Closing the university-business gap: model of blended learning for the collaborative design of learning resources

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***Abstract**: In this work-in-progress paper, we provide the first results obtained from a research project on the design of digital learning resources for blended learning in both academia and industry. Using design based research methodology, we engineered an e-learning module for an introductory course in geostatistics, in real world settings and in collaboration with faculty members from university and instructors from industry. The learning resource, a self-paced tutorial, has been used for blended learning in several institutions: one engineering school, three engineering companies and one public research institute so far. In this paper, we put together the quantitative data we collected from the learners in both contexts. In particular, we provide some comparative statistics on their characteristics, their satisfaction level and their perception of e-learning. We also describe the preliminary Structural Equation Model (SEM) built from the Exploratory Factor Analysis (EFA).*

Introduction

Although Higher Education Institutions (HEIs) and companies have different objectives, organizations, and cultures, they hold similar learning and development necessities to grow engineering minds. According to the Hippo Study (Davey, Baaken, Galan Muros and Meerman, 2011) two third of HEIs undertake University-Business Collaboration (UBC) activities, and technology and engineering have the highest level of UBC. However, the most common kind of cooperation are rather of a transactional nature (Aggarwal and Vernaza, 2012; Crepon, 2013; Davey et al., 2011; Hughes, 2001; Laux and Razdan, 2009; Science Business Innovation Board, 2012). Few research is available on the collaborative design of instructional material which could be used for blended learning in both academia and industry (Crepon, 2013). The collaborative design of such digital Learning Resources (LRs) is deemed able to organize the exchanges between faculty and professionals and to set instructional goals oriented towards the entire population of learners in initial and continuing Engineering Education (EE). Through Community of Practice (CoP) (Wenger, McDermott, and Snyder, W. M., 2002), by working jointly, faculty and instructors would learn from “teachers professional craft knowledge”, would expand their perception of the body of knowledge and of its application, and would open themselves to outside perspectives (professional associations, events, seminars…). In contrast with the Learning Objects (LO) paradigm where the reuse of the resources was almost reduced to technological aspects (Elliott & Sweeney, 2008; Jenni, 2009; Polsani, 2003; Wiley, 2002), our research question became: how can we design learning resources, specifically multimedia based ones, to guarantee their effective use in two different and identified contexts? The main intent of this publication is to account for learners’ feedback during the main phase of the research. We put together the quantitative data and we describe the preliminary Structural Equation Model (SEM) built from the Exploratory Factor Analysis (EFA). The theoretical and practical implications of these results will be published in later reports.

The research project

The research project is aiming to make explicit the assumptions and decisions for the design of digital learning resources that would support blended learning in both academia and industry. We plan to use our grounded observations and their theoretical implications to grow the knowledge on the influence of the academic and corporate contexts on the design of instruction for blended learning. Hopefully, the research outputs would help instructional designers to conceive, develop, reuse and even ease the financing of purposeful learning resources between HEI and companies, and/or between the public and the private sector.

Previous research work resulted too global and abstract to be useful in the particular UBC context. As a consequence, we decided to use Design Based Research (DBR) methodology (Crepon, 2014b), firstly called “design experiments” by Brown (1992) and Collins (1992), then “development research” (Van den Akker, 1999) or “formative experiment” (Newman, 1992) to design and study an innovative solution to educational problems at the same time (McKenney and Reeves, 2012; Johri and Olds, 2011). We have engineered an e-learning module in geostatistics (Crepon, 2014a), in real world settings and in collaboration with faculty members from university and instructors from industry. It has been used for blended learning in several institutions: one engineering school, three engineering companies and one public research institute so far. The LR, a self-paced tutorial, was asked to be completed by the learners before traditional class at university and before training in the companies (Fig. 1).

The research is conducted on interventions, that is to say directly on the methods we used to design the educational resource (McKenney and Reeves, 2012). As a result, the investigation involves a set of mixed research methods, both quantitative and qualitative, to gather and analyse data: interviews, questionnaires and also web analytics to understand how the learners used the resource online. In this paper, we study the information collected from the learners via questionnaires (Fig. 2).

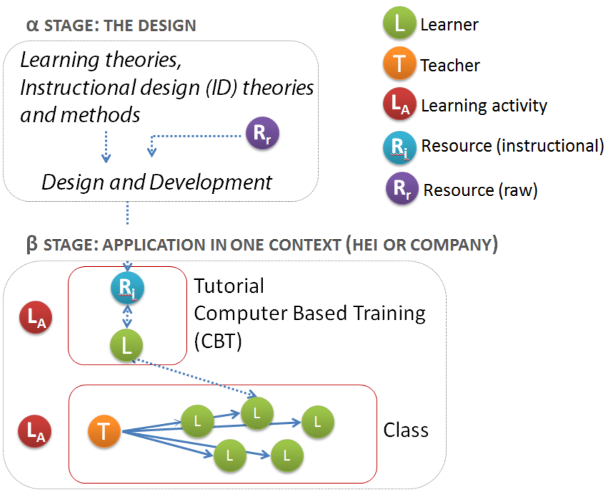

Figure 1: blended learning and instruction

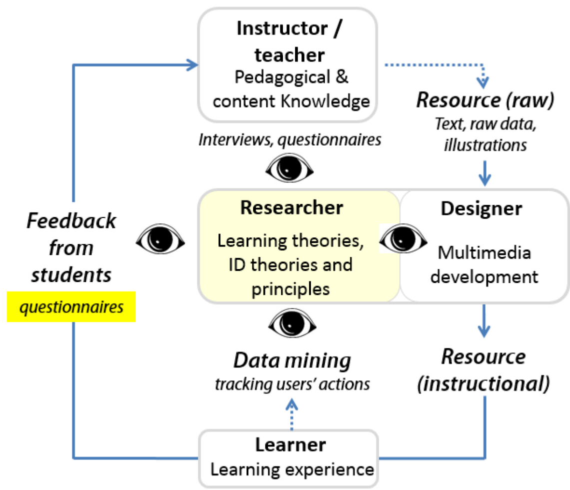

Figure 2: the mixed research methods

The different phases of the study

During a first meso-cycle called “prototyping” in Table 1, we created an initial design with the help of one university teacher and one professional trainer from the industry. We tested the prototype on 79 students and 7 employees. After this first successful application, we decided small design adjustments and we enhanced the data collection system. Indeed, we improved the tracking system to collect users’ interactions and revised the questionnaires with the help of professionals from the e-learning field, from the EE field and from the research field in EE.

Our second meso-cycle called “analysis and reflection” in Table 1 is the evaluation phase of the study corresponding to the empirical testing that is done with the advanced design. It covers six blended courses, two at HEI and four professional trainings, including one training hold in a research institute. The study represents 96 learners, from which 72 students and 24 employees (see Table 2), distinct from the prototyping phase. The current work-in-progress paper provides the first evaluation on how the learners may differ in terms of their characteristics, satisfaction and preferences.

Table 1: the main phases of the DBR. Adapted from the generic model for design research described by McKenney and Reeves (2012)

Analysis and exploration	Design and construction	Evaluation and reflection	Design and construction	Evaluation and reflection	Analysis and exploration
Micro cycle	Micro cycle	Micro cycle	Micro cycle	Micro cycle	Micro cycle
	Meso cycle “**prototyping**”			Meso cycle “**analysis and reflection**”	
Research question Literature review	First design and improvement Test of the research methods (data collection)			Empirical testing of the refined design with validated methods	
	72 students / 7 employees, 5 courses			72 students / 24 employees, 6 courses	

As show in Figure 2, the learners were given the questionnaires, in paper format, at the end of the last class or training session. The questionnaires measure categorical, continuous and discrete variables (see Table 3). Most of the true ordinal variables related to subjective rating (such as the users’ level of satisfaction) were measured with five-level Likert items and have been treated as discrete variables for their use in statistical analysis (Field, 2012).

Table 2: Groups and data collected for the evaluation phase of the study

Course Code	Institution	Number of learners	Number of users		Feedback from learners	
			N	%	N	%
6	Company A	7	7	100	7	100
7	University A	30	30	100	27	90
8	University A	42	29	69	24	57
9	Company B	6	4	67	4	67
10	Institute A	6	5	83	6	100
11	Company C	5	5	100	5	100
Total		**96**	**80**	**83%**	**73**	**76%**

Analysis of the quantitative data

In this part, we put together the quantitative data and we describe the Exploratory Factor Analysis (EFA) used to build our preliminary Structural Equation Model (SEM).

The learners

Hereafter, we provide some relevant information on the learners. First, the median age is 23 to 25 years old for students and 35 to 39 years old for employees. In addition, we used five-level Likert items to measure the preferences of the learners. Considering the e-learning tutorial, students (M = 3.73), are significantly more satisfied than employees (M = 3.34), U = 383, z = -2.1, p = .033, r = -.25 (with a small to medium effect size). Besides, we find that global satisfaction is related to the perception of the amount learnt. The coefficient of determination R^2 between the two variables is 0.29 for university and business together. Interestingly, we also find a significant relationship between the global satisfaction level and the fact that learners think the module made them confident to participate in class (r = .4, p < .003, BCa 95% Confidence Interval = .2 to .6 for students, r = .54, p < .007, BCa 95% Confidence Interval = .2 to .8 for employees). Finally, while 53% of students can estimate how often they will use what they learnt, 74% of the employees do. We called this measure the “perceived usefulness”.

In addition, we asked the learners how much time they would spend to prepare for one day of class. This is how we measured “dedication to learning”. There is no statistically significant difference of means of time learners are ready to spend between university (N = 47) and business (N = 21) (p > 0.05). On average, all learners, from academia and industry, are ready to spend M= 46 min, 95% CI [38, 54], respectively 43 min for students and 51 min for employees. Considering the capacity to dedicate some time for self-learning, we asked if it was easy for them to complete the module on a five-point rating scale. We used the Mann-Whitney test to compare the two independent conditions (the academic and professional context). For students (Mdn = 4), it was significantly easier to dedicate some time than for employees (Mdn = 3), U = 308, z = -3.1, p = .002, r = -.36 (medium effect size). To finish, whereas 94% of students completed the e-learning in the evening or during the week-end (78% at home), 59% of employees did the e-learning during working hours (68% at the workplace).

The three-factor model

In the context of our study, the objective of the EFA is to explore the data and to identify clusters of variables that would represent explanatory constructs, also called factors or latent variables that can't be measured directly. We are interested in determining how well the items relate to each other in indicating learner's attitude towards the e-learning module and more generally towards blended learning. Doing so, we reduce the data set to a more manageable size while retaining as much of the original information as possible (Field, 2012).

Table 3. Summary of EFA results for the questionnaire (*N* = 73*)*

Rotated Factor Matrix[a]

Item	Factor1	Factor2	Factor3
1. Are you satisfied with the e-learning tutorial?	**,748**	,070	,056
2. How much did you learn from the e-learning tutorial?	**,606**	,240	-,035
3. "The module in geostatistics makes me confident to participate in class"	**,537**	,184	,130
4. "The completion of the module should count for my grade"	**,428**	-,105	,093
5. "The module in geostatistics is exhaustive, with all the same detailed explanations as in books"	**,421**	-,101	-,045
6. "An e-learning tutorial should create interaction with the data, with the key concepts"	-,022	**,849**	,076
7. "An e-learning tutorial should explain the main concepts and their relationships"	-,095	**,523**	,222
8. "An e-learning tutorial should include exercises with feedback for self-assessment (quizz)"	,342	**,426**	-,119
9. "An e-learning tutorial should provide a printable file for future inquiries"	,025	-,020	**,626**
10. How much time are you ready to dedicate for your preparation to one day of class?	,197	,221	**,567**
11. "The practical examples and exercises should be reviewed during class"	,086	,130	**,469**
12. Age (5 points scale)	-,150	-,271	,373
13. Was it easy to dedicate some time in order to complete the e-learning module before class?	,335	,334	-,364

Extraction Method: Principal Axis Factoring.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 21 iterations.

Bold values above the criterion level of 0.4.

A principal axis factor analysis was conducted on the 13 selected items with orthogonal rotation (varimax). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .636 (above "mediocre" according to Hutcheson & Sofroniou cited in Field (2012)), and all KMO values for individual items were above the acceptable limit of .5 (Field, 2012). An initial analysis was run to obtain eigenvalues for each factor in the data. Four factors had eigenvalues over Kaiser's criterion of 1 and in combination explained 41.6% of the variance. The scree plot showed an inflexion point at factor 4. We decided to retain 3 factors because of the limited sample size and the convergence of the scree plot and Kaiser's criterion on Factor 4. The first three factors in combination explain 36.4% of the variance. Table 3 shows the factor loadings after rotation.

The items that cluster on the same factor suggest that Factor 1 represents “learning perception”, Factor 2 represents “expectations towards e-learning”, and Factor 3 represents the “persistence over time”. Hereafter, in Fig.3, is the general model built from the EFA analysis. The results indicate that the hypothesized model reasonably represents the data: CMIN/DF = 1.2, CFI = 0.861, TLI = 0.81, RMSEA = 0.053 90% CI [.0, .089], PCLOSE = 0.436.

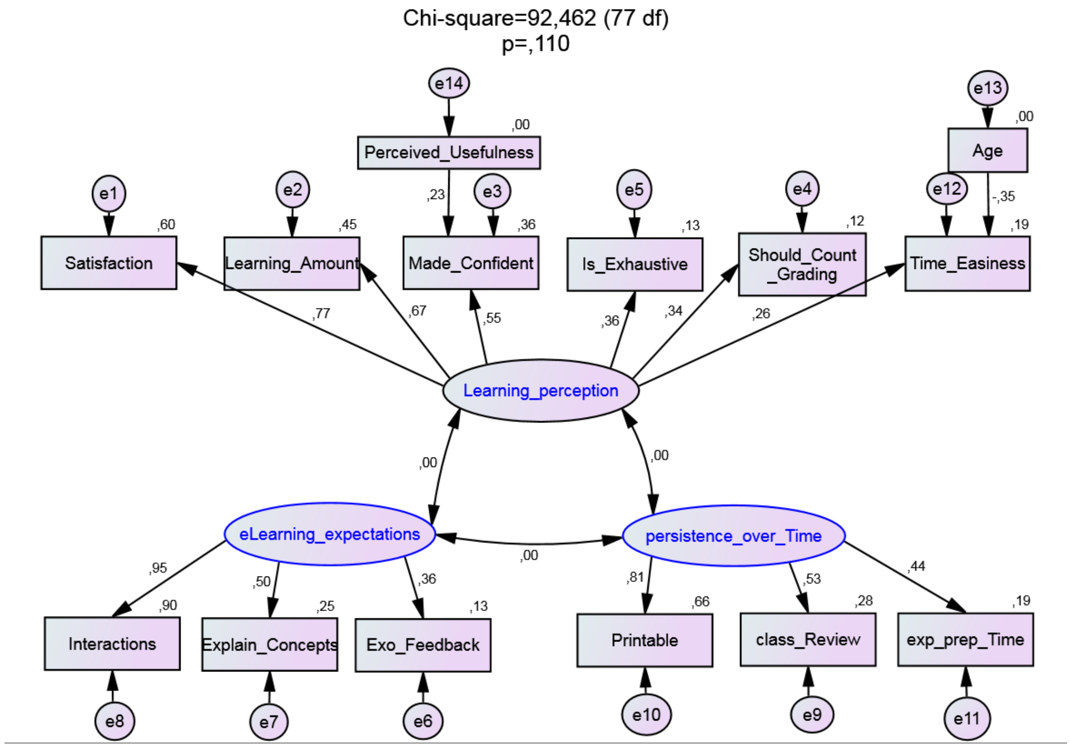

Fig. 3. General model of the items clustering on the three latent variables

In order to understand better the differences between University and Business, we carried out some additional comparison tests between the means of factor scores for the two populations (see Table 4). These results confirm the fact that employees are less satisfied of their learning (perception), they also have less expectations on e-learning but do persist more over time for learning to happen.

Table 4. Comparison tests between University (U) and Business (B) on factor scores

	U	B	Mann-Whitney test		Kolmogorov-Smirnoff		t-test	
Factor1	*M* = 0.18	*M* = -0.42	*U* = 370 *z* = -2.3 *p* = .022 *r* = -.27	**Significant, medium effect size**	*D*(22) = 0.163 *p* = .134	did not deviate significantly from normal	*t*(71) = 2.41 *p* = 0.019	**Significant, medium effect size (*r* = 0.27 and *d* = 0.59)**
Factor2	*M* = 0.11	*M* = -0.27	*U* = 395 *z* = -2 *p* = .046 *r* = -.24	**Significant, small effect size**	*D*(22) = 0.153 *p* = .196		*t*(71) = 1.5 *p* = 0.137	**Not significant, small-sized effect, *r* = 0.17 and *d* = 0.38**
Factor3	*M* = -0.23	*M* = 0.54	*U* = 823 *z* = 3.15 *p* = .002 *r* = -.37	**Significant, medium effect size**	*D*(22) = 0.189 *p* = .04	**deviate significantly from normal**		

Discussion and conclusions

So far, three engineering companies, one public research institute, and one engineering school used the module in distinct programs. This diversity of applications illustrates the relevancy of DBR to account for contextual factors and subjective aspects which are at play in the design and implementation of innovative educational practices in real world settings (Cohen, Manion and Morrison, 2011; McKenney and Reeves, 2012; Newman, 1992; Johri and Olds, 2011).

In the context of our research, we are interested in the differences between the populations of learners, respectively students and employees. First, even if we observed that employees find more difficult to dedicate some time to self-learning (medium effect), employees are less satisfied by the e-learning experience but only by a small to medium effect size. The construct of "learning perception" suggests that the difficulty to dedicate some time is counterbalanced by the fact that employees do project a potential use of what they learn. The underlying explanation might be found in the "readiness-to-learn" principle of adult learning theories. According to Knowles, Holton, and Swanson (2012) "adults become ready to learn those things they need to know and be able to do in order to cope effectively with their real-life situations".

With respect to e-learning expectations, we find one item related to subject-specific and cognitive learning and two other items related to multimedia. On the one hand, it is no surprise to find didactical aspects linked to the e-learning construct. First of all, the module is a tutorial for self-learning. On the other hand, multimedia application allows visualization and interactivity to illustrate the scientific concepts along with short loop feedback (Mayer, 2009, 2014). The fact that students have slightly more experience with e-learning might explain their higher expectation level (25% of students already experienced blended learning against 14% for employees).

The third construct called "persistence over time" is a little bit difficult to analyse. So far, we perceive a relation to time-related aspects of learning. Being able to print the module content implies future expected use of the material. In addition, this construct includes the request to review the exercises in class (similar to the flipped classroom concept) and the time dedication to learning (expected preparation time). Employees rank high in this construct making us think employees call for integrated learning, meaning that e-learning and class delivery should be implemented in a harmonious way, suggesting continuity and a more diffuse use at the workplace. These considerations are associated with the fact that every learning experience is embedded within a natural, social and material context (Robbins & Aydede, 2009). Situated cognition theories are deemed relevant theoretical framework to further analyse the influence of the embedding context on students' and employees' learning.

Finally, the completion rate of 83% overall is promising in respect with collaborative design for EE material. Hopefully, this research will contribute to many more collaborations between teachers and instructors, contributing to close the gap between University and Business.

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