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Karoliina Nisula

Tampere University of Technology, Finland, karoliina.nisula@futurable.fi

Samuli Pekkola

Tampere University of Technology, samuli.pekkola@tut.fi

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ASSESSING BUSINESS LEARNING BY ANALYSING ERP SIMULATION LOG FILES

Karoliina Nisula
Department of Information Management and Logistics
Tampere University of Technology, Finland
karoliina.nisula@futurable.fi

Samuli Pekkola
Department of Information Management and Logistics
Tampere University of Technology, Finland
samuli.pekkola@tut.fi

Abstract:

Business education is facing increasing pressures to equip graduates with both practical competencies and functional knowledge. In addition to developing authentic learning environments where one can learn those competencies, we need to develop authentic assessment methods. Computer-assisted learning environments, such as business games and simulations, assist in achieving the intricate learning goals, and at the same time, provide copious quantities of data. In this paper, we present an authentic assessment approach to measure the students' practical hands-on activities rather than their theoretical knowledge. We analysed the log file data of an ERP-supported simulation to assess learning in a full year case study with first year BBA students. The analysis firstly demonstrates how and when log files can be used, and secondly indicated positive learning results on the cognitive and psychomotor domains of Bloom's taxonomy. The log file analysis holds potential particularly for formative assessment to guide the student's learning process during the simulation. These findings and our lessons learned can be applied to assessing learning in computer-supported learning environments, particularly in business simulations.

Keywords: assessment, business education, computer-assisted learning, log data, ERP simulation

I. INTRODUCTION

Business education is criticized for giving the graduates a fractional view of business, and not equipping them with the skills that the companies require [Holden et al., 2007; Jackson, 2009; Weber and Englehart, 2011]. Increasing pressure exists to modify education to fit the needs of the rapidly changing business world. As the learning objectives should reflect the competencies required by the industry, the assessments should also include practice-oriented components that are applicable in professional contexts. Instead of assessing the learner's ability to write about good practice, the measurements should aim at how the student can put his/her knowledge and learning into practice [Brown, 2004]. The focus on real world activities also makes the assessment meaningful and motivational to students, which correspond with better learning outcomes [Sambell et al. 1997].

The essence of business management is to control and manage multiple demands at the same time in many areas of expertise, and in a continuously changing environment [Chia, 2005]. This makes the business learning assessment challenging. Traditional assessment methods do not necessarily comprehensively capture all competencies and skills that are essential in modern workplaces, [Pellegrino et al., 2004].

Authentic assessment aims at measuring both competencies and knowledge. It focuses on the real world tasks that should be varying, complex and challenging or create a product as an output [Vos, 2015]. The tasks should also include developmental opportunities with feedback, as well as opportunities for reflection, interaction, and collaboration. One of the main objectives for formal education is to practice a skill or a set of actions [Darling-Hammond and Snyder, 2000].

Computers are increasingly used to bring authentic real world experiences to business learning. For example, business education may use enterprise resource planning (ERP) systems, large software packages used by companies to integrate the transaction-oriented data and business processes [e.g. Ask et al., 2008, Ayyagari 2011; Davis and Comeau, 2004; Targowski and Tarn, 2006]. Simulations, on the other hand, can be defined as being a kind of exercise in an artificial environment [Thavikulwat, 2004]. Business simulations can also be games with built-in rules and roles – and an objective to win [Gredler, 2004]. ERP-based business simulations are considered efficient in bringing the complexities of the real business life into the learning context [Cronan et al., 2012; Léger et al., 2011; Léger, 2006; Seethamraju, 2011].

All these technologies; ERP-systems, simulations, and games; collect large quantities of log data. In this paper, we conduct a case study [Yin, 2003] to identify how ERP-simulation log data can be used for learning assessment. We take the game-based assessment perspective and view learning objectives through Bloom's taxonomy. We present examples of log file based assessments with a case study of an ERP-based business simulation that is used throughout the curriculum for a whole study year.

The paper is organized as follows. First, we review related research on assessment in computer-assisted business learning environments. Second, we give a brief introduction of Bloom's taxonomy and its usage as the learning objective framework. Third, we describe our illustrative case study, i.e., an ERP-based business simulation environment and the learning context. Fourth, we provide descriptions of our experiences and suggestions with log file-based assessments from different perspectives of Bloom's taxonomy. Finally, we discuss the results, present the lessons learned and introduce further research areas.

II. RELATED RESEARCH ON ASSESSMENT IN COMPUTER-ASSISTED BUSINESS LEARNING ENVIRONMENTS

Learning assessment can be described as summative or normative [Black and William, 2009]. Summative assessments test the overall achievements at the end of the learning process. They focus on measuring the competency of knowledge and skills for grading purposes. Formative assessments are done throughout the entire learning process to monitor progress and failure continuously [Boston, 2002]. They are more useful to educators, because they enable the educators to adjust the learning process as it proceeds. One form of formative assessment, feedback, is one of the most powerful ways to improve learning [Black and William, 2009; Loh, 2012]. Next we will discuss different types of assessment alternatives and their experiences in the light of previous research.

Game-based assessment

Instead of measuring knowledge and capability directly, game-based assessment enables us to measure the action and performance resulting in learning [Zeying et al., 2007]. In game-based learning, assessments can be distinguished in three categories: game scoring, external assessment, and embedded assessment [Ifenthaler, 2012]. Game scoring focuses on an achievement of targets or the time needed for reaching a target while playing the game. External assessment is realized for example through briefing interviews, knowledge maps, causal diagrams, test scores, and essays. Embedded assessment is part of the gameplay and does not interrupt the game. It gathers data about the learner's behaviour while playing the game in the form of clickstreams or log files. Assessing game-based learning is mostly based on summative methods because they are the easiest to implement [Bellotti et al., 2013].

Game scoring

Some computer-assisted business learning environments support the game scoring assessment.

Business simulation games, for example, provide measures of business success, such as cumulative profits; return on investment or sales; as well as inventory and asset turnover [Dickinson, 2003; Teach and Patel, 2007]. The games also offer statistics that can be compared to other team results [Markulis et al., 2015; Rudd et al., 2008]. Diverse opinions exist whether the business success in a simulation or in a game is an appropriate measure of learning [Gosen and Wasbush, 2004]. It is criticized for giving biased learning results as mistakes and wrong decisions lower the scores. But those mistakes and errors might actually be the best learning options. Mistakes can also be a source for assessing learning: Pasin and Giroux [2011] analysed the evolution of mistakes during an operations management simulation. They found that the simulation provided significant help to those who did not master all the areas presented in the lectures.

External assessment

Markulis et al. [2015]. have studied how external assessments are supported by different business simulations. For example, some large business simulations contain knowledge based multiple-choice questions or written essays with rubrics that can be tailored by the instructor. Also, assessing can be done with scaled-down versions of the simulation where the student performs the simulation activities individually instead of doing teamwork. Some business simulation assessment tools also provide observational questions that require reflecting the simulation progress, student behaviour, and end result.

Earlier research presents a myriad of summative, external methods for assessing learning in computer-assisted business learning environments [Anderson and Lawton, 2009; Clarke, 2009; Léger 2006; Monk and Lycett, 2011]. Those include self-assessments and surveys; instructors' evaluations of the students; multiple-choice and case-based exams; oral and lab exams; learning logs; take home cases; free recall; mid-term and end-of-the-course evaluations; performance-based testing; and evaluating business success in the simulation. The studies measuring learning outcomes tend to focus on subjective opinions and feelings instead of objective and measured data [Clarke, 2009; Monk and Lycett, 2011]. On the other hand, Cronan [2011] approached subjective learning measurement challenges by comparing self-assessed perceptions to objectively measured learning results and found correlation between them. As a result, he suggested triangulating with different assessment modes to obtain more valid evaluations of the learning objectives.

Embedded assessment

Embedded assessment of computer-assisted learning environments holds interesting potential. Data collected from educational settings has been used to increase understanding of students and their learning circumstances [Siemens and Baker, 2012]. In fact, some correlation between student involvement and his/her online activities have been identified in online courses [Wang and Tucker, 2001; Baugher et al., 2003] and elsewhere [Braender and Naples 2013]. Zhang [2015] found that student login consistency, i.e. how regularly the student was using the simulation, correlated positively with the student's contribution in the simulation, which was measured by peer-evaluation.

In addition to the summative assessments for grading purposes, formative assessments are also needed to guide the students in their learning process [Ifenthaler, 2012]. In business simulations and games, log files provide a new angle to an embedded in-simulation assessment that can be used both for summative and formative perspectives. Earlier research has focused on using log files to detect activity and engagement with the learning environment. We take this further, and study whether log data provides new insights into the learning process and learning assessment.

III. BLOOM'S TAXONOMY IN COMPUTER-ASSISTED BUSINESS LEARNING ASSESSMENTS

Bloom's taxonomy is a widely used generic classification of learning objectives [Krathwohl, 2002]. It is well suited to develop educational objectives for experiential learning such as business simulations [Cannon and Feinstein, 2005]. The taxonomy is often used as a guideline for assessing learning in computer-assisted learning environments [Anderson and Lawton, 2009; Ben-Zvi, 2010; Ranchhod et al., 2014].

In Bloom's taxonomy, learning objectives are classified into three domains: cognitive domain referring to knowledge and comprehension; affective domain describing attitudes, emotions and feelings; and psychomotor domain considering mechanical skills [Bloom et al., 1956]. These domains are subdivided into different levels of learning from low level, superficial learning to profound learning.

Assessing cognitive learning

Anderson and Lawton [1988] have described different cognitive domain assessment methods in a business simulation exercise. They list exams on the simulation rules, methods and outputs; exams on conceptual issues; evaluation of a written plan; ability to predict results; performance of the implementation of the team's plan; identification and recovery of mistakes; relative ranking of simulation results; analysis paper; oral presentation; and peer evaluations. Table 1 summarizes assessments that can be used in different cognitive domain levels in business simulation learning.

Table 1: Assessment on the cognitive learning in business simulations [adapted from Anderson and Lawton, 1988].

Learning Objective	Description of Learning	Assessment Process / methods
Basic knowledge	Student recalls or recognizes information	Answering direct questions/tests
Comprehension	Student changes information into a different symbolic form by restating it in his or her own terms	Ability to act on or process (conceptual exams)
Application	Student discovers relationships, generalizations, and skills	Application of knowledge to simulated problems (writing and implementing a plan in the simulation, accurately predicting result)
Analysis	Student solves problems in light of conscious knowledge of relationships between components and the principle that organizes the system	Identification of critical assumptions, alternatives, and constraints in a problem situation (identifying mistakes, recording from mistakes, analysis paper, oral presentation)
Synthesis	Student goes beyond what is known, providing new insights	Solution of a problem that requires original, creative thinking (oral presentation, analysis paper, assessment of one's / team's performance)
Evaluation	Student develops the ability to create standards of judgment, weigh, analyse	Logical consistency and attention to and detail (analysis paper and oral presentation)

We argue that log files could bring yet another perspective into the cognitive learning. Analysing the business processes and transactions in the simulation could aid in assessing the cognitive domain levels of comprehension, application and analysis of knowledge.

Assessing affective learning

The affective domain deals with interests, opinions, emotions, attitudes, and values [Anderson and Krathwohl, 2001]. The five levels of learning as described in Table 2 are receiving, responding, valuing, organizing, and characterizing [Krathwohl, Bloom and Masia, 1964].

Feelings and emotions are difficult to measure objectively. In business simulations, they are most often assessed with self-reports or questionnaires, measuring the students' attitudes towards the discipline or the simulation itself [Anderson and Lawton 2009; Clarke, 2009]. Despite its convenience, Picard et al. [2004] criticize the reliability of self-reported information. It can be coloured by the person's ability to articulate his/her feelings or reflections on how the report will be perceived. Instead, they suggest emotion recognition technologies that operate with sensors and cameras to recognize patterns of behaviour and attach them to the affective state of learning.

Before the ambitious techniques suggested by Picard et al. are widely available, we need to rely on more conventional technologies. We therefore suggest the use of a combination of evaluation methods, for example as presented in Table 2. Apart from Birbeck and Andre [2009], the studies have not directly addressed the objectives of affective domain. However we argue that these methods are appropriate.

Table 2: The affective learning objectives and suggestions for evaluating them in business simulations.

Learning Objective	Description of Learning	Examples of evaluating learning
Receiving	Student pays passive attention	Log file analysis on whether student is using the system [Zhang, 2015]
Responding	Student participates actively in the learning process	Questionnaire on student attitudes and perceptions [e.g. Hopkins and Foster, 2011, Chang et al., 2003] Observation of student behaviour [Antonucci and zur Muehlen, 2003] Log file analysis on how active the student is in the system [Zhang, 2015]
Valuing	Student attaches value to the learnt content	Questionnaire on student attitudes and perceptions [e.g. Hopkins and Foster, 2011, Chang et al., 2003] Peer assessment [Kwan and Leung, 1996]
Organizing	Student organizes the values, information and ideas into his/her own value system, resolves conflicts and elaborates what has been learnt	Focus group [Monk and Lycett, 2014] Interview and observation [Henriksen and Boergesen, 2015] Reflective writing [Boyd, Dooley and Felton, 2006, Wills and Clerkin, 2009] Debriefing discussion [Fritzsche et al. 2004]
Characterizing	Student consistently acts in accordance with the internalized values	Group reflection during and after the process about the roles and responsibilities that were originally agreed upon [Birbeck and Andre, 2009]

We claim that log files can give direct indication of the learning objectives of receiving and responding. In addition, they provide a concrete and realistic view on the activity levels that can be discussed in debriefing sessions, instructor evaluations and group reflection. As Picard et al. [2004] point out, self assessments tend to be bias. The students do not always see their own behaviour in a realistic light or they may intentionally want to give a better impression of their performance than what it actually is. Or conversely, the student may appear to be passive or lack interest, but the log files show high activity.

Assessing psychomotor learning

In the psychomotor domain, learning objectives address the change or development of behaviours, or capabilities such as efficiency and effectiveness [Zeying et al., 2007]. The six levels of learning as described in Table 3 range from the state of sensing stimulus and recognition of one's abilities and limitations to the mechanisms that form habits and abilities to use skills in new situations – just like expected by the industries [Simpson, 1966].

Comparing the simulation success to later career success has been used in evaluating psychomotor learning [Anderson and Lawton, 2009]. However, that approach cannot be used as an assessment method in education for obvious reason. Instead, we have collected a number of evaluation methods from previous simulation studies that could be harnessed to assess psychomotor learning. This is presented in Table 3.

Table 3: The psychomotor learning objectives and suggestions for evaluating them in business simulations.

Learning Objective	Description of Learning	Examples of evaluating learning
Perception	Student is able to sense objects, qualities and relationships via sensory organs	
Set	Student recognizes his/her own abilities and limitations	
Guided response	Student is able to perform a specific act under the guidance of the teacher	Observation of student behaviour in the classroom
Mechanism	Student is able to perform habitually without guidance	Log file analysis on how the student performs [Zhang, 2015]
Complex overt response	Student is able to perform a complex pattern of acts	Peer assessment [Kwan and Leung, 1996] A new round of the simulation (game) done individually [Markulis et al., 2015]
Adaptation	Student can alter an act to meet the demands of a new situation	Student monitoring [Wellington et al. 1995] Analysing mistakes [Pasin and Giroux, 2011]
Origination	Student is able to develop new acts by applying unrelated skills	Peer assessment [Kwan and Leung, 1996] Testing the learning in another simulation setting [Monk and Lycett, 2014] Student monitoring [Wellington et al. 1995]

We again suggest that log files could be used to assess psychomotor learning, particularly from a formative, guiding perspective. For example, time stamps would indicate whether the activities have become mechanistic. Error logs would detect the correction needs in the behaviour and would particularly help in mentoring the students' learning activities to right direction.

IV. ASSESSMENT IN CONJUNCTION WITH A BUSINESS SIMULATION

Next we will give an example of an assessment in a business learning environment that uses an ERP business simulation. The simulation was used in an assisting role, as a part of a "business skill laboratory" [Blaylock et al., 2009] where students worked in physical office spaces and operated with fictitious businesses, making day-to-day business decisions. The learning environment combined role-play, physical office spaces and the open source ERP system with other learning environments and methods such as classroom lecturing, group work, reports, and exams. The learning environment was the foundation the entrepreneurship oriented curriculum throughout the first year of BBA studies.

We present a retrospective analysis of 117 students operating in the learning environment for a full academic year 2010 at Tampere University of Applied Sciences (TAMK) School of Business and Services. In addition to demonstrating how log files were used in assessing affective learning, we also suggest additional methods of using them in other domains.

The learning environment and the curriculum

TAMK first year BBA studies focus on gaining the basic understanding and skills of business management: marketing, sales, logistics, finance, economics and law. The first year curriculum consists of four successive 10-15 credit unit modules that follow the life cycle of a company: 1. Setting up a business enterprise, 2. Running a business enterprise, 3. The profitable business enterprise and, 4. Developing the business enterprise. Each module lasts a quarter. In addition, there is a module called "The skills and competences for working life" continues throughout the year. It has the goals of team work, responsibility, commitment, critical thinking, creativity, ability to tolerate changes, cooperation skills, and acting in the organizational environment.

In the beginning of their studies, the students were introduced to a fictitious market area, presented through a set of webpages. The area included bank, wholesalers, infrastructure providers and government authorities. The students were divided into teams of ten, each team having three departments: marketing, logistics and accounting. The teams were instructed to establish a company in a specific business area, such as office equipment, IT appliances, or work clothing. The students wrote business plans and negotiated funding with the bank, the roles played by actual bank managers.

Next, they acquired the infrastructure needed, i.e., office space, telephones, electricity, and insurances. Virtual companies provided these services. There was a virtual online bank, administered by the learning environment administrator. The students communicated with the administrator-run companies through webpage feedback, order forms, and e-mails. The simulation also contained a business game element, which created consumer demand by generating purchase orders. Web-based wholesale stores were the source for raw materials.

The students conducted their business activities within an open source ERP system. They used it to generate sales and purchase orders, manage inventories and control expenses. The instructors were able to monitor the student companies' activities and business success through the reporting tools of the ERP system.

After the initiation phase, the students began their businesses with other student companies and the administrator-run companies. The student company life cycles were integrated into the curriculum to create a consistent learning experience. For example, when the students began

their businesses, there were accompanying lectures on budgeting and financing start-ups. Each team was also assigned a supervising instructor who mentored them in the learning environment. The students worked in their virtual companies 4-8 hours a week over one academic year, concurrently with their regular studies, lectures and workshops. Each student worked in one of the company's departments for one quarter. At the end of each quarter, the roles rotated. Throughout the year, the students recorded their working hours into the ERP system's work reporting system. The purpose was both to get them familiar with the workplace routines as well as gain data for guiding and assessment purposes.

THE ASSESSMENT PROCESS

The first year BBA studies had learning objectives in all Bloom domains. Obviously, there was a lot of cognitive learning on the different disciplines. But the affective element was also in focus, particularly on the work life skills. The knowledge and attitudes were required to present themselves through behaviour, bringing in the learning objectives of psychomotor domain.

In the beginning of each module, learning objectives and grading criteria were given to the students. In the end of each module, the students were graded by the criteria: 60% of the grade consisted of individual deliverables on the cognitive domain (tests, reports, assignments); 15% was individual performance (affective and psychomotor) in the virtual company assessed by self-, peer, and instructor evaluation; and 25% came from team deliverables, such as the business and marketing plans, project plans and financial reports. The full year module, "The skills and competencies for working life" focusing on the affective objectives was assessed with a portfolio and a learning diary.

Using log files in the affective domain assessments

In the end of each module, the students graded themselves and their fellow students on the individual performance. They also wrote a verbal justification for the grade. The instructor made a summary of the feedback and reviewed it with each student personally in the form of an employee review. The assessment was formative and used as a basis for immediate improvement, not only as result assessment.

The instructors were able to utilize log files as one indication of student activity. They were able to get a performance data report by a student company. The report included elements, such as

- The number of master data (customers, suppliers, and products) by the individual student, by the team, and comparison to the whole class average
- The number of transactions (sales orders, purchase orders, bank transactions, and CRM activities) by the individual student, by the team, and comparison to the whole class average
- The amount of working hours reported by the student him/herself

The instructors were able to compare the student's own perception to the peer perception of the student's work and the actual work performed. This provided for a fruitful feedback discussion. In addition, the instructors were able to use the standard ERP reports, for example on sales, financial statements, and inventory to guide the student teams in their learning process. Without the log data, the instructor would have relied solely on the students' perception of the situation.

The potential of using log files in the cognitive domain assessments

The cognitive assessments were done on more traditional methods, evaluating the outcomes of the individual and team assignments. However, in the retrospective analysis of the learning environment, we came up with new ideas to utilize log files in cognitive and psychomotor assessments. We will next illustrate and analyse them.

The ERP system records every user's transactions. Different activities and phases in the business processes are time stamped. Also, error situations can be found in the system logs. These log files can be analysed, for example to see what kinds of operations the student or his/her team has done; how much time they have spent on different business activities and processes; and what kinds of errors, mistakes, or wrong decisions they had made.

To test their usability, we studied the log files by retrospectively analysing the order-to-delivery process. The process integrates many internal business functions, processes and external parties, such as customers and suppliers. When a customer orders a product, either raw materials or goods need to be ordered from the supplier. Then, an appropriate entry has to be made into the inventory so that the material/good can be delivered to the customer. Finally, the customer needs to be invoiced. The order-to-delivery process, illustrated in Figure 1, takes place entirely within the ERP-based learning environment.

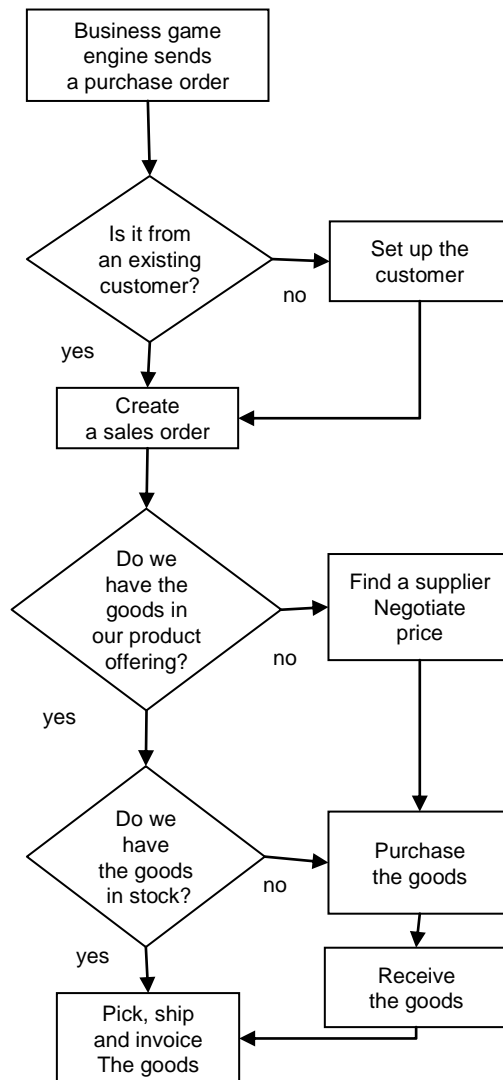


Figure 1: Order-to-delivery process in the ERP-supported learning environment.

To evaluate how the order-to-delivery process had evolved over the course of the pilot year, a sample of 111 orders from the ERP system log files were identified. The sample contained order-to-delivery chains that were traceable throughout the system. The limited sample size was due to technical challenges during the pilot program implementation. Nevertheless, it still provides an example in measuring the learning outcomes. For instance, improvements in the order cycle time, i.e., a shortening of the time period, from the purchase order creation date to the invoicing date reflected some level of learning. In fact, after the training period in October, the average order cycle time declined from 72 days down to a few days (see Figure 2).

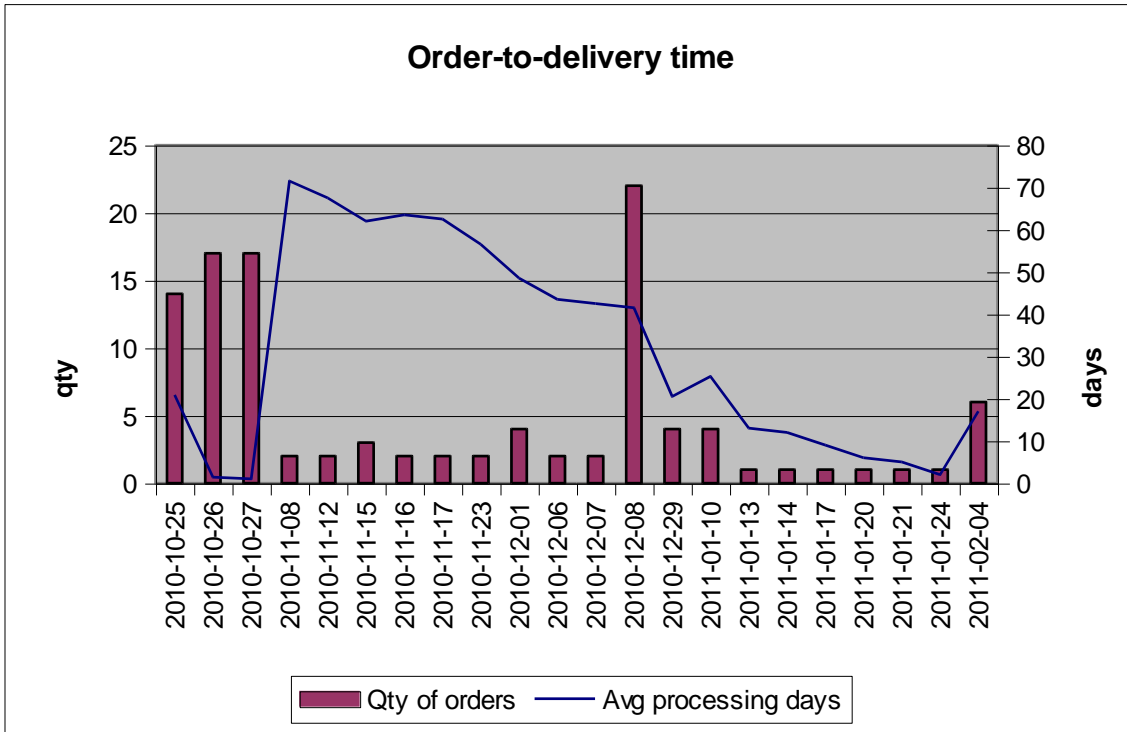


Figure 2: The weekly development of order-to-delivery time in the ERP-supported business learning environment.

The decline can be partially explained by the decreasing number of loops in the process; once a customer has been set up, the next sale activity to the same customer is streamlined. Yet, this is only a partial explanation to the lead-time reduction. One may as easily argue that the students have learned something because of the steep decline in processing times observed in December 2010. The students had learned to order supplies, update inventory, and invoice customers. The variance between the teams was also reasonably consistent throughout the year, which may correlate with the team composition. However, the sample is too small to produce conclusive, objective results on the learning effects. Despite this flaw, the approach offers new possibilities for measuring learning outcomes within computer-assisted learning environments with available log data.

Aforementioned measurement focuses on team learning, not on individual learning, as the order-to-delivery chain requires the involvement of both the sales and the logistics departments. Because the students worked in teams, extracting an individual student's learning curve is impossible. One active student can compensate another's poorer performance. Yet, this seems a

truly authentic, "in-game" assessment; it is not a test where one has to provide answers, but it demonstrates the hands-on, practical work that the students are intended to learn. They were not aware they were measured; they simply performed their work.

We identified the use of order-to-delivery measurement after the ERP-based learning environment pilot program was evaluated. The measurement requirements were not a part of the ERP-based learning environment specification, and the system was not designed to measure the entire order-to-delivery chain. To conduct this simple evaluation, we had to collect the data from many different places. This fact, obviously, reduced the amount of reliable data and the overall reliability of this evaluation. The issue could have been resolved simply by designing the measurements concurrently with the design of the learning environment and the learning process.

The potential of using log files in the psychomotor domain assessments

Similar to the cognitive assessments, we found that the log files offer interesting possibilities for assessing learning in the psychomotor domain. To demonstrate this, we did a retrospective analysis on the time spent on basic business processes: sales order, purchase order and inventory management processing. We now present how the sales order processing time developed for the whole student group.

The sales order process in the ERP system is illustrated in Figure 3. Each step in the process is logged with a time stamp. We measured the sales order processing time as the time difference between entering the order header and creating the invoice. In the simulation, 1046 sales orders qualified as valid research data¹.

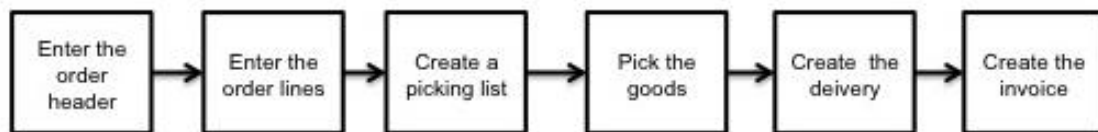


Figure 3. The sales order process in the ERP-supported business learning environment.

The average order processing time (Figure 4) declined from fifteen minutes to three minutes over the course of the academic year. As the sales order process is a straightforward and frequently repeated process in the simulation, it is logical to argue that there was some development in psychomotor skills.

¹ Of the orders, 30 were excluded because their processing time lasted several days. They were considered forgotten and not relevant for measuring the psychomotor learning objectives.

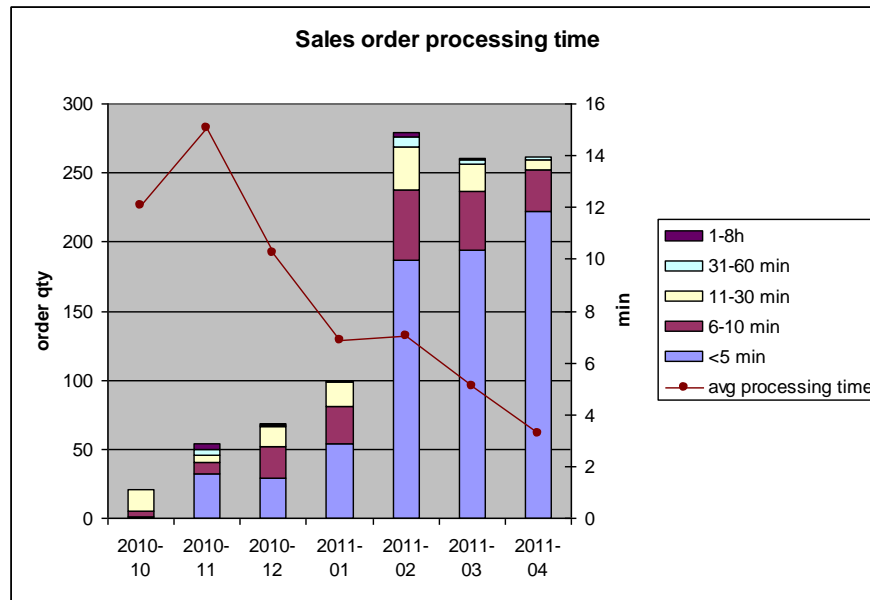


Figure 4. The sales order processing time during the simulation.

We conducted similar analyses for the purchase order and inventory management processes. Purchase order processing time declined from five to three minutes. The inventory processing time declined from 1.1 minutes to 0.6 minutes. This measurement provides an interesting angle from which to assess psychomotor learning in ERP-based learning environments: If the assessment results were presented on an individual level, the student performance could be compared with the average performance of all students. If the value were much lower than the average, we could drill down the process further to see if a particular part of the process is challenging and give the student guideline to additional learning. Another interesting source of analysis would be error logs: does the student have more errors than the average of all students? Are the errors concentrated on a specific area? Again, these equip the instructor with new methods to guide the student's learning efforts.

This measurement reflects the same benefits and challenges as the earlier order-to-delivery cycle analysis. Our analysis was not a separate test but measured genuine work. Contrary to the order-to-delivery chain, an individual student controlled this chain, enabling individual level measurement. Additionally, because the sales order process was simpler to measure than the entire order-to-delivery process, the standard ERP-system reporting tool provided reliable measurements. However, the concept measured – order processing time – is also much simpler.

V. DISCUSSION, LIMITATIONS AND FURTHER RESEARCH

Learning business management is much more complex than acquiring a set of theories or individual learning topics [Chia, 2008]. Assessments should reflect that diversity. Instead, they have traditionally focused on cognitive outputs and affective self-assessments. It is beneficial to use multiple methods for assessment to create a comprehensive picture of the student's learning.

Simulation performance is not necessarily an appropriate measure of learning because mistakes lower the business success [Gosen and Wasbush, 2004]. But in fact, mistakes may be the best learning situations. Also, simulation performance is a result of team efforts. An individual student may learn poorly even if the team's business is doing well or vice versa.

The log file activity levels can indicate affective learning [Zhang, 2015; Wolfe, 2013a; 2013b]. They are free from the bias of the self-assessments noted by Picard et al. [2014]. Following Thavikulwat's [2012] idea of measuring learning curves through the simulation company life span, we expanded the log file perspective to time spent in each process to get indications also of the cognitive and psychomotor learning. The initial results appear promising: the development of skills can be detected through a simple log file analysis.

The log data does not give a comprehensive picture of the student's involvement in the simulation. It is possible that the student is active in the ERP simulation business transactions but takes a more passive role in the discussions, decision making and role-play that happens outside of the ERP system. Also, the activity in the simulation does not necessarily result in learning. That is why these measurements need to be complemented by other self-, peer, and instructor assessment methods - thus following Cronan's [2011] suggestion of triangulating with several methods. This type of a 360 assessment also reflects the performance assessments in real business life: the employees may be assessed by their managers, their peers and also by their concrete performance.

The log data holds potential for formative assessment. Master data entries as well as business and bank transactions indicate the student's engagement in the learning environment. In the case example, instructor was able to check whether the student is active or passive, and provide feedback during the learning process accordingly. Additionally, detailed process logs could be used to detect how the students perform on individual tasks. The amount of time a student spends on a process could be compared to the average time and potential learning challenges could be detected. We measured the time an individual student spent on sales order, purchase order, and inventory management to see skill development on individual business processes. Such log data is easily extracted from a standard ERP system. Similar measurements could be used as an indication of learning also in ERP systems training.

Activities and processing times in more complicated processes that involved more than one student, such as order-to-delivery, were more difficult to extract from the system, but they could provide interesting insights into the team behaviour and learning. The processing times could be compared with other teams. They could also be basis for analysis and discussions within the simulation teams. Error logs were not utilized in this study, but they could provide information about where the students need assistance. That remains a potential area for further research.

We have not checked how the individual processing times or quantities correlated with the student's learning outcomes measured with traditional, external assessments. That would also be an area for further research.

The evaluation of learning outcomes lacks rigor if available tools are not able to provide adequate amounts of reliable data. This is often a challenge when developing and piloting new systems and environments [c.f. Pekkola, 2003]. Therefore, the learning assessments can best be implemented after a pilot phase. Nevertheless, the measurements should be designed simultaneously with the pilot project design [c.f. Oinas-Kukkonen et al., 2010] to enable reliable data collection on the students' activities. This requires long-term projects to create and implement reliable and accurate learning systems with built-in measurement features.

VI. CONCLUSIONS

Assessment is an important part of the learning process. The industry requirement for business competencies calls for authentic learning tasks, environments, and also authentic assessments [c.f. Nisula and Pekkola, 2012]. The diversity of business operations emphasizes the importance of evaluating learning from many perspectives. In addition to being authentic learning environments, ERP-systems and business simulations collect data of the learning process and offer monitoring capabilities. Student involvement in a business simulation is very important for the student's learning, and yet the activity levels have received relatively little research attention

[Zhang, 2015]. In this paper, we have studied how log files, generated by the ERP-based business learning environment, can be used in assessing student involvement and learning. As a result, we offer the following contributions:

- Business management requires a complex combination of knowledge, attitude and skills. This article contributes to the discussion of how to expand the assessment of those skills from the narrow focus of cognitive outputs and self-assessments to include objective, concrete performance measurements. So far learning evaluations in business simulations have concentrated on perceived cognitive learning or attitudes towards the learning environment [Anderson and Lawton, 2009]. We have taken a step further and collected a set of methods that would be suitable for assessing different levels of affective and psychomotor domains.
- The log files provide a useful addition to the traditional assessment methods business learning in all domains of Bloom's taxonomy. Student skill weaknesses and motivation to engage with the simulation are some of the key issues of simulation assessment [Vos, 2015]. The log file data from the business processes and transactions of the ERP systems and business simulations provides material for embedded assessment. It can bring valuable insights into the learning, supplementing the subjective perspective of self-assessment. It also provides a concrete perspective for reflective discussions. Affective learning can be detected from *how active* the students are in the simulation. Cognitive and psychomotor learning can be indicated through *how well* the students perform in the simulation activities. In particular, these measurements are useful as formative tools to guide the students already during the learning process. The more passive students can be encouraged to participate more, whereas the students making mistakes or taking longer time than average, can be instructed appropriately.
- The ERP-supported business learning environment enables business learning. The log file analysis showed significant decrease in the processing time, indicating learning in the cognitive and psychomotor domains.
- The assessments need to be part of the learning environment design from the very beginning. Assessment strategies in business simulations have received little attention even if they are an important part of the learning experience, [Vos, 2015]. When learning and assessment strategies are planned together, the assessment becomes a natural part of the simulation and the infrastructure can be built to support the assessment activities.

Log files in computer-assisted business learning environments propose interesting potential for assessment purposes. The learning objectives and the assessment angle have to be included in the process early on as the environments are being developed. Data produced by the systems does not replace traditional assessment methods, but rather it presents a valuable addition to evaluate the students' learning and support their learning process even better.

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