Learning Core Concepts of Business Information Systems Engineering by Teaching–Lessons Learned from a Comparative Teaching Experiment

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Abstract. Establishing interactive learning settings in higher education requires more learner-centric teaching methods. Therefore, one possible approach is learning by teaching. However, its application has only sparsely been studied for the business information systems (BIS) development domain so far. In this paper, the feasibility of the method for teaching BIS development topics is evaluated by means of a teaching experiment, comparing its application in four different undergraduate courses at two universities. We conducted a survey to investigate students' perception and evaluated selected results of the exam to assess the actual effectiveness of the method. Results indicate that the method is perceived as appropriate to gain knowledge in general. While preparing a subject on their own was perceived as useful for a better understanding, the students' presentations were not considered an improvement over a traditional lecture. However, no negative impacts on the learning outcomes were observed.

Keywords: Information technologies in education · Learning by teaching · IS education · Teaching methods

1 Introduction

For many years, Business Process Management (BPM) and the implementation of business information systems are considered important core topics of the information systems (IS) field [1]. Therefore, related courses form an important part of most IS related study programs. BPM and business process modeling as well as business application engineering capabilities are also required by most employers of graduates of bachelor programs related to IS or information management [12]. On the other hand, these topics are considered difficult and abstract by many students and thus form a didactic challenge for teachers. However, in addition to these "hard" technical skills, today's graduates are also required to have so-called key competencies or soft skills such as good presentation capabilities or

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the ability to explain specialist subjects to non-specialists [8,14]. The learning objectives of modern study courses are therefore usually related to both hard and soft skills. But to achieve both, new didactic approaches are particularly needed to design more interactive and collaborative learn services.

A promising candidate of such a didactic method is learning by teaching [5,6]. Applying this teaching method students have to prepare and teach a teaching unit autonomously. They have to prepare a special topic, which has not been discussed before in the lecture. Additionally, students have to work up the topic in a way which enables them to teach it to their fellow students. The teaching unit is an integral part of the learning by teaching method. Surprisingly, this method has so far not been widely studied for teaching IS topics.

Therefore, in this paper the application of the method for teaching IS-related topics is described. It was applied for teaching four selected topics in a similar way to four different groups of students from IS-related study programs at two German universities of applied sciences. Namely, it was used for two core topics of IS development, firstly the implementation of executable business processes by the Business Process Execution Language (WS-BPEL) and secondly selected aspects of the implementation of web-based business applications with Java Enterprise Edition (EE) technologies. The teaching experiment was evaluated and analyzed.

The rest of this paper is organized as follows: In Sect. 2 an overview of related work from the relevant literature is given and the research gap is identified. Section 3 describes the design of the actual teaching experiment and the corresponding data collection. The results of the evaluation of the experiments are presented in Sect. 4. We conclude with a summary of our findings.

2 Related Work

In recent years, the use of innovative, activating, collaborative and interactive teaching and learning methods came into focus in IS education. Several teaching methods have been tested and applied, such as teaching cases [4], the inverted curriculum [11], web-based information systems which motivate students to teach each other [3], integrated teaching [9] and a programming exercises-only approach without giving lectures [15].

Learning by teaching has been proposed as a general teaching method already since the beginning of the 70s [7]. The term applies to a teaching approach where pupils or students prepare a topic and teach lessons or parts of lessons about the topic on their own, thereby taking the role of the teacher for a limited period of time. They also choose the didactical methods they consider appropriate for teaching their classmates. Elaine Hals describes how she used this method in the context of drug education at high school [7].

Jean-Pol Martin systematically evaluated the method at the beginning of the 80s. His subject area initially was the teaching of foreign language classes at school, especially French. The application in a university environment was investigated later by him and Joachim Grzega [6].

With respect to computer science or IS education, learning by teaching so far was only adopted in a modified form. Two cases describe the learning progress of students teaching a computer, with a positive outcome [2,10]. However, the impact of using learning by teaching as method for teaching core IS topics has not been studied in the literature so far. Therefore, this paper addresses the two research questions:

- **RQ 1:** What are the perceived learning outcomes of the students when the teaching method learning by teaching is applied?
- **RQ 2:** What are the actual learning outcomes of the students when the teaching method learning by teaching is applied?

We answer these questions by analyzing a comparative teaching experiment. Process modeling and web engineering topics were selected as the content of the lessons, since for these the literature on innovative teaching approaches is also sparse in general.

3 Teaching Experiment

3.1 Teaching Situation

For the comparative experiment, learning by teaching was applied in two subsequent terms. In the summer term 2013 it was applied in two parallel courses by the same lecturer at two different German universities of applied sciences (in the following referred to as KE and HNU). In the winter term 2013/14, the method was only applied at HNU in two different bachelor's degree programs.

At KE, students of the bachelor's degree program "Business Information Systems Engineering" who attended the 3rd year course "Integrated Information Systems in Business" had to teach a topic from business process modeling, giving their fellow students an introduction to certain language elements of WS-BPEL (Web Service Business Process Execution Language).

At the HNU, the method was applied in the bachelor's degree program "Information Management and Corporate Communications" (IMUK) within the 2nd year course "Web Engineering". Because HNU is a business school, software engineering related topics are only taught as non-majors. Here, in the summer term 2013, the students had to teach one topic about Java-based web development using Java ServerFaces (JSF). In the winter term 2013/14, they had to teach topics about web development with JavaScript using jQuery.

In addition, the method was used in the winter term 2013/14 in the bachelor's degree program "Information Management Automotive" (IMA). Here, the experiment was conducted in the 2nd year course "Car IT". The teaching topics given to the students were related to communication systems in cars.

Table 1 shows a summary of the four different lecture courses with topics the groups could choose and the number of students in each course as well as the type of exam at the end of the term.

Table 1. Overview of Lecture Courses and According Topics.

University	KE	HNU IMUK A	HNU IMUK B	HNU IMA
Term	Summer term 2013	Summer term 2013	Winter term 2013/14	Winter term 2013/14
BA degree program	Business Information Systems Engineering	Information Management and Corporate Communications	Information Management and Corporate Communications	Information Management Automotive
Stage	3rd year	2nd year	2nd year	2nd year
Lecture course	Integrated Information Systems in Business	Web Engineering	Web Engineering	Car IT
Number of students	27	63	97	14
Main topic	WS-BPEL	Java ServerFaces	jQuery	communication systems in cars
Topics to chose	Branching and joining instructions in WS-BPEL Loops and iterative instructions in WS-BPEL Asynchronous invocation of web services with WS-BPEL Use of compensation handlers in WS-BPEL	Validation and type conversion of user input in JSF Container-managed authentication and authorization in Java Enterprise Edition (EE) Table list view for a large amount of data records using JSF	Validation and type conversion of user input with jQuery Container-managed authentication and authorization in Java Enterprise Edition (EE) Use of jQueryUI Use of Table list view for a large amount of data records using Agility.js	Communication via the CAN-Bus protocol Communication via the MOST and the LIN protocol Communication via the FlexRay protocol
Type of exam	Written exam	Project assignment	Project assignment	Written exam

In all courses, the participants were asked to form groups of 3–5 students. Each group was assigned a teaching topic by the lecturer which had not yet been covered in class during the course. Each student group was given 3 weeks of time for preparation. After this period, the groups had to present their topic within 10–15 min to their fellow students and the teacher. The groups had to research the relevant literature for preparation by themselves, only one optional initial reference was given to them.

During the presentation, each participant had to talk for at least 2–3 min and to respond to questions from the audience. Each group had to prepare 5–10 slides at least, the choice of additional media and of didactic methods was left to the students.

As optional initial references, in the summer term at HNU the IMUK students were given the book by Bernd Müller, "Java ServerFaces 2.0–Ein Arbeitsbuch für die Praxis" (2. Auflage, Hanser Verlag, 2010) and at KE some online resources about WS-BPEL.

Table 2. Number of Participants and valid questionnaires in the survey and type of exam in summer term 2013 and winter term 2013/14.

University	KE	HNU IMUK A	HNU IMUK B	HNU IMA
Number of participants in the survey	21	55	31	7
Number of valid questionnaires	17	45	28	6
Response rate (number of participants/number of students)	78%	87%	32%	50%
Rate of valid questionnaires (number of valid questionnaires/number of participants)	81%	82%	90%	86%

3.2 Data Collection

In order to perform a self-evaluation of the participants' perceived knowledge about the presented topic, students were asked six questions of the following type related to the six knowledge dimensions after their presentations, e.g.:

- ***Remember***: I think I am able to remember the subject-specific knowledge I had to prepare for the presentation.
- ***Understand***: I understand the subject-specific knowledge I had to prepare for the presentation.

The respective six **knowledge dimensions** "remember", "understand", "explain", "apply", "use", and "develop" were chosen according to the taxonomy given in [13].

In addition, the participants' perception of the teaching method was evaluated. For this purpose, they were asked four questions about their perceived learning effectiveness, confidence in topic, subject-specific correctness and comprehension obtained by their presentation to fellow students, respectively.

All questions should be answered on a scale from 1 to 4 (summer term 2013), ranging from 1 ("I completely disagree") to 4 ("I completely agree"). In order to obtain a clearer picture of the assessments, the scale was enlarged up to 6 in the winter term 2013/14, with 1 referring to "I completely disagree" and 6 to "I completely agree".

To compare this self-assessment of the students with their actual knowledge gain, we included the grades of the project assignment (HNU IMUK A, summer term 2013, HNU IMUK B, winter term 2013/14) and the exams (KE, summer term 2013, HNU IMA winter term 2013/14) in the analysis. This allows to compare the self-assessment of the students with the actual gain of knowledge. For this purpose, we **only** looked at **those exam exercises, which had a direct link to the topics which the students "taught"**, and calculated the percentage of achieved points for these.

The survey was conducted anonymously. Therefore, there is no possibility to link the individual results of the project assignment and exam to single questionnaires. Due to this, an investigation of the correlation between students' self-assessed performance and exam-/project grades of the individual student is not feasible.

Table 2 shows the number of participants in the survey as well as the number of valid questionnaires. A questionnaire was considered valid when it was filled out completely. Compared to the overall number of participants the percentage of those taking part in the survey was sufficiently high.

In addition, all teaching units were filmed (with the agreement of the students) and the videos were handed out to the respective students afterwards.

4 Evaluation and Results

The scale of answers was ordinal, so we performed a Kruskal-Wallis-Test to check if the students are of the same population. The test was grouped by terms because of the different scales, which were predefined for answering. The results of the Kruskal-Wallis-Test are presented in Fig. 1.

Test Statistics[a,b]

Semester		remember	understand	explain	use	apply	develop	learning effectiveness	confidence in topic	subject-specific correctness	comprehension through presentation of students
Summer Term 2013	Chi-Quadrat	2,327	4,213	,531	1,675	,027	3,163	5,996	12,099	,385	2,468
	df	1	1	1	1	1	1	1	1	1	1
	Asymp. Sig.	,127	,040	,466	,196	,870	,075	,014	,001	,535	,116
Winter Term 2013/14	Chi-Quadrat	4,825	3,722	12,590	5,691	2,452	1,211	6,765	5,613	12,247	7,212
	df	1	1	1	1	1	1	1	1	1	1
	Asymp. Sig.	,028	,054	,000	,017	,117	,271	,009	,018	,000	,007

a. Kruskal-Wallis-Test
b. Group Variable: University

Fig. 1. Results of the Kruskal-Wallis-Test grouped by the different semesters.

Figure 2 shows the results for the perceived knowledge dimension achievements. In general the students perceived an increase of their competencies after applying learning by teaching. The same holds true for HNU IMUK B in the winter term. Only HNU IMA assesses the knowledge gain rather poor.

One reason might be the relative small overall course group size; students did not have many chances to interact with other teams working on the same topic. Another reason might be a different personality type of students from a computer science program compared to communication studies. The summer term results also show a high self confidence of the HNU IMUK B group with respect to their knowledge gain.

Our results show that the method learning by teaching is applicable from a students' perspective to facilitate knowledge in the dimensions "remember", "understand", "explain", and "use". Students do not think to be enabled to further develop the knowledge they acquired.

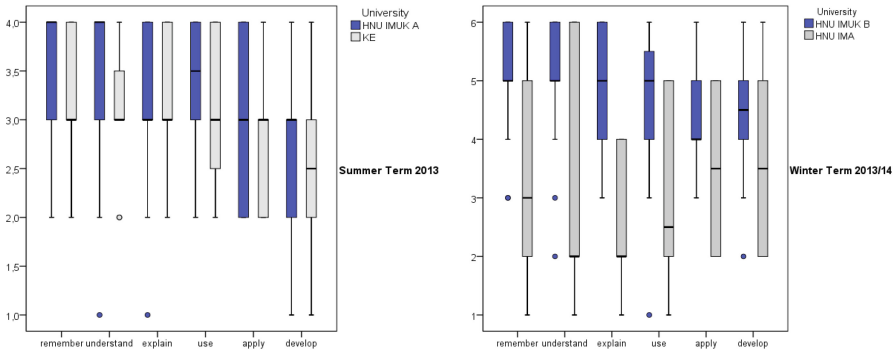

Fig. 2. Results of the four courses for the area Knowledge Dimension presented in a boxplot with median, minimum, maximum, 25%– and 75% quantile.

The results for the perceived learning effectiveness are illustrated in Fig. 3. Here, significant differences between the student groups are observed. HNU IMUK A and HNU IMUK B consider the learning effectiveness very high.

Both groups in average feel very confident with the topic. The situation is different for the comprehension achieved by the presentations of students. Except HNU IMUK B, the median for all groups is lower than the respective mean. This shows that students do not think they understood the topic better by having it taught by other students.

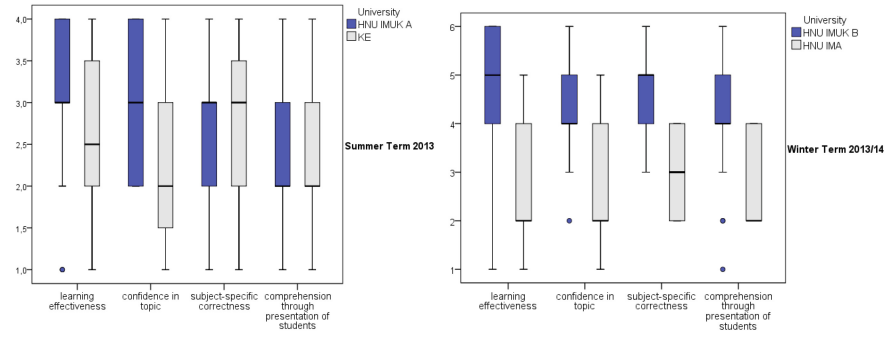

Fig. 3. Results of the four courses for the area Teaching Method presented in a boxplot with median, minimum, maximum, 25%– and 75% quantile.

Regarding the knowledge dimension part, students think they understood the topic and are able to explain and use it. At the same time, they do not think they understood it better through the presentation of other students. This effect is probably caused by the fact that students have to prepare the lesson and have to become acquainted with the topic in a way which enables them to answer questions of their classmates.

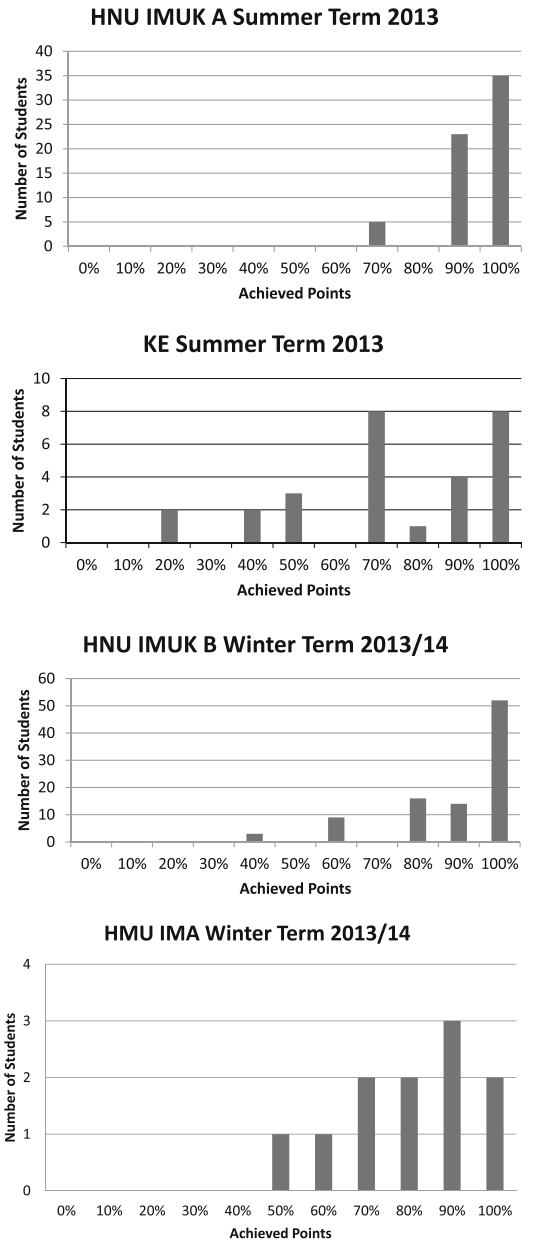

Fig. 4. Results of project assignment and exam - amount of achieved points of tasks linked to the learning by teaching topic

All medians of KE are equal or lower than those of HNU IMUK A. As a group, they assess learning effectiveness, confidence, correctness and comprehension to be inferior. This is maybe a result of different personality types which are appealed to the different study courses. This assumption has to be tested in the future by further studies.

In summary, despite HNU IMA all student groups rate learning effectiveness and subject-specific correctness quite high. KE students do not feel confident in the topic. And–despite HNU IMUK B–all groups do not rate their comprehension through the presentation of fellow students very high.

Combining these results with the those for the knowledge dimension part, from the students' point of view the learning by teaching method is appropriate for introducing students to a new topic and deliver theoretical content. However, the method is not appropriate to enable them to apply knowledge or even develop a topic (Answer to RQ 1).

In order to compare the perception of the students with their actual outcomes, in our study we included results of the final exams of the respective study modules. These exams were organized as a project assignment for HNU IMUK A and HNU IMUK B and a written exam for KE and HNU IMA. Figure 4 shows the distribution of the results of the exams grouped by the four courses.

In general, the method does not have any negative impact on the learning outcomes. The KE students group is an exception. Further data have to be gathered to investigate if this holds true (Answer to RQ 2).

5 Conclusion

In conclusion, in this paper an experimental application of the learning by teaching method has been presented and evaluated. The method was used as an interactive and collaborative approach for teaching two core concepts of business information systems engineering, namely WS-BPEL as topic from business process modeling and Java EE web programming as a web engineering topic.

The method was applied in a similar way to four different groups of students from IS-related study programs at two universities. The evaluation of this comparative teaching experiment show that the method is promising for IS education regarding the achievement of the learning objectives, but the perception of the method by the students depends on other factors like their personality, self-confidence and attitude or even group size.

However, the validity of the obtained results may be affected by the limited number of participants in the study and the differences between the two universities considered, with KE being an engineering and computer science school and HNU a business school with non-computer science majors. Hence, the two universities attract different kinds of students with their different personality types. In addition, the types of exams were different in both universities (project assignment at HNU and written exam at KE). The influence of these factors has to be studied in more detail in the future.

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