Using common Learning Resources in Academia and Industry
From Practice to Theory

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INTRODUCTION

Higher Education Institutions (HEIs) and companies hold similar learning and development necessities to grow engineering minds. However few research is available on the collaborative design of instructional material which could be used in both contexts [1]. In 2011, we started a research project to understand how the academic and corporate environments influence the way a learning resource is used by students and employees in Engineering Education (EE). More particularly, we are aiming to make explicit the assumptions and decisions for the design of digital Learning Resources (LRs) that would support blended learning in both academia and industry. The research question is: how can we design learning resources, specifically multimedia based ones, to guarantee their effective use in two different and identified contexts? In this paper, we give some background information on the research and we describe the analysis we carried out in order to characterize the two populations of learners in academia and industry, namely students and employees. Then we relate these observations to three theoretical frameworks: adult education, multimedia learning and situated cognition.

1 RESEARCH METHODOLOGY AND FIRST RESULTS

To investigate the design and use of a common resource for blended learning in HEI and industry, we decided to set innovative educational practices and to study them at the same time. For that, we used the Design Based Research (DBR) methodology [2], also called development or formative research, in order to engineer an e-learning module in geostatistics [3], in real world settings and in collaboration with faculty members from university and instructors from industry. The LR, a self-paced tutorial, has been used for introductory courses in geosciences in several institutions: one engineering school, three engineering companies and one public research institute so far. The investigation involved 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. The study presented in this paper 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 1).

Table 1. Groups and data collected for the main 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%**

1.1 The learners

In this section, we study the information collected from the learners via questionnaires. 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 (see Fig. 1). 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) (see Fig. 1).

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”. These proportions fluctuate from 40% to 86% depending on the kind of academic and corporate course learners are engaged in. In any case, employees from companies display higher percentages than students with the exception of the public research institute (see Fig 2).

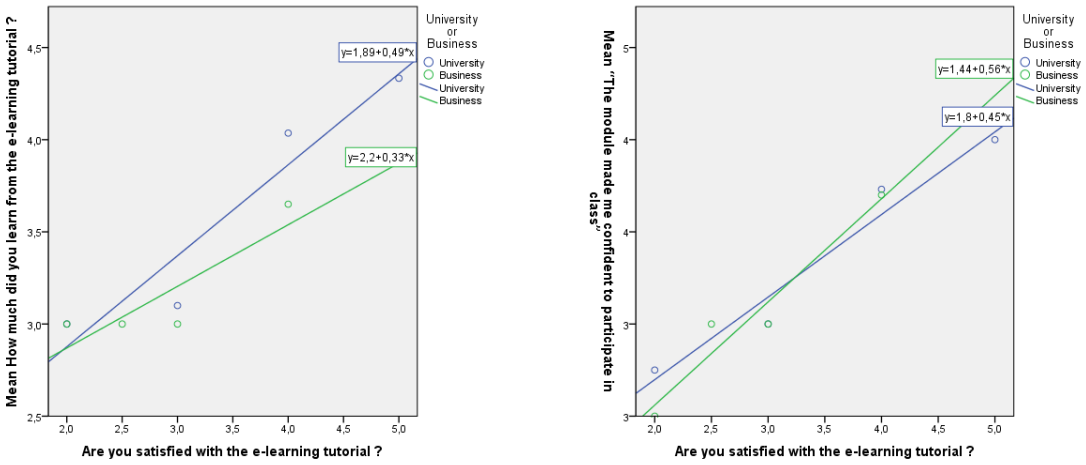

Fig. 1. Variables related to general satisfaction

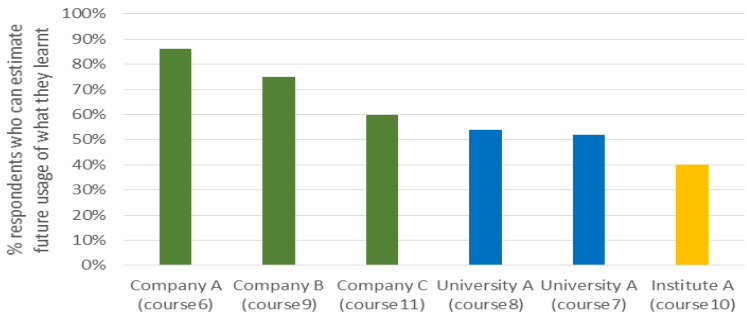

Fig. 2. Dispersion of the "perceived usefulness" across courses

In addition, we asked the learners how much time they would spend to prepare for one day of class. This is how we measured the "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. Employees expressed some difficulties to find time to complete the e-learning. 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).

1.2 Analytics

In this section, we study the information collected from the learners via web analytics. Out of the 96 learners (72 students and 24 employees), 80 learners used the module. It represents a completion rate of 83% overall, 94 hours of online learning and a mean duration of usage of M = 70 min, *95% CI* [59, 81]. Even if on average, employees used the module 77 min and students 68 min, no statistically significant difference has been found between university and business (see Fig. 3).

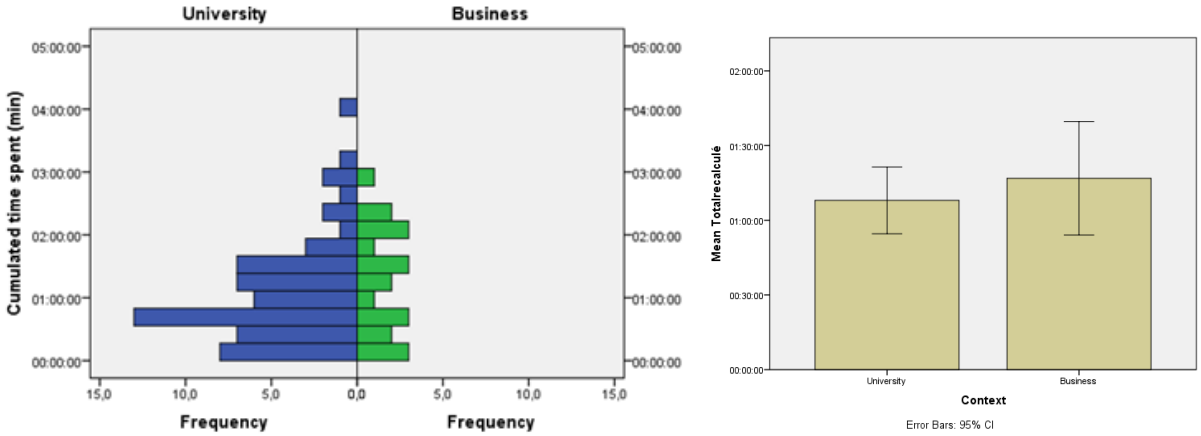

Fig. 3. Comparison of the usage duration between students and employees

The completion rate of the two embedded quizz is 91% for students and 67% for employees. The difference of scores between students and employees is not statistically significant. Both populations scored the same.

2 EXPLORATORY FACTOR ANALYSIS (EFA) AND STRUCTURAL MODELING

In this part, we are aiming to link our observations to principles and more general theories.

2.1 Qualitative analysis

First, we start with the analysis of the learners' verbatim. The items fall in two different categories: a) related to the learning content, and b) related to the e-learning module (see Table 2).

Table 2. Main qualitative feedback per category

	Learning content	**e-learning**
Strengths	• Short explanations, summarized • Easy, simple • Well explained • Clear • "Provides details on basics I wouldn't dare to ask" • Good exercises	• Easy to use • Very interactive • Illustrative • Well organized, good presentation quality • Self-assessment (Quizz), self-learning, convenient • Adapted to three day class
Weaknesses	• Too short, more explanations are required, reference books, recalls on statistics (attached file) • Can be simplified • Add applied examples from the company	• Not easy to use (issues with opening Excel from company network) • Add more interactive explanations, more exercises with instantaneous feedback • Inform better and earlier on blended format • Scaffolding: can't ask to teachers about the exercises, need to ask some questions • E-learning and class shouldn't replicate the same teaching • Took longer than 40min

These two categories include some contradictory feedback depending on the respondent. The conciseness of the module explanations and the level of complexity of the learning content is subject to users' appreciation. Some users considered the conciseness of the module to be a strength and others a weakness. At this stage, we miss a path model with causal effects between variables in order to explain how these preferences are linked to other observed variables and personal attributes. Considering availability concerns for self-learning, it became very interesting to discover that even if employees claim it was difficult for them to find time, at the end, they spent the same amount of time, if not more, studying with the module. This complex relation with regards to time dedication makes us think that a more structured construct with more than two sub-components might be at play in the way people apprehend e-learning and blended learning.

2.2 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 [4].

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

Rotated Factor Matrix[a]

Item	Factor 1	Factor 2	Factor 3
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 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 [4]), and all *KMO* values for individual items were above the acceptable limit of .5 [4]. 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.

2.3 Towards a University Business Model of Blended Learning

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". In order to build a path model related to Factor 1, we used the cluster of variables leading to Factor 1 and added two variables: the "perceived usefulness" we discussed previously and the expectation to include more examples from the industry. The resulting model is represented in Fig. 4 and the results indicate that the hypothesized model adequately represent the data: *CMIN/DF* = 1, *CFI* = 0.999, *TLI* = 0.997, *RMSEA* = 0.009 *90% CI* [.0, .154], *PCLOSE* = 0.532.

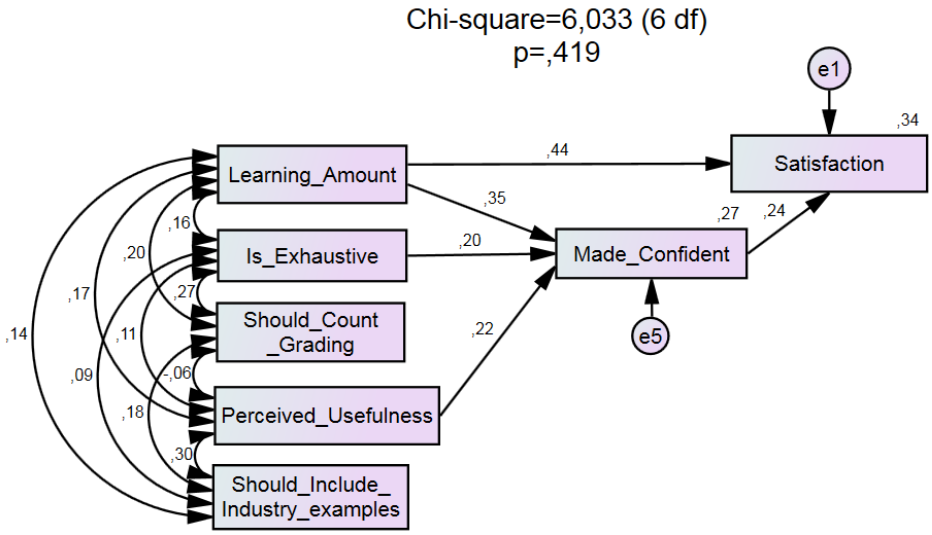

Fig. 4. Model of the relations between the observed variables linked to the subscale construct relative to Factor1.

This model, which is a good fit of the data set tells us that the level of satisfaction is related to the amount of learning perceived by the learner, and also to his/her level of confidence to participate in class. This confidence level is, in its turn, related to the amount of learning perceived by the learner, the comprehensiveness of the e-learning module, and the "perceived usefulness" of what is been taught. The concern to bring examples from the industry and to count the Quiz results for grading are also related to these predictors.

In Fig.5, 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.

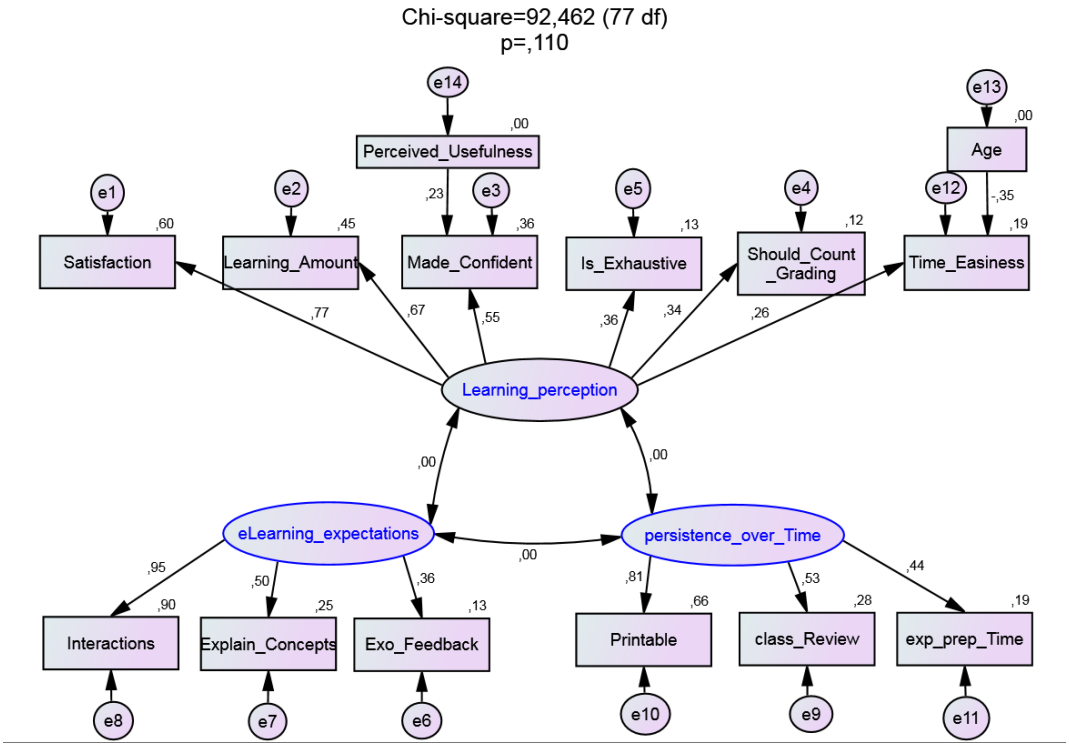

Fig. 5. General model of the items clustering on the three latent variables

Now, with this general model in mind, we contemplate the possibility for the module conciseness, the complexity level and time to vary between the populations and even affect two different subscale constructs at the same time. For instance, the time is first related to the perceived "easiness" to dedicate some time which plays a role in global satisfaction ("learning perception" construct), and second to the time learners are ready to dedicate ("persistence over time" construct).

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).

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**		

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.

3 DISCUSSION AND CONCLUSIONS

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 (remember Fig. 2). The "perceived usefulness" makes them confident and increases their satisfaction level (see Fig. 4). The underlying explanation might be found in the "readiness-to-learn" principle of adult learning theories. According to [5] "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 [6, 7]. The fact that students have slightly more experience with e-learning might explain their higher expectation level.

To finish, 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 [8]. Situated cognition theories are deemed relevant theoretical framework to further analyse the influence of the embedding context on students' and employees' learning.

So far, the e-learning has been successfully used in academia and industry. The understanding of the present research results in addition to the study of their relation with the previously mentioned learning theories will enable to devise principles for the design of common resources between HEI and industry and for blended learning in EE.

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