national and international qualification frameworks (as we have experienced in Europe with the Bologna process and the Dublin Descriptors); 3) teaching and

study methods needs to address the new paradigms of contextual learning in order to fully account for all aspects of students' learning outcomes.

In this article we will explicitly address these issues through a case of information systems education at Copenhagen Business School, Copenhagen, Denmark (CBS).

The outline of the article is: Section background and innovative teaching and study practices introduces the background for the education systems education and outlines the innovative teaching and study practices. Section Student profile is used for analyzing and discussing how a how the innovative teaching and study practices improves students' learning outcomes. Section Model for Dissemination introduces a dissimilation model for the modern classroom. Section discussion/conclusion is used for discussing the theory of higher education in terms of using Lego Mindstorms.

II. BACKGROUND AND INNOVATIVE TEACHING AND STUDY PRACTICES

CBS has a long tradition of explicitly linking together their study programs with current business practice (Nygaard & Andersen, 2004; Nygaard et al, 2008; Meier & Nygaard, 2008). This was declared as a foundational pedagogical principle in 1996, and enhanced in the learning strategy of the business school formulated in 2005 (CBS Learning Lab, 2005), and implemented in the years following. This overall movement within curriculum development at the business school is apparent in different study programs. Here we will share two interesting cases of innovative educational practices in our Information Systems Educations (ISE). The first case is linked to the course "Distributed Systems" (DS). The second case is linked to the course "IT-Innovation" (IT-I). At first we shall briefly describe the course curricula.

First we provide a background setting for the subject. Then we discuss the course development in terms of the student reviews, and how this will undergo analysis before the next semester starts again. In addition, we show a simple model of communication, in a class to illustrate that it is a relevant idea of dialogue-generating activities in the classroom. Afterwards, we present the section on the didactic (teaching method) issues we have identified now and during past lectures. Last but not least comes the section about the new things we plan to use in subsequent semesters. In the last section, we will use visualization to make it easier to show what we mean.

IS teaching is often part of an interdisciplinary program. Teaching in an interdisciplinary program can be challenging because many core subjects carry a large body of so-called prerequisites with it. We analyze one such class taught in an interdisciplinary IT/IS program at a large business school. The class is on distributed systems, and we show how these challenges have been addressed in the present program. Furthermore, we develop a toolbox of methods and ideas for future teaching of similar programming classes taught in interdisciplinary IS programs. We provide a case study on using LEGO MINDSTORMS NXT to provide situated learning in a class room setting.

LEGO® MINDSTORMS® NXT is used at Copenhagen Business School to teach IT-innovation. Our thesis is how can we possibly teach students at a joint IT/business program how to connect computers to the physical world such as healthcare, business information systems, environmental monitoring systems, global warming warning systems etc. The answer in our case has been the robotics development kit from Danish toy manufacturer LEGO Group. They produce the well-known LEGO MINDSTORMS NXT robotics kit. It is an educational system that first and foremost allows its users to experiment with a dynamic system and program it to reach some objective. This can be an objective as simple as producing robot that follows a black line with its light sensors. It is called a line-follower robot and is the basis of many competitions involving team collaboration toward some stated goal.

Learning is contextualised: Sociocultural perspectives imply that cognitive growth is dependent on a process of collaboration within communities of learners (Wenger, 1998). Moreover, the

motivation to learn comes not just from an internal drive, but is also derived from interactions the individual has with others in meaningful activities (Waite & Davis, 2006a).

Important changes occur in learning and teaching when educators try to understand and respect the diverse worlds of students and include this understanding within their teaching practice (Glynn, Otrell-Cass, & Cowie, 2008). Faculty who adopt learner-centred, culturally responsive approaches are constantly evaluating and readjusting their teaching and learning practices as they "need to choose and adapt content, instructional materials, and evaluation instruments to reflect and respond to the rich and complex diversity of the students they teach" (Boles & Kelly, 1999).

In addition, Nygaard and Holtman (2008) suggest that learning is a contextual process and requires complex interactions among various individuals throughout the educational process. From the nursing literature, the concept of cultural responsiveness is described as demonstrating the ability to accept cultural beliefs and values and developing "strategies to improve the cultural competence of future nurses to help them care and intervene effectively with individuals from cultures other than their own" (Cagle, 2006, p. 308).

III. STUDENT PROFILE

We have observed a trend among some of the young people entering the study program. It is that they are essentially what we would call a "Windows generation". They have sometimes an expectation that programming, and other things in education, are as easy as typing in the Microsoft Word editor. Of course it is not quite the case, and the students realize that the stability of Microsoft Word is a result of many hours of programming by Microsoft. 10 years ago, when Windows crashed every now and again, it opened (the hard way) people's eyes up to the fact that computer systems were not infallible. But we cannot (and probably should not) change the new generations, but we must be more aware that they expect that things will work the first time. This is an exciting challenge.

The students enter the IS program at Copenhagen Business School with different backgrounds. Even though all new students are intimately familiar with the use of Word, Excel, and a web browser – they are separated into two groups. The first group are those who have programmed in high school/gymnasium, and the second group are those who have not. The choice that has to be made is which group to address in class. If we teach too slow and too basic, we bore and perhaps loose the best students. On the other hand, if we speed up too fast with object oriented programming techniques then the beginner group is lost. Some of the tools we discuss later accommodates this problem.

Later in the paper, we present and discuss how the use of Lego Mindstorms NXT can address part of this problem(Pedersen 2008). The idea is that the best students are activated with the more challenging embedded programming on the NXT, while the middle group program more traditionally on the PC.

IV. MODEL FOR DISSEMINATION

We will show a graph of how the typical training room looks. The idea behind this is to show what tools a teacher normally have available in a classroom. Moreover, as we show, the majority of students bring laptops to class. Traditionally, teachers do not use this fact to something productive, but rather let the students sit and possibly doing other things. We think that the laptops as a resource and an opportunity to enrich the teaching situation.

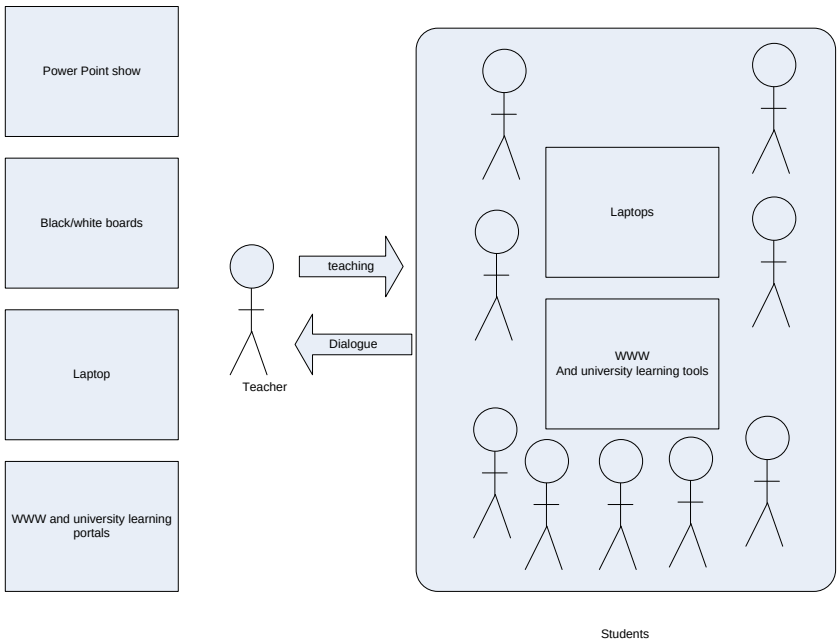

Figure 1. A classroom with a teacher and a group of students (shown as a box).

V. ENGAGING STUDENTS WITH ELECTRONIC EDUCATIONAL TOYS: THE CASE OF LEGO® MINDSTORMS® NXT

Using LEGO MINDSTORMS NXT provides the output-based teaching that we argue for in the introduction. At a business school, especially the marginal disciplines such as programming, mathematics, philosophy etc. have to be taught in innovative ways. Using an educational toy (LEGO MINDSTORMS NXT) raises the awareness level and leverages the sense of competition between students that we have at business school.

Figure 2. Some of the new NXT 2.0 models (Source: http://mindstorms.lego.com)

At Copenhagen Business School (CBS) we teach IT innovation with LEGO® MINDSTORMS® NXT(Pedersen 2007). Many of the systems that the students are exposed to are not only large servers connected to the Internet. An increasing number of systems are connected with sensors and other micro-electronic items. This is a very important fact to realize as a business school, as much of the future IT-innovation are going to take place in this domain.

At the Department of Informatics (INF), CBS, we have used the LEGO MINDSTORMS NXT (LMS) for a number of things. Its versatility is very high since it is packaged in an appealing plastic design making is suitable for other groups that would otherwise be targeted with the traditional electrical engineering development kits. Basically LMS is made safe for kids, so it naturally also fine to use with young adults in the age category of 20-25 years, which are the age profile at INF.

Starting from the top with all the projects we have used LMS for, could be to begin with a master thesis project. The two students in this project wanted to innovate a robot that could find its way out of a box with doors in it. A specific technical challenge was to interpret the feedback from the ultrasonic sensor, and see from the feedback if it would change when a door opening was swept with the robot. Besides that challenge the students used the open source code that comes with LMS to program this decision structure in the programming language C. This was made possible with the open source project called *nxtgcc* (http://nxtgcc.sourgeforge.net).

Figure 3. The open source LEGO MINDSTORMS firmware enhancement kit.

LMS was a very good system for the students because the general idea could be prototyped very quickly with the graphical programming language NXT-G. Then the more advanced functions was implemented directly in a modified firmware (the open source operating system on the ARM micro processor on NXT).


Studenterne robotterer på CBS

Robotsamlesæt fra Lego samlede stor interesse på Forskningens Døgn

Figure 4. Master students with a custom programmed LEGO MINDSTORMS at a community event (Source: Large Danish business newspaper named Børsen).

Further down the education line we have used LMS for programming a new kind of systems which have connections to the physical world. The motivation behind this is that each of us are already interacting with a number of sensor equipped systems many times every day (GPS or mobile phones for example), and it is important to prepare the IT students of tomorrow for this sensor-level information source. Therefore we have an object oriented analysis and design (OOA&D), which includes a LMS which will act as a wind speed measurement station. The overall task is to program a reservation system for a local sailing club, but we have also determined that the wind velocity plays a significant role in the reservation process and this can be modeled with a LMS set that each group borrows.

One the first semester we indirectly use NXT for cross-semester collaboration, because these 90+ students participate in a longitudinal effort, where they act as an outsourcing company for the 3rd semester OOA&D students. These first semester students participate using Netbeans and Eclipse to interface with the OOA&D students. We use the popular leJOS project (http://lejos.sourceforge.net/), because it allows us to use Java all the way from the LEGO sensor to the Java Enterprise Edition programming of a web system. To be specific, the task is to implement the windmeter algorithms that is going to be used by the 3rd semester students. It serves the purpose of exposing the students to the difficulty of working with other entities with a different skill set and not being located physically around the same computer. Instead these students are using the core tools of any outsourcing company: versioning control systems , which is a way for programmers to share source code in a project. From a motivational and innovation perspective, we do this because it build up the skill set necessary for international collaboration. Most business schools would not be able to teach detailed programming skills and source versioning tools, but that is our choice because the business leader of the future must be able to understand how the engineers work, how many resources that go into this sort of project, and staff his or her company with the best possible people from around the globe.

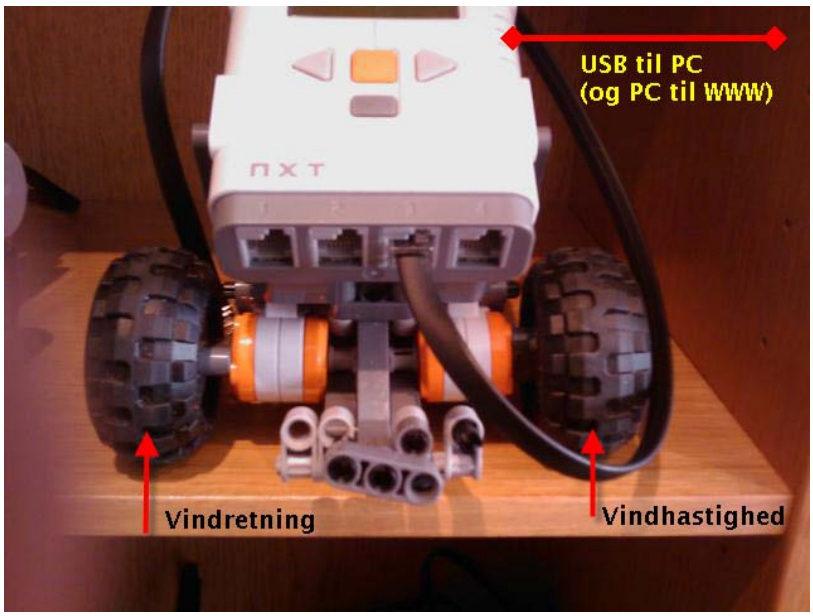

Figure 5. Using LEGO MINDSTORMS NXT to simulate a windmeter (*Vindretning*: wind direction, *Vindhastinghed*: wind speed) in a 3rd semester class.

On the first semester itself, we have previously use NXT to teach basic programming skills, because the NXT-G programming language is very easy to get started with.

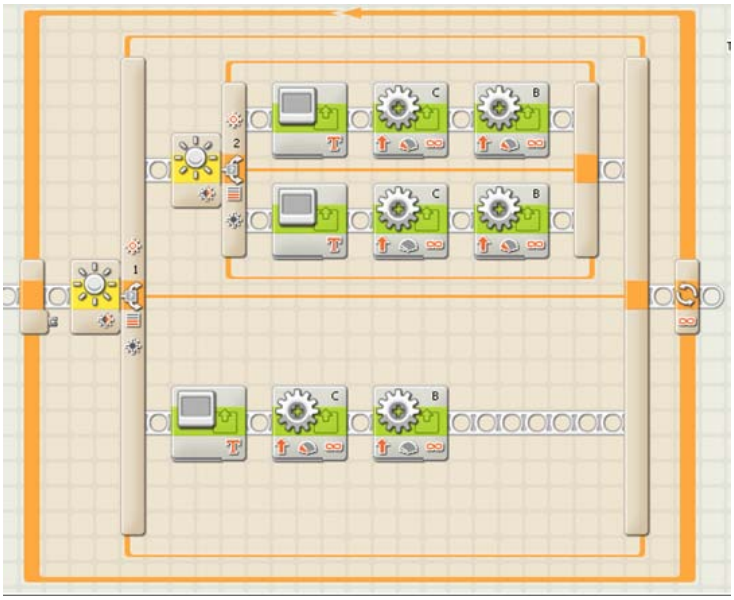

Figure 6. NXT-G program to read a light sensor and control the motors accordingly.

The core programming understanding is supported by the introduction of the relevant iteration, computation, and decision programming blocks as in many other text-based programming languages. A secondary goal of using NXT is that our students arrive at the INF program with substantially different backgrounds. Some of them have already been programming at secondary school using C++ for example. The majority has not been programming before, and therefore the prerequisites of the class are to have not been programming. This interesting didactic challenge is met by using NXT, because those who are inclined toward programming will find this educational toy stimulating. An IT innovation team will consist of both skilled people with a computer science background, and others who see the innovation from a broader perspective. We capture the interest both profiles in this way at INF.


KRÆMMERHUSET 3

Robot-styring i bordhøjde for førsteårs DØKerne

Figure 7. First semester students experimenting with LEGO MINDSTORMS as part of the introductionary programming classes (Source: Copenhagen Business School newspaper named Kræmmerhuset).

The competition among educational institutions have to be addressed as well; to this end we regularly invite high school classes to the department and have them play with NXT. Such a theme day is composed of both an IT case from a theoretical point of view, because the majority of the educational program delivers this kind of teaching, and using NXT to complete a task. We compose teams and within 30 minutes of instruction, the visiting high school students are able to compete against each other. They have to create and program a robot to follow a line. The lines

they have to follow are increasingly bended, so they have to engage in a trial-and-error effort to tweak the motor parameters.

Our future plans go in the direction of using LMS NXT for other educational programs than the IT/business program, because the hands-on experience with such systems are excellent for team building exercises and other learning activities. The use of LMS NXT supports the stimulation of innovation skills at all levels in our educational programs. We can use this system, together with online learning system like Moodle, to create more situated knowledge experiences (Diana Laurillard, *Rethinking University Teaching).* The benefit is that the decentralized nature of IT-innovation is nurtured in optimal conditions. Trial and error is a natural component of this sort of work, and that is why the experimental nature of LEGO MINDSTORMS NXT is well-suited in this endaevor.

VI. DISCUSSION/CONCLUSION

The cases discussed in the paper are examples of instances of the higher education (HI) framework we put forth in the beginning of the paper.

The use of Lego Mindstorm NXT is untraditional in a business school setting, but we often see it used in software engineering and computer science study programs. It is well suited for IS education because the sensors are useful to model real-world phenomena. Furthermore, there is a wide selection of programming languages available for Lego Mindstorms NXT. We use the Java programming language. It is popular in academia as well as in industry. *Alice*[1] is a popular system for teaching programming is an entertaining way using Java. Similar to Alice, Lego Mindstorms focus on the visible result of a programming exercise rather than reading the output from the program in a console.

We have described how our experience has been with teaching a computer science/IS to class at an interdisciplinary IS program. We addressed several teaching methods that student body profile with a diverse skill set requires. Then we went on to discuss several new methods which can enhance both the teaching experience and the programming experience using Lego Mindstorms NXT. Our contribution is that we think in terms of HE theory and couple it with actual classroom teaching at the university level.

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