KU LEUVEN

ALO!

TECHNICAL REPORT

(Part 1: 2014-2016)

Design of Blended Learning Environments for Vulnerable Adult Learners

Towards an instructional design model for blended learning environment that support self-regulation.

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This document reports on the part one (2014-2016) of the PhD-project by Stijn Van Laer (KU Leuven) and supervised by prof. dr. Jan Elen (KU Leuven). The PhD-project is part of work package two (WP 2) of the Strategic Basic Research (SBO) Adult Learners Online project (ALO! – www.alo-iwt.be). The overall goal of the SBO-project is to improve the quality of online and blended learning in formal adult education and continuing vocational education, and training. The project includes five work packages. WP 2 is coordinated both by Ghent University (prof. dr. Bram De Wever) and KU Leuven (prof. dr. Jan Elen). The main objective of WP 2 is to develop and test an instructional design model for blended learning at the micro level focuses on how several learning activities within a course should be designed and combined. In this work package, Ghent University (Ruth Boelens) focuses on Teacher Education, where KU Leuven (Stijn Van Laer) focusses on Second Chance Education. This technical report focusses on the latter.

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Summary

Blended forms of learning in adult education have become increasingly popular. Learning activities within these environments are supported by large varieties of online and face-to-face interventions. However, it remains unclear under what conditions these environments are successful. Studies suggest that blended learning challenges learners' self-regulation. Yet, little is known about (1) which self-regulatory behaviours learners exhibit, (2) which environmental attributes support self-regulation and so (3) how blended learning environments (BLEs) can be designed to impact learners' self-regulatory behaviour. The main objective of this PhD project is to develop and validate an instructional design model for the support of learners' self-regulation in BLEs at the micro (course) level. The target group for this project is vulnerable 'second-chance' learners in adult education.

Four studies are planned in a design-based research approach. The first two were undertaken prior to this report, study three is currently in progress and study four still needs to take place. The first study investigated which attributes of BLEs support learners' self-regulation. Based on a systematic literature review, seven attributes that support self-regulation were identified and defined. A descriptive framework for the description of BLEs was developed and validated in different contexts. Based on these actions, the current instructional state of six BLEs designed for the target group was described. The second study examined the self-regulatory behaviour learners exhibit in BLEs and how this behaviour relates to the design of such environments. Traces were collected from the online learning environments. Three self-regulatory profiles could be determined. The results showed a relation between the design of BLEs and the self-regulatory behaviour learners exhibit in them. The two design attributes that occurred least often in the BLEs described were cues for reflection and calibration. Evidence showed that in environments that had some reflection cues, significantly fewer mis-regulators were observed compared to environments that did not include such cues. Based on the results of studies one and two, a third and fourth study will be undertaken to investigate the integration of reflection cues in BLEs. Study three examines the hypotheses that (a) learners' performance is better in environments with extra reflection cues than in environments that do not have such cues, (b) the self-regulatory behaviour of learners will differ between the two environments and (c) a change in learners' self-regulatory behaviour reflects a change in the learners' characteristics rather than an ad-hoc behavioural change. Both studies take a quasi-experimental design-based research approach, including pre- and post-tests and experimental and control conditions. Through two iterative design cycles entailing (a) the description of the current states, (b) a redesign of the BLE, and (c) a final description of the current states, changes in the learners' self-regulation will be investigated. While studies three and four have the same goal, study four will attempt either to target a different attribute (calibration) or to maximize the effectiveness of study three.

These research actions facilitate the development of a model for the design of BLEs that support learners' self-regulation. Such a model would enable (1) the systematic description of existing BLEs and self-regulatory behaviours exhibited by the learner, (2) an informed analysis of the relationships between design and behaviour, and, subsequently, (3) the (re)design of BLEs that support self-regulation. The project also aims to contribute to two research areas. On the one hand, it strengthens the educational psychology field by identifying and defining attributes that support learners' self-regulation in BLEs. It proposes an instrument for describing such environments. Finally, it proposes a more refined methodology for investigating learners' self-regulatory behaviour, using ecological trace data. On the other hand, it strengthens the educational technology field by providing design guidelines for the implementation of environmental attributes to support learners' self-regulatory behaviour in both online and offline components of blended learning environments.

The project

This technical report reports on the Stijn Van Laer's PhD-project which is part of work package two (WP 2) of the Strategic Basic Research (SBO) Adult Learners Online (ALO! – www.alo-iwt.be) project. The overall goal of the SBO-project is to improve the quality of online and blended learning in formal adult education and continuing vocational education and training. The project includes five work packages. Work package two is coordinated both by Ghent University and KU Leuven. The main objective of work package two is to develop and test an instructional design model for blended learning at the micro level focuses on how several learning activities within a course should be designed and combined. In this work package Ghent University (Ruth Boelens) focuses on Teacher Education, where KU Leuven focusses on Second Chance Education.

Introduction

During the last two decades, we have seen a steep rise in the use of computer- and web-based technologies, which has led to significant changes in education. Blended forms of learning have become increasingly popular (Garrison & Kanuka, 2004; Garrison & Vaughan, 2008; Graham, 2006; Spanjers et al., 2015). Learning activities within these blended environments are supported by a large variety of online and face-to-face instructional interventions. Blended learning environments (BLEs) differ widely in the technologies used, the extent of integration of online and face-to-face instruction and the degree to which online activities are meant to replace face-to-face instruction (Smith & Kurthen, 2007). Despite their popularity, it remains unclear under what conditions these environments are successful (Oliver & Trigwell, 2005). An important observation is that blended learning seems to be especially challenging for learners with lower self-regulatory abilities. Learners with lower self-regulatory abilities seem to struggle with the amount of control they have in BLEs. They have problems with the calibration of their own learning activities and thus with taking appropriate action. The opposite is also true: those who are able to regulate their own learning seem to do well in these blended environments (Barnard, Lan, To, Paton, & Lai, 2009; Lynch & Dembo, 2004a). These learners manage and plan their learning activities well over time and reach every deadline. However, it remains unclear why such differences can be observed and what can be done to help struggling learners with low self-regulation. No guidelines are available for designing environments that overcome this issue. This is problematic since educational research shows that the effectiveness of a learning environment depends on its design (Piccoli, Ahmad, & Ives, 2001), e.g. the nature of the tasks given to learners and the information provided to help them perform the learning activities (Smith & Ragan, 1999; Sweller, Van Merrienboer, & Paas, 1998). Three research questions address this need for an instructional design model that supports learners' self-regulation in BLEs. (1) "Which attributes of BLEs support learners'

self-regulation?", (2) "Which self-regulatory behaviours do learners exhibit in BLEs?" and (3) "What would an instructional design model for BLEs that support self-regulation look like?". This PhD project makes a first attempt to answer these questions. Two main concepts are central to these questions: learners' self-regulatory behaviour and the attributes of BLEs that support self-regulation.

Learners' self-regulatory behaviour

In this project, learning is seen as an activity performed by learners for themselves in a proactive manner, rather than as something that happens to them as a result of instruction (Bandura, 1989; Benson, 2013; Knowles, Holton, & Swanson, 2014). Learning is therefore seen as a self-regulated process (Zimmerman & Schunk, 2001). Over the past three decades, various self-regulated learning theories have been founded on this perspective. Five main theories can be identified in the leading reviews written to date (e.g., Baumeister & Heatherton, 1996; Boekaerts, 1999; Boekaerts, Pintrich, & Zeidner, 2005; Puustinen & Pulkkinen, 2001; Zimmerman & Schunk, 2001). Each of these theories describes a cyclic process of self-regulatory phases, often consisting of (a) defining the task, (b) goal-setting and planning, (c) performance and (d) evaluation. The five theories are: (1) Boekaerts' Model of Adaptable Learning (Boekaerts, 1992, 1995, 1996a, 1996b, 1997; Boekaerts et al., 2005), (2) Borkowski's Process-oriented Model of Metacognition (Borkowski, Carr, Rellinger, Pressley, & others, 1990; Pressley, Borkowski, & Schneider, 1987), (3) Pintrich's General Framework for Self-regulation (Pintrich, 2000; Pintrich & De Groot, 1990; Schunk, Pintrich, & Meece, 2008), (4) Winne's Four-stage Model of Self-regulated Learning (Butler & Winne, 1995; Winne, 1995, 1996; Winne & Hadwin, 1998; Winne & Perry, 2000), and (5) Zimmerman's cyclical Social Cognitive Model of Self-regulation (Zimmerman, 1986, 1990, 1998; Zimmerman, 2000; Zimmerman & Pons, 1986).

Altogether, these five theories identify three categories of characteristics that appear to influence learners' self-regulation: (1) cognition (e.g., Zimmerman, 1986, 1990, 1998; Zimmerman, 2000; Zimmerman & Pons, 1986), (2) metacognition (e.g., Borkowski et al., 1990; Pressley et al., 1987), and (3) motivation (Butler & Winne, 1995; Schraw, Crippen, & Hartley, 2006; Schraw & Moshman, 1995; Winne, 1995, 1996; Winne & Hadwin, 1998; Winne & Perry, 2000; Zimmerman, 2000). Although there are similarities among the different theories, the authors do not seem to agree on the nature and plasticity of self-regulation. Regarding the nature of self-regulation, two main ideas can be identified: (1) self-regulation as a combination of cognitive, motivational and metacognitive processes (Zimmerman, 1995), and (2) self-regulation as part of the overarching construct of metacognition (Winne, 2015). In this PhD project we see self-regulation as "a metacognitive process where regulation takes place via the deliberate use of metacognitive skills" (e.g., Brown, 1987; Efklides, 2008; Kuhn, 2000).

Regarding the plasticity of self-regulation, two views can be taken. The first one sees self-regulation as a general and rather stable concept (e.g., Veenman, Elshout, & Meijer, 1997; Veenman, Prins, & Verheij, 2003; Veenman, Wilhelm, & Beishuizen, 2004). The second one sees self-regulation as context-specific and fluid (e.g., Glaser, Schauble, Raghavan, & Zeitz, 1992); it is influenced both by internal (cognitive, motivational and metacognitive characteristics) and external (e.g. educational practise) conditions (Winne & Hadwin, 1998). In this PhD project we see the two views as intertwined. For example, self-regulation may be stable because of specific constellations of internal learner conditions. These constellations will continue to determine learners' self-regulatory behaviour even when external conditions change. Importantly, however, the external conditions of a given learning situation will also have an impact on learners' self-regulatory behaviour. In this study we focus mainly on the latter perspective because we are interested in how best to design blended learning environments in order to support self-regulation. Finally, it should be stated that in an instructional context self-regulation relates not only to the calibration of behaviour towards one's own goals (e.g., Benhabib & Bisin, 2005; Herweg & Müller, 2008) but also to the combination of these goals and the ones set by an external actor (e.g., the instructor) (Lemos, 1999).

In conclusion, and keeping in mind the different views on self-regulation, self-regulation in this PhD project is seen as: "The deliberate use of metacognitive skills, in a particular context, to achieve goals both internal and external to the learner." Based on this definition, the Winne and Hadwin (1998) model was selected to reflect upon the self-regulatory behaviour of learners, since it has a number of characteristics that makes it very suitable for our purpose. These characteristics will be described in more detail later. As the name suggests, Winne's Four-stage Model of Self-regulated Learning (Butler & Winne, 1995; Winne, 1995, 1996; Winne & Hadwin, 1998; Winne & Perry, 2000) describes four stages: (1) task definition, during which learners develop perceptions of the task concerned, (2) goal-setting and planning, (3) enacting the tactics and strategies chosen during goal-setting and planning, and (4) metacognitively adapting studying techniques, keeping future needs in mind. Each of these phases consists of five elements (COPES): (1) conditions, which affect how a task will be engaged with, (2) operations: cognitive processes and tactics learners employs, (3) product: information created by operations, (4) evaluations: feedback about products (internal or external), and (5) standards: criteria against which products are monitored. The theory emphasizes that learners who are prompted to process effectively in stage one (task definition) and stage two (goal-setting and planning) are more likely to have accurate expectations of the task (Winne & Hadwin, 1998). Finally each stage and its elements is influenced by certain conditions. Winne and Hadwin (1998) identify task-related conditions (e.g., time constraints, available resources and social context) and cognitive-related conditions (e.g., interest, goal orientation and task knowledge) that influence how a certain task will be engaged with

(Winne & Hadwin, 1998). Cognitive conditions are learners' epistemological beliefs, prior knowledge (all information stored in the long-term memory) and motivation (Winne & Hadwin, 1998).

The Four-stage Model of Self-regulated Learning has a number of characteristics that suit the purposes of this project very well. First, the model looks beyond the focus on purely instructional stimuli and their effects on learning, contesting the assumption that all learners process the stimuli as intended (Winne, 1982). The authors see learners as active agents (Winne, 1982, 1985, 2006) or mediating factors in the instructional process (Keller, 2010; Winne, 1982). As the learners in this project are seen as having difficulties with regulating their own learning, this scope allows us to highlight the suitability of particular designs for certain learners and to work toward 'more inclusive' environments better understood by different types of learners. A second consideration is that on the one hand, the model gives clear indications, about which phases should be targeted, namely task definition followed by goal setting and planning (Winne & Hadwin, 1998). On the other hand, each phase (one to four) incorporates the COPES process, which makes up the cognitive system (Greene & Azevedo, 2007). The cognitive system explicitly models how work is done in each phase and allows for a more detailed look at how various aspects of the COPES architecture interact (Greene & Azevedo, 2007). This approach allows us to make as targeted interventions as possible focussing on areas that can be impacted (e.g., conditions by supporting task definition, planning and goal-setting). Third, with monitoring and control functioning as the key drivers of regulation within each phase, Winne and Hadwin's model (1998) can effectively describe how changes in one phase can lead to changes in other phases over the course of learning (Greene & Azevedo, 2007). This allows the model to explicitly detail the recursive nature of self-regulation (Greene & Azevedo, 2007). Fourth, the model holds a behavioural focus on self-regulation, in contrast with a focus on self-reports. This together with previous considerations aligns strongly with the focus of this project. On the one hand, because the main focus of this project lies on the support of and changes in learners' self-regulatory behaviour (by mapping their behaviour instead of asking for their perceptions). On the other hand, because the recursive nature of self-regulation underlines the evolving nature of it and the need of monitoring change over time. The final reason for this model's suitability is that it separates task definition, goal setting and planning into distinct phases. This allows more pertinent questions to be asked about these phases than would otherwise be possible, when focusing on instructional interventions alone (Greene & Azevedo, 2007; Winne & Marx, 1989).

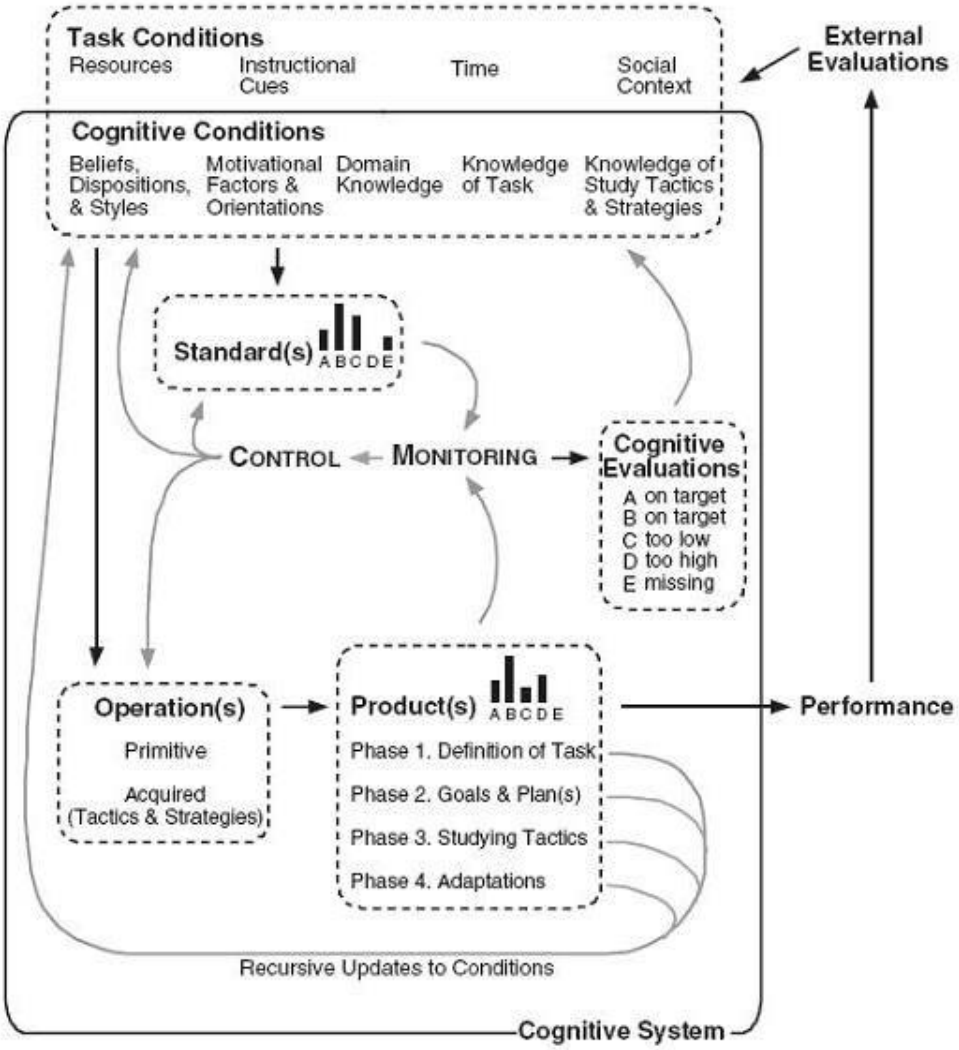

Figure 1. Winne and Hadwin's (1998) Four-stage Model of Self-regulated Learning.

Learner characteristics influencing self-regulation

The Winne and Hadwin's (1998) model of self-regulation used in this PhD project, describes different cognitive conditions (see earlier) learners are exposed to while trying to regulate their own learning. These conditions (similar to other theories) can be divided in three sets of learner characteristics. First is cognition (domain knowledge and knowledge about the task (Winne & Hadwin, 1998)), secondly there is motivation (motivational factors and orientations (Winne & Hadwin, 1998)), and finally, there is metacognition (knowledge of study tactics and strategies, beliefs, dispositions and styles (Winne & Hadwin, 1998)). First we will discuss each set of characteristics in general and, secondly, point out the characteristics we will focus on in this PhD project. Due to the aim is to make distinctions between different types of learners (based on the three sets of characteristics) prior to interventions, we investigated which of the constructs are rather stable over time.

Cognitive characteristics often entail two themes (1) intelligence (Spolsky, 1989), and (2) domain knowledge (Hirschfeld & Gelman, 1994). Domain knowledge is one of the key conditions influencing self-regulation (Winne & Hadwin, 1998). Nietfeld and Schraw (2002) found that higher prior domain knowledge predicted better performance. Alexander, Murphy, Woods, Duhon, and Parker (1997) suggested a three phase model of domain learning states that learners move through in pursuing an academic domain (low, familiar, and competent). Winne and Hadwin's (1998) model suggests the possibility that operations in task identification, and goal-setting and planning may be affected by (prior) domain knowledge. As prior domain knowledge seems to be a good predictor for future academic performance and learners' self-regulatory behaviour (e.g., Murphy & Alexander, 2002), this characteristic will be used as an indicator of cognition throughout the PhD project.

Secondly there are the motivational characteristics. Motivational influences on self-regulation have been well established in the field of self-regulation (e.g., Pintrich, 2004). The different perspectives on motivation are elaborated in different to-date systematic literature reviews (Covington, 2000; Deci, Vallerand, Pelletier, & Ryan, 1991; Dickinson, 1995). Greene and Azevedo (2007) related five motivational constructs to the Winne and Hadwin (1998) model. This to show the models potential for answering questions relating to supporting learners' motivation and its relation to self-regulation. (1) Goal orientation. Elliot and Church (1997) and Pintrich (2000) makes a distinction between mastery and performance goals, along with each approach and avoidance forms. Pintrich and De Groot (1990) found that a mastery-orientation was predictive of engagement in academic tasks. Elliot and McGregor (2001) found an association between this orientation and test anxiety, consistent with the characterization of mastery-avoidant students as perfectionists. In addition, Zusho and Pintrich (2000) found that mastery-avoidance goals were positively related to both need for achievement and math performance. Additionally, learners' goal orientation can also be considered as an important motivational characteristic that possibly influences learners' use of certain tools within a BLE (Lust, 2012). Moreover, because learners' achievement behaviour is strongly guided by the kind of goals learners pursue (Dweck, 1986; Nicholls, 1984). Relating goal orientation back to the Winne and Hadwin's (1998) model, it remains (e.g.) unclear if learners with a performance-avoidance goal orientation assess the fit of products and standards different from learners with a mastery-approach goal orientation? (2) self-efficacy. Self-efficacy or learners' beliefs regarding their ability to perform certain goal-oriented tasks. In essence, these beliefs are learners' expectations for success (Bandura, 1997). Academic performance, persistence, self-regulatory strategy use, and choice of task have all been linked to high academic self-efficacy (Bandura, 1997; Finney & Schraw, 2003; Pajares & Schunk, 2002; Pintrich & De Groot, 1990; Stone, 2000). Winne and Hadwin's (1998) model suggests a possible role for outcome expectations in the maintenance of conditional knowledge which is knowledge of

when and under what circumstances to use certain strategies (Newell & Simon, 1972). (3) expectancy-value theory. Eccles and colleagues (Eccles & Wigfield, 2002; Wigfield, Byrnes, & Eccles, 2006) advanced a model of motivation based on efficacy expectancies and task value. This model focuses on individuals' expectations for success on upcoming tasks. Research on expectancy-value theory has shown that even after controlling for prior performance, academic performance can be predicted by expectancies for success, while task values seem to predict academic decisions such as enrolment (for a review see: Eccles & Wigfield, 2002). (4) Self-determination theory. Self-determination stresses the psychological needs and the benefits of intrinsic over extrinsic motivation (Deci & Ryan, 1985; Wigfield et al., 2006). A sense of self-determination, occurs when three fundamental human psychological needs are met: competence, autonomy, and relatedness. Within Winne and Hadwin's (1998) model, this can be seen as an interaction of a task condition (reward) with a cognitive condition (need for autonomy). Questions remain regarding in what phase this interaction occurs, the kinds of standard it produces, and how it influences operations. Finally, (5) interest. Researchers on learner interest have split the construct into individual and situational types (Wigfield et al., 2006). Individual interest seems to be related to the use of more advanced cognitive strategies (Schiefele, Krapp, & Winteler, 1992) as well as better academic performance (Alexander, Kulikowich, & Jetton, 1994; Pintrich & Schunk, 2002). Within Winne and Hadwin's (1998), whether (e.g.) interest influences learners' cognitive evaluations and monitoring. Reviewing these underlying constructs it becomes clear that many of the constructs are fluid in nature. In our opinion goal orientation is the most stable (over time) and predictive construct (e.g., Dweck, 1986; Lust, 2012; Nicholls, 1984) associated to the Winne and Hadwin (1998) model. In this project goal orientation will be used as an indicator for motivation.

Metacognition has been defined by: (1) Flavell (1979) as cognition of cognition that serves both monitoring and control of cognition, and (2) by Nelson (1996; Nelson & Narens, 1994) as cognition at the object-level and metacognition as the reflection on it at the meta-level. Metacognition is proved to be multifaceted (Efklides, 2001, 2006). Three facets can be identified: (1) metacognitive knowledge. This type of knowledge is declarative in nature. (2) Metacognitive experiences. These experiences are what learners are aware of or feel when coming across a task and processing the information related to it. Efklides (2002; Efklides, Kourkoulou, Mitsiou, & Ziliaskopoulou, 2006) see these experiences as the interface between the person and the task. Research has recently coalesced around the idea that such experiences may mediate the relation between the task and cognitive and motivational strategy use during self-regulation (Butler & Winne, 1995; Paulsen & Feldman, 1999, 2005). Prior experiences often make up learners' perceptions of their own abilities. In this light Marsh and Shavelson (1985) introduced the academic self-concept. This self-concept refers to mental representations of one's abilities within school or academic settings, or in relation to one's academic progress (Bracken, 2009;

Brunner et al., 2010). The academic self-concept includes three underlying construct (academic self-esteem, school subjects self-concept and academic status) (Liu & Wang, 2005). Numerous researchers have shown that more sophisticated beliefs about knowledge are associated with higher academic performance (Bracken, 2009; King & Kitchener, 1994; Schommer, 1990, 1993; Schommer, Crouse, & Rhodes, 1992). Finally there are (3) metacognitive skills. These skills comprise orientation, planning and regulation of cognitive processing strategies, strategies for monitoring the execution of planned actions, and strategies for the evaluation of the outcome of task processing (Veenman et al., 1997). Metacognitive skills are in our opinion the behavioural representation of self-regulation. Winne and Hadwin's (1998) model allows for external evaluations to influence cognitive conditions. Nonetheless the question remains as to what kinds of evaluations are necessary to influence epistemological beliefs. As indicator of metacognition we opted to use the academic self-concept. This type of self-concept out-performed every other type of self-concept and esteem in its predictive relation to performance (Marsh & O'Mara, 2008).

Table 1: *Cognitive, motivational and metacognitive characteristics investigated during the PhD project.*

Cognitive characteristics	*Prior Domain Knowledge*
Motivational characteristics	*Goal Orientation*
Metacognitive characteristics	*Academic self-concept* • **Academic Self-Esteem** • **School subjects Self-Concept** • **Academic Status**

Adult learners in blended learning

Research on BLEs generally praises its flexibility and suitability for adult learners (Ausburn, 2004). These adult learners are often described using the andragogy model developed by Knowles et al. (2014). Others have stressed for example autonomy, self-direction, and affinity for real-life learning as key characteristics of adult learners (see e.g., Brookfield, 1986; Caffarella & Merriam, 2000; Tough, 1978). The andragogy focuses rather on the strengths of the learner (adult in their learning and in regulating their learning). Questions could be asked about how BLEs deal with adults that do not possess these characteristics, for example second chance learners (Connolly, Murphy, & Moore, 2007). In this project, the focus lies on the latter type of adult learners. These learners often have negative prior experiences with education and dropped out of school early. When such learners enter a BLE, they may face different challenges due to their limited skills to deal with these environments. This claim is supported by the to-date research that argues that these environments often require a large amount of self-regulation on the part of learners (Bonk & Graham, 2012; Collis, Bruijstens, & van Veen,

2003). Learners need to possess, when they learn in such environments, different self-regulation related skills (e.g., Lynch & Dembo, 2004b; Sharma, Dick, Chin, & Land, 2007). It seems that BLEs work fine for adults with proper self-regulatory skills, but that they may fail to address learners with lower self-regulatory skills (Cennamo, Ross, & Rogers, 2002).

Attributes supporting self-regulation in blended learning environments

Ifenthaler (2010), Graham (2006) and Whitelock and Jelfs (2003) described three definitions of the concept of blended learning. The first definition (based on Harrison (2003)) views blended learning as the integrated combination of traditional learning with web-based online approaches (Bersin & others, 2003; Orey, 2002a, 2002b; Singh, Reed, & others, 2001; Thomson, 2002). The second one considers it as a combination of media and tools employed in an e-learning environment (Reay, 2001; Rooney, 2003; Sands, 2002; Ward & LaBranche, 2003; Young, 2001) and the third one treats it as a combination of a number of didactic approaches, irrespective of the learning technology used (Driscoll, 2002; House, 2002; Rossett, 2002). Driscoll (2002, p. 1) concludes that "the point is that blended learning means different things to different people, which illustrates its widely untapped potential". Oliver and Trigwell (2005) add that the term remains unclear and ill-defined. Taking these observations into account, the definition used in this PhD project is as follows: "Blended learning is learning that happens in an instructional context which is characterized by a deliberate combination of online and classroom-based interventions to instigate and support learning. Learning happening in purely online or purely classroom-based instructional settings is excluded" (Boelens, Van Laer, De Wever, & Elen, 2015).

A formal definition of learner support in BLEs does not yet seem to have been provided in research literature, although a considerable number of researchers (e.g., Kearsley & Moore, 1996; Keegan, 1996; Robinson, 1995; Tait, 2000; Thorpe, 2002) have made valuable contributions by defining similar concepts such as student or educational support. Learner support in BLEs often refers to meeting the needs learners have, choices at course level, preparatory tests, study skills, access to seminars and tutorials, and so on. These are elements in systems of learner support that are often seen as essential for the effective provision of blended learning (Kearsley & Moore, 1996; Keegan, 1996). Nonetheless, Sewart (1993) notes that a review of key areas of the literature dating back to 1978 does not reveal any comprehensive analysis of learner support (Robinson, 1995). It is therefore particularly challenging to address the issue of learner support in blended learning. Tait (2000) describes the central functions of learner support services in non-strictly face-to-face settings by arguing that it should be cognitive, affective, and systemic (Tait, 2000). In this PhD project, 'support' refers to all measures taken to instigate and / or facilitate learning. As the support of learners' learning has as primary focus the growth of the learners towards mastery of certain skills or goals, a final remark should be made

regarding the term 'learning outcome'. This term is often used in the same sense as learning objectives (Melton, 1997). In our opinion this understanding is too narrow and too focused on an increase in performance. In this PhD project, performance will be used to describe learners' domain specific knowledge or skills, where learning outcomes are defined as changes in cognitive, metacognitive, or motivational abilities, which together constitute the basis for learners' ability to self-regulate (e.g., Allan, 1996; Popham, Eisner, Sullivan, & Tyler, 1969).

Measuring self-regulation

Measurements of self-regulation have a long history in research (Winne & Perry, 2000; Zimmerman, 2008). Conceptual understanding evolved from self-regulation as aptitude (stable character) to self-regulation as an event (turbulent character). When self-regulation is measured as aptitude, a single measurement, aggregates over, or abstracts some quality of self-regulation. (e.g., Endedijk, Brekelmans, Sleegers, & Vermunt, 2015; Pintrich, Smith, García, & McKeachie, 1993; Weinstein, Zimmerman, & Palmer, 1988). These instruments often rely on self-reports of learners. Many authors consider the results of self-reports instruments to be poor indicators of the actual regulation activities that students use while studying (Perry & Winne, 2006; Pintrich, 2004; Veenman, Van Hout-Wolters, & Afflerbach, 2006). The measurement of self-regulation as events, in contrary, is based on multiple self-regulation events (Winne & Perry, 2000). Endedijk et al. (2015) reported on online (during the task) and offline (after the task) methods. These types of measurements appear to be more suitable for finding relations between specific aspects of real time self-regulatory behaviour in authentic contexts (Zimmerman, 2008) and have the potential to be more accurate than retrospective self-reports that require recall of actions and thoughts (Winne et al., 2006).

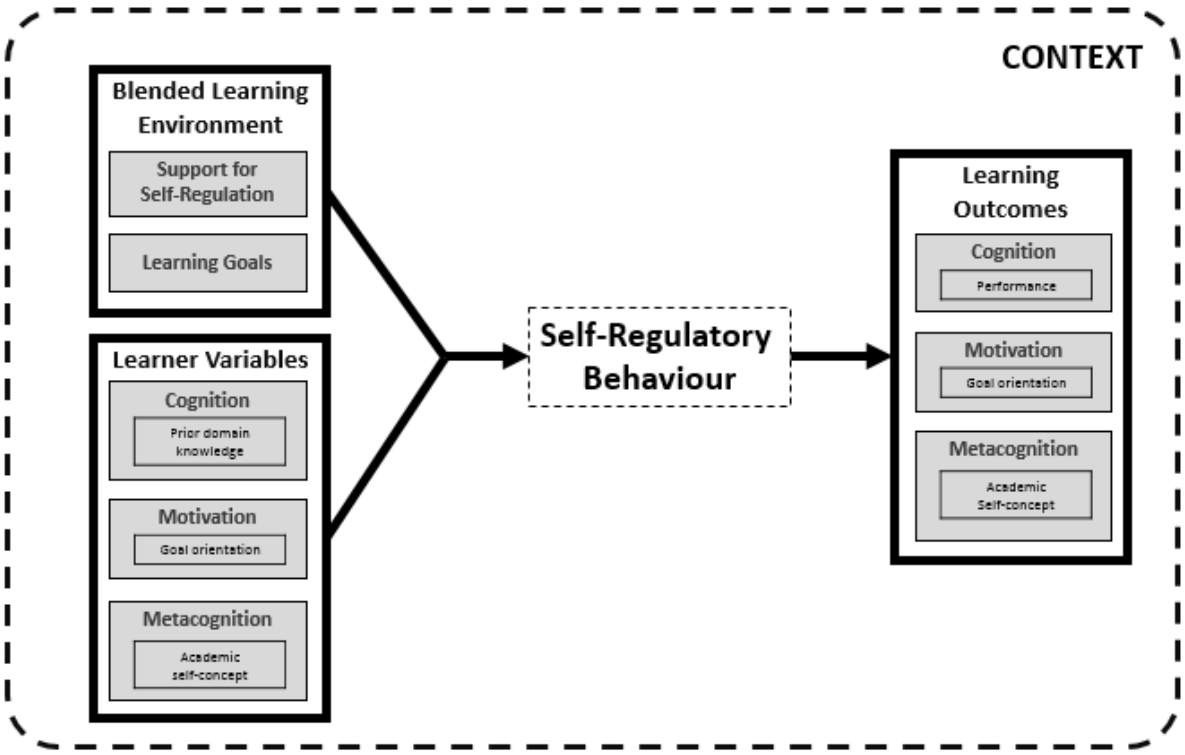

Figure 2. Conceptual model used during this PhD project.

Problem statement and research questions

Although research stresses the suitability of BLEs for adults (Brookfield, 1986; Caffarella & Merriam, 2000; Tough, 1978), research on second chance education suggests that such learners are not necessarily able to regulate their own learning (Connolly et al., 2007). Research on self-regulation in blended-learning environments regularly reports the importance of specific self-regulatory abilities learners need, to be able to benefit from BLEs (e.g., Lynch & Dembo, 2004a). Second chance learners often lack these abilities. To be able to design BLEs that support self-regulation, the following research questions need to be addressed: (1) "What attributes of BLEs support learners' self-regulation?", (2) "What self-regulatory behaviour do learners exhibit in BLEs?", and (3) "Does targeting the attributes changes learners' self-regulatory behaviour?". By answering these research questions the systematic description of existing BLEs and self-regulatory behaviour exhibited by the learner becomes possible. Moreover an informed analysis of the relationships between the two elements can be applied. Finally, an instructional design model and guidelines for the design of BLEs that support self-regulation can be proposed, which may help instructors to design such learning environments.

Research design

To answer these research questions, a design-based research approach (Barab & Squire, 2004; Wang & Hannafin, 2005a) was established. Brown (1987) and Collins, Joseph, and Bielaczyc (2004) characterize this approach as (1) addressing complex problems in real contexts in collaboration with

practitioners, (2) integrating known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems, and (3) conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles. Such an approach often consist of four phases, with in each phase the recurring event of refinement of the problem statement, methods and design principles. The first phase is the analysis of practical problems in collaboration by both the researcher and the practitioners. Next, there is the development of solutions informed by existing theories and practises. The third phase is the iterative cycle of testing and refinement of solutions in practice. Last and final, is the reflection to produce design principles and enhance solution implementation(Reeves, 2006; Wang & Hannafin, 2005b). Although the suitability and appropriateness of this approach is legitimate in this context, some common issues about the design-based research approach need to be addressed (e.g., Bell, 2004; Kelly, 2004; Ormel, Roblin, McKenney, Voogt, & Pieters, 2012). Three types of issues are often mentioned: methodology (e.g., Sandoval, 2014; Shavelson, Phillips, Towne, & Feuer, 2003), agency (e.g., Engeström, 2011; Gutiérrez & Vossoughi, 2009) and scalability (e.g., Bielaczyc, 2013; Fishman & Krajcik, 2003). In this PhD project, the methodological issues (transparency of the methodology used) are taken in consideration by applying theory-based systematic approaches for each study (e.g., systematic literature review and quasi-experimental designs). This idea is operationalized by defining research questions and addressing sub-questions based on the most to date literature and methodology (e.g., event sequence analysis). When interventions are done, they are done both in an ecological valid and quasi-experimental way, including a pre- and post-test and an experimental and control condition. The agency issues were monitored by involving the instructors of the targeted course as early as possible in the research process. Each of them was (a) introduced to the project, (b) introduced to the instruments used, and when a redesign was made this was done (c) in a co-design set-up. The co-design is embedded in the day-to-day practice of the instructors to maximize transfer also after the project. Finally the scalability was addressed by both using the instruments developed and reproducing the studies in different instructional contexts.

As a first research action, a systematic literature review was done to determine attributes of BLEs that support self-regulation. Based on the outcomes of this study a framework for the description of BLEs was developed and validated in different contexts. In a second study, learners' self-regulatory behaviour in BLEs was investigated. This study identified profiles of learners' self-regulatory behaviour within these learning environments and related them to the design of such environments. These two studies constitute the theoretical and methodological basis for studies three and four, which will take place in the second half of the PhD project. The methodological and theoretical background of these studies functioned as tools for analysing the results of future studies (analysis after each redesign).

Based on the outcomes of study one and two (current state of literature and practice), study three and four target the redesign of current BLEs and the refinement of the measurement of the context-specific type of self-regulation. Both empirical studies will take place in ecologically valid settings and in close collaboration with the instructors involved. Study three will be a first empirical redesign cycle. In study four the effectivity of the design proposed in study three will be maximized. The findings will result in concrete design principles. These design-based interventions in study three and four will test if providing more reflection cues increases the performance of the learners. Second they will investigate what changes in self-regulatory behaviour occur when reflection cues are integrated. Last and final there will be examined if the self-regulatory change of behaviour is purely an ad hoc one or if these changes also impact learners' cognition, metacognition and motivation. Combined the four studies function as the basis of a model to design BLEs that support self-regulation.

Studies

Study 1: Literature review

As mentioned before, studies suggest that blended learning challenges the self-regulatory abilities of learners, though the literature hardly explains these findings nor does it provide solutions. In particular, little is known about what attributes are essential to support learners and how these attributes should guide course design. This systematic literature review (n=95) examined evidence published between 1985 and 2015 on attributes of BLEs that support self-regulation. The purpose of this review was therefore to identify and describe the attributes of BLEs that support learners' self-regulatory abilities. The methodological approach used to answer the research question was based both on research literature on systematic literature reviews(Hart, 2009; Joy, 2007) and on the methodologies used in highly valued educational reviews with similar methodological aims (e.g., Bernard et al., 2004; Blok, Oostdam, Otter, & Overmaat, 2002; Butler & Winne, 1995; De Jong & Van Joolingen, 1998; Tallent-Runnels et al., 2006; Tinto, 1975). By comparing both methodological sources, it could be observed that most of the reviews suggest a similar design as presented by (Hart, 2009). His methodological outline and suggestions was therefore used to perform the systematic literature review.

Seven attributes (inherent and essential parts of the learning environment) were identified. The first attribute is authenticity, or the real-world relevance of the learning experience to learners' lives. Secondly, there is personalization, defined as the tailoring of the learning environment to the inherent preferences and needs of each individual learner. Third, learner control is the degree to which learners have control over the content and activities within the learning environment. As fourth, there is

scaffolding, defined as changes in the task or learning environment, which assist learners in accomplishing tasks that would otherwise be beyond their reach. Fifth is interaction, or learners' engagement with elements in the learning environment. Sixth are reflection cues, which are prompts aiming at activating learners' purposeful critical analysis of knowledge. Finally, there are calibration cues that are triggers for learners to test their perceptions against their actual achievement and study tactics.

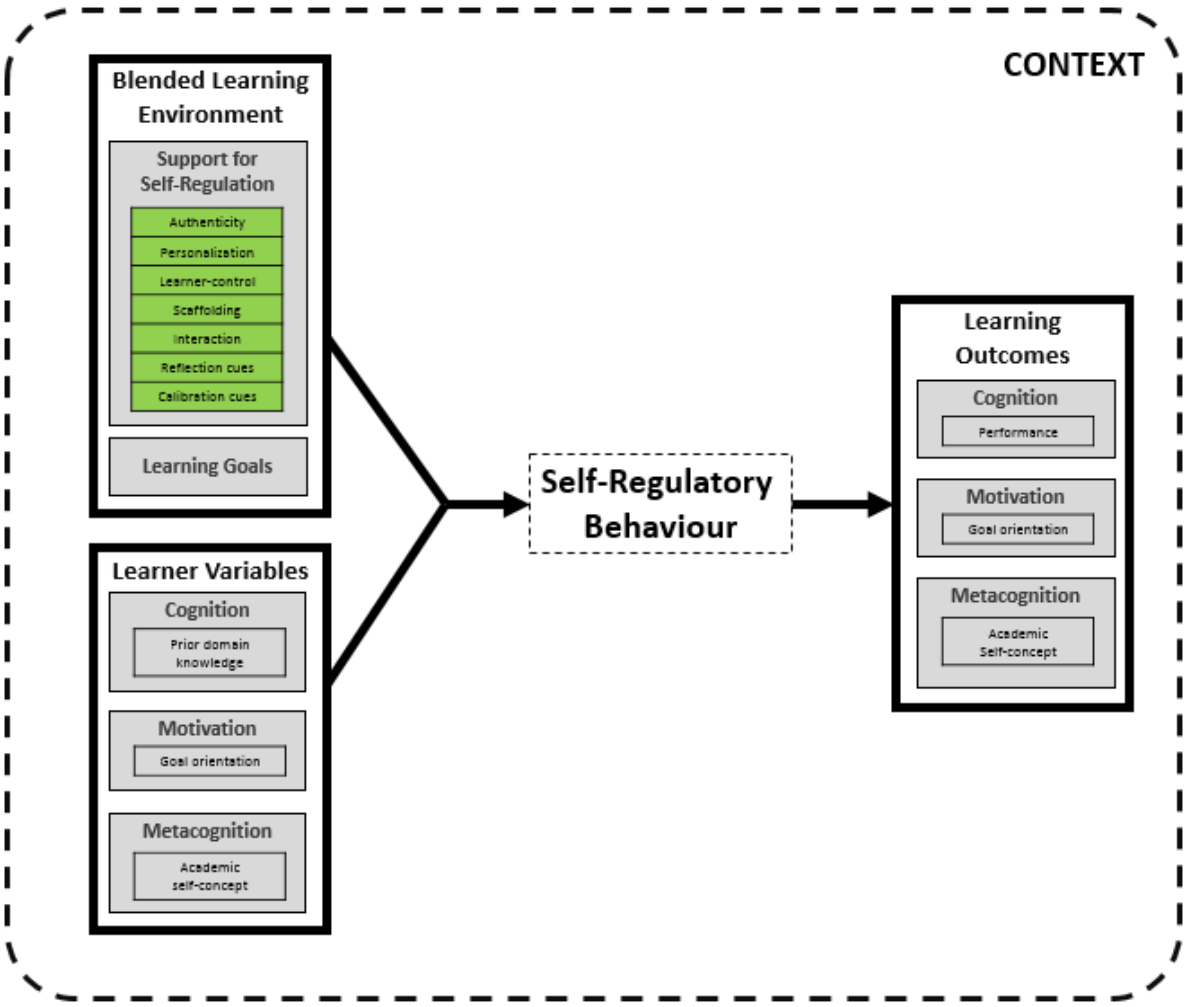

Figure 3. Conceptual relevance of study 1.

This review is the first to identify and define attributes that support self-regulation in BLEs and may serve to facilitate the design of BLEs that meet learners' self-regulatory needs. It also raises crucial questions about how blended learning relates to well-established learning theories (e.g., components of a constructivist learning environment) and provides a basis for future research on the design features for self-regulation in BLEs. The attributes were identified, defined and explained using the COPES-model (Winne & Hadwin, 1998).

Study 2: Identification of learners' self-regulatory profiles

The aim of this study was to identify learners' self-regulatory behaviour profiles in BLEs and to relate them to the design of these environments. To do this, we first captured learners' self-regulatory behaviour in six blended learning courses from two institutions (n=120). We used ecological trace data (log files) to describe learners' behaviour. These were collected from the back-end of the courses' Moodle environments and analysed for frequency, timing, patterns, and sequence of events (Hadwin, Nesbit, Jamieson-Noel, Code, & Winne, 2007). This involved performing cluster analyses in R-Statistics software. Next, in order to capture the design of each BLE, we used a framework to describe them from a self-regulatory perspective. This framework was based on the results of the systematic literature review. The attributes were described using an additional literature study and operationalized using questions for the observation of each attribute. The instrument was piloted and tested for interrater reliability. The instrument's finer grainsize will be validated building up to study three and four.

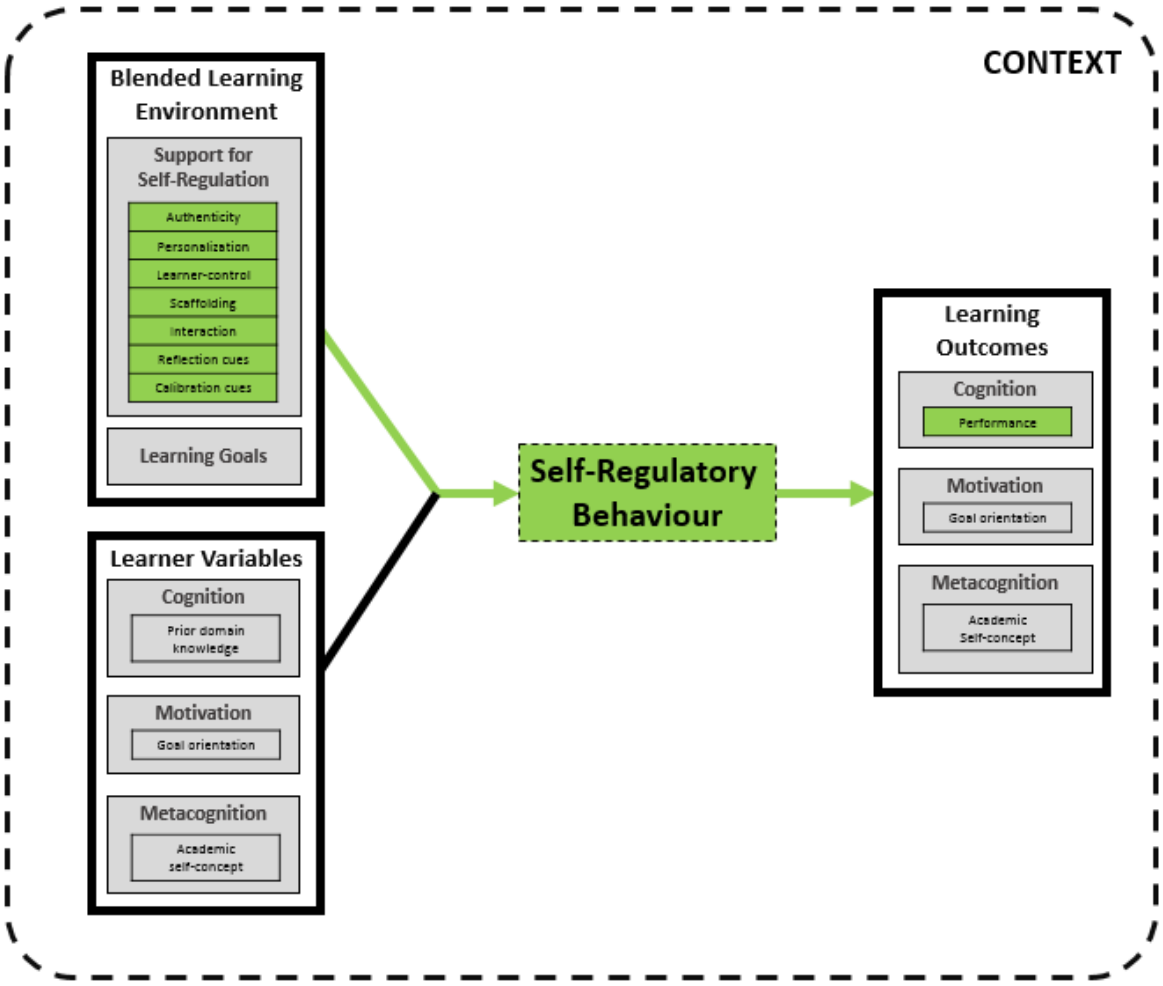

Figure 4. Conceptual research design study two.

In the two institutions, three comparable learner self-regulatory behaviour profiles (internal, external and mis-regulator) were identified. Each of these clusters relate closely to earlier research done by Vermunt and Vermetten (2004), who identified a self-regulating, external regulating and lack of regulation profile. Analysis showed the influence of cluster membership on performance (cognitive learning outcomes). It can be stated that the last cluster profile (mis-regulator) is the least desirable one. This because a significant negative impact on performance was observed for this group. Concluding, a comparison between the different learning environments and the learners' behaviour in them was made to display the impact of the design of the learning environments on the learner behaviour within the environment. It became clear that when the sum score on self-regulation increases, significantly less mis-regulators were observed. This result suggest that when a higher degree of attributes that support self-regulation in BLEs is observed, the chance for mis-regulators to move away from their own profile towards the internal or external regulator profile increases. Although neither internal nor external regulators can be classified as better self-regulators. It would be beneficial to increase the integration of the different self-regulation attributes in the design of BLEs, especially to enable miss-regulators to move away from their profile.

Based on further analysis of the results of study two it became clear that, when reflection cues were integrated more (e.g., in environment four) significantly less learners with the undesirable profile (mis-regulator) could be observed. Such an investigation could not be done for calibration cues, due to the scores for calibration cues were equal for all the environments observed. As there is evidence that the use of reflection cues might impact self-regulatory behaviour it seems evident to further investigate its role with regard to the support of self-regulation.

Study 3: First redesign cycle

Based on the outcomes of previous studies we will investigate if targeting one of the attributes increases learners' performance. This research question tests the hypothesis that learners' performance will increase more in environments with extra reflection cues, compared to environments without such extra cues. The second research question investigates how extra reflection cues change the self-regulatory behaviour of different types of learners. We hypothesized that the self-regulatory behaviour of learners (each with their own cognitive, metacognitive and motivational characteristics) will be different between the environments with or without extra reflection cues. Finally, the third research question investigates if change of learners' self-regulatory behaviour, is a simple ad hoc change, or rather an indication of a change in the learner's cognitive, metacognitive and motivational characteristics.

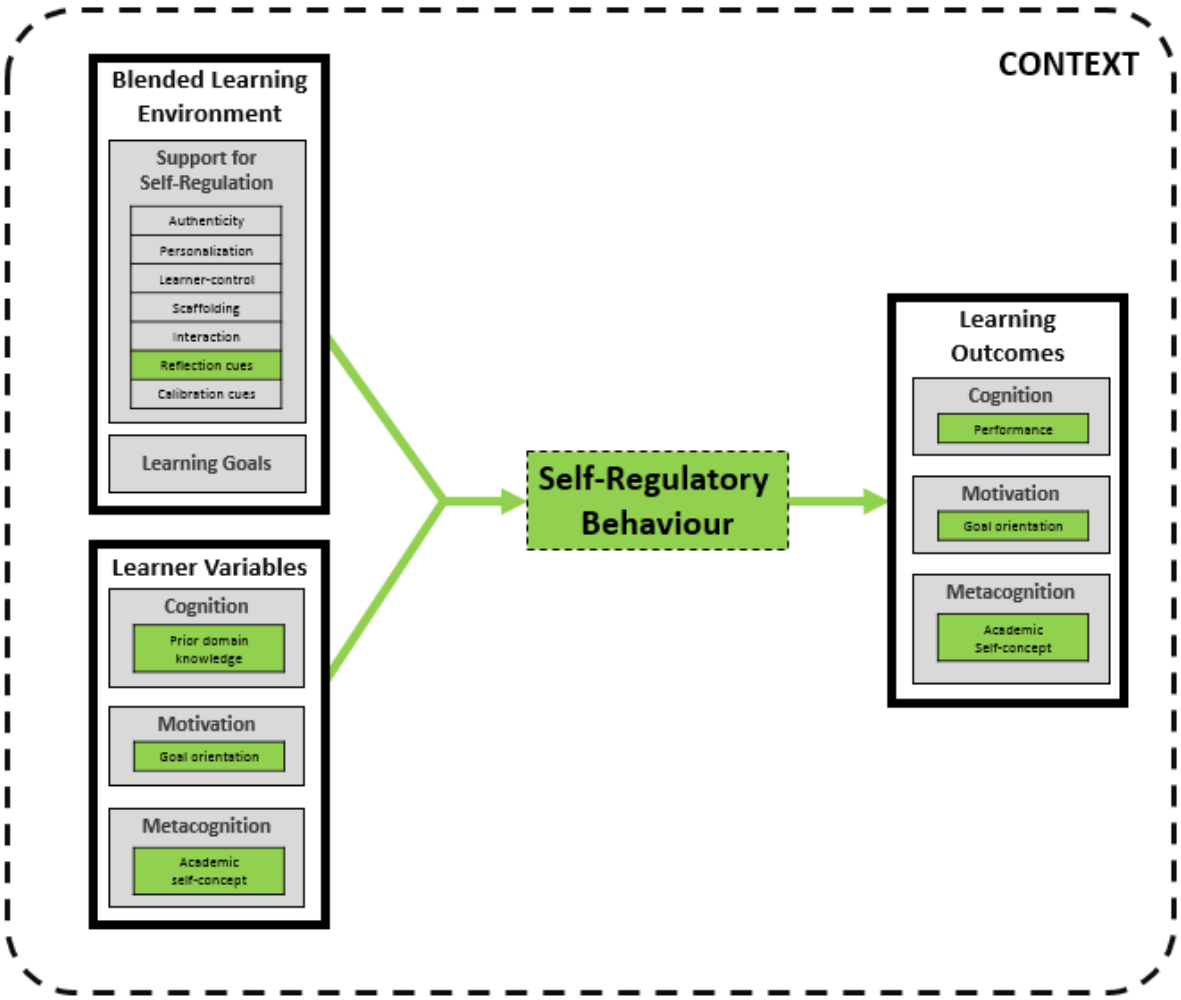

Figure 5. Conceptual research design study three.

Answering these question will be done by applying a design-based (quasi experimental), cross-sectional research design for six courses (three classrooms receive the intervention, three do not). All courses will take part in a pre- and post-test, quasi-experimental study with two conditions. The same six BLEs as in study two, in two Flemish schools of adult education, will be targeted. The population is divided over six courses (n=+/-120). To be able to determine what interventions are successful for which learners, the integration of a variety of learner characteristics is the next step to take. A prior knowledge test will be administered to investigate learners' prior domain knowledge. To measure learners' motivational characteristics we will use the Elliot and McGregor (2001) Achievement Goal Questionnaire (AGQ). This questionnaire measures the four dimensions of goal orientation (mastery-approach, performance-avoidance, performance-approach and mastery-avoidance). The questionnaire consists of 21 items. Finally to measure learners' metacognitive characteristics we opted to use Liu, Wang, and Parkins (2005) Academic Self-concept Questionnaire (ASCQ). This questionnaire contains 39 items and measures three constructs: (1) academic self-esteem, (2) school subjects self-concept, and (3) academic status. For both questionnaires the items were translated to Dutch using

the translation/back translation method in order to avoid semantic problems (Behling & Law, 2000). Both questionnaires will be piloted, checked for reliability and used during the pre- and post-test.

Once the prior-knowledge test and the online questionnaire is completed, the instructor will start the intervention. The intervention will consist of the integration of cues for reflection in the on-line component of the course (for more information see: Clarebout, Horz, Schnotz, & Elen, 2010). These reflection cues focus on both the identification of tasks and the setting of goals and plans (for more information see: MacLeod, Coates, & Hetherton, 2008; Oshige, 2009) and will be delivered prior, during and after (van den Boom, Paas, van Merriënboer, & van Gog, 2004) the completion of a task. Before the actual intervention, a pilot was done to test the intervention (ahead to this report). Practical modifications to the research design will be made and the actual intervention will take place. The control condition will have the same face-to-face design and the same base-line design of the online environment as the experimental condition. In the experimental condition extra reflection cues will be added to the online component.

Both the experimental and control condition will be described using the instrument developed in study one and two. This will be done for both the online and offline environment. To test the hypotheses, the log files for each group (experimental and control) will be analysed using an approach similar to the one adopted in study two. In study three there the grain-size of analysis will be refined to capture learners' self-regulatory behaviour in more detail. The methodology of study two will be elaborated by the identification of traceable variables into an action library, and sequences of them in the online environment. An action library is a coding scheme to recode the traced variables into meaningful sequences. Based on the results of these analyses, statistical trails will be done to investigate the relationship with learners' characteristics (prior-knowledge, performance, academic self-concept and goal-orientation), the design of the learning environment and the self-regulatory behaviour of student in the BLE. The pre- and post-test data from the domain knowledge test and the learners' metacognitive and motivational characteristics will be analysed. For the metacognitive and motivational variables the Cronbach's Alpha will be calculated to check for internal consistency of the scales in the instrument. A repeated measures analysis (pre and post) of covariance will be done to check for evolutions in learners' cognitive (prior knowledge vs performance), metacognitive (academic self-concept) and motivational (goal-orientation) characteristics.

Study 4: Second redesign cycle

Depending on the results of study three a second redesign cycle will take place. Two scenarios might unfold. On the one hand the intervention can be more successful for particular learners (see: the impact of learner characteristics) than for other. When this is the case, further investigation is needed

to clarify what design of reflection cue is more suitable for what type of learners. Although the intervention in study three included both explicit and implicit reflection cues. It might be observed that (e.g.) learners with low prior knowledge have more need for (solely) explicit reflection cues. The same goes for the mix of the use of embedded and unembedded (Clarebout et al., 2010) ways of delivery. Learners with for instance a high academic self-concept might not pay attention to the unembedded cues and might find the embedded ones too easy for them, and so ignore them. Regarding the content of the reflection cues an equal mix of cues focusing on both the identification of tasks and the setting of goals and plans (MacLeod et al., 2008; Oshige, 2009) was provided. Learners with, e.g. performance-avoidance approaches might only pay attention to cues related to reflection on the task identification, because this helps them to avoid non-task-relevant information. Such learners might ignore reflection cues for goal-setting and planning. Finally the timing of the reflection cues might be an issue, during the intervention of study three was equally divided between cues prior, during and after a task (van den Boom et al., 2004). Learners with (e.g.) high prior knowledge might not value this metacognitive information because they process the knowledge needed to fulfil the task, although they might benefit from this information later on in their study process. By documenting the self-regulatory behaviour of different types of learners' exposed to the reflection cues it becomes possible to formulate specific guidelines on how reflection cues can be designed (see fig. 6).

		LEARNER VARIABLES									
		Academic self-concept			Goal-orientation				Prior knowledge		
		Low	Moderate	High	Performance-approach	Mastery-avoidance	Performance-avoidance	Mastery-approach	Low	Moderate	High
Reflection cues	Inplicit/Explicit										
	Embedded/Unembedded										
	Task identification/Goal-setting and planning										
	Prior/During/After										

Figure 6. Possible design guideline framework for reflection cues.

On the other hand it is possible (due to the design) that the intervention works for all learners. If this is the case, a trail will be set up to investigate the integration of calibration cues in the BLEs. These cues will be delivered in the same (1) implicit and explicit and (2) embedded and unembedded way. This focussing on the (1) task identification and (2) goal-setting and planning processes. Finally these

will be presented (1) prior, (2) during and (3) after the completion of a task. Calibration will be chosen because all the environments observed scored particular low for the attribute calibration.

Expected results and scientific contributions to the field

Although research stresses the suitability of BLEs for adults (Brookfield, 1986; Caffarella & Merriam, 2000; Tough, 1978), research on second chance education shows that such learners are not necessarily adult learners as described by some authors (Connolly et al., 2007). Research on self-regulation in blended-learning environments regularly reports the importance of self-regulatory abilities learners need, to be able to benefit from BLEs (e.g., Lynch & Dembo, 2004a). Second chance learners often lack these abilities. To be able to design BLEs that support self-regulation, at the end of this PhD project, four studies will have been administered to answer the four main research questions:

"What attributes of blended learning environments support learners' self-regulation?"

Research in self-regulated learning reveals that learners often fail to control and regulate their learning activities in BLEs due to a deficit in the skills needed to comply to the demands of such environments (Narciss, Proske, & Koerndle, 2007). Like in any learning environment, different instructional interventions are needed to promote learning. Study one identified attributes of blended learning that may support learners' self-regulatory abilities. The study identified and defined, using a systematic literature review (n=95), seven attributes that support self-regulation. (1) Authenticity, (2) personalization, (3) learner control, (4) scaffolding, (5) interaction, (6) reflection cues and (7) calibration cues. Each of these attributes seems to support learners' self-regulation in BLEs. Combined these attributes can configure the support system of learners' self-regulation in the learning environment.

"What self-regulatory behaviour do learners exhibit in blended learning environments?"

Study two identified in two schools, three comparable learner self-regulatory behaviour profiles (internal, external and mis-regulator). Each of these clusters relate closely to earlier research done by Vermunt and Vermetten (2004), who identified a self-regulating, external regulating and lack of regulation profile. Profile one we named the internal regulator (self-regulator). Reflecting on the self-regulation model of Winne and Hadwin (1998), it seems that these learners prefer to evaluate their perceptions and products of learning using resources which can help them generate rich information about their performance. This without the need for explicit scores. By doing so, the learner is capable to monitor his own learning and make an internal judgement about his task success and relative

productivity. This regulator is able to regulate his learning based on formative feedback. The second profile is called the external regulator (external regulator). Based on the Winne and Hadwin's (1998) model, this type of learners seem to favour external evaluation, occurring from performance above formative feedback. These learners seem to value the outcomes of learning high. Last, there are the mis-regulators (lack of regulation). These learners seem to lack every direction and do not interact with embedded or non-embedded instruction. Further analysis showed the relationship of belonging to a certain profile on performance (mis-regulator profile is the least desirable one).

Concluding, a comparison between the different learning environments and the learners' behaviour in them was made to display the impact of the design of the learning environments on learners' behaviour within the environment. It became clear that when the score of the environment on self-regulation increases the chance for external and miss-regulators to belong to the internal regulators increase significantly. This result indicates that when there is a higher degree of integration of attributes that support self-regulation in BLEs, the chance for occurrence of the miss-regulator profile decreases. It seems that miss-regulators (based on the behaviour and its relation to performance) are less successful. Therefore, it would be beneficial to investigate the optimal amount of self-regulation attributes in the design of BLEs, especially with the aim to minimize the occurrence of mis-regulators. Based on study three and four the answer on this question will be more refined.

"Does targeting the attributes changes learners' self-regulatory behaviour?"

Based on the results of study two we expect that the integration of reflection cues (1) increases the performance of the learners, (2) change learners' self-regulatory behaviour (depending on their individual characteristics) and (3) that these changes also impact cognitive (domain knowledge), metacognitive (academic self-concept) and motivational (goal orientation) variables. Based on these outcomes it will be possible to come up with concrete guidelines, applicable in different domains and for learners with different backgrounds, for designing reflection cues into BLEs. Such guidelines on (1) how to delivery such cues (explicit vs implicit and embedded vs unembedded), (2) the context of such cues (combination of task identification, planning or goal-setting vs one at a time) and (3) the timing of the delivery of the cues (prior, during and after) will take learners' self-regulatory behaviour and differences in characteristics into account.

By answering each study's research questions, the systematic description of existing BLEs and the self-regulatory behaviour exhibited by the learner is possible. An analysis of the relationships between both can be done. Last and final, based on these outputs, an instructional design model containing the seven attributes that support self-regulation in BLEs (taking into account learners' prior domain knowledge, academic self-concept and goal orientation), resulting in guidelines for the design of BLEs that support

self-regulation for at least one of these attributes. Besides the answers on these research questions, this PhD project also contributes to on the one hand, strengthening the educational psychology field. This by identifying and relating learners' cognitive, metacognitive and motivational conditions to the design of blended learning environments. On the other hand, it strengthens the educational technology field by the identification and definition of attributes that support learners' self-regulation in BLEs and proposing an instrument for the description of such environments. Secondly, by providing design guidelines for the implementation of reflection cues (based on differences in stable cognitive, metacognitive and motivational learner characteristics) in BLEs to support learners' self-regulatory behaviour this to maximize the learners' learning outcomes. Finally, the project elaborates on the development of a more refined methodology for the investigation of learners' self-regulatory behaviour, using ecological trace data. Figure 7 below shows the instructional design model as it is developed until now.

Figure 7. Current version of the instructional design model.

Further directions

Although the first two studies conducted in this PhD project have their relevance, some limitations need to be addressed if we want to support learners' self-regulation in BLEs. The first limitation relates to the systematic literature review. The aim of the literature review was to identify and define attributes of blended learning that support learners' self-regulation. Although this target was met, each of the attributes needs further investigation to be able to assign qualitative and quantitative requirements to each of them. This is an important next step to be able to adapt learning environments to each stage in the evolution of learners' self-regulation. Only the attribute for which there were indications in the data was investigated more thoroughly (cues for reflection). The other attributes (authenticity, personalization, learner-control, scaffolding, interaction, and calibration) have not yet been explored in an extensive review and targeted interventions. For these attributes, it remains rather unclear to what extent their quality and quantity determine their effect on learners' self-regulatory behaviour. In addition, this is also true for the combination of different attributes, as it is rare for each attribute to occur in isolation. Although these facets have not yet been researched in depth, it is possible to formulate certain hypotheses about the impact of each attribute based on the literature reviewed (and extended by the additional investigation of relevant literature when developing the observation instrument). Further research into the other six attributes of BLEs is needed, however, to explore any potential hypotheses. The research design used to investigate these attributes might be similar to the one used in the first study presented here (systematic literature review), but focussing either on a single attribute at a time or on a combination of different attributes.

A second limitation is the methodology used to investigate learners' self-regulatory behaviour and the design of ecologically valid BLEs. The descriptive framework and the instrument developed during the project describe the actual state of BLEs, both the on- and off-line parts and both at the level of the course and at the level of the sub-questions for each attribute identified. The framework and the instrument are reliable at different grainsizes (sum scores, scores per attribute and each sub-question of each attribute) thanks to extensive validation (of the reliability) during the application of the instrument in a different context (Philippines, Bicol University, Faculty of Arts and Languages, Department of English) and with different numbers of raters. Previous research on models for the design of BLEs (not exclusively for the support of self-regulation) has often failed to provide a framework for the description of such environments and lacked the ability to describe current blended learning designs prior and after interventions, so this contribution represents a step forward, yet remarks can still be made about the grainsize and depth of the instrument. No one-on-one relation is provided between the concept to be observed and question to be answered. No quality indicators are

given, occurrence rather than quality is the focus. Nonetheless, it was the specific aim to address the multi-layered context (intertwined mix of design features) of such learning environments as holistically as possible, keeping the applicability for practice in mind. Despite this limitation, we believe the results of this PhD project provide a basis for further research on the identification of attributes that support self-regulation in BLEs. Secondly, due to the limited amount of prior research in the analysis of log or trace files for self-regulatory behaviour in ecologically valid settings, the methodology used is innovative in the way that it uses up-to-date methodologies for describing experimental trace files and tries to transpose them into ecologically valid settings. These actions resulted in a continuous redesign and optimization of the methodology. Although this can limit the implications of study two, several positive outcomes come with it. This study uses learners' actual behavioural traces in the environment, focussing on sequences rather than on frequency. While there is already some literature on the use of sequenced traces (e.g., Harley, Bouchet, Hussain, Azevedo, & Calvo, 2015; Winne, 2016), few studies tend to favour ecological data and prefer survey-like gathered trace data. This project shows that even in ecological trace data, combinations of variables might be retrieved that can explain aspects of learners' self-regulatory behaviour. To maximize the results of the methodological approach used, further research could benefit from embracing more theoretically grounded searches for appropriate classifications to describe log files. In addition, a more multidisciplinary, analytical approach to trace file analysis might shed more light on learners' self-regulatory behaviour. In business intelligence and learning analytics, for example, some work has already been done on the prediction of people's buying habits, browsing habits, etc.. By combining this expertise with the concept of self-regulation it might be possible to uncover patterns in ecological data that give us insight into the self-regulatory behaviour of learners.

Finally, by relating the designs of BLEs to learners' self-regulatory behaviour and changes in their cognitive, metacognitive and motivational characteristics, we aim to propose a new perspective on the redesign of BLEs based specifically on learner behaviour. Further investigation of the different attributes supporting self-regulation (and their relation to certain arrangements of learner characteristics) should enable a more deliberate (re)design of BLEs. Future research might be directed towards investigating the more systematic integration of attributes that support self-regulation in BLEs, for example by using design-based interventions to test the impact of each attribute (and the relations among them) on learners' self-regulatory behaviour and their characteristics, as shown in studies three and four.

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KU LEUVEN

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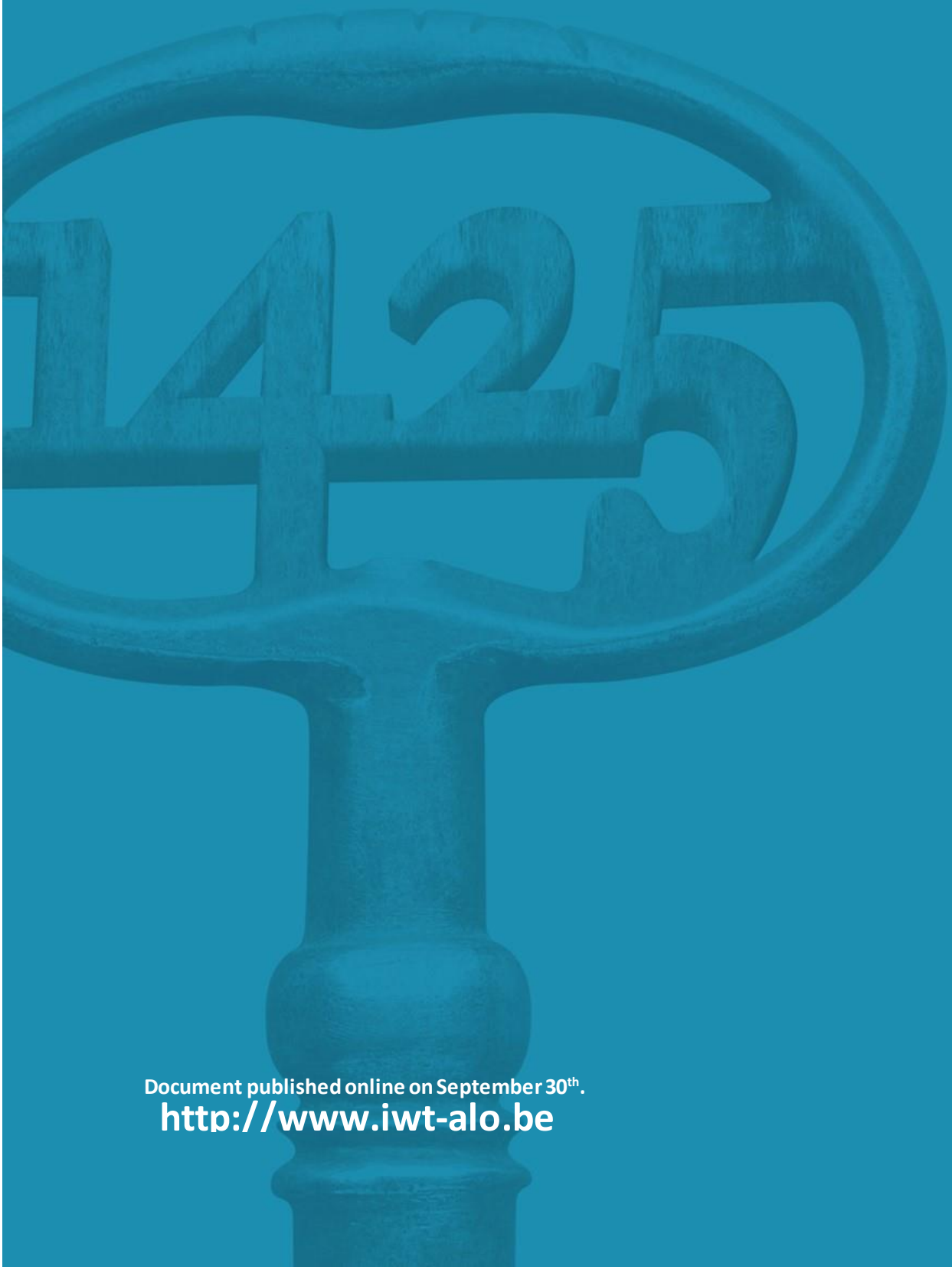

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