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ERP based business learning environment as a boundary infrastructure in business learning

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Abstract

Business education has been criticized for being theoretical and distant from the dynamisms of the business life. To answer to this criticism, different types of experiential learning environments, such as manual role-plays, computer simulations, and enterprise resource planning (ERP) systems, have been used. In this paper, we study how a holistic learning environment, combining a practice enterprise model, an ERP system and a simulation, improves learning results and why. We present a full-year long case study to compare the learning outcomes of the holistic learning environment with a manually-oriented practice enterprise model. Our findings indicate improvements on different domains of Bloom's taxonomy. We suggest that the improvements are due to the holistic learning environment acting as a boundary infrastructure where the practice enterprise model, the simulation and the ERP system are all different kinds of boundary objects. This boundary infrastructure functions as a point of interaction and communication, and enables the students and teachers to cross social, cultural and conceptual boundaries between different communities of practice, and importantly, between theory and practice.

Keywords Business learning · Boundary object · ERP simulation · Experiential learning environment · Practice enterprise

1 Introduction

In the recent years, there has been much criticism of business education for becoming too theoretical, fractional and distant from the business life (Arbaugh and Hwang 2015; Datar et al. 2011). Business management is much more complex than a set of theories or individual learning topics (Chia and Holt 2008). Disciplinary expertise needs to be accompanied by soft skills such business acumen, communication, teamwork, ethics,

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and social responsibility (Jackson 2009; Jones et al. 2017; Robles 2012). In addition, the business graduates need an integrated perspective to business (Jaiswal 2015).

All this is difficult to acquire in traditional classroom settings where the teacher transfers knowledge to students (Brown and Rubin 2017; Chia and Holt 2008). Instead, education needs to weld together imagination and natural experience in a collaborative process between the students and the teachers (Chia 2005; Lenning et al. 2013).

Several means to provide such an experience exist. For example, business skills laboratory and practice enterprise model mimic real workplaces and place students in physical spaces to participate in a role-play in fictitious businesses, including day-to-day business decisions (Blaylock et al. 2009; Bianchi et al. 2017; Gramlinger 2004). They provide a risk-free training ground to practice business transactions in cooperation with other students and teachers, and promote the learning of soft skills (Borgese 2011; Collan and Kallio-Gerlander 2007). Enterprise resource planning (ERP) systems offer tools to learn business processes (Angolia and Pagliari 2016; Jewer and Evermann 2015). Business simulations provide dynamic learning situations (Anderson and Lawton 2009; Kim and Watson 2018; Tiwari et al. 2014).

Despite the attempts to provide realistic learning experiences, each approach has several deficiencies. The practice enterprise model is in a need of tools and dynamism that information technology (IT) can provide. ERP systems and simulations, on the other hand, lack the holistic perspective. The combination of IT and human-to-human interaction results in more effective learning than the technology or the face-to-face environment alone (Cao et al. 2008). This sets the motivation for our study to contribute to the discussion on learning outcomes and the design of efficient business learning environments: how does a holistic learning environment, that combines a practice enterprise model, an ERP system and a simulation, improve learning results, and why.

The paper is structured as follows. First, we view related research on the practice enterprise model and IT-oriented business learning environments through Bloom's taxonomy. We proceed to introduce a case study that compares the practice enterprise model with the ERP-based business learning environment. Then we review the learning results and continue by discussing the reasons for them. We conclude with discussion, limitations, contributions, and suggestions for further research.

2 Related research

We first view research on the practice enterprise model and IT oriented learning environments through Bloom's taxonomy where learning objectives are classified into three domains: cognitive, affective and psychomotor (Krathwohl 2002). Cognitive domain considers knowledge and comprehension, affective domain attitudes, emotions and feelings, and psychomotor domain refers to skills.

2.1 The practice enterprise model

The practice enterprise model is a virtual company that resembles a company but does not trade actual money or physical products. The practice enterprises manage their internal processes and trade with other practice enterprises (Borgese 2011; Bianchi et al. 2017; Deissinger 2007). The model aims at business and entrepreneurship learning (Gramlinger 2004; Santos 2008) through interactions between real people. It is a non-computer based, interactive role-play simulation (Lean et al. 2006).

The model has positive effects on the affective learning on teamwork, communication and motivation (Deissinger 2007; Glombitza 2012; Greimel-Fuhrmann 2006; Santos 2008), but cognitive, disciplinary learning on business domains and their integration leaves room for improvement (Krauskopf and Frei 2012). Low performing students appear to benefit the most from the practice enterprise activity (Borgese 2001; Graziano 2003).

Despite the benefits, the model is criticized for being artificial and static (Santos 2008; Greimel-Fuhrmann 2006; Neuweg 2014). It does not contain a clear business environment or business scenarios, making it more conceptual and abstract than concrete. It lacks standardization and clear processes. It is a role-play of business operations rather than a concrete practice ground for actual business. It also lacks the concrete tools that modern companies use in their day-to-day operations (Nisula and Pekkola 2012).

2.2 ERP systems

ERP systems are often used in teaching business operations, integrating different disciplines and increasing the business process understanding (Jewer and Evermann 2015; Monk and Lycett 2016; Springer et al. 2007; Zabukovšek et al. 2018). The main learning objectives are ERP system skills and integrating information technology to business (Hepner and Dickson 2013).

Earlier research on the ERP systems has identified transfer of learning (Dunaway 2018) as well as positive learning outcomes in the cognitive domain (Johansson et al. 2014; Jewer and Evermann 2015; Rienzo and Han 2011). In the affective domain, there have been indications of increased motivation, attendance, and engagement (Alshare and Lane 2011; Jewer and Evermann 2015; Scholtz et al. 2012).

However, if hands-on learning focuses on executing tasks and ERP technical skills, the value is limited (Wang and El-Masry 2009). Especially in the large, complex ERP, the students struggle to understand the links between information, business processes, and managerial decisions (Monk and Lycett 2016). When learning is carried out with pre-planned cases (Bradford et al. 2003) or point-and-click exercises (Angolia and Pagliari 2016) learning situations tend to be static and predictable.

2.3 Business simulations

A computer simulation is an exercise involving reality of function in an artificial environment (Thavikulwat 2012) where computer model attempts to reflect the basic dimensions of a business environment (Anderson and Lawton 2009). Business simulations consist of open-ended, changing situations with many dependable variables (Thavikulwat 2012). They are often used in summarizing capstone courses when learning from different disciplines is integrated, although there may also be benefits to using them early in the studies (Angolia and Reed 2019).

ERP-simulations use the ERP system as the student interface into scenarios that are mediated by a simulation. An example of such business simulation game is widely used

ERPSim that combines simulated market data and automated business functions with the user interface of a real SAP system (Cronan et al. 2012; Chen et al. 2015; Labonte-LeMoyne et al. 2017). The ERPSim is normally played in short rounds taking less than a day.

Business simulations have shown to improve learning on the cognitive domain (Anderson and Lawton 2009; Clarke 2009; Cronan et al. 2012; Palmunen et al. 2013; Seethamraju 2011). There have also been positive affective learning results such as increased motivation, improved analytical and decision making skills, transferred knowledge, and engagement to real business situations (Cadotte and MacGuire 2013; Chen et al. 2015; Clarke 2009).

Research on psychomotor or skill-based learning has focused on the progression in the simulation performance rather than business task performance. Several studies indicate improvement between the beginning and the end of the simulations (e.g. Davidovitch et al. 2008; Olhager and Persson 2006). Pasin and Giroux (2011) detected that the simulation aided those who had learning deficiencies from the lectures.

Business simulations also have their drawbacks and challenges. They emphasize strategy formulation and management decision making (Faria et al. 2009). When they aim at reproducing multi-faceted business problems, they often become too complex for the students to comprehend (Teach and Murff 2009). In fact, rather than focusing on recreating actual business problems, simulations should create the feeling of real situations (Kibbee 1961). Simulations are typically played in short rounds where the time lapses in compressed business episodes, further reducing the feeling of reality (Lainema and Makkonen 2003). In addition, for a simulation to be a real learning experience, all participants need to have some degree of commonality in understanding the simulated environment (Teach and Murff 2009).

The communality can be provided by the practice enterprise model, where the core benefit is the interaction between the people. We will next introduce our case that investigates whether a combination yields in improved learning results.

3 The CASE

In TAMK School of business and services, first year business students, fresh from the high school, were taught by using an integrated curriculum approach, supported by the practice enterprise model. This method had been used for some years, so evident improvement needs have emerged, for example the dynamics of a business environment were missing. A project was initiated to replace the practice enterprise model with an ERP-based business environment. This study focuses on the assessment of the learning results in this learning environment change.

Our target is the total population of the two groups of 117 first year students each. The first freshman class using the practice enterprise model is the control group, the PE group. The second freshman class using the ERP-based business learning environment is the experimental group, the ERP group. Both groups followed identical curriculums (Fig. 1), consisting of four modules that reflected the life-cycle of a startup company: 1. Setting up a business enterprise, 2. Running the business enterprise, 3. The profitable business enterprise, and 4. Developing the business enterprise.

Each module combined different disciplinary studies emphasizing its theme. The students were divided into teams, who were supervised, coached and mentored by an appointed teacher-coach. Altogether six teacher-coaches acted as consultants to the other teams, representing different areas of expertise – business law, marketing, accounting, finance, logistics, and management. They also provided most of the disciplinary teaching. The coaches planned each module implementation and held weekly updates to plan the upcoming activities. This setting was the same for both student groups.

3.1 The practice enterprise model

In the practice enterprise model used by the control group, the PE group, the studies included operating a simulated company in a practice enterprise model administered by the national practice enterprise center. In addition to lectures, the student teams worked 4–8 h a week in their simulated companies for one year. They traded with administrator-run and student companies. There was an online bank, but the rest of the business transactions were handled manually with e-mails to and from the national practice enterprise center administrator. The simulated companies and their life-cycles were synchronized with lectures and exercises. For example, when the companies were starting their business, there were lectures on budgeting and financing start-ups. The teams also had a physical "company office" with computers and a mobile phone. The teams were divided into three departments of 3–4 students each: marketing; logistics; and accounting and finance. Each student worked in a department for one module. The teams organized themselves and rotated responsibilities.

3.2 The ERP-based business learning environment

The ERP group used a learning environment where the practice enterprise model was combined to an open source ERP system with a business simulation. The simulation was a fictional city, presented in the form of a web-site with the city facts and links to basic infrastructure providers: real estate, electricity, telephones, insurance, transportation, and health services. The raw market was made of wholesalers that each had a web-store where goods could be purchased. A virtual banking system provided financial

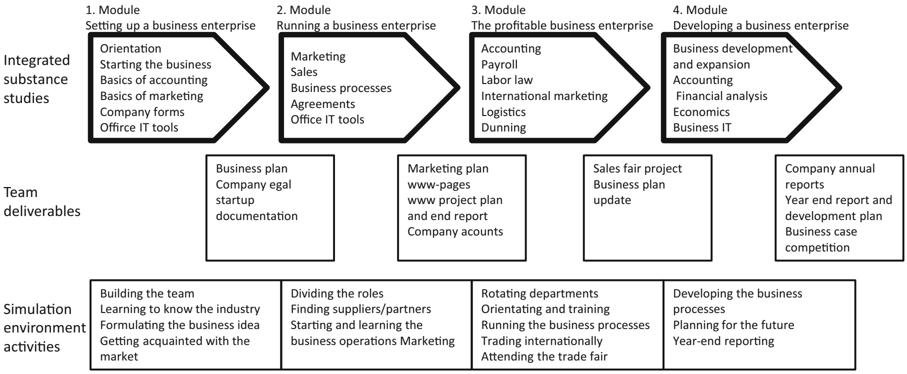

Fig. 1 The first year BBA curriculum

services. Taxes were reported with an electronic tax account. A web publication simulated local media by combining imaginary local news with real external news from rss-feeds. The environment was managed through simulation-generated transactions and activities managed by a systems administrator.

Simulated student companies traded with each other and with the administrator-run companies. They managed their finances in the online bank and their internal operations in the ERP system. The operating procedures were standardized and brought clarity and rigor to the activities. The coach monitored the students' activities and business success through the ERP reporting. The simulation created a momentum by generating consumer demand, again bringing the sense of reality and concreteness.

4 Evaluation of the learning outcomes

4.1 Learning outcomes in the cognitive domain

According to Gosen and Washbush (2004) and Hutchinson (2016), assessing the effects of the simulation on learning, the study should include both pre- and post-tests; and experimental and control groups. Also the importance of defining the learning objectives and identifying appropriate, objective measurements for them, are emphasized (Gosenpud 2018).

The cognitive learning objectives focused on the disciplinary understanding of business management: marketing, sales, logistics, finance, economics, and law. Knowledge levels were evaluated in three phases: at the beginning of the year, in the mid-term and at the end of the school year. An identical set of tests was presented to both groups, being independent from each other.

The pre-test analyzed the students' previous understanding and provided a basis to compare the Practice enterprise (PE) and the ERP groups. As the students had no prior business training or experience, open-end questions were considered a suitable method to evaluate their general understanding. The students were given seven case-questions on different business situations, ranging from starting a company to marketing, production and accounting related issues. The answers for both groups were graded by the same teachers with mutually agreed grading principles on a scale 0–3 (0 = no understanding, 3 = very good understanding).

In the mid-year test, we followed Wolfe's (1985) model on assessing simulation learning on functional business areas and business integration with multiple-choice exam. Our test contained 44 multiple-choice questions on different disciplinary topics: marketing, sales, logistics, finance, economics and law. The disciplinary teachers created the question on their area of responsibility according to the learning objectives. The online test was carried out at the same time to all students to avoid information passing between them. The students were not informed in advance, but they were encouraged to use it as a self-test. The test did not affect their grade.

The year-end test was designed with the same principles. Again it contained 44 multiple-choice questions. The test was not given immediately after the school year in May, but after the summer break, at the beginning of the next semester in August to measure long-term learning effects, not just short-term memorizing.

The number of respondents in each test is provided in Table 1. The total population declined due to absences, dropouts and transfers to other universities. Also, a group of 20 students moved to another department as a normal part of their studies after the first year.

The quality of the test questions was assessed with an item analysis (Livingston 2006). Difficulty index of a question measures the ratio of correct responses to all responses. A high percentage indicates an easy question. The discrimination index of a question describes the ability to differentiate between the more and less knowledgeable students. A discrimination index varies between −1 and 1; and it should be positive to show discrimination. Values over 20% are acceptable, over 30% are good and over 40% are excellent (Ebel 1972). The mean index values for the questions in each test are shown in the Table 2. In the pre-test, the item difficulty was high – as expected, since the students had no prior business knowledge. In the mid-term and year-end tests, the questions were easier. Our questions' discrimination indexes averaged on acceptable level, above 20%. The item analysis thus shows that our test questions were not too easy, being able to differentiate knowledgeable and less knowledgeable students.

Table 3 presents the test results. In the pre-test, the means and the standard deviations were close to each other, indicating that the groups had approximately the same basic knowledge. There were no significant differences between the groups in the mid-term test either. However, the year-end test showed a significance increase in the mean value of the ERP group, indicating improvement in learning. Also, the ERP group had a smaller standard deviation indicating that the test results were less spread out.

A t-test analysis for independent samples was performed to check whether the differences in the results were significant. In the pre-test and the mid-term results the p values were significantly over 0.05. This indicates that no significant differences in the groups' prior knowledge nor learning at the mid–term existed. The p value for the year-end test was 0.005, indicating a significant difference in the results in favor of the ERP group. It thus seems that ERP improved and harmonized learning results.

Figure 2 shows that there are little differences in the score distributions of the pre-test.

The same trend can be observed in the mid-year test, shown in Fig. 3. The PE had a slightly broader spectrum at both ends whereas the ERP group had scores that were more focused on the average 60–70 range. However, there are no remarkable differences between the groups.

In the year-end test, differences between the groups emerged (Fig. 4). The graphs are identical at the higher end of the distribution while low and average scores are significantly improved in the ERP group. This pattern indicates that better students perform

Table 1 The number of respondents in the tests

	Number of respondents	
	PE group	ERP group
Pre-test	117	117
Mid-term	100	101
Year-end	73	60

Table 2 Item analysis of the tests

	Mean for question difficulty indexes	Mean for question discrimination indexes
Pre-test	7%	23%
Mid-term	50%	23%
Year-end	45%	27%

well regardless of the learning environment, whereas lower and average performers seem clearly to benefit from the additional boundary structures provided by the ERP-based simulation. This also suggests some improvements in the long-term learning. This concurs with earlier research indicating that the ERP systems and simulations benefit the lower performers (Monk and Lycett 2016; Pasin and Giroux 2011).

4.2 Learning outcomes in the affective domain

Halfway through the academic year in February, the students were given a questionnaire on the learning environment. Although our main goal was to collect feedback for immediate improvements in the learning environment, the test also allowed us to measure affective learning, since questionnaires are a typical method for that in business simulations (Anderson and Lawton 2009).

Six statements (Likert-scale 1–5) and two open-end questions, based on the curriculum objectives were included: integration between disciplines, overall business process understanding and teamwork. We also wanted to know the effects on motivation and the feeling of versatility for the interests of the learning environment project. Altogether the average Likert-scores were very similar between the groups, and reflected satisfaction and motivation. The highest scores of over 4 for both groups were on applying theory to practice and making studying versatile. The biggest challenge was the division of labor between the team members, scoring around 2.5 for both groups.

The open-end responses contained feedback and learning points. The responses were analyzed inductively, by counting the frequency of different topics. Table 4 shows that both groups brought up similar learning points on teamwork, concrete work-life orientation and connections from theory to practice. The greatest difference was on the practical hands-on approach that was mentioned twice as often in the ERP group than in the PE group. This indicates that standardization and practical tools provided by the ERP system and the business game functionality increase the sense of concrete hands-on work.

Table 3 The results of the tests

	PE group Mean	ERP group	p value	PE group Std deviation	ERP group
Pre-test	62.4	61.6	0.29	0.11	0.10
Mid-term	70.8	69.8	0.16	0.07	0.08
Year-end	57.8	61.8	0.005	0.10	0.07

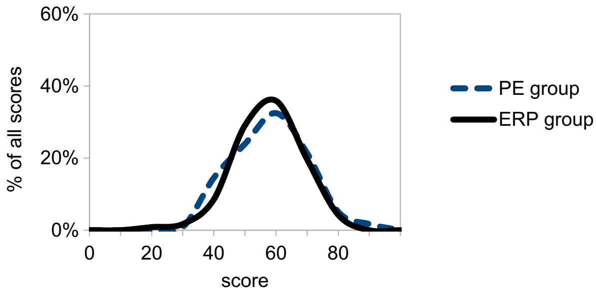

Fig. 2 Pre-test score distributions

4.3 Learning outcomes in the psychomotor domain

An appropriate measurement to assess psychomotor domain learning in both environments was a challenge. During the research process, we found a potential psychomotor measurement within the ERP system: the log files (Nisula and Pekkola 2016). They produce large amounts of transactional and log data. However, they do not serve for comparative purposes since the practical enterprise model does not produce such data.

Efficiency, accuracy, and response magnitude are psychomotor learning outcomes (Sharda et al. 2004). Efficiency is measured in terms of the time to complete a task. Effectiveness can be assessed counting the number of errors committed during task completion. Response magnitude is measured by the complexity of the task completed (ibid.).

We analyzed the efficiency of the order-to-delivery process, the purchase order process, and inventory management process. Psychomotor learning *within* the ERP-based business learning environment was measured by the development in processing times. The sales order processing time declined from fifteen minutes to three minutes, on average, during the course of the simulation. The other processes and their analysis showed similar decline.

Even if we did not find comparative learning data between the practice enterprise model and the ERP-based business learning environment, we argue that using the computers improves the students' efficiency in carrying out the business processes. In addition, the ERP system data repository provides new tools for the teachers to assess and guide learning and yet another common ground to discuss the learning process.

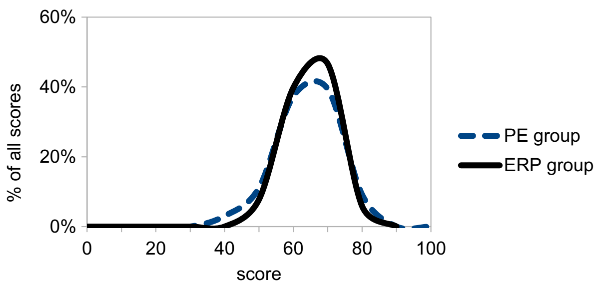

Fig. 3 Mid-term test score distributions

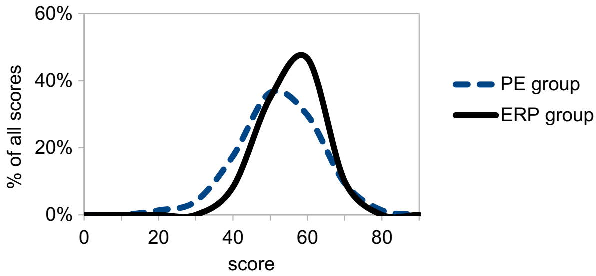

Fig. 4 Year-end test score distributions

5 Why does the ERP-simulation enhance learning?

Combining ERP-simulation with the practice enterprise model seem to improve the poor and average students' cognitive learning. This finding supports earlier research that low-performing students benefit from IT in the learning situations (Monk and Lycett 2016; Pasin and Giroux 2011). In order to understand why this improvement happened, we decided to analyze the situation through the concept of boundary object (Star and Griesemer 1989).

The concept of boundary object is used because learning often involves the crossing of social, cultural and conceptual boundaries between different social worlds of students, academics and business (Akkerman and Bakker 2011; Aprea and Cattaneo 2019). Marketing, logistics, accounting, and other disciplinary communities of practice all approach business from different perspectives. Teachers belonging to the social

Table 4 Frequently mentioned topics in the open-end questions

Discussed topics	Number of times mentioned	
	PE group ($n = 100$)	ERP group ($n = 101$)
1. What works well, what have you learnt?		
Practical hands-on approach	27	55
Team work	42	49
Combining theory with practice	34	31
Connections to real work life	20	20
Versatility, variation and change to traditional studying methods	12	16
2. What does not work well?		
Uneven distribution of work load, free riders	28	30
Technical problems	29	23
Difficulty to draw the line between the simulation and real life	16	20
Scheduling challenges between the simulation and substance teaching	14	17
Problem-based learning orientation	15	16
Lack of instructions from teachers		10
Poor communication by the teachers		9

world of academics aid the students, who in turn, aim at crossing the boundary between novice and expert.

Each community has its own social context, language and concepts (Bowker and Star 1999). Yet different communities need to be brought together to share goals and contributions (Rousseau 2012). In this setting the brokers, i.e. members that simultaneously belong to several communities of practice and form bridges between them by translating, coordinating and creating the alignment of perspectives, are significant players (Cobb et al. 2003; Pawlowski and Robey 2004). The role of a broker is demanding because it requires competence in several disciplines and sensitivity to social cues (Levina and Vaast 2005).

In any organizational context – be it a business organization or a university, the social and the material world are inseparable (Orlikowski 2007). There the actions between people are often mediated by objects (Bowker and Star 1999). A boundary object serves as a bridge between different social and cultural worlds and enables interaction and cooperation without having consensus (Star 2010; Nicolini et al. 2012). It provides a common ground that is "*plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites.*" (Star and Griesemer 1989, p. 393). A boundary object can be abstract or concrete, but it is always "*something… people act toward and with*" (Star 2010, p. 603). Different communities of practice can use it for their needs. They may use their own representations and terminology but still refer to the same object. This makes cooperation possible.

5.1 Practice enterprise as a boundary object

Analogies and metaphors can act as boundary objects, creating bridges between novice and expert understanding (Bruun and Toppinen 2004). Common discourses enable crossing boundaries between disciplines (Dillon 2008). Dillon (ibid.) analyzed books as boundary objects providing cross-disciplinary discourse. Christiansen and Rump (2008) studied thermodynamics as a boundary object discourse for physics, chemical and mechanical engineering. Münster et al. (2016) used the architectural structure of a cathedral as a boundary object to facilitate cross-disciplinary and expert-novice communication in a learning project.

Boundary objects simplify communication and coordination in multidisciplinary learning. Instead of taking coordination transactions between the disciplines, the actors interact with one common frame of reference, boundary object (see Fig. 5). This boundary object is concretized for example in teaching how logistics and marketing are interrelated. There, a case study, a group project, or some other approach of combining the disciplines is needed. The chosen approach functions as a boundary object, necessitating coordination of activities between the disciplinary teachers. Similarly, another boundary object is needed in illustrating the relations between accounting and sales, and yet other boundary objects to show the connections between other multiple disciplines. The disciplinary integration easily consists of a set of individual, isolated activities. However, a well-designed boundary object may serve several activities and relations. When all disciplines work towards a common boundary object, one artifact provides a common ground for them. The practice enterprise model connects different disciplines and provides a discourse for expert-novice communication. It thus serves as a boundary object, mediating discourse between different disciplines.

The practice enterprise discourse is rather generic and abstract. Highly abstract boundary objects are enough for the purpose of coordination between different communities of practice but, with the aim of creating a common understanding, boundary objects need to be more specific and combined to other objects that support and reinforce each other (Fujimura 1992). With the practice enterprise model, the common understanding was provided by different disciplinary teachers, whose interpretation of the potential of the learning environment varied. Consequently the discourse remained on an abstract level. This kept the students rather distant from the practical activities of the learning environment – as seen in Table 4.

5.2 Simulations and ERP systems as boundary objects

Technology-based boundary objects are "*software tools that adapt or extend symbolic artifacts identified from existing work practice, that are intended to act as boundary objects, for the purposes of employees' learning and enhancing workplace communication*" (p. 17, Hoyles et al. 2010). Examples of information technology-based concrete and specific boundary objects are document archives, database repositories, groupware and collaboration systems, and ERP systems (Forgues et al. 2009; Jonsson et al. 2009; Levina and Vaast 2005; Pawlowski and Robey 2004). The characteristics that make an ERP system a boundary object are modularity, abstraction, concreteness, accommodation and standardization (Abraham 2013; Levina and Vaast 2005). Different departments use only the modules they need. The common reference points between departments are on high levels of abstraction and yet the systems provide concrete tools for day-to-day work. Information in the systems is predefined, enforcing standardized local use and eroding the common perspective.

Simulations can be seen as technology-based boundary objects (Aprea and Cattaneo 2019). Simulations increase inter-organizational learning and innovation (Jensen and Kushniruk 2016; Dodgson et al. 2007). Business simulations contain scenarios where the learning objective is tied to a story or a narrative (Salas et al. 2009). People can create, apply and exchange knowledge through common narratives that allow coordination and interaction without consensus or shared goals (Bartel and Garud 2003). Each individual can interpret the narrative from their own perspective. Case studies, for

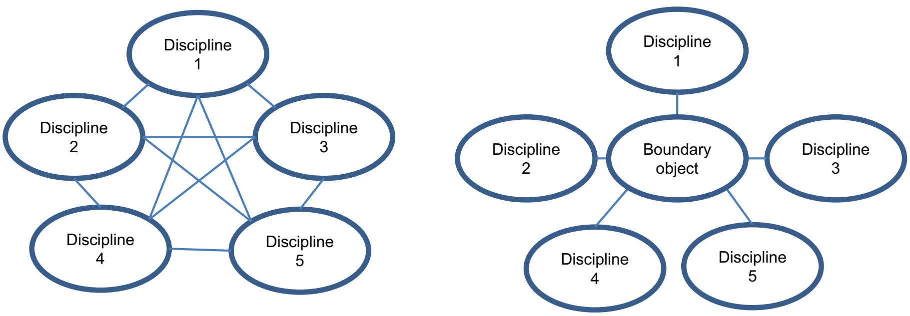

Fig. 5 Boundary object in multi-disciplinary teaching

example, have been used as narratives and boundary objects in the learning context (O'Leary et al. 2016).

In our case the ERP simulation converted the abstract discourse of the practice enterprise into a concrete form with a narrative (stories on the web pages and in the online publication) and concrete artifacts (ERP system, online bank, tax system). The ERP system is a repository for common business data and a platform for learning activities. It supplies tools for *how* to process the common issues across boundaries, and the simulation presents the content of *what* is being processed. Consequently, our ERP simulation provided a map to navigate within and across the other boundaries. With a dynamic business case, this combined the business network of the practice enterprise model to the activities performed in the ERP system. This aggregate became a boundary infrastructure (Star 2010) that is maintained through an interwoven network of related boundary objects (Oswick and Robertson 2009) reinforcing each other (Fujimura 1992).

6 Discussion and limitations

We set out to research whether a combination of an ERP system and a simulation would improve the learning outcomes in the practice enterprise model. The learning results were measured and compared by using two groups; an experimental group and a comparison group. Both groups consisted of the total population of the freshman BBA class. They followed an identical curriculum and 70% of the teachers were the same for both groups. The main difference between the groups was the learning environment. The experimental group studied in the ERP-based learning environment while the control group used the practice enterprise learning environment. The cognitive learning was measured using pre- and posttests that were based on the learning objectives of the curriculum and created by the responsible disciplinary teachers. An item analysis indicated the tests were able to differentiate between better and poorer students. The affective learning was measured using a questionnaire that collected feedback of the learning environment and posed questions about the overall affective objectives of the curriculum.

Our findings indicate improved learning on the cognitive and affective learning of Bloom’s domain. The ERP-based environment improved the long-term cognitive learning of the poorer students. This supports earlier research suggesting that ERP systems and simulations benefit the lower performers (Monk and Lycett 2016; Pasin and Giroux 2011).

From the affective learning perspective, both the practice enterprise and the ERP simulation were seen as motivating learning environments, concurring with earlier research (Anderson and Lawton 2009; Greimel-Fuhrmann 2006). The ERP-based environment was particularly appreciated for the hands-on approach. This indicates that real-life tools increase the sense of learning by doing, which has been a challenge in the practice enterprise model (Greimel-Fuhrmann 2006; Santos 2008). The psychomotor learning was measured only *within* the ERP-based business learning environment and therefore cannot be used to assessing learning differences between the groups. The ERP log-file analysis, however, indicated significant improvements in the processing times, implying that some learning had taken place.

The ERP simulation improved the learning results. The practice enterprise discourse has been criticized for being too vague and artificial (Santos 2008; Greimel-Fuhrmann 2006; Neuweg 2014). For the novice students with little business experience, the discourse remains too abstract. The ERP simulation enhanced the abstract discourse of the practice enterprise to a boundary infrastructure that contains concrete artifacts, processes and narrative. This benefited particularly the lower performers.

The business simulation created narrative through scenarios and concrete artifacts, such as the fictional city web page with facts and a map. When the students founded a company, they “rented” an office space that got an address in the map, binding the virtual companies to a visual representation of the narrative. The abstract discourse was reinforced by other objects, suggested by Fujimura (1992): simulated service providers, supplier web-stores and tax officials resembling their real counterparts. The student teams created their own company web-pages to make their fictional company visible to other student companies. They operated in the common environment, combining intersecting social worlds of students and disciplinary teachers. The coaches were brokers at the boundaries representing different disciplines and bridging between the teacher and the student communities of practice.

The ERP system brought standardized forms and processes for running the operations. It made the business concrete and real. The basic data was standardized to keep coherence (Levina and Vaast 2005), but the system was flexible enough for a local student team use. It formed a common ground to discuss business operations among the group of students, coaches and disciplinary teachers. The lack of action (Santos 2008; Neuweg 2014) was tackled with a simulation-generated consumer demand and competition, further enforcing the narrative and the concrete activities in the environment.

When the coaches and the disciplinary teachers wanted to demonstrate a business issue or communicate the meaning of a theoretical or a practical concept, they used the ERP system terminology and the transactions. For example, the logistics teacher elaborated on the order-to-delivery flow whereas the accounting teacher discussed the profit and loss. They were operating through the same narrative of the student company and the artifacts of the ERP system without having to coordinate directly with each other on each exercise.

Using IT systems to monitor processes and event data also provides ways to cross boundaries (Barik et al. 2016; Jonsson et al. 2009). The ERP logs enabled the coaches to monitor learning in a coordinated way and further support the students’ learning efforts (Nisula and Pekkola 2016).

The ERP-based business learning environment was more than just a collection of web pages and ERP systems. It was a common infrastructure where the student companies formed relationships with each other. The teams were free to create their own internal rules and routines, as long as they carried out the required learning exercises. The boundary infrastructure was plastic and adaptive to the needs of the different actors and yet, it provided the common ground. The coaches acted as brokers between boundaries: they mediated between the student, the academic and the business communities of practice.

The role of a boundary object can change over the course of collaboration. A central object can move into the background and back into the center when needed (Nicolini et al. 2012). Representations, activities and physical artifacts are used in learning situations as scaffolds, or temporary supports that improve novice learning and get removed when learning has taken place (Pennington 2010). When an object becomes such a natural part of daily routines and processes that it is no longer thought of, it gets *naturalized*. If a boundary object is naturalized in several communities of practice, it loses its boundary nature (Bowker and Star 1999). When the students started understanding the terminology and processes of the business world, they began transforming from the novice to business professional diminishing the need for the boundary infrastructure to support their learning. Our business learning environment as a boundary infrastructure makes itself obsolete for the students – only to start with the novice students next year.

The greatest limitation is our single case approach. More research is definitely needed in broader settings. The learning tests should be replicated with similar curricular learning objectives. Also the research tools set limitations. The pre-test contained open-end questions, with subjective grading. We coped with this by having commonly agreed grading principles and anonymized answers to minimize intentional bias. Also the same teachers graded both groups. The mid-term and the year-end tests were done as multiple-choice to avoid the subjective grading. The item analysis showed that the cognitive learning tests were able to differentiate between better and poorer students, yet the discrimination indexes were relatively low. However, we did not aim to measure absolute learning per se, but rather the differences between the groups' business understanding. Another limitation is that the students may have underperformed as the tests were not graded. Yet this was the same for both groups. The limitation of the affective learning questionnaire was that it was originally intended for feedback on the learning environment, and consequently did not follow any pre-tested tool. Nonetheless, it reflected the affective learning objectives of the curriculum. Also, although the groups followed an identical curriculum, the differences in teachers caused some changes in the learning situations. Creating identical settings for independent comparison groups has also been a challenge in earlier research (Gosen and Washbush 2004; Gosenpud 2018). In fact, there are very few attempts to evaluate overall learning in simulations (Gosenpud 2018). Although the differences in learning outcomes may not be caused solely by the learning environment, knowing the case, settings, and the methods we argue that the learning environment had a significant impact there.

7 Conclusions

This study investigated how a holistic learning environment, combining a practice enterprise model, an ERP system and a simulation, improves learning results and why. We answered that by presenting

- An implemented example of a boundary infrastructure and a holistic learning environment that combines the practice enterprise model and the ERP-simulation
- Evidence that this holistic learning environment improves the poor and average students' cognitive learning. This is a domain that needs improvement in the practice enterprise model (Krauskopf and Frei 2012). This also supports the earlier research (Graziano 2003; Monk and Lycett 2016; Pasin and Giroux 2011) that the low-performing students benefit from an infrastructure of several concrete boundary objects

- An explanation for the improvements in learning: the holistic learning environment acts as a boundary infrastructure. The practice enterprise model forms the abstract discourse, while the ERP system concretizes it by bringing standardized forms and processes and the simulation constructs into a narrative that ties the boundary objects together. The boundary infrastructure gives a common ground for the students, the coaches and the disciplinary teachers. The ERP-simulation also provides momentum and sense of reality, which are lacking in the practice enterprise model (Greimel-Fuhrmann 2006; Santos 2008). This combination of concrete boundary objects reinforcing each other supports the creation of mutual understanding (Fujimura 1992) and crossing the boundary from novice to expert.
- Indications on the affective domain areas where the students appreciate the benefit of crossing the boundaries: joining theory to practice, integrating the learning environment to the curriculum and intersecting the social worlds of other students

These contributions will help us in developing learning environments that facilitate the students' transition from novice to professional. The worlds of students, teachers and business professionals are often far from each other. Also, there are boundaries separating the different disciplines from each other. Bridges at the boundaries increase the ability to understand the other worlds. A business learning environment, constructed as a boundary infrastructure prepares the future business managers for the complex, multi-disciplinary working environments in a continuously changing world.

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