NET BENEFITS OF FACE-TO-FACE VERSUS ONLINE INSTRUCTION AT SCHOOL: A REPETITIVE FACTORAL EXPERIMENT IN AN ECOLOGICAL SETTING

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ABSTRACT

Within the field of e-learning, numerous studies focus on the benefits of online delivery systems and tools for learners. Nevertheless, there is still limited understanding of why learners perform better or worse and experiments are only rarely the method of inquiry. This study reports on findings of a repetitive factoral experiment in an ecological setting with 151 secondary school pupils in order to scrutinize crucial determinants for perceived and observed benefits of two delivery modes: face-to-face versus online instruction. For these purposes, the study incorporates the DeLone and McLean's information systems success model, extended to cover perceptions of enjoyment. The findings show that pupils' performance in the e-learning condition is significantly poorer than in the face-to-face condition. The results further point to the dominant position of perceived enjoyment as a determinant of satisfaction and e-learning preference. By examining system and individual antecedents of learning performance in an experimental design, we contribute to the body of knowledge regarding online learning effectiveness. The study's limitations and opportunities for further study are discussed.

KEYWORDS

Learning Performance, Online Instruction, Secondary Education, Delone & Mclean, Factoral Experiment

1. INTRODUCTION

In the past decade a lot of research effort has been put in explaining e-learning success in terms of learning performance and (continued) deployment of systems by individuals and organizations. Despite the increasing attention, there is limited understanding of why learners, especially pupils within secondary schools, perform better or worse, or how their personal preference for online or offline approaches is affected.

In this paper we describe an experimental study focused on the beneficial outcomes of a particular e-learning (EL) approach in a secondary school, as compared to a more traditional offline approach, and on assessing potential influencing variables related to the EL system and individual characteristics. The study was initiated by a group of Belgian secondary schools, searching for evidence about the benefits and drawbacks of the EL system they had been using for several years. In order to keep up with the fast pace of technological change and to better adapt to the learning needs of the 'millennium learners' (Ananiadou & Claro, 2009) the headmaster conveyed a sense of urgency to employ the wide range of tools available at the schools in order to create a more attractive and effective learning environment. A comparative perspective of delivery formats was preferred: face-to-face (F2F) versus online (EL). Despite existing publications on such comparisons (e.g. Abdous & Yoshimura, 2010; Jang et al, 2016), none of them give sufficient information on how to design e-learning, using the available tools in the virtual learning environment (VLE) Smartschool, with the purpose of improving or at least not reducing pupils' learning outcomes and satisfaction. In addition, there is a shortage of relevant experiments in real-life school settings in studies regarding the impact of educational technology, due to organizational complexity (Grubišić et al, 2009) or ethical issues.

For the purpose of understanding individual differences in benefits of using an e-learning application, Delone and Mclean's Information System's success model (ISSM) offers a well-established approach, suited to be used to evaluate both mandatory and voluntary use of a multitude of information systems in various

types of organizations and contexts. Contrary to a behavioral model like the Technology Acceptance Model (TAM), the ISSM concentrates on the evaluation of actionable system and information characteristics (Wixom & Todd, 2005). The model corroborates that the system, information, and service quality of an information system are the key dimensions affecting users' intentions or actual behavior and their satisfaction. In their latest model (Delone & McLean, 2003), the construct of 'net benefits' is proposed as a key dependent factor, influenced by intention to use and satisfaction (Figure 1).

Although the ISSM has been deployed to study a plethoria of ISs (including enterprise systems, and e-commerce and e-government systems), some studies also used the ISSM in an e-learning context (e.g. Aparicio et al, 2017; Daghan & Akkoyun, 2016; Wang et al, 2007; etc.). The findings indicate the importance of system and information quality and learners' satisfaction as drivers of e-learning success.

However, most of these reports target higher education students and analyze learners' perceptions by means of a cross-sectional survey. In addition to a shortage of experiments in real-life school settings, we further observed a limited understanding of the objective and subjective nature of the net benefits related to EL system usage. To our knowledge, previous contributions did not scrutinize antecedents of both learners' performance (objective measure) and learners' perceived benefits (subjective measure), and their interrelationships. We therefore propose to extend the ISSM with particular components and to apply it an experiment in an ecological setting, using a comparative approach.

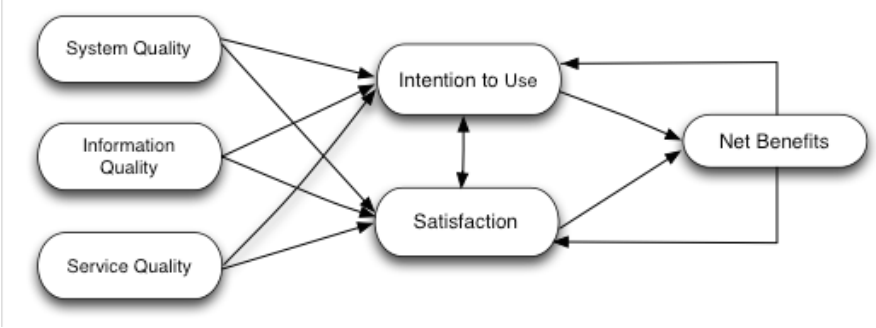

Figure 1. The Information Systems Success Model (DeLone and McLean, 2003)

In the following, we address 2 main research questions: 1) Do secondary school pupils benefit from online instruction when compared to face-face instruction? And 2) Which factors contribute to individual differences between pupils in terms of net benefits?

2. METHOD

2.1 Research Design

We conducted an experiment in a mid-sized secondary school in Belgium as a first iteration in design-based research, 'a methodology (…) that seeks to increase the impact, transfer and translation of education research into improved practice' (Anderson and Shattuck, 2012: 16). Following Grubišić et al. (2009), we opted for a factoral experimental design in which two or more parallel groups and two or more cycles are created (Figure 2). Each teacher taught the same course content using two delivery methods: online and face-to-face. So pupils followed two lessons, one online and one face-to-face. Immediately after instruction, their learning performance was assessed by means of a written test.

We strongly advocate the use of the factoral experiment with two parallel groups and two cycles in order to overcome typical biases due to undesired group or topic effects. As Grubišic´et al. (p. 595) pointed out: '*If we find that in each cycle one and the same factor is more efficient than the other, then we can conclude that a certain factor is better regardless of a difference between taught domain knowledge. In the same way, if the same factor is more efficient in each cycle, in spite of the groups that it has been introduced in, then we can conclude that a certain factor is better regardless of a difference between the groups.*' A repetition of such a factoral approach, in several classes and grades in the underlying study, strengthens the reliability of the findings. Because our factoral design is reiterated 6 times with different teachers and subjects, potential biases due to teacher and subject effects are minimized.

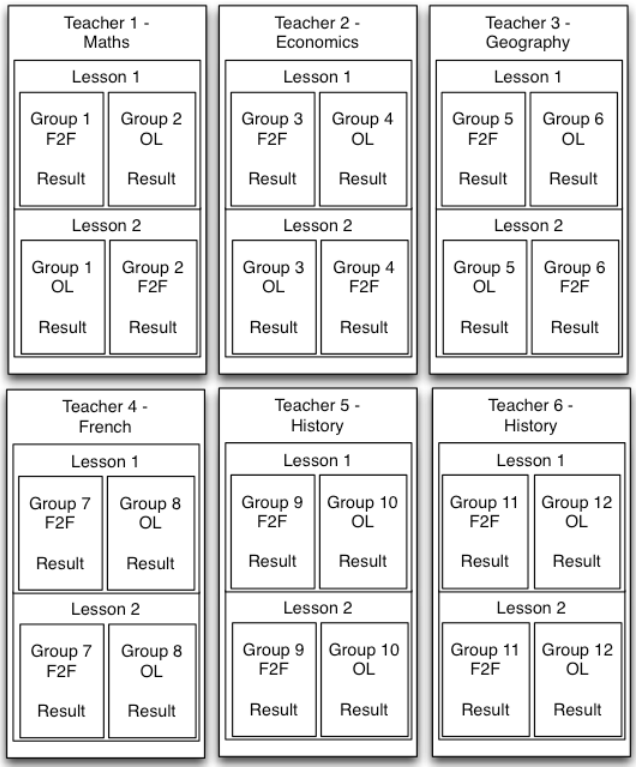

Figure 2. The Repeated Factoral design

2.2 Participants

The full sample consisted of 151 pupils between 12 and 18 years old, from the 7th until the 12th grade of secondary education. 70% are male. 39.7% of the participants were enrolled in a general secondary education program, 32.5% in technical secondary education, 19% in a vocational program, and 9% in a secondary arts program. Within a class, 10 to 15 pupils were randomly assigned to one of the test conditions (EL or F2F). In the course of one week, one group received a F2F lesson and the other group received the digital equivalent. The next week, the order was reversed. For example, a pupil belonging to group 1 received a history lesson in EL mode. In that same week, group 2 received the F2F version of that lesson, by the same teacher. In the following week group 1 received F2F a subsequent history lesson, whereas group 2 received the EL equivalent. As a result, each pupil followed one F2F and one EL lesson. After each lesson, all pupils took the same closed book tests which were constructed in accordance with the regular school procedures and regulations. Test scores ranged from 0 to 10. In total, 24 lessons were organized, covering 5 subjects and 12 different groups. The subjects were: Mathematics, History, Geography, French and Economics (see Figure 2).

Each of the 6 involved teachers prepared 2 lessons for their subject. The learning contents were part of the regular curriculum. Each lesson in the EL condition was developed as a digital 'learning path', a number of pre-ordered learning activities which offer ‘a road map to learners’ (De Smet et al, 2014). Each path contained multiple learning objects including online text materials, pictures, online exercises and hyperlinks to external websites and video clips. A pupil worked individually on a desktop computer, using a headphone. Teachers were present in the classroom, they assisted pupils in the event of a technical problem.

2.3 Research Model

The research model incorporats the original constructs of the ISSM, extended by using variables related to perceived enjoyment, and redefines the concept of ‘net benefits’ (Figure 3). In the following, we elaborate on the rationale behind the model and its hypotheses.

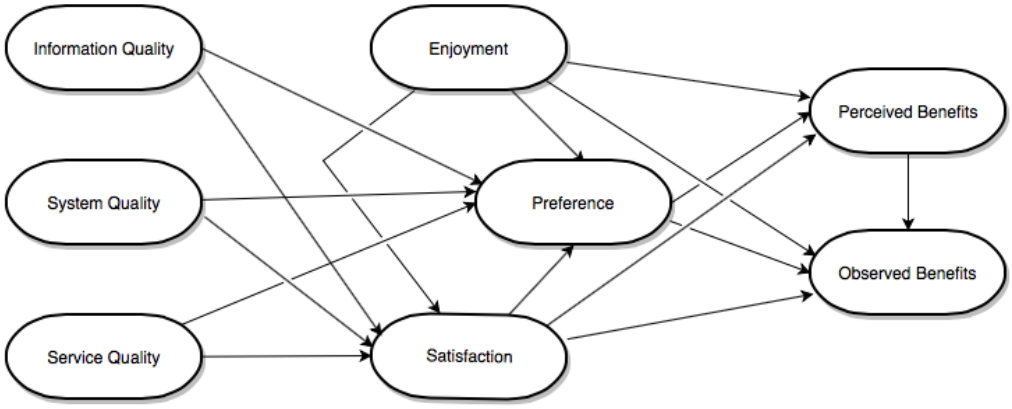

Figure 3. The Research Model

The observed benefits are conceived as differences in learning performance between the EL and F2F conditions. The latent construct of perceived benefits is defined as the 'perceived usefulness of the EL system for learning, as compared to the conventional way of teaching'. In this regard, we assume that learners evaluate previous experiences with ICT and make a total judgment as to whether the benefits outweigh disadvantages (Kirkman, 2000). In line with this stance, we ascertain the value of perceived benefits and consider it to be a real proxy and predictor of observed (tested) benefits. The model further posits that net benefits are dependent on three primary beliefs: preference, satisfaction and enjoyment.

Within a secondary school context 'voluntary (intention to) use' is restricted, since educational institutions or teachers decide on when and how to use EL tools. As a consequence, we included the concept of 'preference' as a replacement for the ISSM's 'intention to use', as proposed by Bourgonjon et al (2009). Preference is defined as 'the positive and preferred choice for the continued use of e-learning systems in the classroom'. We contend that preference for a system will affect pupils' learning experiences positively and thus lead to better results, i.e. improved net benefits. Satisfaction is another principal determinant, expressed as 'the feelings and attitudes that stem from aggregating a user's efforts and benefits from using an information system' (Wixom and Todd, 2005). As such, satisfaction is conceived as an aggregated attitude that positively influences the system's net benefits (as proposed by DeLone and McLean, 2003). Perceived enjoyment is defined as 'the extent to which using technology is perceived to be enjoyable in its own right, independent of any performance consequences' (Cheng, 2011). Sufficient evidence validates perceived enjoyment as a significant driver of intention to use, usage and ease of use of EL systems (e.g., Cheng, 2011; Teo & Noyes, 2011). We argue that an increase in perceived enjoyment stimulates pupils to make use of the EL course materials.

The ISSM further distinguishes between the system quality, the quality of the information that is provided by the system, and the quality of the service that is provided to use the system. In our context, we defined information quality as 'the level of difficulty of the EL system, the multimedia components and the related learning activities'. System quality was, in line with the ISSM literature, conceived as 'the degree to which the system is easy to manipulate and interact with'.

Pupils were not trained beforehand; if necessary they received technical support by a teacher during the lesson. Thus, in this study service quality is conceived as the degree to which support was available and sufficient. Congruent with the ISSM, we propose system, information and service quality as determinants of preference and satisfaction.

In the literature, enjoyment has been established as a direct determinant of the use of learning systems (or the usage intention) (cf. Saade et al, 2008). Using preference instead of (intention to) use, it is plausible to contend that if a pupil enjoys the sheer use of the EL environment, s/he will likely prefer its further use and be more satisfied with it. Consequently, we propose perceived enjoyment as a determinant of both use preference and satisfaction.

2.4 Measures and Analyses

Several previously validated instruments were employed (cf. Wang et al, 2007). Both self-reported (perceived) and objectively measured (observed) gauges were used to evaluate the pupils' learning performance. The observed benefits were calculated as differences in test performance between pupils in the EL and F2F condition, resulting in a differential score between -10 and 10. Perceptions were measured as latent constructs, using multiple items (see the appendix).

Table 1 shows the factor loadings and internal consistency measures for every latent construct. All constructs show sufficient internal consistency with Cronbach's alphas of higher than 0.7. The composite reliability and average variance extracted (AVE) are both above the expected thresholds of 0.7 and 0.5 for all the constructs, suggesting adequate convergent validity (Hair et al, 2006). While omitting the display of all item cross-loadings in the interest of brevity, we confirm that discriminant validity is established and that all items loaded on their constructs as expected. In the case of multiple determinants, the variance inflation factor was below 2.0 level, excluding collinearity issues.

Table 1. Internal consistency of the measures

Construct	***Items & their Factor Loadings***	***Composite Reliability***	***Cronbach's Alpha***	***AVE***
Perceived Benefits	PB1: 0.79; PB2: 0.86; PB3: 0.76	0.85	0.73	0.65
Preference	Pref1: 0.90; Pref2: 0.94; Pref3: 0.90; Pref4: 0.92	0.95	0.93	0.83
Satisfaction	Sat1: 0.88; Sat2: 0.72; Sat3: 0.88	0.87	0.78	0.69
Perceived Enjoyment	PE1: 0.90; PE2: 0.94; PE3: 0.92	0.95	0.91	0.85
Information Quality	IQ1: 0.68; IQ2: 0.81; IQ3: 0.80; IQ4: 0.83; IQ5:0.83	0.89	0.85	0.63
System Quality	SQ1: 0.77; SQ2: 0.67; SQ3: 0.88; SQ4: 0.73	0.83	0.72	0.55
Service Quality	SeQ1: 0.91; SeQ2: 0.96	0.93	0.86	0.87

We tested the measurement and research model by applying a partial least square (PLS) modelling approach using the SmartPLS application (Ringle et al, 2005).

3. RESULTS

3.1 Descriptives

On average, the EL instruction was modestly accepted (see Table 2). The information, system and service quality received rather positive scores between 3.30 and 3.55 (on a scale of 1 to 5); with a mean score for satisfaction of 3.09. Perceived benefits, perceived enjoyment, and in particular preference, however, received scores below the neutral point (3). Remarkably, pupils' performance in the EL condition was significantly poorer compared to the F2F instruction mode (with test scores of 75.7% for the F2F versus 56.8% in the EL condition). It seems pupils appreciated the quality of the system and the EL materials but were not in favour of it and would not choose it if it were optional.

Table 2. Global Descriptives

	Mean	***Std. D.***	***Min***	***Max***
Test Results F2F	7.57	2.25	0	10
Test Results EL	5.68	2.75	0	10
Test Results Difference	-1.89	3.34	-10.0	10.00
Perceived Benefits	2.63	0.82	1.00	5.00
Preference	2.24	1.05	1.00	5.00
Satisfaction	3.09	0.86	1.00	5.00
Perceived Enjoyment	2.61	1.02	1.00	5.00
Information Quality	3.30	0.68	1.00	5.00
System Quality	3.55	0.66	1.00	5.00
Service Quality	3.49	0.98	1.00	5.00

The most salient outcomes of a comparative analysis considering grade, subject and programme type (see Table 3), can be summarised as follows:

(1) The observed benefits' score, i.e. the differences in test results among respondents from the 7th grade, is -4.96, which is significantly lower than the scores of the pupils in other grades.

(2) The observed and perceived benefits' score of the pupils enrolled in general secondary education (-3.43 and 2.29) is significantly lower than that of vocational, technical and arts pupils.

(3) The observed benefits' score for maths is significantly lower than that for other course subjects. The 'perceived benefits' scores are the highest for French.

Table 3. Mean scores according to grade, subject and programme type

School grade[a]	**7th gr.**	**9th gr.**	**10th gr.**	**11th gr.**	**12th gr.**
N	24	49	28	21	29
Observed Benefits	**-4.96***	-1.86	-0.25	-0.71	-1.83
Perceived Benefits	2.31	2.65	2.90	2.43	2.74
[a] *There were no students of the 8th grade*					
Subjects	**Geography**	**Economics**	**French**	**History**	**Mathematics**
N	30	28	30	39	24
Observed Benefits	-1.97	-2	-0.03	-1.44	**-4.71***
Perceived Benefits	2.79	2.79	**2.96***	2.39	2.22
Education Type	**General**	**Vocational**	**Arts**	**Technical**	
N	49	28	14	60	
Observed Benefits	**-3.43***	-1.68	-0.64	-0.25	
Perceived Benefits	**2.29***	2.79	2.55	2.90	
** : Significance is based on Kruskal-Wallis or 1-way Anova*					

3.2 The Tested Structural Model

The tested model is depicted in Figure 4. Enjoyment plays a key role in explaining satisfaction and use preference. System and service quality have no significant impact. Information quality and satisfaction are significantly related (β=0.20; p<0.05). The impact of enjoyment on the net benefits is fully mediated via satisfaction and preference. Preference has a strong impact on perceived benefits (β=0.47, p<0,001) but a negative impact on observed benefits (β=-0.29, p<0.05). Thus, the data suggest that pupils who are in favour of EL system usage are not the pupils with the best test results. Satisfaction is only weakly related to perceived benefits. It has no impact on the observed benefits, but a considerable effect on preference. A strong relationship exists between perceived and observed benefits (β=0.45; p<0.001).

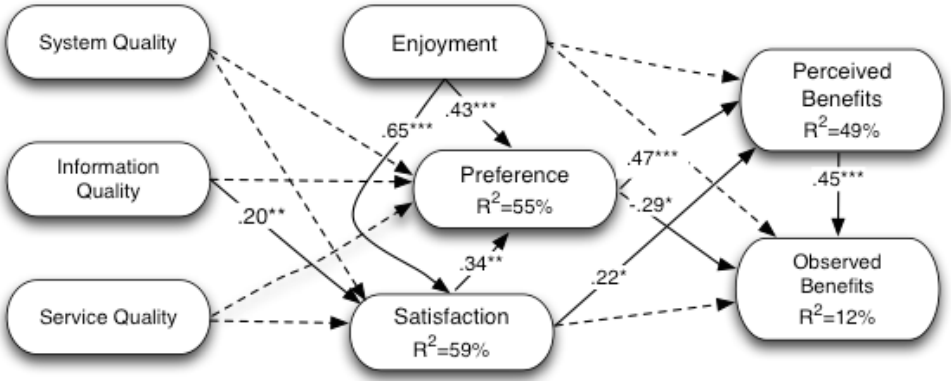

Figure 4. The Tested Structural Model

4. DISCUSSION

4.1 Findings

Our experiment reveals that secondary school pupils have better test results in a face-to-face instructional situation. The pattern is consistent across subject, grade and educational type (despite some differences (see table 3)). This finding is also strengthened by rather low overall scores on the perceived benefits (M=2.63) and on pupils' preference for using the system (M=2.24). Given the radical nature of the EL approach, where pupils had to deal with the online contents without further assistance, and the novelty of it in secondary education in Belgium, these results are understandable. The explanatory model, built upon the ISSM that we tested, helps to explain why the EL instruction mode resulted in lower scores on perceived and observed benefits.

The model includes both instrumental and emotional determinants of preference and satisfaction. It is clear that the emotional variable, perceived enjoyment, is the most important determinant of satisfaction and preference, the latter being a dominant predictor of net benefits. Perceived enjoyment has a modest mean of 2.61 and its impact on user preference and satisfaction is strong and significant. In other words, if pupils think they (will) enjoy working with an EL system, they really prefer its use and are satisfied with it.

The instrumental determinants that focus on observable qualities of the deployed system, i.e. service, system and information quality, are not the reason for the lack of preference for the EL instruction mode. Only information quality impacts satisfaction significantly, indicating that a higher level of appreciation of the EL contents slightly increases satisfaction.

4.2 Contributions and Limitations

Our approach not only targets the less-studied group of secondary education learners, but also integrates a research model with an experimental design in an ecological setting. Moreover, it includes both perceived and objectively measured learning outcomes, and the construct of 'preference' as a substitute for 'intention to use'. The latter is particularly pertinent in a context of non-voluntary usage, which is common in secondary education. The resulting validated model is re-usable for future research endeavors in- and outside the context of secondary education research, and it can be applied within an experimental design or in a mere survey-based investigation.

On a methodological level, by applying the factoral approach we have been able to minimize typical biases due to undesired group or topic effects. The repetition of the design (in several classes and), only strengthens the findings.

A first plausible limitation of the study is the fact that teachers were only allowed to intervene in the event of technical problems. In other words, a quite radical EL approach was introduced. A second limitation is related to the limited number of cycles employed within the larger framework of a design-based research (DBR) approach. The quest for sound, validated sets of guidelines for educational design, adapted to one's organization, preferably involves multiple iterations in a longitudinal set-up (Anderson and Shattuck, 2012) and multiple methods (Wang et al., 2011).

4.3 Implications

At first glance, our findings are somewhat contradictory to the current body of research findings that stress the importance and beneficial contributions of e-learning. However, our results should not be regarded as being opposed to such a stance. In essence, we have explored the limits of EL in secondary education and our results primarily point to aspects and considerations that need to be addressed when introducing EL systems in schools.

In particular, when following new trends in education, such as 'flipping the classroom' (FtC), one should take into account the nature of the materials and learner characteristics. In a context where pupils are used to conventional classroom teaching, the transition to more EL instruction is not evident, not even for millennials (the subjects of the underlying study). We contend that pupils today may be technology-oriented but when it comes to learning, they have limited proficiencies. Reading and comprehending learning materials

independently and on-screen, without outside guidance, seems less fruitful than conventional F2F lessons. In the light of FtC, where pupils are provided with EL artefacts they need to process themselves, our findings clearly mark a warning. Teaching should not be confined to providing learning materials and follow-up class-based activities, as pupils need to be scaffolded in their knowledge acquisition process as well. A principal consequence of this stance implies a shift of focus to frameworks such as 'self-regulated learning' (e.g., Lee and Lee, 2008), explaining learners' cognitive strategies and control of their efforts; and/or the self-determination theory, a theory of motivation that taps into our natural tendencies during a task-achievement process (e.g. Jang et al, 2016).

5. CONCLUSIONS

This study contributes to EL research by assessing the antecedents of perceived and observed benefits of EL instruction as compared to F2F teaching, in secondary education. 151 pupils and 6 teachers from a secondary school participated in a repetitive factoral experimental design in an ecological setting. This design facilitated the comparison of instructional formats in an empirical sound way, while yielding interesting information for practitioners. The DeLone and McLean's ISSM underpins the experimental approach. The model was extended with three factors: perceived enjoyment, and perceived and observed net benefits.

Overall, both the observed test results and the perceived benefits are determinants for lower effectiveness rates of EL as compared to F2F classes. This finding was confirmed across subjects, educational levels and types. Our results show the importance of perceived enjoyment. However, pupils who preferred and enjoyed the system are not necessarily the best performing ones. This finding is very important. It indicates that a shift towards EL to achieve better learning results should not be taken for granted. We assume that the particular EL approach we opted for - in close cooperation with the school's headmaster and his team of teachers - requires from pupils that they master self-regulated learning skills. In short, schools should preferably try to find the optimal equilibrium between F2F and EL instruction, while focusing on both enjoyment and performance.

Follow-up studies could further extend the proposed model with context and individual characteristics related to teaching and cognitive presence (Joo et al, 2011), alongside self-regulated learning (Lee & Lee, 2008).

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APPENDIX. QUESTIONNAIRE ITEMS

Constructs	***Item***
Perceived Benefits	PB1 To what extent is a learning in Smartschool better than a conventional class (given by a teacher) PB2 By using Smartschool, I can understand the course material PB3 By using Smartschool, I could study my lesson
Satisfaction	Sat1 To what extent are you satisfied with the lesson in Smartschool? Sat2 Are you satisfied with this way of teaching? Sat3 Are you satisfied with the use of Smartschool within the school?
Preference	Pref1 If I had to choose between a learning path in Smartschool and a conventional class, I would choose a learning path in Smartschool Pref2 I prefer to use Smartschool Pref3 If it was up to me, Smartschool would be used more frequently Pref4 In the future, I would like work more with Smartschool in the classroom
Perceived Enjoyment	PE1 I find the use of Smartschool enjoyable PE2 Learning via Smartschool is pleasant PE3 I find it pleasurable to learn via Smartschool
System Quality	SQ1 Smartschool is easy to use SQ2 To what extent did you experience technical problems during the class SQ3 Did you find it easy to work with Smartschool SQ4 How responsive was the system (the pages shown on the screen)
Information Quality	IQ1 Was the learning path (with its components) clear and understandable IQ2 How much do you appreciate the contents presented (text, video's, pictures) IQ3 Were the presented assignments in the system clear IQ4 Could you understand the topic with the available information IQ5 The topic was well presented in the learning environment
Service Quality	SeQ1 If I needed help from the teacher I received valuable help SeQ2 The support I got was sufficient