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Cindy De Smet, Martin Valcke, Tammy Schellens, Bram De Wever, Ruben Vanderlinde

A Qualitative Study on Learning and Teaching With Learning Paths in a Learning Management System

This article presents the findings of a qualitative study (carried out between 2011 and 2013) about the adoption and implementation of learning paths within a Learning Management System (LMS). Sixteen secondary school biology teachers of the GO! Network in Flanders (an urbanized region in Belgium) were involved in the study and questioned via semi-structured interviews. Two research questions are addressed: (1) what are the perceived conditions at school and at teacher level affecting the use of learning paths? (2) how are these conditions related to the expected outcomes? Research results show teachers are satisfied with learning paths as an educational tool, but reflect mixed feelings as to the impact on student learning outcomes. Clear barriers are identified at the school and teacher level, thwarting the implementation of learning paths in secondary education. The availability of a reliable and accessible ICT infrastructure, the quality of technical and pedagogical support, teacher professional development and the mastery of teacher Information and Communication Technology competencies, among others, were found to be essential.

Questo articolo presenta i risultati di uno studio qualitativo sull'adozione e l'attuazione di percorsi di apprendimento all'interno del Learning Management System (LMS). Sedici insegnanti della scuola secondaria sono stati coinvolti nello studio e interrogati tramite interviste semi-strutturate. Si sono prese in considerazione due domande di ricerca: (1) quali sono le condizioni percepite nella scuola e fra gli insegnanti capaci di influenzare l'uso di percorsi di apprendimento (learning paths)? (2) come sono legate ai risultati attesi queste condizioni? I risultati della ricerca mostrano che gli insegnanti sono soddisfatti dei percorsi di apprendimento (learning paths) come strumento educativo, ma mostrano sentimenti contrastanti per quanto riguarda l'impatto sui risultati di apprendimento degli studenti. Si identificano chiari ostacoli a livello di scuola e di insegnanti, vanificando l'utilizzo dei learning paths nell' istruzione secondaria. Si sono rivelati essenziali, fra l'altro, la disponibilità di infrastruttura ICT affidabili e accessibili, la qualità del supporto tecnico e pedagogico, lo sviluppo professionale degli insegnanti e la padronanza delle tecnologie dell'informazione e della comunicazione.

Dr. Cindy De Smet is researcher and lecturer within the Faculty of Education, Health and Social Work at the University College Ghent. Her research interests are situated in the field of instructional design, eLearning and educational innovation.
Email: cindy.desmet@hogent.be
Prof. Dr. Martin Valcke is full professor in the field of "Instructional Sciences" at Ghent University, Belgium and head of the Department of Educational Studies in the Faculty of Psychology and Educational Sciences.
Email: martin.valcke@ugent.be
Prof. Dr. Tammy Schellens is professor in Educational Technology at Ghent University. Educational reform by means of technology-assisted instruction (TEL), the implementation of innovative teaching strategies and alternative forms of assessment are her main research topics. *Email:* tammy.schellens@ugent.be
Prof. Dr. Bram De Wever is a professor at the Department of Educational Studies at Ghent University. His research is focusing on technology enhanced learning and instruction, peer assessment and feedback, computer-supported collaborative learning activities, and inquiry learning in higher education. *Email:* bram.dewever@ugent.be
Prof. Dr. Ruben Vanderlinde is a Tenure Track professor at the Department of Educational Studies at Ghent University. His research interests are in the field of educational innovation, teacher training and professionalisation, and the integration of Information and Communication Technologies (ICT) in education.
Email: ruben.vanderlinde@ugent.be
Postall address for all authors: Ghent University, Department of Educational Studies, H. Dunantlaan 2, 9000 Ghent, Belgium

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1 Introduction

In their internationally recognized NMC Horizon Report; Johnson, Becker, Estrada and Freeman (2014) discuss several Information and Communication Technology (ICT) trends, expected to change education. They forecast Learning Management Systems (LMS) would underpin online, blended and collaborative learning in the short-term and foresee data-driven learning environments in the mid-term. According to the American technology website Techcrunch.com (Shieber, 2014), governments and venture capital firms have – to date – never invested such amounts of money in the educational market.

Learning Management Systems (LMS) are information systems running on a server, offering various tools like document publishing, assessment modules, wiki, etc. LMS can be accessed using a web browser. Within the LMS, educational material is processed, stored and disseminated; teaching and learning related administration and communication is supported (McGill & Klobas, 2009). LMS originated in the late nineties and have seen a permanent market rise since then. The latest 2014 analysis by the Edutechnica blog (2014) of LMS

usage involving all US higher education institutions, confirms that more than 90% of these institutions actively use an LMS. While the future for the LMS may sound promising, research remains scarce about the LMS learners' perception, experiences and satisfaction (Joo, Lim & Kim, 2011); their learning outcomes, as well as their teachers' motivation and training for using the system (Keramati, Afshari-Mofrad & Kamrani, 2011). In addition, recent research by Schoonenboom (2014) investigated why some tools are used more than others, as little is known about the instructional use of the LMS.

2 Studying LMS and learning path usage: Towards a theoretical model

In their LMS-related study, De Smet, Bourgonjon, De Wever, Schellens & Valcke (2012) investigated the instructional use and the technology acceptance of learning management systems by secondary school teachers. In this study, an extended TAM2-model (Venkatesh & Davis, 2000) was tested, by studying LMS usage intentions in terms of social influence, perceived usefulness and perceived ease of use. Next to the direct impact of teacher perceptions about the ease of use of an LMS and its usefulness, the researchers observed a direct and indirect impact of internal ICT support to understand LMS acceptance. The latter implies that supporting teachers at the school level plays an important role to use technology. In addition, it was found that a basic usage level (e.g. documents or exercises published by the teachers) is required before more advanced LMS functionalities (interactive activities) like collaborative writing, moderated discussions and learning paths) are being adopted.

The present paper focuses on 'learning paths', which is one of the more advanced LMS functionalities. Learning paths are described as "The LMS functionality to order a number of learning objects in such a way that they result in a road map for learners. Within a learning path, learning steps are structured in a general way (as a navigation map or a table of contents) or in a very specific sequenced way (e.g. 'complete first step 1 before moving on to step 2')" (De Smet, Schellens, De Wever, Brandt-Pomares & Valcke, 2014, p. 2). The most important building blocks of a learning path are the learning objects. Kay and Knaack (2008a, p.6) define the latter as "interactive web-based tools that support the learning of specific concepts by enhancing, amplifying, and/or guiding the cognitive processes of learners".

The latter authors report in their literature review about a robust body of research discussing the design, development, reuse and accessibility of learning objects. However, little systematic research is available covering the actual use of learning paths in classrooms. The few available studies report on student perceptions or qualitative studies about learning outcomes. Research gaps are identified in relation to teacher attitudes about the use of learning objects in a real classroom and studies investigating the actual use of learning objects in a secondary school setting. In addition, Ozkan, Koseler and Baykal (2009) stress that research addressing the conceptualization and measurement of related learning outcomes - within educational organizations - is scarce.

To develop a theoretical base about conditions affecting the implementation of an LMS in general and learning paths in particular, we can build on the study of Piccoli, Ahmad and Ives (2001) who distinguish between a human dimension (including students and instructors) and a design dimension (including learning models, technology, learner control, content and interaction). The design dimension was examined in an earlier evaluative study, linking the design, implementation and impact of learning paths with student learning outcomes (De Smet et al., 2014; De Smet, De Wever, Schellens & Valcke, 2015). Evidence was found about superior performance in the learning path condition compared with the conventional instruction (control condition). Furthermore, it became apparent that learning outcomes are influenced by design factors, next to implementation factors such as students working in groups or individually, and the group gender composition (same-sex or mixed-gender). In the present study, we firstly focus on the human dimension as defined by Piccoli et al. (2001).

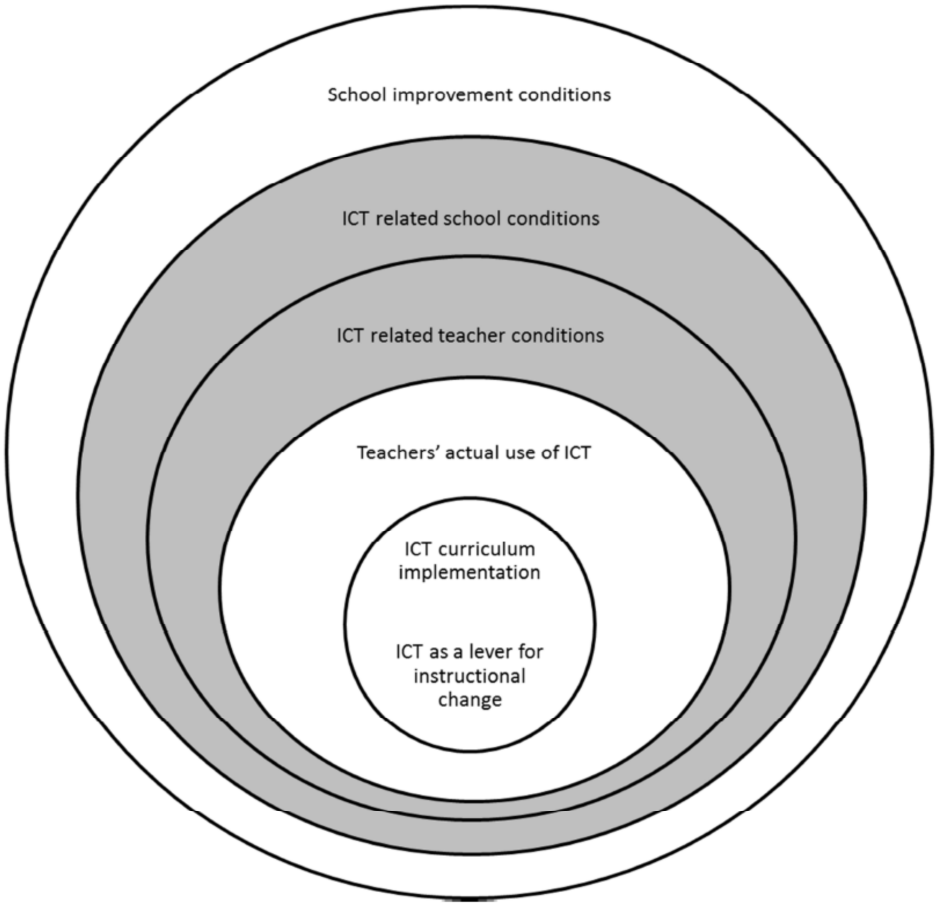
To develop a better insight into the human dimension, other researchers refer to 'barriers' hindering technology integration: external (first-order) and internal (second-order) barriers (Ertmer, 1999). According to Ertmer (1999), internal barriers are intrinsic to teachers and include their beliefs about teaching, their learning approaches and their teaching practice; external barriers are linked to computer access, training and support to help teachers becoming more effective or efficient. The external barriers hardly challenge underlying teacher beliefs. Consequently, Ertmer (1999) concludes that external barriers can be solved by providing the necessary resources, but internal barriers can only be changed by influencing a teachers' belief system and teaching practices. Research of Hermans, Tondeur, van Braak and Valcke (2008) confirms that teacher beliefs are at least as important as technology-related teacher characteristics to explain successful ICT integration. Teacher beliefs have therefore been explored by several researchers, since they play an important role in technology adoption (Smarkola, 2008) and technology integration (Ertmer, 2005; Ertmer, Ottenbreit-Leftwich, 2010; Hermans et al., 2008). In this respect, two approaches are frequently studied: teacher-centred versus student-centred beliefs about instruction (Kember, 1997), referring to the beliefs teachers hold about how technology enables them to translate those beliefs into classroom practice (Ertmer, 2005). Teachers holding a teacher-centred belief (based on a traditional learning model) rather adopt traditional teaching methods such as lecturing and focus on knowledge reproduction. Teachers reflecting student-centred beliefs engage in active learning environments that permit critical thinking, discovery, and collaboration (Chan & Elliot, 2004). But, some researchers (e.g. Liu, 2011) present less conclusive evidence about the relation between teacher beliefs and particular teaching practices and

stress that the dynamics of this relationship needs further research.

Next to internal barriers (human dimension), the literature is – as already suggested above – clear about the impact of external barriers influencing technology integration; though little research is available in the domain of LMS and learning path usage. The distinction between internal and external barriers may neglect the interrelated nature of these variables; e.g., how professional development about LMS or a school level ICT-policy affects teacher beliefs. A more embracing perspective is needed. Therefore, we adopt the e-capacity framework of Vanderlinde and van Braak (2010) and conceptions derived from the research about user perceptions of e-learning systems (Liaw & Huang, 2007; Liaw, Huang & Chen, 2007; Liaw, 2008) to attain a more embracing perspective.

The e-capacity framework of Vanderlinde and van Braak (2010) deals with "creating and optimizing sustainable school level and teacher level conditions to foster effective change through ICT" (p. 542). Figure 1 shows how consecutive circles encompass and interact with other processes and variables that affect the two central dependent variables: ICT curriculum implementation and ICT as a lever for instructional change.

Figure 1. Model based on the e-capacity framework of Vanderlinde and van Braak (2010, p.254)**.**



The framework consists of four mediating concentric circles with conditions that support ICT uses in education. In the present study we focus on the two inner 'circles' (see Figure 1, grey coloured): 'ICT related school conditions' and 'ICT related teacher conditions'. This particular emphasis does not neglect the potential impact of e.g., societal influences, leadership or decision-making formats, but these are less the responsibility of the teachers and/or they are less related to their professionalism and expertise.

Also the work of Liaw and Huang (2007), Liaw, Huang and Chen (2007) and Liaw (2008) helps to develop this more embracing perspective on our research problem. These authors—on the base of the analysis of teacher interviews—suggest four interrelated 'environmental conditions' to develop effective and motivating e-learning environments as perceived by teachers: 1) useful environment characteristics, 2) effective learning activities, 3) enhanced environmental satisfaction, and 4) positive learner characteristics. Given our focus on the usage of LMS, we can redefine these conditions as follows:

'Useful environment characteristics' are related to the quality and multimedia features of the LMS. Next, 'Effective learning activities' provide learners and instructors with possibilities to share knowledge and experiences by using advanced LMS functionalities. Given our particular focus on learning paths within the

LMS environment, we prefer to cluster these two conditions into 'Environmental characteristics'.

'Enhanced environmental satisfaction' refers to the feelings and the attitude towards the usefulness of the technology. In the context of the present study, we link this to teacher satisfaction with the student learning outcomes as a result of studying with learning paths. We therefore re-label this condition as 'Teacher satisfaction with the learning outcomes'.

'Positive learner characteristics' are defined as learner attitudes, motivation and beliefs that foster learning in the LMS. In the present study,—because of our focus on teachers—we ask teachers how they perceive student participation in the LMS'.

Table 1 integrates the theoretical frameworks discussed above in view of our study. Given the lack of in-depth research about the factors that affect learning in an LMS in general and with learning paths in particular, we put forward the following two research questions:

1) What are the perceived conditions at school and at teacher level affecting the use of learning paths?
2) How are these conditions related to expected outcomes?

Table 1. Main themes, sub themes and concepts used to explore and map our research questions.

Themes	Sub themes	Concepts
ICT-related school conditions	ICT infrastructure	Hardware, software, connectivity, peripherals, and access to and availability of ICT-related resources
	ICT support	Technical and pedagogical support, often by an ICT coordinator
	ICT policy plan	A school's vision about the use of ICT as agreed upon by the school team
ICT-related teacher conditions	Teacher professional development	Internal and external ICT training courses
	Teacher ICT competencies	Knowledge, skills and attitudes about the use and integration of ICT in the classroom
Environmental conditions	Environmental characteristics	The nature and quality of the LMS and/or learning paths
	Teacher satisfaction with the learning outcomes	Teacher satisfaction with student learning outcomes
	Positive learner characteristics	Perceived student participation in the LMS

3 Research design

A qualitative study was set up, building on data gathered during semi-structured interviews. These interviews were set up after teacher involvement in two quantitative studies about the impact of studying with learning paths in science education (De Smet et al., 2014; De Smet, De Wever, Schellens & Valcke, 2015). In a pre–post–retention repeated-measures design, involving learners in control and experimental conditions, learning path functionalities were studied in more detail. An experimental learning path about 'bacteria collection and growth' and complementary didactical materials were used with secondary school students. This research context guarantees that all teachers involved in the present study have comparable experience with LMS and learning paths. The 'bacteria collection and growth' topic from the biology curriculum was selected in view of a planned curricular reform. As the first author works as a teacher trainer, she was assisted by two recently graduated biology teachers who created the learning materials and by 18 pre-service teachers majoring in biology under the supervision of their lecturer.

3.1 Sample

In view of the former quantitative studies and the present qualitative study, 13 schools of the GO! Network were contacted. All biology teachers, contracted in these schools were willing to participate in the studies. The GO! Network is one of the three dominant educational authorities organizing education in Flanders, the Dutch-speaking region of Belgium. This resulted in a total of 16 teachers (12 female and 4 male teachers). This gender distribution is typical of the secondary education context in Flanders where 60% of all secondary school teachers are female (Pynoo, Kerckaert, Goeman, Elen & van Braak, 2013). The biology education studies were set up with students from grade 8, who are on average 15 years old. All studies (conducted as part of the first author's PhD thesis) were carried out between 2009 and 2013 and financially supported by the Research Fund of University College Ghent.

3.2 Interview instrument and procedure

Twenty pre-defined questions were presented following the semi-structured interview protocol (Taylor & Bogdan, 1998). The questions focused subsequently on teachers' conditions (ICT experiences, expertise etc.) and school conditions affecting their LMS and learning path use, as well as their perceptions and expectations about the LMS and learning path next to student characteristics and learning outcomes. Teachers were also invited to bring up additional questions and remarks.

The interviews were carried out on a one-to-one base and lasted between 30–45 minutes each. All sessions were recorded on videotape and transcribed by a third person. Informed consent was obtained from all participating teachers as to the anonymous recording, transcription and analysis of the interviews.

3.3 Coding and analysis procedure

During the coding-phase of the analysis, the first author was assisted by a junior researcher, who is an experienced secondary school teacher. She had received training in view of the coding process.

All interview transcripts were split up into individual meaningful units. Graneheim and Lundman (2004) define

meaningful units as 'words, sentences or paragraphs containing aspects related to each other through their content and context' (ibid., p. 106). They also recommend 'condensation' as a process of shortening while pre-serving the core content, and not substantially changing this content. Next, the analysis procedure moved to abstracting the condensed text at a higher order level by adding codes or categories to the individual meaningful units. In other words, each interview was divided in shorter paragraphs, which in their turn were grouped into categories according to shared characteristics. The software package Nvivo was used for segmentation (identifying meaningful units) and categorization of the data. Results from NVivo were compared and discussed until a saturated list of codes was generated. Initially, these codes were freely generated to describe the key content of the interviews. Next these codes were clustered considering the theoretical base as reflected in Table 1 and based upon Vanderlinde and van Braak (2010), Liaw and Huang (2007), Liaw, Huang and Chen (2007) and Liaw (2008). Disagreement as to further coding was resolved after discussion. Interrater-reliability was calculated, reflecting a high level of agreement (96 %).

NVivo matrices were used to tabulate the coded units in the interviews. Following Coniam (2011), a matrix approach allows a researcher to develop a complete picture of the data, rather than selecting random quotes to suit biased ideas or presumptions. This approach also enables the researchers to develop a quantitative perspective of the qualitative respondents' data.

4 Results and discussion

As summarized in Table 2 (see next page), analysis of the sixteen interviews resulted in three main coding themes. Of the themes coded, 16% were related to 'ICT-related school conditions', 24% to 'ICT-related teacher conditions' and 60% to 'Environmental conditions'.

4.1 Conditions at school and teacher level

4.1.1 ICT-related school conditions

Within this cluster, 80% of the responses were coded as related to the ICT infrastructure subtheme, 14% focused on ICT support and 6% on the ICT policy plan.

The importance of the availability and reliability of an ICT infrastructure can be deduced from Table 2. Because of its importance, related problems and complaints were formulated in nine out of sixteen interviews, sometimes leading to the conclusion that using LMS in the classroom might become impossible. During our two quantitative studies, we required biology teachers to work during four consecutive hours in a computer classroom, although not all teachers were able to make reservations for the acquired number of hours. Some even reported that access to the infrastructure was not admitted at all.

> "The same problem always arises: computer classrooms are ample available, and if they are, it is very hard to find a classroom with a sufficient number of operational computers with internet access." [Teacher 6]

Moreover, being successful in making a reservation does not guarantee availability.

> "I reserved fifteen laptops, but only got nine. The previous teacher didn't properly return them as he was supposed to, and this happens all the time. That's inconvenient." [Teacher 8]

One teacher does only get access to a beamer in the biology classroom.

> "We don't even have a computer in our classroom. We can pick up a laptop at the office, but if we need specific software installed, we have to reinstall it over and over again, because the program uninstalls automatically every time we shut down a computer. And they don't get it, that this is not working out". [Teacher 12]

A report by the European Commission (2013) on the use of ICT in education shows a computer/pupil ratio of 1 to 5 in grade 8. Belgium scores above average with a ratio of 1 to 4; Flanders scores even better with 1 to 2 (Pynoo et al., 2013). However, the EC report also stresses that insufficient ICT equipment is still a major obstacle to educational ICT use and that policies at infrastructure level are a matter of urgency. The high proportion of related teacher responses about the ICTinfrastructure reflects this concern. At least for the teachers involved in the present study, access to well-functioning infrastructure remains problematic.

Another conditional factor, determining the degree of ICT integration, is the availability to the teacher of technical and pedagogical support. In Flanders, support is mostly supplied by an ICT coordinator or a colleague from the same school (Tondeur, Van Keer, van Braak, & Valcke, 2008). But additional research of Devolder, Vanderlinde, van Braak and Tondeur (2010) adds that ICT coordinators adopt more than half of their time a technical role and only a third of the support time an educational role. The latter was confirmed by six teachers who mentioned technical support was provided, but none of them referred to the availability of pedagogical support. Most teachers felt well supported – at the technical level – to integrate ICT in their teaching, but some teachers nevertheless perceived the quality of the technical support as rather poor.

> "I asked the ICT coordinator for a login and a password to access the LMS, but several months later, I am still waiting for it. … Two people were supplying technical support, but only one of them was capable to help us, and he recently moved to another school. The other one has been forced to do the job, but he is still unable to answer our questions". [Teacher 12]

In the latest MICTIVO report, which builds on active monitoring of the status of ICT integration in Flemish

education, 99% of the ICT coordinators said they offered technical support and 69% refer to pedagogical support

Table 2: Coding scheme overview and detailed percentages of categories coded.

ICT-related school conditions	ICT infrastructure	Hardware	31
		Software	11
		Components	6
		Smartschool	13
		Internet	5
		Infrastructure failure	25
		Access and availability	7
	Total	Count	98
		% of ICT -elated school conditions	80%
	ICT support	Didactical support	17
		Technical support	0
	Total	Count	17
		% of ICT-related school conditions	14%
	ICT policy plan	ICT policy plan	0
		Colleagues' vision on ICT	6
		School authorities' vision on ICT	2
	Total	Count	8
		% of ICT-related school conditions	6%
	Total ICT related school conditions	Count	123
		% of total coding	16%
ICT-related teachers conditions	Teacher professional development	Internal and external training courses	4
	Total	Count	4
		% of ICT-related teachers conditions	2%
	Teacher ICT competencies	Didactical ICT-knowledge	34
		Technical ICT-knowledge	24
		Using new instructional methods	86
		Class management skills to integrate ICT in the classroom	46
	Total	Count	190
		% of ICT-related teachers conditions	98%
	Total ICT-related teachers conditions	Count	194
		% of total coding	24%
Environmental conditions	Environmental characteristics	Learning path design remarks (content, digital exercises, lab exercises etc.)	45
		Learning path instructional remarks	39
		Instructional wording	9
		Estimated instructional time	54
		Worksheets (iteration 2)	19
		Teacher scenarios	12
		Questionnaires used (pre/post/retention)	24
	Total	Count	202
		% of Environmental conditions	42%
	Teacher satisfaction with the learning outcomes	Count	104
		% of Environmental conditions	22%
	Positive Learner characteristics	Remarks on the learners' ICT knowledge	24
		Learners' remarks on using new instructional methods	52
		Attitudes and beliefs	29
		Motivation	66
	Total	Count	171
		% of Environmental conditions	36%
	Total Environmental conditions	Count	477
		% of total coding	60%

(Pynoo et al., 2013). Nevertheless, school principals called insufficient pedagogical support their major concern when being asked for factors that affect ICT use in their schools (European Commission, 2013). A similar

observation and a clear call for further investment in human, technical and financial resources was formulated by The Flemish Education Council (VLOR, 2013), as they state that needs with regard to pedagogical and content-related support are high and under pressure. Our observations and the reports from the Flemish Education Council consistently indicate that pedagogical support is available, at least theoretically, but that in practice this support is hardly effective or does not achieve its goal.

Although successful ICT integration is often preceded by the presence of an ICT policy plan (Vanderlinde et al., 2010), no responses in relation to an ICT policy plan were spontaneously reported. In addition, Hayes (2007) stressed the importance of the school leader's vision and support towards an ICT policy plan. In our research, two teachers explicitly mentioned their school principal during the interviews: one principal actively encouraged the teachers' participation in the learning path research; another one was very much open to new technologies and installed a (temporary) iPad classroom that was eagerly used during the LMS/learning path study lessons.

4.1.2 ICT-related teacher conditions

As can be observed in Table 2, 2% of the ICT related teacher conditions were coded as indicators referring to teacher professional development and 98% referred to teacher ICT competencies.

According to Bingimlas (2009), the most cited barrier to successful ICT integration, is a lack of teacher professional development. In this study, few statements (only 2%) were made about internal (school as training location) or external (outside the school) professional development opportunities. One teacher stated, although she participated in several ICT courses, she did not feel confident to use ICT and still heavily relied on the ICT coordinator's support. Another teacher mentioned pre-service training did not pay enough attention to ICT classroom use. These observations are in line with the report of the European Commission (2013), in which Belgium was mentioned as one of the two countries where teachers reflect a relatively lower level of confidence in their ability to perform operational tasks using ICT. In the report, this result was linked to the percentages of grade-8 students being taught with the support of ICT. Whereas the average EU-number is 25%, this was only 13% in Belgium. In other words, these findings and our observations suggest an underinvesttment in professional development of teachers in Belgium.

According to Drent and Meelissen (2008), innovative ICT usage implies teachers use ICT as a tool to pursue educational objectives. In the present study, the LMS tool was challenging as teachers had to teach on the base of learning paths. This LMS functionality is hardly used - i.e. 10% of all teachers indicated they ever used learning paths in their teaching - in Flemish secondary education (De Smet & Schellens, 2009). The importance of the teacher-related ICT competencies can be deduced from the high proportions of interview units coded accordingly (i.e. 98%). The following four subthemes were identified: didactical ICT-knowledge, technical ICT-knowledge, using new instructional methods and class management skills to integrate LMS.

The most frequently mentioned feeling, in twelve out of sixteen interviews, is the loss of control when teaching with learning paths. Several teachers explained they prefer an active but more directive teaching role rather than letting students work more autonomously. Some teachers even tried to gain back some control:

> "I added some work sheets… reformulated questions … and added writing lines. I had to create structure. I just could not resist." [Teacher 9]

Another teacher was very negative in relation to teaching with LMS.

> "I instructed via learning paths, but immediately afterwards, I started over from scratch, using my own teaching approach. I wanted all my students being taught the way I usually teach. Even if that meant they had to study the same material twice." [Teacher 4]

These observations and analysis results can be linked to the teacher beliefs discussed earlier. Several researchers stress learner-centred approaches (Ertmer, 2005; Inan, Lowther, Ross & Strahl, 2010). In the present study, teachers taught with learning paths that build on related student autonomy, collaborative learning, etc. As such, some of our teachers—adhering to a teacher-centred belief—were confronted with an incongruent instructional approach. Research shows that changes in teaching practice requires an extensive amount of time (Brinkerhoff, 2006) and is best implemented in small steps (Kanaya, Light & McMillan Culp, 2005). In the current study, there may have been a conflict between teacher beliefs and the research teaching approaches. Secondly, research also points at a lack of teacher competencies to explain resistance to change (Bingimlas, 2009). In this view, it is not surprising teachers have the feeling to lose control when having to teach via learning paths.

Based on the present analysis results, we have to conclude – focusing on school and teacher conditions - that the e-capacities of the schools under study are underdeveloped. Teachers referred to critical missing conditions: a reliable and accessible ICT infrastructure, the availability and quality of technical and pedagogical support, integrated teacher professional development and the mastery of critical teacher ICT competencies.

4.2 Teachers' perceptions and expectations

4.2.1 Learning environment characteristics

In total, 42% of the codes were related to environmental characteristics, pointing at subthemes such as: design and instructional remarks, estimated instructional time, etc. (see Table 2). Our learning path and the didactical materials covering 'bacteria collection and growth' was based on the official GO! biology school curriculum, and was designed and developed by recently graduated

biology teachers and revised by pre-service teachers and their lecturer. It replaced the traditional teaching materials, usually developed by teachers themselves, as most of them do not adopt commercial textbooks.

Teachers were asked to evaluate the new learning materials (i.e. learning path, lab exercises, worksheets and teaching scenarios); with respect to the way they were designed as well as to their ease of use. Teachers' input was used to improve these learning materials that were further used in subsequent quantitative studies. In addition, teacher feedback was also a way to sample data to learn whether the learning materials achieved their instructional objectives, whether they were attractive to learners and sustained their interest. In general, teachers were positive about the materials provided. The required instructional time was judged adequate.

4.2.2 Teacher satisfaction with the learning outcomes

22% of the codes focused on teacher satisfaction with the learning outcomes, resulting from studying in the LMS with learning paths. Teacher opinions were mixed. Four teachers reported that the performance was lower than expected; six teachers did not mention any differences and six teachers reported higher learning results than expected.

> "What I really appreciate about learning paths, is the fact they stimulate students to learn and develop essential insights autonomously." [Teacher 2]

> "When average students were working collaboratively, they achieved better results than the high performing students, who usually prefer to work alone." [Teacher 9]
> "A learning path is particularly suitable for high-performing students. It also works for the low performing students, but they need more guidance." [Teacher 5]

Earlier research about secondary education teachers' satisfaction with learning objects, showed positive reactions (McCormick & Li 2005; Kay & Knaack 2008b). In the present study, teachers are satisfied with the learning paths' ease of use, but doubt their adequacy to attain learning outcomes. Earlier research, e.g. De Smet et al. (2012), demonstrated the importance of both ease of use and usefulness in the acceptance of LMS. In addition, Kember (1997) stressed that teacher conceptions influence their teaching approaches, which in their turn have an impact on student learning and ultimately affect learning outcomes. As stated above, some of our teachers holding a teacher-centred belief may have felt insufficiently prepared to work with this learner-centred approach.

4.2.3 Learner characteristics

Liaw, Huang and Chen (2007) emphasized that a key issue to consider when developing e-learning environments, is a good understanding of the target group. De Smet and Schellens (2009) found that teachers make ample use of advanced LMS functionalities; e.g., 6% use the chat module, 10% learning paths, 11% wikis and 14% asynchronous discussion groups. As this study was carried out in a similar context, we can expect related remarks about learning paths, since they are new for most teachers and students. While teachers had to adjust to the new learning tool, students adapted quickly.

> "These students grew up with a computer; they are very comfortable with using new tools." [Teacher 4]

> "Sometimes they already know what to do before my explanation was finished." [Teacher 6]

Almost all teachers reported the same lesson 'flow': in the beginning learners were very enthusiastic to work on the computer, but after three lessons (out of four) they got bored. Teachers even reported some students were eager to return to a conventional instruction format.

> "Some students, who wish to accelerate their studies, prefer lessons where I instruct them. After 3 lessons they said: can you instruct us? We think we will be able to remember it better via conventional instruction." [Teacher 1]

Kay and Knaack (2008b) found that teacher ratings of learning, quality and engagement related to learning materials were significantly correlated with student ratings. Given the mixed feelings of our teachers and an ambiguous relationship between teacher beliefs and learning approaches, it should not be surprising students expressed similar concerns. Wu, Tennyson and Hsia (2010) reported similar findings. They concluded that the more confident and accustomed students become with online learning within an LMS; the more likely they will expect benefits from using it, foster a positive learning climate, and also be more satisfied.

4.3 Similar research in social science education

Finally, we want to mention examples with comparable outcomes on the adoption and implementation of technology-enhanced learning within social science education. Callahan, Saye and Brush (2014) developed online lessons on US History (1877-the present), embedding digital resources (hyperlinked textboxes and streaming video cases) to serve as scaffolds. The authors mentioned conditions on both the school and teacher level hindering the integration of these web-based educative curriculum materials in their teaching: teachers reported frustration as they were constantly interrupted while teaching (frequent school bells, intercom announcements, visits from colleagues etc.), but also felt uncomfortable using the new approach of embedded video scaffolds. In another experimental study, Huizenga, Admiraal, Akkerman and ten Dam (2009) researched the acquisition of historical knowledge of medieval Amsterdam via a mobile city game called Frequency 1550. In their conclusion, they point to

technical failures to explain the observed lack of effects on pupil motivation and the high rates of disengaged behaviour. Other research we would like to refer to are: Samuels and Berson (2012) on webquests to explore race riots; Jekel, Gryl and Schulze (2015) on spatial citizenship and Mikropoulos (2006) on personal and social presence.

5 Conclusion and limitations

In view of our first research question, we tried to find out which conditions at the school and teacher level affect the use of learning paths. At the school level, several problems with the availability and the well-functioning of the ICT infrastructure were reported, sometimes even leading to the conclusion that the use of ICT in the classroom became impossible. Technical support was available to some of the teachers, but the quality differed greatly. Pedagogical support or teacher training courses were almost non-existent. The role of the school principal or school management was mentioned by only two teachers. All these barriers have been identified in earlier research as factors preventing the successful ICT integration in the classroom (Bingimlas, 2009; Tondeur et al., 2008), and lead to the conclusion that the e-capacity (Vanderlinde & van Braak, 2010) of the schools participating in our study is yet not at an optimal level.

To answer our second research question, we especially built on teacher perceptions and expectations about learning paths as an educational tool, related learning outcomes and student characteristics when learning with the LMS/learning paths. According to Liaw et al. (2007), the latter are essential in order to obtain effective e-learning environments. Most teachers were satisfied with the content and the design of the educational materials provided, but had mixed feelings about student learning outcomes. We referred to a potential incongruence between current educational teacher beliefs and the learning approaches deployed in the LMS (Ertmer & Ottenbreit-Leftwich, 2010). Moreover, while teachers had to adjust to the new learning methods, students adapted quickly, but expressed similar concerns as their teachers.

The present study adds to the literature in several respects. Firstly, qualitative research about the use of learning paths within an LMS in a real secondary classroom setting is scarce. Secondly, this study identified several barriers at the school and teacher level affecting the successful implementation of learning paths. Thirdly, this study explored the key stones to develop successful e-learning material and provides an insight into teacher attitudes and perceptions towards using learning paths as an educational tool, on students' learning outcomes and on learner characteristics that foster learning in an LMS.

Despite the advantages of the authentic research context, this study reflects some limitations. Firstly, we build on teacher perceptions as expressed during interviews, not on their actual behaviour. Secondly, our research only involved teachers, while students were not consulted. Thirdly, our sample was small and very specific considering the stratification framework being used. Fourthly, the expected influence of studying with the learning paths can have been partially confounded due to uncontrolled mixing with additional teaching techniques (as reported by some teachers).

We can conclude that currently barriers in secondary education prevent teachers from adopting and integrating LMS in their teaching. Given these observations, it is unlikely teachers are ready and willing to adopt innovative teaching and learning approaches based on LMS and/or learning paths; as stated also by the NMC Horizon Report (2014) doubting major progress in the short term. The implications for policy makers and school leaders are that they need to push the conditions preventing teachers from integrating ICT and LMS within their teaching. Only then will our teachers and learners benefit from technological changes and opportunities.

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