Deliverable 2.2. Design guidelines and description of context

ALO!-project - Work package 2:

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Preface

Work package 2 focusses on the identification and development of design guidelines for blended learning at the micro level, i.e. specific learning activities within a course. The focus is on how several learning activities performed by the learners come to be and can be influenced. In this deliverable we focus on the description of the context. Three studies describe this process. On the one hand there is focused on how blended learning environments can be and are designed. On the other hand there is shown how learners' characteristics influence their reaction to blended learning designs. Below you can find a short summary of the three studies, followed by each of them.

An Instrumentalized Framework for Supporting Learners' Self-regulation in Blended Learning Environments.

Stijn Van Laer & Jan Elen (KU Leuven, Centre for Instructional Psychology and Technology)

The premise in instructional design theory is that, in order to identify and target instructional shortcomings, designers should conduct a thorough analysis of the various elements involved in the instructional process. This is also the case for technology-rich means of instruction such as online and blended learning. Nevertheless it often seems that insufficient attention is directed to the description of learning environments when re-designing them. In the case of blended learning, studies suggest for example that this type of learning often challenges learners' self-regulation. Existing research provides little insight into how blended environments can support learners' self-regulation. These observations are problematic since such insights are needed for effective (re)designs. Therefore, the aim of this chapter is to present an instrumentalized framework which can be used to describe and thus characterize support for learners' self-regulation in blended learning environments as a basis for investigations and empirical trials to uncover effective re-designs and guidelines. The instrumentalized framework elaborates on seven attributes of learning environments that may be expected to support self-regulation according to the current literature on self-regulation. The framework is operationalized in an instrument that facilitates the description of any blended learning environment from the perspective of learners' self-regulation support. We demonstrate the validity and reliability of the instrument in two empirical research cycles which included six blended learning environments. The instrument can be used to describe and characterize environments as a starting point for their redesign and, consequently, improve support for self-regulation.

Van Laer, S., & Elen, J. (2018). An Instrumentalized Framework for Supporting Learners' Self-regulation in Blended Learning Environments. In M. J. Spector, B. B. Lockee, & M. D. Childress (Eds.), *Learning, Design, and Technology: An International Compendium of Theory, Research, Practice, and Policy*: Springer, Cham.

Uncovering the Relation Between Learners' Characteristics and Their Self-Regulatory Behaviour Patterns in Blended Learning Environments.

Stijn Van Laer & Jan Elen (KU Leuven, Centre for Instructional Psychology and Technology)

Research offers limited insight into what self-regulatory behaviour learners exhibit in blended learning environments (BLEs). This is problematic since such insights are needed for effective designs. This study investigated the relation between learners' cognitive, motivational, and metacognitive characteristics and their self-regulatory behaviour in BLEs, in order to facilitate the design of more effective BLEs. First we described the instructional context to ensure comparability throughout the study. Secondly, we administered a prior-domain-knowledge test and parts of the Motivated Strategies for Learning Questionnaire and the Metacognitive Awareness Inventory. Finally, we performed event sequence analysis on ecologically valid log-file data. The results show that the majority of the learners' characteristics were associated with significant differences in self-regulatory behaviour. These findings highlight, firstly, the important role of learners' characteristics in learners' self-regulatory behaviour, and secondly, the appropriateness of using event sequence analysis to analyse learners' self-regulatory behaviour and inform the design of BLEs.

Van Laer, S., Bartolata, J., Meneses, M., Bellena, G., and Ignacio, M., & Elen, J. (2018) Uncovering the Relation Between Learners' Characteristics and Their Self-Regulatory Behaviour Patterns in Blended Learning Environments. *Computers in Human Behavior*, under review.

The design of blended learning in response to student diversity in higher education: Instructors' views and use of differentiated instruction in blended learning.

Ruth Boelens & Bram De Wever (University of Ghent, Department of Educational Studies)

The implementation of blended learning in higher education is increasing, often with the aim to offer flexibility in terms of time and place to a diverse student population. However, specific attention for the diversity of this group, and how to cater individual needs, is still scarce. Therefore, this study explores instructors' strategies for and beliefs about differentiated instruction in blended learning, together with how the differences between instructors can be explained. A total of 20 instructors working in two adult education centers participated in semi-structured interviews focusing on their (a) use of strategies for differentiated instruction, and (b) beliefs about designing blended learning to address student diversity. The findings reveal that the most commonly used differentiated instruction strategy in a blended learning context was providing students with additional support throughout product development. In addition, three instructor profiles about designing blended learning to address student diversity emerged from the data: (1) *disregard*: instructors considered no additional support in the blended learning arrangements to match students' needs, (2) *adaptation*: instructors believed that increased support in the existing blended learning arrangements was sufficient to match students' needs, and (3) *transformation*: instructors thought that blended learning arrangements should be designed in a completely different way, and be tailored to the characteristics of the students. The results show that half of the instructors considered a transformation of their blended learning arrangements in response to student diversity. Furthermore, instructors' beliefs appear to be strongly connected to the organization and trajectory in which they work. A major implication of these findings is that professional support focusing on instructors' beliefs is of crucial importance to unlock blended learning's full potential. As such, it is important for organizations to develop a clear stance on this issue, which pays explicit attention to responding to learners' needs in blended learning contexts.

Boelens, R., Voet, M., & De Wever, B. (2018). The design of blended learning in response to student diversity in higher education: Instructors' views and use of differentiated instruction in blended learning. *Computers & Education, 120*, 197–212. http://doi.org/10.1016/j.compedu.2018.02.009.

AN INSTRUMENTALIZED FRAMEWORK FOR SUPPORTING LEARNERS' SELF-REGULATION IN BLENDED LEARNING ENVIRONMENTS

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Abstract

The premise in instructional design theory is that, in order to identify and target instructional shortcomings, designers should conduct a thorough analysis of the various elements involved in the instructional process. This is also the case for technology-rich means of instruction such as online and blended learning. Nevertheless it often seems that insufficient attention is directed to the description of learning environments when re-designing them. In the case of blended learning, studies suggest for example that this type of learning often challenges learners' self-regulation. Existing research provides little insight into how blended environments can support learners' self-regulation. These observations are problematic since such insights are needed for effective (re)designs. Therefore, the aim of this chapter is to present an instrumentalized framework which can be used to describe and thus characterize support for learners' self-regulation in blended learning environments as a basis for investigations and empirical trials to uncover effective re-designs and guidelines. The instrumentalized framework elaborates on seven attributes of learning environments that may be expected to support self-regulation according to the current literature on self-regulation. The framework is operationalized in an instrument that facilitates the description of any blended learning environment from the perspective of learners' self-regulation support. We demonstrate the validity and reliability of the instrument in two empirical research cycles which included six blended learning environments. The instrument can be used to describe and characterize environments as a starting point for their redesign and, consequently, improve support for self-regulation.

Keywords

Self-regulation; Instructional design; Blended learning; Descriptive instrument; Design guidelines

Introduction

In recent decades, interest in the use of blended forms of learning has increased considerably. This type of learning happens in an instructional context which is characterized by the deliberate combination of online and classroom-based interventions to instigate and support learning (Boelens, Van Laer, De Wever, & Elen, 2015). Recent research on the effectiveness of blended learning has led to a proliferation of studies that emphasize the importance of learners' self-regulation in such environments. Results show, for instance, that if learners are to succeed in blended learning environments, a greater amount of self-regulation is often required (e.g., Kuo, Walker, Schroder, & Belland, 2014). This finding raises questions about how blended environments can be (re)designed to overcome this issue and how learners' self-regulation can be supported in such environments.

In response to these questions, design guidelines have been derived from syntheses of research on particular elements of self-regulation, such as monitoring, self-efficacy, and metacognition. Such guidelines suggest embedding self-regulation training into instruction by, for example, modelling self-regulation, using cognitive apprenticeships, and providing attributional feedback to identify appropriate strategies (e.g., Ley & Young, 2001; Perry & Drummond, 2002; Perry, Nordby, & VandeKamp, 2003). Although these studies seem to agree on the importance of self-regulation for learning and provide guidelines for embedding it in learning environments, they are rarely generalizable, nor have they been operationalized as (validated) instruments for describing learning environments. Consequently, no frameworks or systems are available (let alone instruments) for describing support for learners' self-regulation in blended learning environments. This observation is problematic since without such frameworks and instruments, the systematic description and (re)design of a (blended) learning environment is almost impossible.

The aim of this chapter is therefore to present an instrumentalized framework for the systematic description of support for learners' self-regulation in blended learning environments. This instrumentalized framework consists of a conceptual framework and an instrument, validated here in two empirical research cycles. The conceptual framework originates from an analysis of the literature (by Van Laer and Elen (2016)) on support for self-regulation and provides seven attributes that characterize blended learning environments' potential support for learners' self-regulation. The seven attributes in the conceptual framework are: authenticity, personalization, learner control, scaffolding, interaction, cues for reflection, and cues for calibration. The conceptual framework and the instrument constructed around it can assist in the description and characterization of blended learning environments, but do not propose empirical guidelines on (re)design.

The aim of the conceptual framework and instrument is to facilitate research and practice by taking a systematic approach to investigating and supporting learners' self-regulation in blended learning environments. Such an approach can serve as a starting point for redesign and, consequently, improved support for self-regulation. Before elaborating on the conceptual foundations of the framework presented by Van Laer and Elen (2016), we discuss the blended learning concept and its challenges, explain the need for systematic descriptions in environment design and elaborate on how self-regulation is developed and can potentially be supported.

Blended learning and blended learning environments

Blended learning is a popular concept. A common aspect in many definitions of blended learning is that it combines online and face-to-face learning. Hence, it is assumed to combine the advantages of both modes of delivery (Graham, Henrie, & Gibbons, 2014). In line with this idea, blended learning in this study is defined as learning happening in an instructional context which is characterized by a deliberate combination of online and classroom-based interventions to instigate and support learning (Boelens et al., 2015). Nonetheless, the relation of blended learning to concepts such as the flipped classroom and hybrid learning is unclear, and the instantiation of the blend remains vague (Oliver & Trigwell, 2005). Despite this, blended learning as a notion is widely used in higher and adult education; K-12 education; and corporate training (Bonk, 2017).

Over the years, blended learning has been the focus of many research studies. The majority of studies on blended learning have focused either on comparing blended and face-to-face learning or on the characteristics that learners need to thrive in such environments (Deschacht & Goeman, 2015). With regard to the latter, research has identified that learners with high amounts of verbal ability and self-efficacy and learners with high self-regulatory capabilities often perform better in blended learning environments compared to learners who lack these capabilities (Kizilcec, Perez-Sanagustin, & Maldonado, 2017). Despite the importance of these types of research, hardly any research has discussed how to propel the quest for empirical evidence to support the design of blended learning environments in which less ‘capable’ learners can also find success.

The need for systematic descriptions

To be able to design appropriate solutions for educational problems, stakeholders supporting learners' self-regulation are advised to use a systematic approach. Instructional design, as the design of learning environments is often referred to, emphasizes a systematic approach and is concerned with understanding, improving and applying methods of instruction to shape learning environments (Reigeluth, 2013). It is the process of selecting and configuring methods for bringing about the desired changes in learners' behavior. The results of instructional design are often a blueprint for the development of the actual course (van Merriënboer & Kirschner, 2017). This blueprint prescribes which methods, and in which configuration, can be used in a specific context to support learners in their attempts to achieve instructional goals.

To be able to advance in the (re-)design of learning environments, it is necessary to evaluate the effectiveness of current instructional designs. There are two main reasons for this. The first one is to describe the instructional conditions under which learning is supported. The second one is to make systematic adaptations to these conditions to strive towards increased learning. Although the necessity of considering the learning environment in the design of instruction is widely recognized by instructional design theory, no significant attention seems to be given to describing them and using these descriptions to formulate questions and a context for verification and hypothesis testing (Shavelson, Phillips, Towne, & Feuer, 2003). This finding might be explained by the observation that most models approach the designs of learning environments as blank canvases to be drawn on. This is rarely the case in practice, however. Without a system to describe and characterize the learning environment, instructional design theory produces theoretically sound but practically unusable results, meaning no practical (re)design is possible.

Self-regulation and its influencing conditions

By definition, effective learners are self-regulating ones (Butler, 1998). Self-regulation is the process that unfolds when learners use metacognitive skills, in a particular context, to achieve goals both internal and external to themselves. Many models of self-regulation include or are constructed around four main cyclic stages: (1) task identification, (2) goal-setting and planning, (3) enacting, and (4) adaptation (for an overview see: Puustinen & Pulkkinen, 2001). When learners encounter a new task for the first time, they try to (1) identify or categorize it. While doing this, they develop perceptions of the task concerned. Based on these perceptions learners (2) set goals and plan how to achieve them. Once goals are set, learners use their (3) metacognitive knowledge and skills and act to achieve the goals set. Finally, when the learners are confronted with their actual achievements (for example through summative feedback), self-regulating learners may (4) adapt their studying techniques, keeping the freshly acquired experiences and their future needs in mind. Each of these stages of self-regulation is influenced by conditions within and external to the learner (e.g., Winne & Hadwin, 2013).

Variables within the learner

Research identified three major sets of variables in relation to differences in self-regulation: cognitive, metacognitive and motivational ones. With respect to cognitive variables (e.g., Zimmerman & Schunk, 2006) two frequently investigated concepts are (a) learners' intelligence and (b) learners' prior domain knowledge. With regard to the latter, research showed that learners who had more prior domain knowledge used fewer information sources and focused more on sources related to appropriate strategies to regulate one's learning towards achieving the desired learning outcomes (Song, Kalet, & Plass, 2016). Intelligence proved to be positively related to metacognitive skillfulness, with learners with higher scores on intelligence being better able to select the desired metacognitive skills and thus self-regulate towards the desired learning outcome (Veenman, Elshout, & Meijer, 1997).

A second set of variables relates to metacognition (e.g., Borkowski, Carr, Rellinger, & Pressley, 1990). Two metacognitive domains related to learners' self-regulation can be extracted from literature. On the one hand there is metacognitive knowledge, which is the information needed to be able to select appropriate metacognitive skills. On the other hand there are the metacognitive skills themselves, which reflect learners' ability to make actual changes to their own behavior. Results show that learners with a wide array of metacognitive skills use more varied strategies while studying compared to learners who are less skilled (Pintrich, 2002). According to the researcher this difference can be attributed to a more skillful analysis of the situation which may result in the selection of more appropriate strategies.

The last set of variables relates to motivation (e.g., Schraw, Crippen, & Hartley, 2006). As self-regulation within educational psychology refers to settings in which goals are set not by learners alone, but also by formal institutions (and in ideal scenarios in mutual agreement), motivation is often seen in the light of learners' goal-orientation. Learners' goal-orientation encompasses different ways learners deal with the goals they receive and eventually appropriate. Learners can approach or avoid either performance or mastery. When learners have a mastery-approach orientation they internalize the goal as their own and are motivated to master the goal. When learners have a performance-avoidance orientation, however, they attempt to avoid appearing incompetent compared to others. One finding which illustrates the impact of goal-orientation on self-regulation is that learners who want to master a task consult materials outside of the course content, whereas performance-avoidance learners will stick to the task more rigidly and regulate their learning towards the desired outcome (Pintrich, 2002). Similar findings were retrieved in relation to Deci and Ryan's (2010) notion of internal and external motivation.

Variables external to the learner

Different stages, dimensions, and processes of self-regulation may be influenced by specific instructional interventions (Ifenthaler, 2012). As pointed out by Ley and Young (2001), several self-regulation interventions have been tailored to specific content, learners, or media. Interventions have been suggested for writing, reading comprehension, and mathematics (e.g., Schunk, 1998). Others have incorporated support for self-regulation into college learning-to-learn courses or in computer-mediated instruction (e.g., Winne & Hadwin, 2013). The literature contains only a limited number of studies that have focused on support for self-regulation in blended learning environments (Kassab, Al-Shafei, Salem, & Otoom, 2015). Some approaches have been directed toward specific populations such as children, adolescents, and learning disabled learners (Butler, 1998).

Although there is a substantial amount of research available that describes ways to support learners' self-regulation, there are several remaining issues that make the practical application of these guidelines impossible. First, while much research does consider self-regulation as an inherent part of learning, research that takes this perspective and presents concrete design guidelines is scarce. The guidelines formulated often see self-regulation as a specific goal (to design for) instead of as an inherent attribute of learning (Zimmerman & Schunk, 2006). This results in descriptions of interventions that focus on increasing specific elements of self-regulation (e.g., task definition, monitoring, etc.). Only a few studies attempted to combine findings from different backgrounds into a set of guidelines or principles towards a conceptual framework or emphasized the inconclusiveness of guidelines for learners with particular characteristics. Among those who attempted to come up with guidelines to support self-regulation were Ley and Young (2001), Perry and Drummond (2002) and Perry, Nordby, and VandeKamp (2003). Ley and Young (2001) proposed guidelines to design learning environments that support self-regulation:

a. To help learners prepare and structure an effective learning environment;
b. To organize instruction and activities to facilitate cognitive and metacognitive processes;
c. To use instructional goals and feedback to present the learner with monitoring opportunities; and
d. To provide learners with continuous evaluation information and opportunities to self-evaluate.

With regard to the conceptualization of self-regulation used in this chapter, the guidelines formulated by Ley and Young (2001) seem to relate most closely to the enacting and modifying phases of self-regulation (phases 3 and 4, respectively). No indications are provided about how to support learners in identifying the task at hand or in setting appropriate goals and planning to achieve them, however.

Perry and Drummond (2002) and Perry et al. (2003) approached support for self-regulation in a broader, more general fashion. They suggested that:

a. Learners and instructors should function as a community of learners;
b. Learners and instructors should be engaged in complex, cognitively demanding activities;
c. Increasingly, learners should take control of learning by making choices, controlling challenge, and evaluating their work;
d. Evaluation should be nonthreatening. It is embedded in ongoing activities, emphasizes processes as well as products, focuses on personal progress, and encourages learners to view errors as opportunities to learn; and
e. Instructors should provide instrumental support to learners' learning, combining explicit instruction and extensive scaffolding to help learners acquire the knowledge and skills they need to complete complex tasks.

The guidelines of Perry and Drummond (2002) and Perry et al. (2003) seem to take a more holistic approach than those of Ley and Young (2001) and focus on interventions that trigger the four different phases of self-regulation through specific interventions (e.g., community of practice, assessment, etc.).

The literature review revealed no models for the design of learning environments that support learners' self-regulation dating from after 2003. After 2003, educational psychological research focused on specific metacognitive strategies and skills, rather than on learning environments as a whole. Although Ley and Young (2001), Perry and Drummond (2002) and Perry et al. (2003) established sets of guidelines for supporting self-regulation, to the best of our knowledge none of these guidelines have been either (a) translated into a generalizable conceptual framework for the support of self-regulation, or (b) operationalized to describe and characterize (blended) learning environments in a systematic way. This observation is problematic since without such approaches, no systematic investigations or empirical attempts at more effective (re)designs are possible (van Merriënboer & Kirschner, 2017). Without a systematic approach and framework for describing and characterizing learning environments, such guidelines might do more harm than good. This can be illustrated with the case of learner control, for example: depending on the learners' characteristics, increased learner control may be either beneficial or detrimental to effective self-directed behavior (Duffy & Azevedo, 2015).

Problem statement

Research on self-regulation in blended learning environments shows that learners need to have specific characteristics and self-regulation abilities to be successful in such environments. Literature seems to provide only a limited set of guidelines on how to design blended learning environments in this respect. Although some fruitful attempts have been made to come up with sets of guidelines, more recent literature (e.g., Lallé, Taub, Mudrick, Conati, & Azevedo, 2017) has begun to acknowledge that insufficient empirical insights are currently available to distinguish which guidelines are most effective for which learners in which contexts. Yet, to be able to advance in our investigations of which support in blended learning environments is best for which learners, we do need conceptual frameworks, instruments, and methods to describe and thus to characterize learning environments. Such methods can serve as a starting point for empirical and more experimental investigations and might enable the field to provide guidelines and models on how to design blended learning environments that support learners' self-regulation. In the next section, we discuss the conceptual framework before explaining the development and validation of an instrument and method for describing and characterizing support for self-regulation in blended learning environments.

Conceptual foundations of the framework

Using a (n=95) systematic literature review (see original study for methodological details), Van Laer and Elen (2016) identified seven attributes that support self-regulation in blended learning environments. The results of this literature review provided the conceptual foundations for the framework developed here. For each of the attributes, (i) a definition and (ii) evidence from the literature that demonstrate a potential link between the attribute and self-regulation were provided in Van Laer and Elen (2016). In what follows we first summarize this information before describing (iii) the attributes' operationalization and illustrating them with examples. Finally we (iv) instrumentalize each attribute as a number of questions. Table 1 presents a summary of the conceptual framework (see original study for references and in-depth theoretical background). In the second step, we elaborate on the development of the instrument and method for describing and characterizing blended learning environments.

Authenticity

Definitions of authenticity range from real-world relevance, needed in real-life situations, and of important interest to the learner for later professional life. Taking into account these definitions Van Laer and Elen

(2016) define authenticity as the real-world relevance of both the learning environment and the task.

Authenticity and self-regulation

The relation of authenticity to self-regulation has to do with the realistic and ill-structured nature of the learning environment and tasks presented to learners. Well-structured tasks (which are common in education) rarely challenge learners to explore tactics for learning, which may hinder their ability to reach their full potential (Perry & Drummond, 2002). More specifically, they are likely to undermine self-regulation, encourage only shallow processing, and limit performance (Salomon & Perkins, 1998). With regard to the learning environment, authenticity in the learning environment helps learners to develop adequate perceptions of their future professional context, improving their understanding of what is expected (Ley & Young, 2001). While authenticity is very important for self-regulation, moderation is essential. Not all learners will benefit equally from ill-structured authentic tasks and environments. Poorly structured authentic tasks and environments may increase learners' anxiety and may also be too challenging, leading to withdrawal instead of engagement (Winne & Hadwin, 2013).

Authenticity in learning environments

A large body of literature has investigated the design of authentic tasks and environments (e.g., Reeves & Reeves, 1997; Wiggins, 1993). According to this research, authentic learning environments are characterized by (a combination of): (1) Authentic contexts, or contexts which reflect how knowledge will be applied in real life. Research on authentic contexts shows that it is not sufficient to provide real-world examples to illustrate what is being taught. Instead, the value of authentic contexts lies in their complex, allenveloping nature; (2) Authentic activities or ill-defined activities which present a single complex task to be completed over a sustained period of time, instead of a series of shorter disconnected examples; (3) Expert performance, which entails the facilitation of access to expert thinking, the modelling of processes, and access to the social periphery; (4) Multiple roles or different perspectives which enable learners to investigate the learning environment from more than one viewpoint, enabling and encouraging them to explore the learning environment repeatedly; (5) Collaborative knowledge construction, which refers to knowledge construction opportunities for learners to collaborate and thus to estimate their own perceptions of learning. Consequently, tasks assigned to a group instead of to an individual seem to be key to establishing such knowledge construction; (6) Tacit knowledge made explicit, or opportunities for learners to articulate knowledge already available within to foster planning of further learning; and finally, (7) Authentic assessment of learners' learning which provides the opportunity for learners to be effective performers with acquired knowledge, and to craft polished performances or products in collaboration with others. This requires the assessment to be seamlessly integrated with the activity, and to provide appropriate criteria for scoring varied products.

To instrumentalize the abovementioned characteristics with the aim of determining whether a given learning environment contains authentic real-world relevance, the following questions were formulated:

- Is an authentic context provided that reflects the way the knowledge will be used in real life?
- Are authentic activities provided?

- Is access to expert performances and the modelling of processes provided?
- Are multiple roles and perspectives provided?
- Is support for collaborative construction of knowledge provided?
- Is articulation provided to enable tacit knowledge to be made explicit?
- Is authentic assessment of learning within the tasks provided?

Personalization

Personalization in this chapter is defined as the modification of the learning environment to the inherent needs of each individual learner. This definition is in line with current definitions that describe personalization as non-homogenous experiences related directly to the learner, associated with elements of inherent interest to the learner, and connected to topics of high interest value (e.g., Wilson et al., 2007).

Personalization and self-regulation

Current research literature emphasizes the connection between personal agency and self-regulation, and argues that personalized instruction results in a change of self-representation based on psychological needs such as competence (perceived self-efficacy), relatedness (sense of being a part of the activity) and acceptance (social approval), which are components of learners' self-regulation (e.g., Türker & Zingel, 2008). Evidence has also been provided of a relationship between personalization, learners' goal-setting and planning, performance, and self-reflection (e.g., Dabbagh & Kitsantas, 2004). By receiving modified instruction related to one's current skill-level, it might be possible for learners to monitor their learning more accurate and thus boost their learning. When the learning environment is aligned with learners personal preferences, their interest might increase and thus self-regulation will be impacted positively. In conclusion there seems to be a clear link between personalization and self-regulation particularly in the task identification and goal-setting and planning phase of learners' self-regulation.

Personalization in learning environments

Three major ways to incorporate personalization into learning environments could be identified (e.g., Devedžić, 2006; Martinez, 2002). (1) Name-recognition: This type of personalization aims at the acknowledgement of the learner as an individual. For example, the learner's name can appear in the instruction or previous activities or accomplishments that have been collected and stored can later be presented when appropriate; (2) Self-description: Self-described personalization enables learners, (using questionnaires, surveys, registration forms, and comments) to describe preferences and common attributes. For example, learners may take a pre-course quiz to identify existing skills, preferences, or past experiences. Afterwards, options and instructional experiences appear based on the learner-provided answers; The last type of personalization is based on (3) learners' cognitive needs: Cognitive-based personalization uses information about cognitive processes, strategies, and ability to deliver content specifically targeted to specific types (defined cognitively) of learners. For example, learners may choose to use an audio option because they prefer hearing text instead of reading it. Or, a learner may prefer the presentation of content in a linear fashion, instead of an unguided presentation with hyperlinks.

To instrumentalize the abovementioned characteristics with the aim of determining whether a given learning environment contains personalization, the following questions were identified:

- Is the personalization name-recognized?
- Is the personalization self-described?
- Is the personalization cognitive-based?

Learner control

Learner control refers to the amount of control learners have over support in learning environments. Definitions vary from freedom of task-selection by the learner, control of learning sequences, allowing decisions on which contents to receive, allowing decisions on how specific content should be displayed and control over the pace of information presentation. Van Laer and Elen (2016) define learner control in line with these definitions and see learner control as the degree to which learners have or have not control over the pacing, content, learning activities and sequences.

Learner control and self-regulation

Theorists such as Merrill (2012) assert that learners need to be given control. In addition to this control supporting motivation, exercising control over one's learning can be a valuable educational experience in itself. The results can be experienced and the best tactics for different instructional situations can be discovered in the process. In this way, the exercise of learner control can be thought of as a precursor to the development of self-regulation. The idea that learner control is the fine-tuned application of self-regulation is based on the assumption that learners who command the greatest range and depth of learning skills will be the best equipped to handle learner control and other forms of instructional self-management (Resnick, 1972). From this perspective, skills in self-regulation become essential for the effective use of learner control, resulting in the importance of the optimal tuning of learner control to the actual level of self-regulation to avoid undirected behavior. As might be expected learner control can only be granted when learners possess the ability to effectively use it to purposefully direct their learning. If learners are not able to do so, they will lack to ability to regulate their learning and begin to drift (Lawless & Brown, 1997).

Learner control in learning environments

Literature reports on the manifestation of learner control often in four ways (e.g., Sims & Hedberg, 1995; Williams, 1993): (1) Control over pacing: Learners have control over the speed and time at which content is presented; (2) Control over content: The learner is permitted to skip over certain instructional units. This option generally refers to the selection of topics or objectives associated with a specific lesson, although it does not extend to a choice of which content items are displayed. This component of learner control does not focus on the micro level of interaction, in which the learner must make certain choices in response to questions or problems. Therefore, while the learner has control over the content selected for study, the actual presentation of that content has generally remained instructor driven. Thus, there would appear to be two levels of content control: one at which the learner chooses a module of study, and one at which the presentation and associated display elements are also controlled by the learner; (3) Control over learning activities: This type of control includes options for the learner to see examples, do exercises, receive information, consult a glossary, ask for more explanation, or take a quiz; Finally there is the (4) Control over sequence: Learners can skip forward or backward through activities or they are allowed to retrace a route through the material, and options to control when to view such features as content indexes or content maps. Sequence control refers to the order in which the content is viewed, and often is defined in terms of being able to move to and from content items.

To instrumentalize the abovementioned characteristics with the aim of determining whether a given learning environment contains learner control, the following questions were identified:

- Is control over pacing allowed?
- Is control over content allowed?
- Is control over learning activities allowed?
- Is control over sequence allowed?

Scaffolding

Scaffolding in this chapter is defined as changes in tasks and the learning environment, so learners can accomplish tasks that would otherwise be out of their reach. This definition derives from a collection of different approaches to scaffolding which mainly emerged from design research on interactive learning environments. These approaches all emphasized that scaffolding involves providing assistance to learners on an as-needed basis, fading the assistance as learner competence increases (e.g., Wood, Bruner, & Ross, 1976) Based on these approaches a variety of design guidelines or principles have been proposed.

Scaffolding and self-regulation

According to Vygotsky (1978), learners improve when they are assisted by more advanced or knowledgeable sources of instruction (e. g., instructors or peers). The concept of zone of proximal development refers to "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers ” (p. 86). This external guidance or support helps learners monitor their current abilities and calibrate their further actions. Scaffolding also contributes to the planning and monitoring of learners. By providing them with suggestions for potential next steps, learners will be able to direct (regulate) their own learning more towards desired goals (Moos & Azevedo, 2009). The same goes for the use of metacognitive strategies, self-management, information seeking, and adaptive behavior. Finally, scaffolding might also provide the necessary tools to support learners in making adaptations to one’s personal learning environment and define the problems that need to be overcome (Feng & Chen, 2014). In conclusion, scaffolding can be seen as the temporal replacement of learners’ self-regulation. Over time the responsibility for it will shift towards the learner.

Scaffolding in learning environments

Three major ways in which scaffolding is represented in learning environments are (e.g., Garza, 2009; Puntambekar & Hubscher, 2005): (1) Contingency of support: Support is adapted to the current level of the learners’ performance and should either be at the same or a slightly higher level. A tool for contingency is the application of diagnostic strategies. Such strategies often encompass small, recurring formative tasks to be able to monitor learners’ current level. To provide appropriate support, it is key to determine the learners’ current level of competence; (2) Fading of support over time: As the ability of the learner increases the support fades over time with regard to the level and/or the amount of it. Examples of such fading support is the elaborate explanation or instruction at the beginning of a course, there were later in the course fewer instruction is given for a similar task; Finally, there is the (3) Transfer of responsibility: As support fades, responsibility for the learner's performance of a task is gradually transferred to the learner. Responsibility can refer to cognitive (for example responsibility for the correctness of the task) and metacognitive activities (for example responsibility for the approach of the task) as well as to learners' affect.

To instrumentalize the abovementioned characteristics with the aim of determining whether a given learning environment contains scaffolding, the following questions were identified:

- Is support tailored to the learner through continuous monitoring?
- Does the support fade over time?
- Is there a transfer of responsibilities over time?

Interaction

Van Laer and Elen (2016) describe interaction as the involvement of learners with elements in the learning environment. In this chapter we adopt the same definition. This definition encompasses the nature of interaction in various forms of learning environments and in a variety of ways, considering the learners' level of involvement in a specific learning opportunity and as the objects of interaction such as other participants or content materials. The nature of interaction is also dependent upon the contexts in which interaction occurs, in a face-to-face situation or at a distance.

Interaction and self-regulation

Previous research (e.g., Zimmerman & Schunk, 2006) emphasizes the importance of interaction in providing (a) modelling, (b) opportunities for guided practice, and (c) instrumental feedback to impact learners' self-regulation. Through these processes, learners develop competence with the task, content, and context, thereby becoming self-regulated learners. Self-regulated learners rely on internal standards, self-reinforcement, self-regulatory processes, and self-efficacy beliefs. Subsequently, by interacting with elements of the learning environment learners get to reflect and judge on their own performance. By interacting with peers, content, etc. self-evaluation, the use of metacognitive skills and the production of metacognitive knowledge, one's self-efficacy and test anxiety, and modelling capabilities are likely to increase and impact how learners regulate their learning.

Interaction in learning environments

Five types of interaction were observed in learning environments (e.g., Sutton, 2001; Woo & Reeves, 2007): (1) Learner-content interaction: This type of interaction is interaction between the learner and the content or subject of study. This type of interaction is often limited to a big portion of one-way communication with a subject expert (or medium), intended to help learners in their study of the subject; (2) Learner-instructor interaction: This type of interaction is interaction between the learner and the expert who prepared the subject material, or some other expert acting as instructor; (3) Learner-learner interaction: This type of interaction is between one learner and other learners, alone or in group settings, with or without the real-time presence of an instructor; (4) Learner-interface interaction: This type of interaction describes the interaction between the learner and the tools needed to perform the required task; and (5) Vicarious interaction: This final type of interaction takes place when a learner actively observes and processes both sides of a direct interaction between two other learners or between another learner and the instructor.

To instrumentalize the abovementioned characteristics with the aim of determining whether a given learning environment contains interaction, the following questions were identified:

- Is learner-content interaction facilitated?
- Is learner-instructor interaction facilitated?
- Is learner-learner interaction facilitated?
- Is learner-interface interaction facilitated?
- Is vicarious interaction facilitated?

Cues for reflection

Dewey (1958) defined reflection as ‘‘active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusion to which it tends’’ (p. 9). Moon (1999) describes reflection as ‘‘a form of mental processing with a purpose and/or anticipated outcome that is applied to relatively complex or unstructured ideas for which there is not an obvious solution’’ (p. 23). Boud, Keogh, and Walker (2013) define reflection as ‘‘a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to a new understanding and appreciation’’ (p. 19). All three definitions emphasize purposeful critical analysis of knowledge and experience, in order to achieve deeper meaning and understanding, therefore reflection cues in this chapter will be identified as prompts that aim to activate learners’ purposeful critical analysis of knowledge and experience, in order to achieve deeper meaning and understanding.

Reflection and self-regulation

By reflecting on one's own learning, learners become aware of their learning processes and possible alternative strategies. This is important because the perception of choice is a critical aspect of self-regulation, and the awareness of alternatives is a prerequisite for changing less than optimal study habits (Boud et al., 2013). On the one hand reflection promotes the development of the necessary cognitive structure, on the other hand it makes this structure available for learning activities. Reflection can thus be conceived of as the bridge between metacognitive knowledge and metacognitive control (self-regulation), facilitating the transfer of metacognitive knowledge to new situations (Ertmer, Newby, & MacDougall, 1996). These processes impact not only learners' cognitive structures but also their ability to deal with them. Learners' self-explanation capabilities, their awareness of the learning process and their self-reflection ability (Michalsky & Kramarski, 2015) also seem to be related to how reflection impacts learners' self-regulation.

Cues for reflection in learning environments

Three types of cues for reflection can occur during instruction (e.g., Davis & Linn, 2000; Farrall, 2007): (1) Cues for reflection-before-action: These types of cues aim to trigger learners' proactive reflection. For example, learners are asked about what they think the upcoming task will be about; (2) Cues for reflection-in-action: These types of cues aim to trigger learners' reflection while they are performing a task and aim at encouraging learners to reflect upon if they needs to alter, amend, change what they are doing and being in order to adjust to changing circumstances, to get back into balance, to attend accurately, etc. Learners might benefit from checking with themselves if they are on the right track, and if not, what are better ways? For example, an instructor asks to review the actions they are undertaking; Finally there are (3) Cues for reflection-on-action: These types of cues attempt to trigger learners to systematically and deliberately think back over their actions. In other words this type cues encourages learners to think back on what they have done to discover how knowing-in-action might have contributed to unexpected action. For example learners are asked about their experiences regarding a task that is just finished. The more cues for reflection are given, the more likely it is that learners will actually use them. Diminishing the number of cues over time ensures that learners do not become cue-dependent.

To instrumentalize the abovementioned characteristics with the aim of determining whether a given learning environment contains cues for reflection, the following questions were identified:

- Does the reflection-for-action approach apply?
- Does the reflection-in-action approach apply?
- Does the reflection-on-action approach apply?

Cues for calibration

Calibration cues are defined by Van Laer and Elen (2016) as triggers for learners to test their perceptions of achievement against their actual achievement and their perceived use of study tactics against their actual use of study tactics. This definition is comparable to others who see these cues as prompts to compare learners' perceptions of achievement to the achievement compared with external standards and perceived use of study tactics and actual use of study tactics. Calibration concerns on the one hand the deviation of a learner's judgment from more objective measures, introducing notions of bias and accuracy and on the other hand metric issues regarding the validity of cues' contributions to judgments and the grain size of cues (e.g., Azevedo & Hadwin, 2005).

Calibration and self-regulation

If a learner encounters an impediment while pursuing a goal, the interruption triggers a reassessment of the situation (Carver & Scheier, 1990). Engaging in this reassessment leads learners to estimate how probable it is that they can achieve their goal if they invest further effort, modify their plan, or both. If confidence or hopefulness exceeds an idiosyncratic threshold, then the learner is likely to persevere and when a deficit between estimated performance and actual performance is identified to adapt the plan that has been guiding engagement and continues working toward the initial goal. At this point in the stream of cognitive processing, self-regulation has been exercised (Bandura, 1993). For learners to be able to achieve the desired learning outcomes, they need to calibrate their perception of the task at hand and the goals to be achieved.

Cues for calibration in learning environments

With regard to the design of cues for calibration in learning environments five methods could be identified (e.g., Nietfeld, Cao, & Osborne, 2006; Thiede, Anderson, & Therriault, 2003): (1) Cues for delayed metacognitive monitoring: This type is based on a phenomenon labelled 'the delayed judgement of learning effect' that shows improved judgments after a learning delay similar to improved achievement associated with distributed sessions over time. For example, learners might be first asked to highlight a text and at a later time evaluate the highlighted content relative to how well it is understood, how easily it can be retrieved, and how it relates to the learning objective. In this case, learners are asked to evaluate previous made judgements; (2) Forms for summarizing: Summarizing information seems to improve calibration accuracy. It is suggested that the summaries are more effective when forms and guidelines are provided. For example an instructor gives the learners the task to summarize a specific content component and to review it using a correction key; (3) Timed alerts: Thiede et al. (2003) state that summarizing information after a delay improved calibration accuracy; (4) Review of "right" information: Learners have a tendency to select ''almost learned'' or more interesting content for restudy. If learners were to rate test items on judgement of learning and interest they could be provided feedback indicating that selection of content for restudy based on interest and minimal challenge may not be the best choices. For example an instructor advices the learners to select exercises that are challenging for them; Finally, (5) Effective practice tests: Learners might need to be aware of the change in behavior they should make. By informing them on the mistakes they already made, learners might direct further attempts. For example an instructor gives the results of the previous test as guideline for the completion of the next test.

To instrumentalize the abovementioned characteristics with the aim of determining whether a given learning environment contains cues for calibration, the following questions were identified:

- Is a strategy applied to guide learners to delay metacognitive monitoring?
- Is a strategy applied for the provision of forms that guide learners to summarize content?
- Are timed alerts given that guide learners to summarize content?
- Is a strategy applied for helping learners review the ''right'' information?

- Is a strategy applied for effective practice tests that provide learners with records of their performance on past tests as well as items (or tasks) on those tests?

In summary, based on the description of each of the attributes presented above, an instrumentalized version of the framework was developed. This instrument was used to describe support for self-regulation in blended learning environments. The instrument can be found in Appendix 1. In the following section we will discuss the validity and reliability of the instrument.

Table 1. Overview of the conceptual framework presented, based on the Van Laer and Elen's (2016) seven attributes (see original study for references and in-depth theoretical background).

Attribute and definition	***Manifestation in learning environments***	***Relation to self-regulation***
Authenticity *The real-world relevance of on the learning environment and the task.*	• Authentic context • Authentic activities • Expert performance • Multiple roles • Collaborative knowledge construction • Tacit knowledge made explicit • Authentic assessment	• Exploration of tactics for learning • Planning and self-monitoring • Information-seeking behavior • Need to self-regulate, adopting strategies and attuning to the goal, adopted forms of SR, and learning as identity development. • Intrinsic goal orientation, task value, use of elaboration strategies, critical thinking, and metacognition
Personalization *The modification of the learning environment to the inherent needs of each individual learner.*	• Name-recognition • Self-described • Cognition-based	• Interest value • Self-representation, self-efficacy, relatedness, and social approval • Goal-setting and planning, performance, and self-reflection
Learner control *Learners having or having not control over the pacing, content, learning activities and sequences.*	• Control over pacing • Control over content • Control over learning activities • Control over sequence	• Self-control • Instructional self-management • Metacognitive skillfulness • Development of learning strategies • Planning and goal-setting • Rehearsal and self-checking
Scaffolding *Changes in the task and learning environment, so learners can accomplish tasks that would otherwise be out of their reach.*	• Contingency • Fading over time • Transfer of responsibility	• Planning and monitoring • Strategy use • Self-management, information seeking, and adaptive behavior • Self-structuring and problematizing
Interaction *The involvement of learners with elements in the learning environment.*	• Learner-content interaction • Learner-instructor interaction • Learner-learner interaction • Learner-interface interaction • Vicarious interaction	• Self-evaluation • Strategy use • Metacognitive knowledge • Self-efficacy and test anxiety • Modelling

Cues for reflection *Prompts that aim to activate learners' purposeful critical analysis of knowledge and experience, in order to achieve deeper meaning and understanding.*	• Reflection-before-action • Reflection-in-action • Reflection-on-action	• Cognitive structures and abilities • Self-explanation • Metacognitive knowledge and metacognitive control • Awareness of learning process • Self-reflection ability
Cues for calibration *Triggers for learners to test learners' perceptions of achievement against their actual achievement and their perceived use of study tactics against their actual use of study tactics.*	• Delayed metacognitive monitoring • Forms for summarizing • Timed alerts • Review of "right" information • Effective practice tests	• Reassessment • Goal-orientation • Task identification • Problem solving • Cognitive strategies, problem solving strategies, and critical thinking skills, knowledge of cognition, regulation of cognition, self-efficacy, and epistemology

Methods

In the introduction of this chapter the conceptual foundations of the framework based on Van Laer and Elen's (2016) attributes that support self-regulation were described resulting in an instrument to describe the support for learners' self-regulation by learning environments. For each of the attributes, we (i) formulated a definition, (ii) gathered findings from the literature that demonstrate a link between that attribute and self-regulation, (iii) elaborated the attribute's operationalization and illustrated it with examples, and finally (iv) instrumentalized each attribute as a number of questions. Based on this instrument two empirical research cycles were used to investigate the suitability of the instrument for both research and practice. Below the procedure followed is presented.

Research design

To construct the instrument and achieve high reliability and validity, a validating approach was used. According to Andersson and Bach (2005) such an approach includes the following elements. First there is the design and development phase of the instrument, based on a conceptual framework. The result of this is the translation of the conceptual framework into an instrument which is then embedded in a methodology to assure high reliability and validity. Finally both the instrument and the methodology are tested and optimized when needed by continuously challenging them to assure further replicability. For the design, development and validation of the instrument presented in this chapter, Andersson and Bach's (2005) elements were captured in three phases. The first phase included the elaboration of the seven attributes as defined by Van Laer and Elen (2016) into a conceptual framework and the translation of this framework into an instrument to describe the support of learners' self-regulation in blended learning environments. This phase was reported upon in the previous section of this chapter. The second phase (first empirical research cycle) included embedding the instrument in a methodology and the first time use of this methodology. In the third and final phase (second empirical research cycle) modifications were made and the methodology was applied for the second time in a different context.

Phase 1

Based on the work of Van Laer and Elen (2016) a conceptual framework was constructed. This framework consists of seven attributes that support learners' self-regulation in blended learning environments:

- *Authenticity:* real-world relevance of the learning experience to learners' lives and professional context;
- *Personalization:* tailoring of the learning environment to the inherent preferences and needs of each individual learner;
- *Learner control:* degree to which learners have control over the content and activities within the learning environment;
- *Scaffolding:* changes in the task or learning environment which assist learners in accomplishing tasks that would otherwise be beyond their reach;
- *Interaction:* learning environment stimulating learners' involvement with elements of and in the learning environment;
- *Reflection cues:* triggers aiming at activating learners' purposeful critical analysis of knowledge;
- *Calibration cues:* triggers for learners to test their perceptions against their actual performance and study tactics.

The combination of these attributes characterizes the support system of learners' self-regulation in the learning environment from different but related theoretical perspectives. The validation of the instrumentation of the conceptual framework entailed:

a. The formulation of questions to test for indicators of each attribute
b. The use of these questions to describe and hence characterize support for self-regulation in blended learning environments.

By operationalizing the conceptual framework as guidance questions, an instrumentalized framework was created. This instrumentalized framework was used during the testing and optimization phases (Phases 2 and 3).

Phase 2

The second phase of the instrument validation took place in a study aiming at the identification of the relation between designs of blended learning environments that support self-regulation and learners' learning outcomes. During this study the instrument was used for the first time.

Sample

We used four blended learning courses taught in two Flemish centers for adult education. The four courses were categorized as blended learning courses as they deliberately combined online and classroom-based interventions to instigate and support learning (Boelens et al., 2015). All the courses covered the same subject, 'Introduction to basic statistics'. The topics included means, modes, frequency tables, etc. Each course had an identical length of eight weeks. Learners took the course in the first semester of the school year. Both schools were similar in size and context. They were located near a major city and had similar heterogeneous target groups and institutional needs. Both of them were among the largest of their kind and leading institutions of adult education in Flanders, with each providing over 50 courses and catering for over 1000 learners.

Blended learning courses

In line with the operationalization of blended learning, all of the courses involved in the study used a deliberate mix of face-to-face lessons and online lessons. Each face-to-face lesson lasted three hours either from 09:00h to 12:00h or from 14:00h to 17:00h. The learners were expected to spend the same amount of time on the online lessons. In the first school each course addressed five topics: quantitative and qualitative characteristics of data, representative surveys, descriptive tables, presentation of statistical data using ICT, and the use of grouped data. Course 1 contained two face-to-face meetings, one at the start and one on the day of the examination. During the first lesson, the instructor introduced the materials and methodology of the course. Following this introduction, eight online lessons were provided. Course 2 included five face-to-face lessons and five online lessons. It started and ended with a face-to-face lesson. Between these, a face-to-face or online lesson took place every other week. During the face-to-face lessons, the instructor briefly summarized the content of the instructional videos and presentations provided in the online lessons. In both courses, each topic started with the presentation of 'Theory', including general definitions and different examples. At the end of the conceptual part, an individual research project was introduced both via the online learning environment and by the instructor. The conceptual part was followed by 'Exercises'; each of the exercises was framed in a different context. After the completion of the last exercise of each topic, a test followed. In the second school, Course 3 was divided into seven weekly meetings. The course consisted of three consecutive topics: ‘Data collection’, ‘Data collection’, and ‘Statistical key concepts’. Five of the weekly meetings were in a face-to-face format during which both the instructor and learners used online materials. Finally, Course 4 started with a face-to-face session, during which the instructor introduced the individual research project, the learning materials, and the methodology of the course and gave a brief overview of the entire course. Seven online lessons were then provided.

Procedure

First, a back-up was made of all online components (virtual learning environment) of the four blended learning environments. These back-ups were uploaded to our servers for description. Subsequently, each off-line component (classroom environment) was registered using an audio-visual recorder. These recordings were also uploaded onto the server for description. The researcher and a (non-domain-expert) colleague functioned as raters.

In blended learning environments it is a challenging task to find a unit of analysis that encompasses both the online and offline context. It is almost impossible to parse these media into comparable ‘chunks’. The use of equal chunks of information is important because changes to the size of this unit will affect description decisions and comparability of outcome between different models (Cook & Ralston, 2003). To assure that different raters using the same instrument see the blended learning environment under investigation in the same fashion literature suggest to identify a consistent ‘theme’ or ‘idea’ (unit of meaning) as the unit of analysis (e.g., Henri, 1992). This is because themes and topics can carry on over the boundaries of the online and offline contexts and often entail the same elements (see Strijbos, Martens, Prins, and Jochems (2006) for a more in-depth discussion of the issue of unitization). To overcome the issue of varying units of analysis due to differences in proportion online and offline components the raters agreed to use a unit of analysis which related to the topics addressed. The two raters coded the four environments completely and independently by reviewing both the online and offline components of the course and filling out the descriptive instrument for each of the topics addressed.

The instrument was translated into an Excel document to ease the data collection. Raters were not able to answer the conceptual questions at once. A mean score would be calculated based on the answers gathered for each of the questions. To be able to apply such an approach a scoring scheme based on a Likert-type scale was introduced. For each question a score needed to be assigned. Important is that the scoring is based on occurrence, not on, for example the quality of the materials as assumed by the scorer. The scoring possibilities were: 1=Never, 2=Little, 3=Somewhat, 4=Much and 5=Always. When a score of 1 (Never) is given this means that there is not the slightest relation between the unit observed and the question raised. When scored 2 (Little) is given there are minimal (implicit) references to the question. Score 3 (Somewhat) is answered when there are clear (explicit) references to the question. Score 4 (Much) is answered when there is a systematic integration of the characteristic addressed in the question throughout the unit. Finally, the score 5 (Always) is given when consistent throughout the unit every element contains the characteristic addressed in the question. As the instrument was developed in Excel the observations (and scoring) could be summarized in a bar chart. This chart makes it easy to interpret the scores with regard to the inclusion of the different attributes, the individual scores for each of the units and even the entire course.

Based on the raters' scoring the inter-rater score was calculated. In this chapter inter-rater reliability is defined as the extent to which different raters, each describing the same content, come to the same decisions (Rourke, Anderson, Garrison, & Archer, 2001). In this phase among other coefficients the Kendall's W (also known as Kendall's coefficient of concordance) is used to investigate inter-rater reliability. This coefficient is particularly of interest for the purpose of the method presented. It is a normalization of the statistic of the Friedman test, and can be used for assessing agreement of ordinal variables (Likert-type scale) among multiple raters. Kendall's W ranges from 0 (no agreement) to 1 (complete agreement) and is reported with a significance score. After the inter-rater score was calculated both raters met to discuss features of the instrument that were not clear.

Results

Based on the reports of the two raters the Kendall's W was calculated. It became clear that there was high agreement (Fleiss, 1993) between both raters, $W = .683$, $p < .033$. Both raters agreed (Schmidt, 1997) that with regard to the attributes that support self-regulation, authenticity of the different learning environments differed depending on the nature of the topic. Authenticity was observed more when the topic was in direct relation to applications of a task (for example the individual 'research' project learners had to do). Personalization in the online learning environment was primarily focused on the presentation of different contextualized exercises and on the choice learners had in selecting a topic to work on in their individual project. Personalization in the face-to-face context was mostly done by addressing learners by their name or by presenting examples from learners' professional or private life. Further, the instructors delivered instruction mainly in a one-size-fit all approach. Learners were allowed much more learner control in the online learning environment compared to the face-to-face environments. In the online learning environments, they were free to select the sequence of topics; all topics were visible from the first lesson onwards. Nonetheless, learners did not have control over what activity to do in which topic; these were selected by the instructors. In the face-to-face context, learners were allowed to take control over additional exercises when others were still working on previous ones. Scaffolding throughout the duration of the course was done by shifting responsibility towards the learner. A lot of support was provided when learners solved exercises, the individual project received the least support. In the face-to-face context, instructors tailored support to the learners' capabilities by giving personal (verbal) feedback. In the online learning environments, instructors did not tailor support to the learners. The difference in interaction between the face-to-face and online contexts was remarkable. In the online learning environment, interaction focused on learner-content and learner-interface interaction. In the face-to-face context, interaction was more focused on learner-instructor and learner-peer interaction. Finally, both cues for reflection and for calibration were addressed the least in all environments described. Reflection cues for one's own learning were not provided, neither before, during nor after one's actions. If reflection cues were given, they entailed hypothetical mistakes learners could make while solving a specific exercise. Finally, some feedback was provided on specific content elements. In either case no action was expected from the learners. The graphical representation of the four different courses can be found in Figure 1.

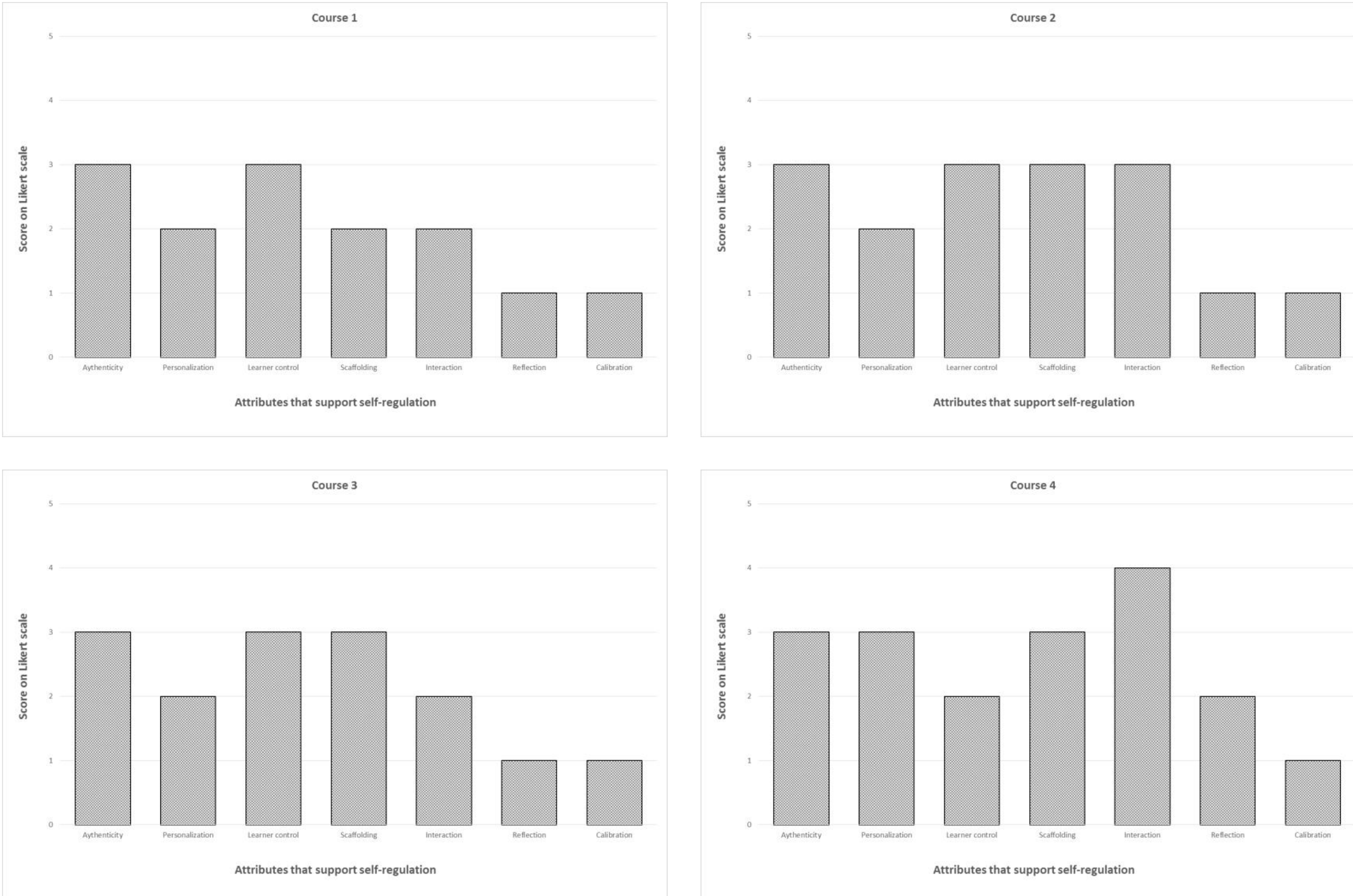

Figure 1. Mean score of attributes identified for each course in schools 1 and 2.

Based on their experiences, both raters discussed issues related to the use of the instrument and formulated recommendations for further development. Two issues arose. The first issue was the lack of concrete guidelines on how to interpret each attribute and its questions. The second issue related to the use of the Likert-type scales to report the occurrence of each of the attributes in the targeted blended learning environments. Although the Kendall's W was high, both researchers had the feeling that they did not had the same understanding of when to give what score on the Likert-type scale. To overcome these issues and to increase the inter-rater reliability further we aimed in phase three to improve the methodology used.

Phase 3

In the third phase, which took place in a study investigating the impact of learners' characteristics on their behavior in blended learning environments, modifications were made based on the experiences of the first application of the instrument. These modifications included the integration of a two-hour rater training session and a rater manual to the methodology. Secondly, the instrument was applied for the second time in a different context.

Sample

We used two blended learning environments employed during a freshmen's Business Communication course taught at a university in the Philippines. The courses entailed three different modules. Topics addressed in the course were: writing letters, giving presentations, etc. Each course ran for eight weeks. The courses had different constellations of both online and offline components.

Blended learning environments

The first Business Communication course contained two face-to-face meetings, one at the start and one on the day of the examination. During the first lesson, the instructor introduced the materials and methodology of the course. Following this introduction, five online lessons were provided. The second course included four face-to-face lessons and two online lessons. It started and ended with a face-to-face lesson. In-between of these, every other week a face-to-face or online lesson took place. During the face-to-face lessons, the instructor provided the learners with the needed information and exercises to master the goals of the course. During the online lessons the learners received extra exercises and small tasks. For both environments each module started with the presentation of 'Theory', including general definitions and several examples. The conceptual part was followed by 'Exercises'; each of the exercises was framed in a similar context. After the completion of the last exercise of each topic, a practical test followed.

Procedure

Comparable to the previous phase, all online components (virtual learning environment) and off-line components (classroom environment) were registered. All the data was also uploaded onto the server for description. In contrast to the previous phase, four raters were involved in the description of each module of the two blended learning environments. The raters were the researcher, the instructor, one domain-expert-colleague and one non-domain-expert colleague of the instructor.

Based on the reflections of phase two, two extra tools (rater training and rater manual) were used to improve the reliability of the descriptive instrument. On the one hand, a 2-hour rater training session was developed based on the conceptual background of the framework and the procedures to ensure reliability and validity. Three main actions were undertaken during the training. The first relates to the identification of a unit of analysis among the raters. During the training, the raters identified and agreed on a suitable unit of analysis for the description of the targeted blended learning environments. A second action related to the scoring of the different attributes. The raters discussed and agreed on when they would give each score to a question using the same scoring guidelines as used during phase one. The last action was the discussion of each of the attributes and their operationalized concepts and examples. In addition all the guidelines formulated were also described in a rater manual developed to support the raters during the scoring. This manual contained the conceptual background of the framework and the procedures to ensure reliability and validity.

After the training the four raters coded the two environments completely and independently by reviewing both the online and offline components of the course and filling out the descriptive instrument for each of the topics addressed. Finally the inter-rater score was calculated in a similar fashion as in phase two.

Results

Based on the reports of the four raters the Kendall's W was calculated. The results showed that in phase two there was high agreement (Schmidt, 1997) between the four independent raters, $W = .776$, $p < .000$. These results show that the four raters highly agreed that both courses could be rated equally for all seven attributes. Authenticity of the both courses was similar, but differed depending of the nature of the topic. Authenticity was observed more when the topic was in direct relation to applications of a task (for example writing a complaint letter, compared to the introduction of the formal rules of writing a letter). Personalization in the online learning environment was primarily focused on the presentation of different contexts exercises could take place in. In both the online and offline environment learners were for example free to choose what product they wrote a complaint letter for. Further, the instructors (both online and offline) delivered instruction mainly in a one-size-fit all approach. Learners were allowed equal learner control in the online learning environment compared to the face-to-face environments. In the online learning environments, they only were able to start exercises of each topic once the instructor made the exercises available. Similar, in the offline environment learners did not have control over what activity to do in which topic either. Scaffolding throughout the duration of the course was done by shifting responsibility towards the learner. A lot of support was provided when learners solved exercises in both contexts. In the face-to-face context, instructors tailored support to the learners' capabilities by giving personal (verbal) feedback. In the online learning environments, instructors did tailor support to the learners via the discussion forum. Although interaction was facilitated differently the two courses the face-to-face and online contexts contained similar amounts of interaction. In the online learning environment as well as in the offline environment, interaction focused on learner-learner and learner-instructor interaction. Finally, both cues for reflection and for calibration were addressed the least in both courses. Reflection cues for one's own learning were provided, neither before nor during learners' exercises. If reflection cues were given, they focused only on prior-performance, they never looked into the future nor did they investigate ongoing action. Some feedback was provided on specific content elements. In either case no action was expected from the learners. It was concluded that all attributes were manifested equally in both course so that it was possible to compare both courses throughout. The graphical representation of the two different courses can be found in Figure 2.

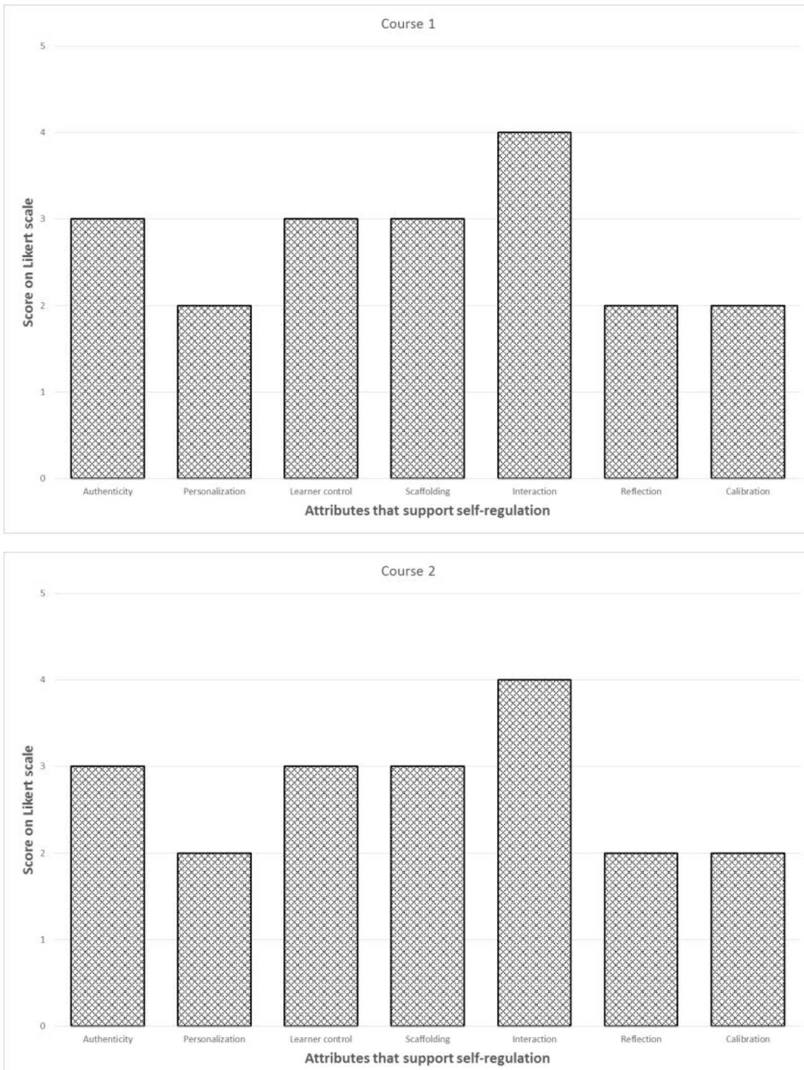

Figure 2. Mean score of attributes identified for each course.

Discussion and conclusions

This chapter presented an instrumentalized framework based on which support for learners' self-regulation in blended learning environments can be described and characterized. A conceptual framework was provided, consisting of seven attributes that support learners' self-regulation in blended learning environments. The combination of these attributes comprises a support system for learners' self-regulation in the learning environment. For each of the attributes, (i) a definition was formulated, (ii) findings from the literature that demonstrate a potential link between the attribute and self-regulation were gathered, (iii) the attribute's operationalization was developed and illustrated via examples, and finally (iv) each attribute was instrumentalized as a number of questions which together make up the overall instrument.

The next step was the development and validation of an instrument (and methodology) for describing and characterizing the support of learners' self-regulation in blended learning environments. In phase two the instrument achieved high reliability (W = .683, p < .033) for the entire sample coded, without the need for substantial rater training or guidance. In phase three the results showed that when the rater training (unit of analysis, scoring and discussion of the attributes) was applied and the raters were provided with a raters manual, inter-rater reliability among four learners increased significantly W = .776, p < .000. The results of both phases indicate that the instrument is a reliable and valid instrument for its purpose.

The conceptual framework and current guidelines

Based on the outcomes of the instrumentalization of the conceptual framework we compared the conceptual framework presented in this chapter to on the one hand two highly regarded sets of guidelines related to the support of self-regulation (i.e., Ley & Young, 2001; Perry & Drummond, 2002; Perry et al., 2003) and on the other hand to more up-to-date literature focusing on guidelines for each of the attributes separately, often taking into account learner characteristics. We found that the conceptual framework presented in this chapter encompasses (though on different levels) the same elements as both sets of guidelines and current literature. In a post-hoc qualitative analysis it became clear that:

Authenticity as perceived in our framework relates closely to elements described by Perry and Drummond (2002) and Steiner (2016), who emphasize that learners should be engaged in authentic, complex, cognitively demanding activities. Complex authentic tasks address multiple goals, and result in the production of extensive knowledge and strategies (McCardle & Hadwin, 2015). Ley and Young (2001) and Oxford (2016) place similar emphasis on the nature of the learning environment in maximizing learners' learning.

With regard to *personalization*, Ley and Young (2001) and Guerra, Hosseini, Somyurek, and Brusilovsky (2016) indicate that when learners relate to the learning environment they will be able to identify information needed for their learning more appropriately. Perry and Drummond (2002) and Tabuenca, Kalz, Drachsler, and Specht (2015), on the other hand, add to this that personalization provides support for each learner's strengths and weaknesses.

Regarding *learner control*, Perry and Drummond (2002) and more recent Duffy and Azevedo (2015) suggest that learners should take control of learning by making choices, controlling the level of challenge, and evaluating their work by doing so they are more likely to persist when difficulties arise (Stevenson, Hartmeyer, & Bentsen, 2017). For Ley and Young (2001) learner control relates to giving learners the possibility to deal with distractions and organize the learning environment according to their own needs (Murray, 2014).

With regard to *scaffolding* both Ley and Young (2001) and Perry and Drummond (2002) and many more in recent years (e.g., Lin, Lai, & Chang, 2016) indicate that the key to scaffolding is decreasing instrumental support for learners' learning and combining explicit instruction and extensive scaffolding to help learners acquire the knowledge and skills they need to complete complex tasks.

Regarding *interaction*, Perry and Drummond (2002) and Järvelä, Järvenoja, Malmberg, Isohätälä, and Sobocinski (2016) indicate that learners should actively interact with others to construct new insights and strategies to deal with changes. Ley and Young (2001) and Kuo et al. (2014) emphasize that learners should constantly be exposed to examples and interactions showing a variety of strategies they are able to apply.

Finally, in line with the conceptual framework presented in this chapter, the sets of guidelines proposed by Perry and Drummond (2002) and Ley and Young (2001) and current literature (e.g., Bannert, Sonnenberg, Mengelkamp, & Pieger, 2015; Verpoorten, Westera, & Specht, 2017) also considers *cues for reflection* (triggers for monitoring) and *cues for calibration* (effective monitoring) to be essential. This body of literature emphasize the organization of instruction and activities to support metacognitive processes and the use of instructional goals and feedback to present the learner with monitoring opportunities.

The investigation of current guidelines to support learners' self-regulation in the light of the conceptual framework described in this chapter shows that the framework presented here contains similar elements as included in the guidelines proposed by Perry and Drummond (2002), Perry et al. (2003) and Ley and Young (2001) and by more to date literature on each of the attributes separately. This finding not only validates the conceptual basis of our framework but may also serve as a starting point for its further elaboration towards guidelines for designing blended learning environments supporting learners' self-regulation based on ongoing empirical trials.

The instrumentalized framework and designing blended learning

Despite its conceptual similarities to the models described above, the instrumentalized framework presented in this study does not suggest any guidelines on how to (re)design blended learning environments to support learners' self-regulation. Nor does it provide a clear demarcation between the different attributes, as to date no such demarcation has been established conclusively in the literature. Instead, the aim of the instrumentalized framework presented in this chapter is to help researchers and practitioners characterize and describe blended learning environments by identifying these attributes and operationalizing them as an instrument. This is achieved using a systematic approach to investigating and supporting self-regulation in blended learning environments. An important remark with regard to the latter is that while using this instrumentalized framework can improve the design of the blended learning environment with regard to support for self-regulation, this can only be achieved through continuous redesign and testing against empirical trials.

Limitations and considerations

While the instrumentalized framework presented has proven its value for research and practice, certain considerations and limitations should be pointed out. A first set of considerations relates to the underlying conceptual framework. As argued by theorists of the self-regulation concept, self-regulation is influenced by variables within and external to the learner (Winne & Hadwin, 2013). This chapter focuses on the latter type of variables, yet self-regulation theory hypothesizes that combinations of the two types determine the self-regulatory behavior of learners, resulting in different impacts for learners with different learner variables. Although the conceptual framework presented does not give guidelines on how to operationalize each of the attributes in relation to learner variables, it provides the means to investigate them in relation to each attribute. A good example of such an investigation might be a study investigating the amounts of learner control beneficial for skilled learners versus inexperienced learners (e.g., Niemiec, Sikorski, & Walberg, 1996). Further research is still needed to clarify the relation of each of the attributes to learner variables.

With regard to the attributes themselves, it must be acknowledged that the conceptual framework only provides principles for describing and thus characterizing blended learning environments, not for designing them. Although this gives a clear idea of how each attribute can be defined and identified within blended learning environments, it also leads to unclear demarcations and overlap. It should be kept in mind that the aim of this instrumentalized framework is to enable the characterization of the blended learning environment, not its redesign. To be able to identify and analyze new research and insights which could contribute to the characterization of blended learning environments, Van Laer and Elen's (2016) systematic review should be repeated over time. The way in which the attributes are currently described and illustrated is conceptually up-to-date, but the literature is rather dated. In addition, the framework ignores the possibility that certain combinations of attributes might be more beneficial than others. Such hypotheses are often illustrated by research findings that highlight (for example) that a combination of cues for both reflection and calibration have a higher impact on learning than when only cues for reflection are provided (Sonnenberg & Bannert, 2015). Further research is needed to investigate which combinations of attributes are most suitable for which types of learner.

The final consideration in relation to the conceptual framework is the focus on blended learning. As each of the attributes was derived from research deliberately aimed at combined online and offline interventions, we expect the framework to be applicable to blended learning environments. Based on previous findings about the impact of technology on learning (e.g., Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011) we hypothesize that the conceptual framework can also be applied in purely online and purely offline contexts. Further research on the applicability of the framework in purely online or offline environments would improve the generalizability of the conceptual framework.

A second set of considerations relates to the instrument itself. On the one hand there is the grainsize used for the description of the occurrence of each of the attributes. In contrast to frameworks which focus on detailed descriptions of learning environments (per minute or hour), we adopted the ‘principle’ approach in a context where units of analysis are the themes, modules or topics covered over a number of weeks. Although this approach is common practice in instructional design theory (e.g., Merrill, 2012), it is rarely applied to investigating support for learners’ self-regulation from an educational-psychological perspective (Winne & Hadwin, 2013). However, as in Perry et al. (2003), such an approach might also be desirable, especially for feasible course (re)design.

On the other hand, there is what appears to be the quantitative, summative approach to the instrument. Because we used an Excel spreadsheet to score each attribute, it might appear that each unit of the course is scored based on quality. As mentioned above, however, this is not the aim of this instrument (see Likert-type scale used). The sole goal of the instrument is to map the actual character of a blended learning environment. Based on this state redesigns can be made, which can be evaluated using any subsequent changes in learners' self-regulation.

Conclusions

While the instrumentalized framework presented has its limitations and further research is needed to optimize its capabilities, this chapter has attempted to illustrate that it contributes to existing literature and practice in two ways. Firstly, by providing both a conceptual framework and an instrument focusing on the characterization of support for learners’ self-regulation, we are to the best of our knowledge the first to focus on support for self-regulation in blended learning environments. The instrumentalized framework makes it possible (a) to describe and thus characterize blended learning environments in terms of self-regulation; (b) to provide, based on this characterization, a starting point for investigations to overcome design issues related to learners' self-regulation in blended learning environments (e.g., Kuo et al., 2014); and (c) to advance the design of blended learning environments more systematically by monitoring its characteristics.

Secondly, research and practice will benefit from this more systematic approach to describing and characterizing support for self-regulation in blended learning environments. The ability to describe (blended) learning environments in a systematic and replicable way opens doors to an array of research opportunities and practical interventions and thus facilitates further investigation of self-regulatory issues. It also makes it possible to investigate the impact of each attribute and combinations of attributes in relation to differences in learner variables, thus allowing designers to target learners' self-regulation more accurately.

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Appendix 1: Visual representation of the instrument.

Course: …

Topic: …

	1 Never	2 Little	3 Somewhat	4 Much	5 Always	
Does the learning environment contain authentic real-world relevance?			**0**			**Comments**
Is an authentic context provided that reflects the way the knowledge will be used in real life?						
Are authentic activities provided?						
Is there access to expert performances and the modelling of processes provided?						
Are there multiple roles and perspectives provided?						
Is there support for collaborative construction of knowledge provided?						
Is articulation provided to enable tacit knowledge to be made explicit?						
Is authentic assessment of learning within the tasks provided?						
Does the learning environment contain personalization?			**0**			**Comments**
Is the personalization name-recognized?						
Is the personalization self-described?						
Is the personalization cognitive-based?						
Does the learning environment allow learner control?			**0**			**Comments**
Is control of pacing allowed?						
Is control of content allowed?						
Is control of learning activities allowed?						
Is control of content sequence allowed?						
Does the learning environment scaffold support?			**0**			**Comments**
Is support tailored to the learner through continuous monitoring?						
Is the support fading over time?						
Does the support fade over time?						
Does the learning environment entail interaction?			**0**			**Comments**
Is learner-content interaction facilitated?						
Is learner-instructor interaction facilitated?						
Is learner–learner interaction facilitated?						
Is learner-interface interaction facilitated?						
Is vicarious interaction facilitated?						
Does the learning environment contain reflection cues?			**0**			**Comments**
Does the reflection-for-action approach applies?						
Does the reflection-in-action approach applies?						
Does the reflection-on-action approach applies?						
Does the learning environment contain calibration cues?			**0**			**Comments**
Is a strategy applied to guide learners to delay metacognitive monitoring?						
Is a strategy applied for the provision of forms that guide students to summarize content?						
Are timed alerts given that guide students to summarize content?						
Is a strategy applied for helping learners review the ''right'' information?						
Is a strategy applied for effective practice tests, that provide students with records of their performance on past tests as well as items (or tasks) on those tests?						

Uncovering the Relation Between Learners' Characteristics and Their Self-Regulatory Behaviour Patterns in Blended Learning Environments

Abstract

Research offers limited insight into what self-regulatory behaviour learners exhibit in blended learning environments (BLEs). This is problematic since such insights are needed for effective designs. This study investigated the relation between learners' cognitive, motivational, and metacognitive characteristics and their self-regulatory behaviour in BLEs, in order to facilitate the design of more effective BLEs. First we described the instructional context to ensure comparability throughout the study. Secondly, we administered a prior-domain-knowledge test and parts of the Motivated Strategies for Learning Questionnaire and the Metacognitive Awareness Inventory. Finally, we performed event sequence analysis on ecologically valid log-file data. The results show that the majority of the learners' characteristics were associated with significant differences in self-regulatory behaviour. These findings highlight, firstly, the important role of learners' characteristics in learners' self-regulatory behaviour, and secondly, the appropriateness of using event sequence analysis to analyse learners' self-regulatory behaviour and inform the design of BLEs.

Keywords: blended learning; self-regulation; instructional design; trace data; learning analytics; event sequence analysis.

Highlights:

- Learners' self-regulatory behaviour in blended learning environments is examined.
- Trace data was used to investigate learners' self-regulatory behaviour.
- Event sequence analysis showed differences based on learners' characteristics.
- Negative links between prior domain knowledge and content sequences were found.
- Motivation and metacognition linked positively with elaboration sequences.

1. Introduction

The personal computer and the Internet have caused a revolution in education (Spector, 2015). Over the years, blended forms of learning have become increasingly popular (Bates, 2005; Spanjers et al., 2015). "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" (Boelens, Van Laer, De Wever, & Elen, 2015). Research on blended learning often praises the flexibility and suitability of blended learning environments for learners with beneficial constellations of cognitive, motivational, and metacognitive characteristics (e.g., Means, Toyama, Murphy, & Baki, 2013; Picciano, Dziuban, & Graham, 2013). Despite this, it remains unclear under what conditions these blended learning environments are successful (Means et al., 2013; Oliver & Trigwell, 2005) and why they seem more successful for some learners than for others (Lynch & Dembo, 2004; Wang, Shannon, & Ross, 2013). It seems that blended learning environments, as they are currently designed, work well for learners who demonstrate the self-regulatory behaviour needed to comply with the instructional demands of such environments, but that those same environments may fail to address the needs of learners who do not demonstrate the required behaviour (Barnard-Brak, Lan, & Paton, 2011; Barnard, Lan, To, Paton, & Lai, 2009; Cennamo, Ross, & Rogers, 2002). To be able to address not only learners who suit the design of the blended learning environment, but also other types of learners (different levels of cognition, motivation, and metacognition) more insight is needed into how to design adequate blended learning environments (Adekola, Dale, Powell, & Gardiner, 2016; Connolly, Murphy, & Moore, 2007; Güzer & Caner, 2014). The limited insight available into the design of blended learning environments is problematic since without this information, evidence-based interventions and redesigns are almost impossible. In order to elaborate a model for designing blended learning environments that support learners' self-regulation and thus make learning more effective, this study addresses the following research question: "How do learners' characteristics relate to learners' self-regulatory behaviour in blended learning environments?".

1.1. Self-regulation in blended learning environments

In this study, self-regulatory behaviour is seen as "the 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. Winne's Four-stage Model of Self-regulated Learning (Butler & Winne, 1995; Winne, 1995; 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 finally (4) adapting studying techniques, keeping future needs in mind. Additionally, each stage and its elements are influenced by certain conditions. Winne and Hadwin (1998) identify external conditions (e.g., time constraints, available resources and social context) and internal conditions (e.g., interest, goal orientation and task knowledge) that influence how a certain task will be engaged with (Winne & Hadwin, 1998). The Winne and Hadwin (1998) model was chosen since it has a clear behavioural focus on self-regulation as a series of events, rather than as an aptitude (Endedijk, Brekelmans, Sleegers, & Vermunt, 2016).

1.2. Conditions influencing self-regulation

1.2.1. External conditions

As indicated above, research on self-regulated learning reveals that learners often fail to control and regulate their learning activities in blended learning environments due to a deficit in the skills necessary to cope with the demands of such environments. As in any learning environment, different instructional interventions are needed to promote learners' learning and to support learners in taking appropriate action to do so. Based on this notion, Van Laer and Elen (2016) identified seven attributes that support self-regulation in blended learning environments. The first of these 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. The fourth attribute 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 the way in which the learning environment stimulates learners' involvement with this environment. The sixth is *reflection cues*, which are prompts designed to activate learners' purposeful critical analysis of knowledge. Finally, there are *calibration cues*, triggers for learners to test their perceptions against their actual performance and study tactics. The combination of these attributes comprises the support system of learners' self-regulation in the learning environment.

1.2.2. Internal conditions

Although self-regulation seems to be influenced by external conditions, which lead to various decisions and learning outcomes (e.g., Panadero, Jonsson, & Strijbos, 2016; Perels, Otto, Landmann, Hertel, & Schmitz, 2007), ultimately the learners themselves (and their cognitive, metacognitive, and motivational characteristics) influence and affect learning processes the most (e.g., Bransford, Brown, & Cocking, 2000; Endedijk, Brekelmans, Verloop, Sleegers, & Vermunt, 2014; Zimmerman, 2002). In line with the Winne and Hadwin model (1998) in this study we focus on (a) prior domain knowledge, (b) expectancy-value, and (c) metacognitive awareness as internal conditions influencing learners' self-regulation.

Prior domain knowledge relates to how competent learners already are at a task. Learners who can automatically and seemingly effortlessly retrieve effective knowledge from memory, have minimal needs to deliberately self-regulate (Greene & Azevedo, 2007). An example of how learners' prior knowledge influences self-regulation processes might be the difference between an expert and a learner who is a novice. The latter faces quite a different task, one in which self-regulation can substantially enhance achievement (Winne & Butler, 1994). As widely demonstrated in the literature on expertise, the more extensive one's prior domain knowledge is, the less there is a need to search for, use, and regulate metacognitive tactics or strategies when grappling with complex tasks or when attempting to learn information in the domain (e.g., Lesgold et al., 1988; Song, Kalet, & Plass, 2016).

With regard to the use of expectancy-value as a motivational characteristic Wigfield and Eccles (2000) advanced a model of motivation based on efficacy, expectancies, and task value. This model focuses on learners' expectations for success on upcoming tasks, the values, and the affect learners assign to this task. The expectancy-value theory includes three components: value (intrinsic and extrinsic goal orientation and task value), expectancy (self-efficacy and control of learning), and affect (test anxiety). Moos (2014), Duffy and Azevedo (2015), Nelson, Shell, Husman, Fishman, and Soh (2015) and Conley (2012) provided evidence for the impact of the task value, expectancy and affect component on learners self-regulation processes. They identified that learners with differences in intrinsic motivation, extrinsic motivation, or task value significantly differed in the extent to which they monitored their goals and so self-regulated their learning.

Finally, metacognitive awareness relates to knowledge of study tactics and strategies. Metacognitive awareness includes three types of knowledge. The first is declarative knowledge (that describes what a tactic or strategy is), the second is procedural knowledge (of how to use a strategy), and the third is conditional knowledge about a strategy's utility (that is, when and where a strategy can be used to meet particular purposes and how much effort is involved in using it). Bannert, Sonnenberg, Mengelkamp, and Pieger (2015) and Sonnenberg and Bannert (2015) investigated, in an experimental study, whether metacognitively aware learners showed different navigation behaviours compared to learners who were less metacognitively aware. Results showed that learners who configured their own metacognitive prompts and learned with them, showed significantly different navigation behaviour in the learning session afterwards compared to learners in the control condition. Similar results were obtained by Azevedo et al. (2016).

1.3. Self-regulation and learner behaviour

Due to the shift in perspective on self-regulation, traditional off-line measures can no longer be argued to fully capture the nature of self-regulation (e.g., Azevedo, Moos, Johnson, & Chauncey, 2010; Reimann, 2009; Schoor & Bannert, 2012; Schraw, 2010; Winne, 2010). Generally, such off-line measures concern learners' self-reports gathered prior to or after task performance. The fundamental problem of the off-line nature of self-reports is that it requires learners to reconstruct their earlier performance. This reconstruction process might suffer from memory failure and distortions, especially if experiences from the past have to be retrieved (Veenman, 2011). Additionally, validity issues occur when questions about the relative frequency of certain activities ("How often do/did you...?") are asked. In contrast to off-line measures, on-line measures for measuring self-regulation gained substantial interest. These types of measurements are obtained during task performance, that is, they are based on actual behaviour of the learner. Typical online measures include observational methods, the analysis of thinking-aloud protocols, eye-movement registration, or log file analysis. The unobtrusiveness of some of these methods (i.e., log-file analysis) enables researchers to track learning events in a learning environment and "re-play" learners' self-regulatory behaviour. Tracing methods such as log-file analysis provide us with a fuller understanding of how learning, cognition, motivation, and metacognition intersect and vary throughout the process of self-regulation.

1.4. Measuring self-regulation online

The measurement of self-regulation as a series of events, is based on the dynamic nature of the phenomenon and so relies on continuous measurements to determine the quality of self-regulation. In this study we will focus on online measures, more specifically, log file analyses. These types of measurements appear to be better suited to finding relations between specific aspects of real-time self-regulatory behaviour in authentic contexts (Zimmerman, 2008) and may be more accurate than retrospective self-reports that require recall of actions and thoughts. The idea that self-regulation unfolds in the four main phases, described in the Hadwin and Winne model, suggests a cyclical relation among the components. Cleary, Callan, and Zimmerman (2012) proposed the term 'sequential phases of regulation' to describe this cycle, which involves transitions from one event to the next. Several researchers have expressed the need to explore time and order in self-regulatory processes (Greene & Azevedo, 2010; Molenaar & Järvelä, 2014; Morris et al., 2010).

1.4.1. Event sequences

In this study, we use the term “event sequence” to describe patterns of learners’ self-regulatory behaviour. In many fields of research the terms “event” and “sequence” are used to describe different sorts of patterns (e.g., Abbott, 1995; Suthers & Verbert, 2013), so some clarification is in order. The first distinction relates to whether patterns contain information related to a state or an event. An example of a state in the context of log file analysis is being on a discussion forum page, while clicking on an exercise link would be an event, which changes the state to being on the exercise page. Thus, each change of state is an event, and events imply that the state has changed (Müller, Studer, Gabadinho, & Ritschard, 2010). The next distinction to be drawn is whether the order of events or states is logged and preserved. If this is the case, the data is sequenced; if not – for example, if the focus is on the frequency or diversity of the events rather than their order – then the data is perceived as an item set (e.g., Schraw, 2007). In the current study, the data (subject ID, event, and time stamp) is treated as event sequence data. This is because (1) the events revealed by the log files fall between unknown states and (2) the data is ordered by time stamps.

Investigations of event sequence data can be divided into three main types: pattern mining, pattern pruning and interactive visualization design (Liu, Dev, Dontcheva, & Hoffman, 2016). In the current study, the focus is on pattern mining, the first type, which involves identifying meaningful event sequences (patterns). Mining these patterns involves two key elements: the order of the events (when the order is maintained, we refer to ‘sequential’ patterns) and the containment of sub-sequences, which are sections of a sequence that also appear in other sequences. Thus, sub-sequences are unique sets of events carried out in the same order by a threshold number of learners. They can be identified by applying the minimum edit distance (Levenshtein distance) between two sequences. The minimum distance between sequences is calculated based on the minimum number of editing operations: (a) insertion, (b) deletion, and (c) substitution of an event needed to transform the sequence into another sequence (Levenshtein, 1965). Containment relates to support for a sub-sequence in the sample. Support for a sub-sequence is the number (or percentage) of sub-sequences matching other learners’ sub-sequences. A frequent sub-sequence is a sub-sequence that is present in at least the threshold number of times among learners (see Figure 3). Following the identification of such sub-sequences, statistical trials (e.g., chi-square tests) can be carried out in an attempt to relate significant differences in the occurrence of sub-sequences to specific learner characteristics.

1.5. Learner characteristics and learners’ self-regulation behaviour sequences

Although the investigation of the relation between learner characteristics and learners’ self-regulatory behaviour using (event) sequence analysis is new in educational research extensive research has been done , in recent years on differences in learners’ course performance based on differences in learners’ self-regulation (e.g., Cho & Yoo, 2016; Pardo, Han, & Ellis, 2016; Romero, Ventura, & García, 2008; Sonnenberg & Bannert, 2015; You, 2016). This work is valuable, but it often fails to uncover how the differences observed in self-regulation can be attributed to differences within learners (internal conditions) and how they can be influenced by the designs of interventions or learning environments (external conditions). In-depth insights seem to be needed into how self-regulatory behaviour is influenced by learner characteristics and how this (in a later stage) can be stimulated by targeted interventions towards better course performance (e.g., Greene & Azevedo, 2010; Hwang, Shadiev, Wang, & Huang, 2012; Molenaar & Järvelä, 2014; Morris et al., 2010).

The literature includes a number of studies related to the role of learners' prior domain knowledge, expectancy value, and metacognitive awareness in learners' self-regulatory behaviour. Liu, Lee, Kang, and Liu (2016) for example, used two cases to describe the behavioural differences between experts and novices and concluded that learners with different learning characteristics exhibited different learning behaviours. Jang et al. (2017) applied person-oriented analytic methods to multimodal data including verbal protocols, questionnaires, and computer logs from 78 task solutions and found that learners' clinical diagnosis abilities were positively correlated with advanced self-regulated learning behaviours, such as increased cognitive strategy use, critical attention to experts' feedback, and their responses to feedback. Finally, Blikstein (2011) used learning analytics to assess learners' behaviour in open-ended programming tasks. He concluded that a better understanding of each learner's coding style and behaviour provides us with an additional window into learners' cognition. In sum, the literature review on the relation of prior domain knowledge, motivation (expectancy value), and metacognition (metacognitive awareness) to learners' self-regulatory behaviour patterns (event sequences) shows that only a limited amount of research is available with this specific aim. However, identifying patterns and examining the relationship between this behaviour and learner characteristics is essential to creating the necessary scaffolding for facilitating increased course performance (Liu, Lee, et al., 2016).

1.6. Problem statement

In the search for guidelines for designing blended learning environments that support learners' self-regulation, it remains unclear how learners' self-regulatory behaviour is affected by the learner characteristics. This information will help us determine how interventions may affect different types of learners and so at a later point their learning outcomes. The ultimate goal is to identify learners' characteristics based on their behaviour and to provide targeted guidelines for designing learning environments to suit different types of learners. In this study, we treat self-regulation as an event rather than an aptitude. Based on the assumptions related to this conceptualization of self-regulation, and because little research has connected learner characteristics (internal conditions) to learners' self-regulatory behaviour, we analyse ecologically valid blended learning environment log files, using an event analysis approach to answer the research question: How do learner characteristics relate to learners' self-regulatory behaviour in blended learning environments?

2. Method

Three steps to answer the research question were taken. First, to safeguard the comparability of the external conditions, the course was analysed using a framework for the description of blended learning environments that support self-regulation (Van Laer and Elen (2016). Secondly, based on the learner characteristics identified (a) a prior domain knowledge test, (b) the Motivated Strategies of Learning Questionnaire (Pintrich, 1991), and (c) the Metacognitive Awareness Inventory (Schraw & Dennison, 1994) were administered. Finally, event sequence data of the log files from the virtual learning environment (Moodle) were extracted for the analysis of the learners' self-regulatory behaviour.

2.1. Population and context

In this study, learners (n=25) from a Philippine university participated. The learners were freshmen enrolled in an eight-week Business Communication course. They all had a similar age (M = 18.12, SD= 0.23) and the majority of them were female (87%).

2.2. Design of the blended learning environment

The study took place in an ecologically valid blended learning environment. No adaptations to the course were made by the researchers in order to keep the context as authentic as possible. The course entailed six different topics, all of which had a similar structure (see 2.3.1). The six topics covered business communication in general, business writing, business letters, employment communication, and finally oral communication. The course consisted of 75% (6 sessions) online instruction and 25% (2 sessions) offline instruction. It was started online (see Figure 1 for the landing page of the online component of the course) and ran for four weeks, until the first offline session (see Figure 2 for an impression of the offline component). Following this session, there were another three weeks of online sessions. The course ended after eight weeks, at which point the instructor set the learners a classroom-based paper and pencil exam.

2.2.1. Online component of the course

At the start of the course, the instructor sent an e-mail to the learners including the deadlines for task-submission, information about the offline component of the course, and how to progress through the online component of the course. From then on, all communication about the course occurred via the online platform. The platform was a Moodle-based learning management system, running on the institute's server. After logging into the course, learners saw the landing page (see Figure 1). This page included a welcome message from the instructor, links (via icons) to two support topics ((1) How to study? and (2) Where to find help?), the different topics addressed in the course, and two discussion forums ((1) content issues and (2) practical issues). The learners were able to consult each part of the course at any time.

As indicated above, the structure of each of the topics was similar. Each topic started with a short introduction (examples, often a short video), followed by course content information (PowerPoint presentation in pdf), and exercises accompanied by scoring rubrics. Completed exercises would be uploaded via the platform. Finally, each of the topic pages contained a link to the discussion forum in case learners felt the need to discuss things as well as links to additional resources such as extra examples or non-compulsory content. The instructor was on hand to correct exercises, to moderate and answer questions when needed, and to emphasize the importance of sending in tasks on time in order not to miss deadlines. After four weeks, the instructor placed an announcement about the offline component of the course. This announcement stated that each learner had to be able to talk about and discuss each topic covered so far. After the first offline component of the course, the learners and the instructor continued their routine. In the run-up to the exam, the instructor posted a notification about the procedure for the exam on the platform. After the exam, the students' grades were also communicated via the platform.

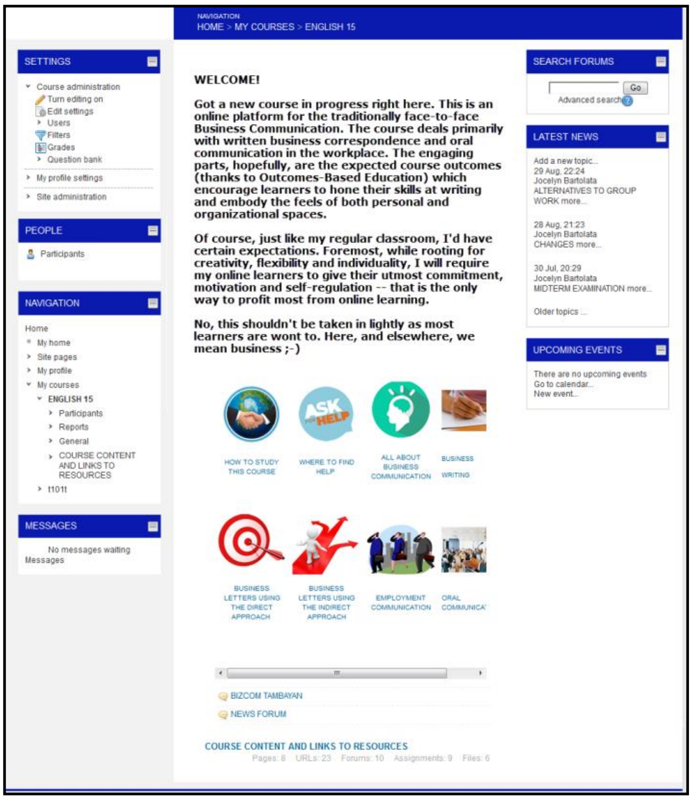

Figure 1. Course landing page – online component.

2.2.2. Offline component of the course

The offline components of the course consisted of an interactive problem-based session and the formal exam. The interactive session involved the instructor questioning the learners about the different topics plenary-style. Following this, small-group discussions were organized on the different topics presented in the online component of the course. With regard to the final offline session, the exam was a 90-minute (10 questions) sit-in exam consisting of cases that the learners had to address. Examples of such cases were for example “write a complaint letter” or “Discuss the steps of oral collaboration”.

Figure 2. Course in progress – offline component.

2.3. Instruments

The instruments used assessed (a) the description of the external conditions, (b) the description of learners' internal conditions (cognitive, motivational, and metacognitive), and (c) learners' self-regulatory behaviour.

2.3.1. Description of external conditions

To ensure that differences in learners' self-regulatory behaviour did not relate to changes in the blended learning environment the stability of the design throughout the runtime of the course was investigated. During the course the offline components of the course was video-recorded. After the runtime (8 weeks) of the course the online component was copied to a server for research purposes, this to ensure its sustainability over time. The different topics addressed during the course were investigated using a framework (Van Laer & Elen, 2016) containing the seven attributes that support self-regulation. The unit of analysis chosen was a topic, this because a topic was representative for an inclusive cycle of instruction. Based on the coding of the entire course by the raters, following rater training (including (a) the discussion of the rater manual, (b) agreement over the scoring, and (c) unit of analysis used) the inter-rater reliability was calculated. Inter-rater reliability here is defined as the extent to which different raters, each describing the same content, come to the same decisions (Rourke, Anderson, Garrison, & Archer, 2001). Among other coefficients the Kendall's W (also known as Kendall's coefficient of concordance) is used to investigate inter-rater reliability. This coefficient is of particular interest for the purpose of the method presented. It is a normalization of the statistic of the Friedman test, and can be used for assessing agreement of ordinal variables (Likert-type scale) among multiple raters. Kendall's W ranges from 0 (no agreement) to 1 (complete agreement) and is reported with a significance score. According to Cicchetti (1994) a Kendall's W score of .63, $p = .033$ indicates good reliability. It became clear that all six topics addressed in the course were rated equally for all seven attributes (minimum: 1 and maximum: 5) (authenticity: 3, personalization: 2, learner control: 3, scaffolding: 3, Interaction: 4, cues for reflection: 2, and cues for calibration: 2) and could be regarded as stable throughout the course.

2.3.2. Description of internal conditions

To assess learner characteristics three actions were undertaken. First, a performance based prior domain knowledge test was administered to investigate learners' prior domain knowledge. This test was a trial exam that represented the content of the entire course consisting of 5 questions. The trial exam consisted of exercises on each of the topics. The learners were asked to write a complaint letter, elaborate on the different steps of oral communication, and so on. The complete trial exam took 90 minutes and was administered in a traditional classroom set-up. After completion of the test, the exercises were scored by another instructor who was not participating in the study. Based on the score of the learners on the test they were divided into three percentile scores (i.e., 33.33, 66.66 and 100.00) and were labelled low, moderate or high. Secondly, regarding the motivational conditions of the learners the motivation part of the Motivated Strategies of Learning Questionnaire (MSLQ) was administered (Pintrich, 1991). The MSLQ is a self-report instrument designed to assess college learners' motivational orientations and their use of different learning strategies for a course. The MSLQ is based on a general cognitive view of motivation and learning strategies. This 81-item questionnaire is composed of two major sections: learning strategies and motivation. On the one hand, there is the learning strategies section. This section is divided into a cognitive, metacognitive and resource management section. Because the aim of the current study is to uncover learners' behaviour this part of the MSLQ was not used. Prior research (e.g., Muis, Winne, & Jamieson-Noel, 2007) also showed the misfit of this section with learners' behaviour. The motivation section on the other hand is shown (e.g., McClendon, 1996) to be highly effective for investigating learners' motivational conditions influencing self-regulation. This section involves scales that involve value (intrinsic and extrinsic goal orientation and task value), expectancy (self-efficacy and control of learning), and affect (test anxiety). In the MSLQ, learners respond to questions on a Likert-type scale that ranges from 'not at all true for me' to 'very true for me'. Third and final for metacognition, the knowledge about cognition part of the Metacognitive Awareness Inventory (MAI) was administered (Schraw & Dennison, 1994). The MAI targets the two major components of metacognition: knowledge about cognition and regulation of cognition. The latter in this study is seen as self-regulation and therefore not included. The knowledge about cognition component includes beliefs about declarative, procedural, and conditional knowledge. This instrument was chosen for its focus on the influence of metacognition on self-regulation (e.g., Sperling, Howard, Miller, & Murphy, 2002). Each of the instruments, with their scales was piloted and investigated for reliability (Cronbach's Alpha). Table 1 show the reliability scores for each variable investigated.

Table 1.

Reliability scores per construct measured.

Latent variable	**Construct**	**Cronbach's Alpha**
Cognition		
	Prior domain knowledge (PDK) (5 items)	.78
Motivation		
Value	Intrinsic goal orientation (IGO) (4 items)	.66
	Extrinsic goal orientation (EGO) (4 items)	.65
	Task value (TV) (6 items)	.87
Expectancy	Control of Learning Beliefs (CoLB) (4 items)	.73
	Self-efficacy of learning and performance (SEoLaP) (8 items)	.83
Affective	Test anxiety (TA) (5 items)	.88
Metacognition		
Knowledge of cognition	Beliefs about declarative knowledge (DK) (8 items)	.85
	Beliefs about procedural knowledge (PK) (4 items)	.83
	Beliefs about conditional knowledge (CK) (5 items)	.73

2.3.3. Description of self-regulatory behaviour

To describe learners' self-regulatory behaviour, log files from the online learning environment were extracted. These log files contain ecologically valid traces related to the different actions learners did. The Moodle environment tracked variables related to assignments, calendars, discussions, forums, notes, pages, URLs and user profile. Each of these variables was elaborated with components such as submit, view, or delete. Combined these variables described 52 unique events tracked by the environment. Each of these unique events included an action (view, submit, modify, etc.) and could be categorized into nine unique categories of variables used by the learners: (1) the course's landing page (course), (2) a content-related page (page), (3) an obligatory assignment (assign), (4) a discussion forum (forum) and (5) post on the forum (post), (6) a user page containing personal information (user), (7) a note page where learners could collect notes (note) and finally (8) non-obligatory extra resources (resources) and (9) URLs (url). Not each event was used by all learners. Each of the events was related to the learner-ID and timestamped. This resulted in an event sequence dataset that included more than 10,000 events recorded over the 25 learners.

2.4. Procedure

At the start of the course each of the learners' filled in an informed consent and was asked to complete the prior domain knowledge test, the questionnaire targeting their motivation (MSLQ) and metacognition (MAI). During the course, the offline components of the course were recorded using a video camera. All the events in the online course were tracked. After the 8-week runtime of the course, a back-up of the course was taken and the data secured on a separate server. Based on these data sources, analyses including statistical trials were done. All the learners agreed to participate in the study, so all the data collected could be used.

2.5. Analysis

Following the data collection, the data was cleared from events prior to the start and after the end of the course. Only the learners who participated in the prior domain knowledge test and the motivation and metacognition questionnaire were withheld. The data was imported in R-statistics and analysed using the TraMineR package (Gabadinho, Ritschard, Mueller, & Studer, 2011). Below the event sequence analysis will be discussed.

2.5.1. Event sequence analysis

The event sequence analysis consisted of two major steps. First, an exploratory sequence analysis was done by the identification of frequent event sub-sequences. Secondly, an explanatory approach was taken by the identification of discriminant frequent event sub-sequences by considering learners' internal conditions (cognition, motivation, and metacognition).

2.5.1.1. Frequent event sub-sequences: exploratory sequence analysis

Three parameters are of importance when identifying frequent event sub-sequences. The first one is the maximum length (k) of a sub-sequence. Due to the limitations of the R-package used, k was set on three. The second one is the minimal relative support (pMinSupport) of a sub-sequence among the different learners. In this study, this parameter was set on .05. The last parameter is the Levenshtein distance. This to be able to distinguish when a sub-sequence can be seen as unique. To be able to calculate this distance, the following is needed: (a) an event sequence object (seqe), (b) the insertion/deletion cost (idcost) of the different type of event (amount of events observed), here nine, and (c) the cost of moving an event one time unit (vparam). For the cost of moving (vparam) the value was kept on the default of .1. The calculation of the distance measure is fully described in Studer, Mueller, Ritschard, and Gabadinho (2010). Figure 3 gives a visual representation of the procedure described.

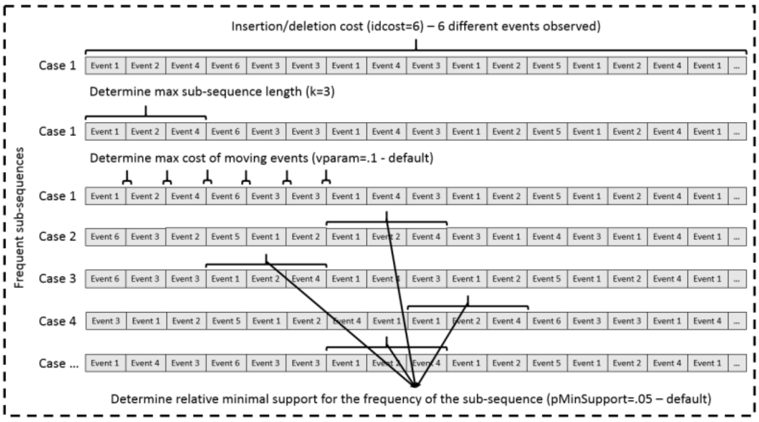

Figure 3. Visual representation of the determination of a frequent sub-sequence.

2.5.1.2. Discriminant frequent event sub-sequences per learner condition

The significant discriminating ability of the sub-sequences was based on differences between groups (e.g., cognition, motivation, or metacognitive conditions) by using the chi-square test. To be able to calculate the discriminating abilities of a frequent sub-sequence two arguments are needed (a) a sub-sequence (subseq) object containing the sub-sequences considered for discriminating the groups and (b) the variable that defines the groups (groups). The use of the chi-square test is appropriate as it investigates the significance of the relation between the observed and expected occurrence of a frequent sub-sequence for each value of the measured variables. Finally, the effect sizes are calculated using Cohen's d. The Cohen's d was calculated to express the relation between a certain discriminating frequent sub-sequence and the learners' characteristics. This analysis is based on the mean frequency of the occurrence of the frequent sub-sequence per score for each learner condition. Figure 4 gives a visual representation of the procedure described.

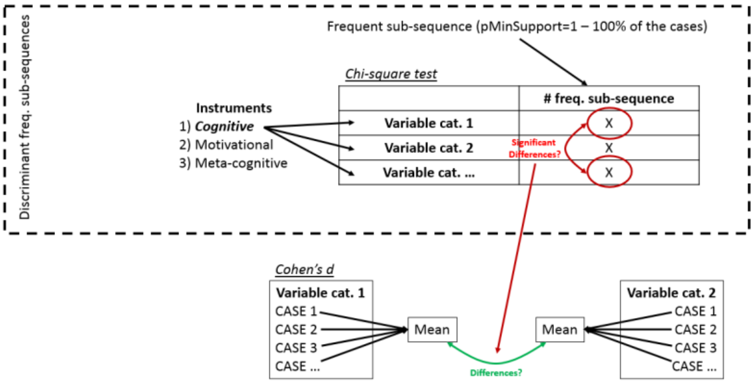

Figure 4. Visual representation of the determination of a discriminant frequent sub-sequence and the calculation of the Chi^2 -measure and the effect.

3. Results

3.1. Learner characteristics

Of the 25 learners, 22 were included in the analysis (exclusion based on missing values). Descriptive statistics showed that for the prior domain-knowledge test, eight learners scored below the 33.33^{rd} percentile (i.e., low or below 32.00 out of 100.00), eight learners scored between the 33.33^{rd} and 66.66^{th} percentile (i.e., average or between 32.00 and 43.33 out of 100.00) and six learners scored above the 66.66th percentile (i.e., high or between 43.33 and the maximum score achieved of 60.00 out of 100.00). Regarding the Likert-type scales (1 for totally disagree and 5 for totally agree) for (1) motivation and (2) metacognitive awareness the mean score, standard deviations and variance statistics was calculated. Table 2 gives an overview of these calculations.

Table 2.

Descriptive statistics learner characteristics.

Latent variable	construct	Mean	Std. Deviation	Coefficient of Variation
Motivation				
Value component	IGO	4.45	.671	.151
	EGO	4.68	.568	.121
	TV	4.82	.395	.082
Expectancy component	CoLB	4.41	.590	.134
	SEoLaP	4.23	.685	.162
Affective component	TA	3.55	.912	.257
Metacognition				
Metacognitive awareness	DK	4.45	.596	.134
	PK	4.55	.800	.176
	CK	4.59	.666	.145

In a first step, 703 frequent sub-sequences were identified. The sub-sequences contained maximum three events (k=3), nine unique categories (idcost=9) of variables were used by the learners: (1) the course's landing page (course), (2) a content related page (page), (3) an obligatory assignment (assign), (4) a discussion forum (forum) and (5) post on the forum (post), (6) a user page containing personal information (user), (7) a note page where learners could collect notes (note) and finally (8) non-obligatory extra resources (resources) and (9) URLs (url). Table 3 gives an example of the interpretation of such an event sub-sequence.

Table 3.

Example of the description and interpretation of event sub-sequences.

Sequence	Interpretation
(course)-(page)-(forum)	The learner first entered the course landing page, progressed via a content-related page (including information and exercises) to a discussion forum topic.
(assign)-(forum)-(course)	The learner made an assignment followed by a visit to the discussion forum and finished by visiting the course's landing page.
(user)-(forum)-(page)	The learner visited a colleague's user page followed by a visit to the discussion forum and a visit to some content related course material.

Secondly, the influence of the learner characteristics on learners' behaviour throughout the course was investigated. To investigate the relationship of learners' cognitive, motivational, and metacognitive levels and the occurrence of frequent sub-sequences (703) chi-square tests were done followed by the calculation of the effect sizes. Based on this analysis it was possible to extract discriminant frequent sub-sequences that occur significantly more (and their frequency effect size) per score on each variable. The idea was explicitly, first to use this data-driven approach and to later relate the findings to the theory.

3.2. Cognitive conditions influencing learner's self-regulatory behaviour

Related to the relationship of learners' level of prior domain knowledge (PDK) and the occurrence of certain frequent sub-sequences, the results showed both a significant negative correlation (high score, low occurrence) between the level of PDK and sequences containing pages related to content (χ^2 (2) = 11.41, p < .05, *d* = -1.37) and a positive correlation (high score, high occurrence) between the score for PDK and frequent sub-sequences containing the use of the discussion forum (χ^2 (2) = 16.38, p < .05, *d* = .60) and the consultation of other users' personal page (χ^2 (2) = 7.84, p < .05, *d* = 1.22). These results indicate that when learners have a high score for prior domain knowledge, they use significant fewer sequences containing content page visits and significantly more sequences containing interactions with the discussion form or other learners' personal page.

3.3. Motivational conditions influencing learner's self-regulatory behaviour

Related to the value component of motivation, for intrinsic goal orientation (IGO), results showed significant positive correlations between the level of IGO and sequences containing other learners' personal information page (χ^2 (2) = 5.10, *p* < .05, *d* = .56) and visits to the course discussion forum (χ^2 (2) = 5.10, *p* < .05, *d* = .56). A significant negative correlation was found between IGO and sequences containing assignments (χ^2 (2) = 6.70, *p* < .05, *d* = -.48).

For extrinsic goal orientation (EGO) results showed significant positive correlations between the level of EGO and sequences containing content related pages (χ^2 (2) = 6.88, *p* < .05, *d* = .76) and visits to assignment pages (χ^2 (2) = 6.88, *p* < .05, *d* = 1.44).

Finally chi-square tests between learners' perceived task value (TV) and the occurrence of frequent sub-sequences showed significant positive correlations with regard to sequences containing external web links (χ^2 (2) = 3.87, *p* < .05, *d* = .50) and additional sources related to the content (χ^2 (2) = 3.87, *p* < .05, *d* = .33).

Related to the expectancy and affective component, for control of learning beliefs, self-efficacy of learning and performance and test anxiety no significant differences among the learners' behaviour could be determined. The results show significant positive correlations between IGO and sequenced related to the discussion forum and other learners' pages, and a significant negative correlation related to sequences containing assignment pages. The higher learners' scored on extrinsic goal orientation (EGO), the more they were involved in sequences related to assignments and content pages.

3.4. Metacognitive conditions influencing learner's self-regulatory behaviour

For the investigation of the effect of knowledge of cognition on learners' self-regulatory behaviour, first learners' beliefs about declarative knowledge (DK) was investigated. The results of the chi-square test showed significant correlations between learners' beliefs about DK and frequently used sequences. Significant positive correlations were found between beliefs of DK and sequences containing additional resources (χ^2 (2) = 8.92, *p* < .05, d = .58), other users' personal information page (χ^2 (2) = 6.89, *p* < .05, *d* = .52), urls (χ^2 (2) = 7.68, *p* < .05, *d* = 1.04) and posts on discussion forum (χ^2 (2) = 6.89, *p* < .05, *d* = .52).

Also for learners' beliefs about conditional knowledge (CK) and the occurrence of frequent sub-sequences the results showed significant positive correlations when learners reported higher beliefs of CK and sequences containing the submission of assignments (χ^2 (2) = 8.69, p < .05, d = 1.60) and visiting content related information pages (χ^2 (2) = 7.27, p < .05, d = .79).

Finally, for learners' beliefs about procedural knowledge (PK) and the occurrence of frequent sub-sequences the analysis showed significant negative correlations between learners who reported higher beliefs about PK and sequences containing the course homepage (χ^2 (2) = 14.13, p < .05, d = -.73), visiting content related information pages (χ^2 (2) = 9.37, p < .05, d = -1.19) and visits to the forum (χ^2 (2) = 8.48, p < .05, d = -.71).

The results indicate that learners scoring higher on beliefs about declarative knowledge used sequences that include significantly more additional resources, other learners' personal pages, and posts on the discussion forum. Learners' scoring higher on conditional knowledge applied significantly more sequences that included assignments and content related pages. Finally, learners who scored higher on beliefs about procedural knowledge applied significantly fewer sequences that included visits to the course homepage, content pages, and the forum.

4. Discussion

4.1. Findings

4.1.1. Influence of cognition on learners' self-regulatory behaviour

With regard to cognition, it became clear that a higher score on prior domain knowledge (PDK) leads to the occurrence of "fewer sub-sequences that include content pages" and "more sub-sequences that include other users' personal profiles and the discussion forum". Although no prior research seems to be available using event sequence analysis to investigate the relation between learners' internal conditions and learners' self-regulatory behaviour, there is comparable research in the tool-use literature. In the light of this research the findings are comparable with those of Renkl (2002), who found that PDK mainly affects the amount of tool use (negatively correlated). In relation to this, Chapelle and Mizuno (1989) emphasized that this is only the case for content-related pages and not for discussion forums or assignment pages. A more recent study of Taub, Azevedo, Bouchet, and Khosravifar (2014) investigated the sequences presented by learners differing in prior domain knowledge. The results from this study demonstrated how low and high prior knowledge learners might have used cognitive and metacognitive self-regulation strategies as they learned about the human circulatory system. Results indicated that prior domain knowledge groups significantly differed in their use of total cognitive and metacognitive self-regulation processes; and more specifically, learners with high prior domain knowledge engaged in metacognitive strategies before cognitive strategies because they were more focused on monitoring what they knew from what they did not know, and this requires metacognitive knowledge and skills; they also had more working memory capacity to allocate to metacognitive monitoring processes. Learners with low prior domain knowledge engaged in cognitive strategies before metacognitive strategies because they were focused on learning the material, therefore using more cognitive strategies. Similar results were found by Trevors, Duffy, and Azevedo (2014). An explanation for the differences in sequences and number of occurrences of content pages from a self-regulation perspective was formulated by Moos and Azevedo (2008), who concluded that unlike high prior domain knowledge learners, low prior domain knowledge learners are engaged in what is called ‘knowledge acquisition’. Given their lack of a well-established knowledge base of the topic, they regulate their learning by frequently using content-related pages (or sequences) to learn as much as possible about the topic to accomplish the overall learning goal within the time imposed time restrictions. In sum, the results presented in our study support Moos and Azevedo (2008) second conclusion that learners with high prior domain knowledge seem to use different self-regulation strategies. A possible explanation for this may be that these types of learners no longer need to focus on the content as much as learners with lower levels of prior domain knowledge. These results lead us to hypothesize that learners with high prior knowledge engage more in self-regulation processes (e.g., monitoring) than learners with low prior knowledge, who focus more on cognitive processes.

4.1.2. Influence of motivation on learners’ self-regulatory behaviour

With regard to motivation, our results showed that (1) learners with higher intrinsic goal orientation use more sequences that include external (additional) resources, forums, and URLs compared to learners with low intrinsic goal orientation; (2) learners with high extrinsic goal orientation focus more on sequences that include the formal requirements of the course; and (3) when learners perceive the value of a task to be higher, they use more resources to supplement the course material. The finding that learners who score high on intrinsic goal orientation use more resources outside the formal course structure is in line with Lust (2012), who found that these type of learners made more use of elaborate information tools compared to learners with lower scores for intrinsic goal orientation. Secondly, we found that learners with higher scores for extrinsic goal orientation seem to focus more on sequences related to testable course elements that yield a performance output (Elliot & Church, 1997). This finding could be explained as the operationalization of intrinsic goal orientation, which comprises exploration, spontaneity, and interest in the surroundings (Piaget, 1971; White, 1959).

The findings about task value are comparable with those of Neuville, Frenay, and Bourgeois (2007), who found that learners who scored high on the MSLQ construct for task value (TV) used more elaborate and deeper processing strategies characterized by the use of elaborate information tools (e.g., extra resources, URLs and forums). Thirdly, it was observed that neither the expectancy nor affective constructs produced significant discriminant sequences. These findings echo Lust (2012); however, they challenge self-efficacy theory’s assertion that learners’ self-efficacy beliefs have an important influence on learners’ behaviour (e.g., Pajares, 1996; Pintrich & De Groot, 1990) and they also contradict prior findings that highly test-anxious learners have difficulties encoding and organizing the material in the learning stages (e.g., Birenbaum, 2007). This observation may have two causes. On the one hand, it is possible that there is no relation between either of the two concepts and learners’ self-regulatory behaviour. This seems unlikely given the findings of prior research (Schunk & Ertmer, 2000). A more plausible explanation is that the scales used were unable to capture the nature of self-efficacy in relation to learners’ self-regulatory behaviour (Muis et al., 2007). This should be explored in future investigations.

Overall the results presented are comparable to the findings of Moos (2014), Duffy and Azevedo (2015), Nelson et al. (2015) and Conley (2012). Although no significant relations were found for expectancy and affect, the findings presented above lead us to the hypothesis that learners who are intrinsically motivated and value the task at hand high will show more elaborated use of tactics and strategies. In contrast, learners who are extrinsically motivated and value the task at hand low will show less elaborated use of tactics and strategies, but will monitor the external goals set more closely.

4.1.3. Influence of metacognition on learners' self-regulatory behaviour

Finally, our findings on the knowledge of cognition component indicate that learners who score higher on beliefs about declarative knowledge used significantly more sequences that include additional resources, other learners' personal pages, and posts on the discussion forum. Learners who scored higher on conditional knowledge went through significantly more sequences that include assignments and content-related pages. Finally, learners who scored higher on beliefs about procedural knowledge applied sequences that included significantly fewer visits to the course homepage, content pages, and the forum. These findings are supported by a large body of literature investigating the relation between learners' metacognitive awareness and their use of metacognitive tactics and strategies. Bannert et al. (2015) and Sonnenberg and Bannert (2015) carried out an experimental study to explore whether learners with different levels of metacognitive awareness would exhibit different navigation behaviours, finding that the navigation behaviour of learners who configured and used their own metacognitive prompts differed significantly in a subsequent learning session from that of learners in the control condition. Azevedo et al. (2016) observed similar results. Pintrich (2002) explained these findings by stating that, if learners are not aware of the approaches they can use to solve problems, they will probably not be able to use them (Bransford et al., 2000). If learners know about a range of approaches, they are more likely to use them than when they have only a limited repertoire (Schneider & Pressley, 1997). If learners know about general approaches, they are more likely to use them in different situations (Weinstein, Mayer, & Wittrock, 1986). These results lead us to the hypothesis that learners with high levels of beliefs on the three types of knowledge (declarative, procedural, and conditional) leading to high metacognitive awareness (or knowledge about cognition) engage more in a diversity of self-regulation processes than learners with low levels of metacognitive awareness.

4.2. Implications for research

A first implication for research is a methodological one. More specifically the presentation of a study administered in an ecologically valid online environment, using an as data-driven approach as possible, which is able to generate comparable results as studies administered in strict experimental settings using deductive approaches. Whereas other studies rely on the use of visualisations (e.g., process-mining) or inferences straight from object-level to meta-level self-regulation via the recoding of raw data, this study presents a data-driven approach using statistical key-figures identifying meaningful and discriminating sub-sequences. Although this approach is far from perfect, it allows research to transfer from a pure deductive approach towards a more data-driven and ecological approach. To be able to further develop the methodology proposed in this study, it would be interesting in future research to recode the overt, object-level variables using non-self-regulation related object-level categories. Such categories provide a theoretical sound categorization (Lust, 2012) and could be based on for example tool classification schemes. This would allow the identification of meaningful sub-sequences (generalizable to broader contexts), which could be tested and triangulated against other online measures.

Secondly, there are some theoretical implications. On the one hand, our study validates prior research on the relation between prior-domain knowledge (e.g., Kramarski, Weiss, & Sharon, 2013; Song et al., 2016; Taub et al., 2014), expectancy-value (e.g., Ali, Hatala, Gašević, & Winne, 2014; Karabenick & Zusho, 2015; Mega, Ronconi, & De Beni, 2014), and metacognitive awareness (de Fátima Goulão & Menéndez, 2015; Duffy et al., 2015; Feyzi-Behnagh et al., 2014) and learners' self-regulatory behaviour in technology-rich environments. On the other hand, it highlights that learners not always perceive (based on differences in their cognition, motivation, and metacognition) designs of learning environments (prompts and cues) as intended by the instructor. This raises the question: "what accounts for the differences between learners?". This question calls for a more thorough investigation of the relation between (1) learners' internal conditions, (2) characteristics of the task conditions as provided by the learning environment, (3) the behaviour learners engage in in these environments and (4) the relation of the latter with learners' learning outcomes. By conduction experimental studies including learners with differences in learner characteristics (in both experimental and control condition), describing the design of the learning environments in both conditions, and comparing their outcomes and self-regulatory behaviour (in both experimental and control condition) insights might be gained about which interventions work best for what learners.

4.3. Implications for practice

Although several studies (e.g., Lopez, Nandagopal, Shavelson, Szu, & Penn, 2013) have shown unique differences between high- and low-achieving learners in the specific strategies they engage in to achieve academically (Zimmerman & Martinez-Pons, 1990), the awareness that learners not always perceive prompts and cues as intended by the instructor (Winne & Hadwin, 1998) seems not to be disseminated thoroughly into practice. As the aim of this study was not to investigate under what internal (learners' characteristics) and external (design of the learning environment) which learner behaviour (event sequences) led to increased learning outcomes (course performance), no concrete guidelines on how to design effective learning environments are provided. Instead, the findings of the study underscore the importance of being aware that learners react differently to one-size-fits-all designs. In combination with prior research on the role of external conditions, our findings confirm the theoretical model for self-regulation used in this study, which states that both internal and external conditions influence learners' self-regulatory behaviour.

With regard to the impact of external conditions more specific the design of learning environments, ample evidence is provided in current research by Gašević, Dawson, Rogers, and Gašević (2016), who have investigated the extent to which instructional (external) conditions predict course performance. These authors conclude that differences in technology use, especially those related to whether and how learners use the learning environment, require consideration before a generalized model for predicting course performance can be created. A lack of attention to instructional (external) conditions can lead to over- or underestimation of the effects of environments' features on learners' course performance.

With regard to the impact of internal conditions and in line with prior research mainly focussing on tool-use, this study demonstrated that when the design of the learning environment is controlled and identical (one-size-fits-all) for all learners, differences in behaviour can still be observed. Keeping this in mind, we can conclude that a lack of attention to conditions within (internal to) the learner may also lead to over- or underestimation of the effects of environments' features on learners' course performance. Although only a few studies have used a behavioural sequence approach, this finding is in line with a large body of tool-use research that emphasizes the importance of design in learners' individual differences. Nakic, Granic, and Glavinic (2015) and Thalmann (2008) found in their reviews that interventions in learning environments were highly successful when they were adapted to learners' cognitive, motivational and metacognitive variables. Only by taking into account both internal and external conditions will we be able to investigate the full effect of interventions on both self-regulatory behaviour and course performance.

5. Limitations and conclusions

5.1. Limitations

To enable further research to build upon the theoretical and methodological approach presented in this study, some issues need to be addressed. The first consideration relates to the balance between inductive (data-driven) and deductive (theory-driven) approaches. This study differed from the traditional approach to investigating self-regulation as an event (e.g., Azevedo, 2002; Taub et al., 2014; Winne, 2011; Zhou, Xu, Nesbit, & Winne, 2010) in that it took an inductive, learning analytics approach to gathering and analysing data. Clow (2013) points out that, "as a field, learning analytics is data driven and is often atheoretical, or more precisely, is not explicit about its theoretical basis", so such an approach might have certain benefits for theory-building. A data-driven approach could be used to identify and operationalize specific behaviours that are believed to reflect self-regulation (Winne & Baker, 2013). Based on the outcomes of data-driven trials, theoretical models can be developed through prediction modelling. This type of modelling involves obtaining specific learners' behavioural profiles using a data-driven approach and developing a model, which can match the profiles to new data, and it may prove more promising than, for example, practises which attempt to validate a theory by recoding variables using the same theory. Nonetheless, in further research it might be useful to integrate a theory-driven approach in a subtler way (i.e., in the analysis phase). This could be achieved for example by recoding the events or sequences based on a theoretical framework unrelated to self-regulation theory. This would reduce the number of events in the analysis drastically and potentially make them more meaningful. In contrast to this, the data would not speak so well for itself and be more of a representation of the theoretical model imposed on it.

Another limitation, although related, relates to the format of the data and the analysis techniques used. Questions regarding the optimal grainsize for uncovering self-regulatory behaviour remain unaddressed. Likewise, the level of some parameters included in the analysis (length of sequences (k=3), cut-off score for categorization as frequently occurring, etc.) is somewhat arbitrary. Although the parameter setting used to define the length of event sequences (k=3) was set based on technical limitations, in our opinion and for validation purposes this nevertheless remains a transparent means of investigating the relation between overt behaviour and the covert nature of self-regulatory behaviour. Other relevant studies with similar focusses (e.g., Taub et al., 2014; Zhou et al., 2010) preferred to recode the object-level variables into meta-level self-regulatory behavioural inferences. Taking this deductive approach would have minimized the computational power needed for the sequential analysis, as it would have limited the number of meta-level constructs depending on the theoretical basis of the framework used. Nonetheless, we did not take such an approach because of our data-driven focus (see: inductive vs deductive approaches). Other data-driven researchers (e.g., Kovanović, Gašević, Joksimović, Hatala, & Adesope, 2015; Siadaty, Gašević, & Hatala, 2016) used the methodological approach presented in our study, but treated self-regulation as a state. Leaving aside the appropriateness of such an approach (see: state vs event), it does not require the same amount of computational power as it does not cross-tabulate all data to identify frequent sub-sequences. Finally, with regard to the use of the TraMineR package for the event sequence analysis of self-regulatory behaviour, we are the first authors to use it in this fashion. However, to be able to develop the methodology proposed in this study further, it would be interesting in future research to recode the overt, object-level variables using non-self-regulation-related object-level categories. Such categories could be based on, for example, tool classification schemes. This would allow for the identification of meaningful sub-sequences, which could be tested and triangulated against other online measures.

Also the statistical background of the data also needs to be investigated further. The algorithms used often limit the analysis (chi-square) to checking the significance of the discriminant occurrence of certain sequences based on the more frequent occurrence. Although the approach uses sequences, it is still based on frequencies rather than on patterns. It would be useful to be able to investigate the order and temporality of sub-sequences to uncover patterns of events. Furthermore, triangulation of the data (events) would help uncover their relation to learners' self-regulatory states. Finally, due to the limitations of the analysis techniques, it was not possible to test the multicollinearity of the different learner characteristics investigated. The development of standards for conducting event sequence analyses would be a desirable next step in future research. In summary, to reap the full potential of log-file data there is a need for (a) a careful balance between data-driven and theory-driven approaches and (b) standards for conducting event sequence analyses. Although this study has its limitations, it reports a number of sound and validated findings related to learners' characteristics and their relation to self-regulatory behaviour.

5.2. Conclusions

The results of this study demonstrate the impact of learners' cognitive, motivational, and metacognitive characteristics on learners' self-regulatory behaviour. Additionally, they lend support to the notion of investigating log files using sequences in events extracted from ecologically valid learning environments. Most of the cognitive, motivational, and metacognitive conditions investigated in this study were associated with differences in learners' self-regulatory behaviour throughout the course. These findings are similar to previous research and thus contribute to evidence of the influence of learners' characteristics in their learning processes. This finding has both theoretical and practical implications.

The study contributes to two research fields. On the one hand, it contributes to the field of learning analytics by shifting away from a descriptive perspective (data visualization) towards an approach that combines data with theory. On the other hand, it also contributes to the field of self-regulation. It critically reviews the theoretical assumptions and empirical findings of self-regulation as well as its mechanisms of external control. Second, it integrates learner characteristics such as motivation, metacognition, and prior domain knowledge into the overall model of self-regulation. Third, it empirically investigates the potential of event sequences gathered unobtrusively through log files from an ecologically valid online learning environment (Moodle). Finally, it suggests theoretical and practical implications for the design of online and blended learning environments.

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The design of blended learning in response to student diversity in higher education: Instructors' views and use of differentiated instruction in blended learning.

Abstract

The implementation of blended learning in higher education is increasing, often with the aim to offer flexibility in terms of time and place to a diverse student population. However, specific attention for the diversity of this group, and how to cater individual needs, is still scarce. Therefore, this study explores instructors' strategies for and beliefs about differentiated instruction in blended learning, together with how the differences between instructors can be explained. A total of 20 instructors working in two adult education centers participated in semi-structured interviews focusing on their (a) use of strategies for differentiated instruction, and (b) beliefs about designing blended learning to address student diversity. The findings reveal that the most commonly used differentiated instruction strategy in a blended learning context was providing students with additional support throughout product development. In addition, three instructor profiles about designing blended learning to address student diversity emerged from the data: (1) *disregard*: instructors considered no additional support in the blended learning arrangements to match students' needs, (2) *adaptation*: instructors believed that increased support in the existing blended learning arrangements was sufficient to match students' needs, and (3) *transformation*: instructors thought that blended learning arrangements should be designed in a completely different way, and be tailored to the characteristics of the students. The results show that half of the instructors considered a transformation of their blended learning arrangements in response to student diversity. Furthermore, instructors' beliefs appear to be strongly connected to the organization and trajectory in which they work. A major implication of these findings is that professional support focusing on instructors' beliefs is of crucial importance to unlock blended learning's full potential. As such, it is important for organizations to develop a clear stance on this issue, which pays explicit attention to responding to learners' needs in blended learning contexts.

Keywords Distributed learning environments, pedagogical issues, post-secondary education, teaching/learning strategies, blended learning.

1. Introduction

Due to increasing student numbers, student populations in higher education are generally becoming more and more diverse (Fry, Ketteridge, & Marshall, 2008). This trend has sparked a surging interest in blended learning, an instructional approach that combines online and face-to-face instructional activities (Boelens, Van Laer, De Wever, & Elen, 2015), to create more flexible modes of education, and personalized learning trajectories (Fry et al., 2008; McKenzie et al., 2013; Wanner & Palmer, 2015; Watson, 2008).

There are different points of view on how blended learning may contribute to achieving this goal. Traditionally, blended learning has been used to make higher education more accessible to students (Graham, Woodfield, & Harrison, 2013), as online activities allow students to go through the learning materials when and wherever they want (Norberg, Dziuban, & Moskal, 2011). However, more recent conceptualizations of blended learning go beyond this notion of flexibility in terms of time and place. In addition to this increased accessibility, blended learning also offers opportunities to cater students' individual needs and achieve real personalized instruction (Wanner & Palmer, 2015; Watson, 2008). For instance, the popular flipped classroom approach to blended learning aims to free up classroom time for student questions, in-depth discussion, and personal feedback, by requiring students to prepare for learning activities online, according to their own levels of understanding (Kim, Kim, Khera, & Getman, 2014; Wanner & Palmer, 2015).

Unfortunately, there is not much information about how instructors in higher education actually use blended learning to provide more personalized instruction. This issue is especially important, as blended learning may help instructors to overcome a number of challenges that frequently obstruct more personalized instruction in traditional contexts, such as large classrooms or a lack of time (Nicolae, 2014; Tomlinson et al., 2003). The present study therefore examines how instructors in higher education use personalized instruction in a blended learning context, how they think about designing blended learning to address student diversity, and how possible differences between instructors may be explained.

2. Literature review

2.1. Differentiated instruction through blended learning

As noted before, most students in higher education vary significantly in terms of interests, competences, readiness for learning, and prior (educational) experiences (Fry et al., 2008, Tomlinson & Imbeau, 2013). As these differences matter greatly in learning (see e.g., Räisänen, Postareff, & Lindblom-Ylänne, 2016; Vasileva-Stojanovska, Malinovski, Vasileva, Jovevski, & Trajkovik, 2015), personalized learning environments are key to enhancing the quality of students' learning. Such learning environments typically involve differentiated instruction, which provides different avenues to learning in relation to students' individual needs (Tomlinson & Imbeau, 2013). Differentiated instruction can be organized on two levels. At the *institutional level*, student diversity is generally handled in an organizational way, often by grouping or tracking students on the basis of certain characteristics, such as their prior educational experiences (Ruys et al., 2013). At the *classroom level*, individual instructors modify their teaching approach to address the diverse needs of individual students in a classroom (Tomlinson et al., 2003).

Previous research in the field of differentiated instruction has mainly focused on the classroom level (see e.g., De Neve, Devos, & Tuytens, 2015; Humphrey et al., 2006; Smit & Humpert, 2012), and has put forward four components to describe how instructors match their classroom instruction to students' individual differences: content, process, product, and affect (Tomlinson, 2001; Tomlinson & Imbeau, 2013). First, *content* is defined as the information and ideas that students need to acquire in order to reach learning goals (Tomlinson & Imbeau, 2013). Flexibility in content can be provided in two ways: by adapting the curriculum, or what is being taught, and by modifying resources, or how the content is presented (Santangelo & Tomlinson, 2009; Tomlinson, 2001). Second, *process* is understood as how students process the content and acquire new skills (Tomlinson, 2001; Tomlinson & Imbeau, 2013). The process is generally modified by changing the level at which learning takes place, for example, by alternating between whole class instruction, flexible grouping, and individualized activities (Hall, Strangman, & Meyer, 2003; Tomlinson, 2001). Third, *product* refers to how students demonstrate what they know, understand, and can do after having received instruction (Santangelo & Tomlinson, 2009; Tomlinson & Imbeau, 2013). In this respect, instructors can create varied assessment options to capture mastery of learning goals, and provide students with different forms of support throughout product development (Santangelo & Tomlinson, 2009; Tomlinson & Kalbfleisch, 1998). Fourth, the concept of *affect* can be interpreted as students' feelings about the classroom environment. The main question here is whether all students feel safe, accepted, and valued (Tomlinson & Imbeau, 2013). Instructors can cultivate such feelings by ensuring that students interact and discuss in constructive ways, without making a person or certain part of the group feel smaller (Tomlinson, 2001).

Most of the research on differentiated instruction has been carried out in the contexts of primary and secondary education, with little attention to differentiated instruction in higher education (Santangelo & Tomlinson, 2009). Still, this work suggests that instructors may encounter a number of challenges when organizing differentiated instruction (De Neve et al., 2015; Humphrey et al., 2006; Smit & Humpert, 2012). Frequently cited challenges include limited human or physical resources, restrictive curricula, perceptions that organizing differentiated instruction is a time-consuming task, or a lack of skills for organizing differentiated instruction (De Neve et al., 2015; Humphrey et al., 2006; Smit & Humpert, 2012). Blended learning can help to overcome some of these challenges. For example, it may help to free up classroom time through online preparatory activities (Kim, Kim, Khera, & Getman, 2014; Wanner & Palmer, 2015), or make differentiated instruction in large classrooms more manageable through online personalized activities (McKenzie et al., 2013).

Through its combination of face-to-face and online activities, blended learning thus holds great potential for organizing differentiated instruction in higher education. Unfortunately, previous research on blended learning mainly focusses on instructors' use of and perceptions about blended learning in general, rather than in relation to differentiated instruction (Bliuc, Casey, Bachfischer, Goodyear, & Ellis, 2012; Ellis, Hughes, Weyers, & Riding, 2009). Overall, these studies report that instructors' thinking about blended learning may vary from low-level views focused on smoothening existing learning activities, to more high-level views that are mainly concerned with meeting students' learning needs (e.g., Bliuc et al., 2012; Ellis et al., 2009; C. Kim, Kim, Lee, Spector, & DeMeester, 2013; Voet & De Wever, 2016b). More specifically, several studies have shown that instructors are more likely to focus on content delivery and meeting practical needs, rather than on student learning and providing tailored support to meet students' needs (Bliuc et al., 2012; Davies, Dean, & Ball, 2013; Ellis et al., 2009). Even so, it is still not clear how instructors may actually envision blended learning in view of differentiated instruction, or what kind of strategies they put forward for differentiating between students. The finding that instructors' views and use of blended learning may vary also raises the question about how these differences might then be explained.

2.2 Explaining differences between instructors

A review of the literature on instructors' instructional decisions reveals two types of factors that may help to explain differences in instructors' use of differentiated instruction, and views of designing blended learning to address student diversity. On the one hand, several authors have argued that *the individual* is crucial for explaining differences between instructors (Bliuc et al., 2012; Ellis et al., 2009). It seems that what instructors do is primarily determined by their beliefs about education (Ertmer, 2005). Such beliefs are the sum of instructors' personal judgements and evaluations about education, and include, for example, ideas about effective forms of instruction and organization, or student and teacher roles (Valcke, Sang, Rots, & Hermans, 2010). These beliefs form a mental framework for making decisions and interpreting new experiences (Goodman, 1988; Pajares, 1992), and in this way, determine instructors' classroom behavior (Ertmer, 2005; Goodman, 1988; Kagan, 1992; Kim et al., 2013; Pajares, 1992; Valcke et al., 2010; Voet & De Wever, 2016a). This can explain why, for example, instructors who are primarily concerned with students' learning needs are more likely to design blended learning arrangements that support deep and meaningful student learning (Bliuc et al., 2012).

On the other hand, other authors instead emphasize the importance of *the organization*, as decisions at the institutional level also have an impact on the decisions that individual instructors make about the way they approach blended learning (González, 2012). This line of reasoning is supported by several studies that have been able to explain differences in the use of strategies for differentiated instruction based on the institutional context (De Neve et al., 2015; Smith, 2011). For instance, it appears that instructors are more likely to incorporate blended learning in meaningful ways if there is a clear and supportive institutional strategy, such as providing room for experimenting with blended learning (González, 2012).

To summarize, it is thus rather unclear how differences in instructors' strategies for and beliefs about differentiated instruction in blended learning might be explained. In particular, previous research raises the question to what extent differences may be explained by respectively the individual or the organization.

2.3 The present study

Situated against the background of a diverse student population within the context of higher education, the present study focuses on instructors' strategies for and beliefs about differentiated instruction in blended learning. In addition, it explores how differences between instructors may be explained. As such, the research questions are:

(1) What strategies do instructors put forward to differentiate between students in a blended learning context?
(2) What are instructors' beliefs about designing blended learning to address student diversity?
(3) How can differences in instructors' strategies for differentiated instruction and beliefs about designing blended learning to address student diversity be explained?

3. Method

3.1 Research setting

The present study is part of a larger research project in Flanders (Belgium), on the design of blended learning arrangements for students enrolled in a teacher training program within adult education (see

Eurydice (2009) for more information about adult education in Flanders). Flanders has currently two types of teacher training: (1) the integrated teacher training, in which students follow a three-year program focusing on a combination of subject-specific and pedagogical courses, and (2) the specific teacher training, in which students follow a shorter program solely focusing on pedagogical courses. This study is situated in the latter type, and as such, the focus of this training primarily lies on teaching methods, as students must be qualified for a specific subject in order to enroll. In the case of general subjects, such as history, psychology or chemistry, subject qualification is associated with a higher education degree, while for vocational subjects, such as electricity, hairdressing or baking, subject qualification is associated with a degree of vocational or technical secondary education. In other words, for some students, the teacher training program is their first experience with higher education, while other students have already obtained a degree in higher education. This implies that instructors in this context are confronted with students who are highly diverse in terms of prior educational experiences.

Participants of this study were instructors working in a teacher training program in an adult education center in Flanders. Two adult education centers were contacted. These two centers differed in size and in how they organize the teacher training programs. More detailed information about the context of these centers is presented in Table 1 and the most important differences in how these centers organize the teacher training programs are further explained below.

Table 1
The teacher training program's organization across the two adult education centers.

	Center A	**Center B**
Grouping (institutional level)	Heterogeneous groups	Homogeneous groups
Specific teacher training (60 credits)	(1) E-learning with weekly face-to-face meetings (2) Non-modular (3) Modular	(1) For students with a degree of vocational or technical secondary education (2) For students with a degree of higher education
Instructors' average experience in teacher education	7.32 years (SD=5.51, n=14)	4.58 years (SD=1.43, n=6)

First, the main difference was the allocation of student teachers to specific class groups. In center A, student teachers with secondary and higher education degrees were put together in class, while in center B, student teachers with a degree of higher education were not taking classes together with those holding a degree of vocational or technical secondary education. In other words, students in center B were tracked, at institutional level, in homogeneous groups based on educational background, while center A opted for heterogeneous groups.

Second, both centers offered their teacher training programs in blended learning formats. However, there were some differences in the organization of these blended learning programs. Center A offered three different trajectories, which differed in the amount of online learning. Two trajectories (i.e., the non-modular and the e-learning trajectory) were organized in clusters, rather than in separate courses: a theory cluster, an experimentation cluster, and an experience cluster or internship. In the (1) e-learning trajectory, the theory cluster consisted of 18 online thematic modules, while the experimentation cluster consisted of maximum one weekly face-to-face meeting to integrate the theory into practice, for instance through microteaching. In the (2) non-modular trajectory, there were also face-to-face meetings for the theory cluster (with the online part being reduced to about 25% of the cluster). In contrast to the first two trajectories, the (3) modular trajectory consisted of nine individual courses, next to an internship. Each course had an online part that took up about 25% of the course. Although student teachers could freely choose between trajectories, the e-learning trajectory was especially followed by those with a higher education degree, while those with a secondary education degree mainly enrolled in the modular trajectory. In the non-modular trajectory, the group was more diverse. In center B, all trajectories consisted of individual courses and an internship. The trajectory for student teachers with a secondary education degree was similar to the modular trajectory in center A, while the trajectory for those with a higher education degree was similar to the e-learning trajectory in center A.

3.2 Participants and data collection

Invitations to participate in the study were sent out to all instructors working in teacher training in one of the two adult education centers. The first author contacted the instructors through email, and requested a response within two weeks. Afterwards, a reminder was send to those who had not yet responded. In center A, 15 out of 19 instructors were willing to participate, while in center B, 6 out of 7 instructors were willing to take part. In other words, the response rate was about equal in both centers, with respectively 79% and 86% in center A and B. Prior to data collection, all participants received an explanation of the project. Participation was voluntary and the instructors gave their informed consent for participation, having been made fully aware of the nature and purpose of the research.

Semi-structured interviews were conducted to explore instructors' strategies for differentiated instruction and beliefs about designing blended learning arrangements for students with different prior educational experiences. Qualitative approaches and indirect measures are commonly used to explore instructors' beliefs (Miles & Huberman, 1994), and conducting interviews allowed to get a detailed understanding of individual experiences and interpretations that are of importance to the present study's research questions (Cohen, Manion, & Morrison, 2007).

The interview protocol was organized around a set of predetermined open-ended questions, which allowed the interviewer to ask for more details or to clarify misunderstandings (Cohen et al., 2007). The protocol centered on three main themes: participants' (1) background information (e.g., age, experience in education), (2) use of strategies to differentiate between students in a blended learning context, and (3) beliefs about designing blended learning arrangements for students with different prior educational experiences. The complete protocol can be found in Appendix A.

All participants were interviewed by the first author of this study. The duration of an interview varied between 40 and 113 minutes, with an average of 69 minutes (SD=20). To avoid social desirability biases, the interviewer ensured that all participants felt comfortable and secure to talk freely during the interview (Cohen et al., 2007). To make each participant feel as comfortable as possible, the interviewer told the participants that there were no right or wrong answers, and that all data would be treated and reported confidentially.

All interviews were audio-recorded with permission from the participants, and afterwards transcribed for data analysis. Due to the bad quality of one audio recording, one interview (with an instructor of center A) could not be transcribed and analyzed. Consequently, 20 instructors remained in the study. Of these 20 participants, 14 were female and 6 were male. Participants' mean age was 41.95 years (SD=9.58), and their average experience in teacher education was 6.50 years (SD=4.80).

3.3 Data analysis

In order to analyze the qualitative data, the interview transcripts were coded using NVivo 11 (Miles & Huberman, 1994). A predetermined coding scheme was established based on the conceptual framework and research questions described above. Units of meaning (i.e., units that could be classified into a single category) were chosen as the unit of analysis. A final coding scheme with additional (e.g., ICT support) and refined codes (Cohen et al., 2007) was obtained by re-reading the transcripts several times, and applying the initial coding scheme to eight randomly chosen transcripts. The final version of the coding scheme consisted of two parts (see Appendix B). First, the four components of differentiated instruction (content, process, product, and affect) were divided into nine subcategories, and one new category described as *ICT support*. One differentiated instruction strategy, the modification of curricula, was left out of the results, as it was not mentioned by the participants during the interviews. This was, however, not surprising, since the study took place in a formal setting with a fixed curriculum. Second, the coding scheme focused on identifying challenges that students can be confronted with in blended learning arrangements, together with instructors' views of how they would deal with these challenges. Emerging codes from the data were adaptation, transformation, and disregard (for details, see appendix B).

The final coding scheme was used by the first author to analyze all transcripts. To check its reliability, a second coder independently analyzed 16 transcripts. For this purpose, the independent coder was given a training, which focused on the aims and method of the study, construction of the coding scheme, and meaning of the codes. During this training, the first author and second coder jointly worked on four transcripts and openly discussed the coding strategy. This allowed the independent coder to familiarize herself with the coding scheme. Subsequently, the second coder independently analyzed the 16 remaining transcripts, and inter-rater reliability was calculated. Percent agreement for the coding of differentiated instruction strategies was 82%, while that for the categorization into types of beliefs about design of blended learning was 90% (18 out of 20 cases). According to Miles & Huberman (1994), both outcomes are considered to indicate good inter-coder agreement. Afterwards, all disparities were discussed by the two independent coders until agreement was reached.

Finally, two matrices were compiled based on the final coding (Miles & Huberman, 1994). The first matrix listed which strategies for differentiated instruction instructors used (see also Table 2 in section 4.1.2 strategies for differentiated instruction), while the second matrix contained an overview of participants' beliefs about the design of blended learning arrangements in answer to student diversity. Based on these two matrices, each instructor was then positioned on two axes: one included the number of differentiated instruction strategies, whereas the other contained the types of beliefs about the design of blended learning that emerged during the data analysis.

4. Results

In keeping with the three research questions, the results section is divided into three subsections. The first subsection provides more information about the strategies put forward by instructors to differentiate between students with a degree of vocational or technical secondary education, and those holding a degree of higher education. The second subsection then presents an overview of instructors' beliefs about how blended learning should be designed to take these differences between students into account. Finally, the third subsection links the findings of the previous two to one another, and also relates this to the organization in which instructors work. To further substantiate and illustrate the findings, each of these subsections draws on instructors' quotes (translated from Dutch to English). Instructors' names were replaced by a code, of which the letter (A-B) refers to the center where they worked, while the number (1-20) refers to their individual identification.

4.1 Strategies for differentiated instruction in a blended learning context

4.1.1 Perceived differences between students

During the interviews, instructors were asked to indicate which differences they noticed between students with a degree of vocational or technical secondary education and students with a degree of higher education, and how this was related to their teaching approach. All instructors reported that they noticed at least one difference between these two groups during their lessons. The most recurrent themes were (1) language abilities (n=20), such as writing skills, familiarity with jargon, English terms, or official school language, (2) ICT skills (n=17), related to using the center's learning platform, formatting or editing a Word document, sending e-mails, or communicating online, (3) competences for processing the content (n=15), such as identifying core information, structuring, or summarizing content, and (4) competences for monitoring one's own learning (n=9), including the need for feedback and confirmation, and ability to analyze task demands. For all these themes, instructors noted that mastery of these skills was generally lower for students with a degree of vocational or technical secondary education, compared to those with a degree of higher education.

4.1.2 Strategies for differentiated instruction

An overview of the individual instructors' use of strategies for differentiated instruction is presented in Table 2. Of all instructors, one instructor did not report any strategy to deal with differences between students. The other 19 instructors indicated several strategies to change their instruction based on individual students' needs. The average number of reported strategies for differentiated instruction was 3.25 (SD=1.74), with a maximum of seven different strategies.

Table 3 presents these results in a different form, by focusing on the categories and strategies for differentiated instruction, rather than on the individual instructors. It provides an illustration of each strategy, and notes how often each strategy was mentioned. It turns out that instructors most frequently reported strategies for differentiated instruction on *product* (n=15) and *process* (n=13) level, while interventions on the *affect* (n=8) and *content* (n=9) level were reported less frequently by the instructors. Next to these four main categories, ICT support was added as an additional category. Seven instructors stated that they often needed to provide additional ICT support to students with a degree of vocational or technical secondary education. Furthermore, within these main categories, some specific strategies are implemented more often than others. The most frequently reported strategies were the provision of additional support throughout students' development of a product that shows what they have learned (n=12) and strategies using whole class instruction (n=11), whereas grouping strategies (n=3) and individualized activities (n=4) were reported far less.

Table 2
Instructors' individual use of strategies for differentiated instruction

Instructor	Differentiated instruction categories[1]									Total number of differentiated instruction strategies
	Content		Process			Product		Affect		
	More varied teaching materials	Additional support	Whole class instruction	Grouping	Individualized activities	Additional support	Varied assessment options	Climate	ICT support	
B1	✓	✓	✓				✓		✓	5
B2		✓	✓		✓	✓	✓	✓		6
B3		✓	✓			✓	✓			4
B4		✓	✓			✓	✓	✓		5
B5							✓	✓	✓	3
B6								✓	✓	2
A7	✓		✓							2
A8				✓		✓				2
A9			✓			✓	✓		✓	4
A10	✓	✓	✓			✓	✓	✓	✓	7
A11			✓	✓	✓				✓	4
A12			✓			✓		✓		3
A13	✓								✓	2
A14										0
A15						✓		✓		2
A16	✓		✓			✓				3
A17		✓				✓	✓			3
A18			✓	✓	✓	✓		✓		5
A19					✓	✓				2
A20							✓			1

[1] Based on Lawrence-Brown (2004), Tomlinson & Imbeau (2013), Tomlinson & Kalbfleisch (1998), Tomlinson et al. (2003), and Tomlinson (2001), Santangelo & Tomlinson (2009)

Table 3
An overview of the strategies for differentiated instruction, together with an illustration and instructors' use of them

Differentiated instruction categories[1]	**Illustration**	**Used by N instructors**
1. Content	-	*9*
1.a. Provide varied teaching materials	"I make a distinction between basic subject matter and additional subject matter, or provide students with additional video fragments, tools and quizzes to exercise, so that students can choose which materials they want to use to process subject matter (instructor A10)."	5
1.b. Provide additional support in teaching materials	"I integrate pictograms in the learning material to show students what is important, less important, a problem statement, or an exercise (instructor B1)."	6
2. Process	-	*13*
2.a. Whole class instruction	"During my face-to-face lessons for students with a degree of higher education I do not really follow the course manual when I am teaching, while during my lessons for students with a degree of vocational or technical secondary education, I use the course manual as a guide and I stick to that course content (instructor B4)."	11
2.b. Grouping	"Students have to make an assignment in heterogeneous groups. They need to present their group product to the whole class and the whole class can react to their product. In this way, they are confronted with the diversity in the group, and everyone is challenged to do something more than he or she already could (instructor A8)."	3
2.c. Individualized activities	"Students could choose between several topics in some of the distance assignments: on the one hand we offered new, additional topics that were not discussed in class, and on the other hand we offered topics that were extensions from the content provided during the lessons (instructor A19)."	4
3. Product	-	*15*
3.a. Provide additional support throughout product development	"When students need to write a reflection, I provide them with different instructions. For learners with a higher education degree I give one open question and say: 'this is the maximum number of words'. For learners with a degree of secondary education, I divide the assignment into smaller parts and ask them to respond to multiple specific questions (instructor B2)."	12
3.b. Provide varied assessment options	"Students have the choice to make a digital brochure or another product instead of a paper since this focuses less on learners' writing skills (instructors B3, A17)."	9
4. *Affect*	"I often say to students with a degree of vocational or technical secondary education that they will be very important teachers. I try to create little success experiences, and help them to believe in their own successes (instructor B4)."	*8*
5. ICT support	"After a face-to-face meeting, or during breaks, I show them how Moodle works, or how to format documents. I give them the space to grow and learn. For the first assignment, they may submit a flat, unformatted Word document, and then I provide some brief feedback on how they can format and edit the Word document (instructor A9)."	7

[1] Based on Lawrence-Brown (2004), Tomlinson & Imbeau (2013), Tomlinson & Kalbfleisch (1998), Tomlinson et al. (2003), and Tomlinson (2001), Santangelo & Tomlinson (2009)

4.2 Beliefs about designing blended learning to address student diversity

Even though blended learning may help to provide differentiated instruction, instructors commonly pointed out that blended learning may also give rise to additional challenges for some students. After discussing these challenges, this section introduces three distinct profiles related to the design of blended learning arrangements for this specific student group, which emerged from our interviews.

Eighteen of the instructors indicated that blended learning programs are often more challenging for students with a degree of vocational or technical secondary education, compared to those holding a degree of higher education. Only two instructors (A8, A20) did not see challenges for this specific student group. The three most recurrent challenges in instructors' answers were that students with a degree of vocational or technical secondary education (1) experience more problems with technology (n=8), (2) are not used to independently acquiring and processing content (n=10), and (3) have more trouble with meeting deadlines (n=3).

Based on the interview responses, three profiles could be discerned regarding instructors' beliefs about the design of blended learning arrangements for students with a degree of vocational or technical secondary education. First, four instructors' answers corresponded with a *disregard* profile, since they offered no specific ideas about how to design blended learning arrangements to meet the needs of these students. Second, six instructors had an *adaptation* profile. They argued that their existing blended learning arrangements need increased or adapted support to better match the needs of students with a degree of vocational or technical secondary education. Third, 10 instructors had a *transformation* profile. These instructors believed that more profound changes were needed, and that blended learning arrangements for students with a degree of vocational or technical secondary education should be designed in a totally different way than blended learning arrangements for students with a degree of higher education.

4.2.1 Disregard

This profile had two different interpretations. First, two instructors (A8, A20) did not report any challenges for students with a degree of vocational or technical secondary education, and logically expressed no modifications in their design of blended learning. Second, two instructors (A9, A7) reported challenges for students with a degree of vocational or technical secondary education, but no concrete modifications in their design of blended learning. For instance, instructor A7 was not convinced that blended learning was an appropriate approach for this group, but then also did not offer any solutions. Instead, he stated that: “My story is that blended or distance education brings a lot of stress for low-educated learners, while for high-educated learners it is a relief in many ways.”

4.2.2 Adaptation

Six instructors indicated several actions to provide more guidance and support to students with a degree of vocational or technical secondary education in their existing blended learning arrangement, but did not explicitly state that the whole design a blended learning course should be changed. The most frequently reported actions were: (1) the provision of a guidebook or concrete guidelines to communicate expectations (instructors B6, A18), (2) the provision of clear guidelines about the learning platform, including instructions on where to post assignments or where students can find their feedback (instructors B6, A17, A18), (3) following up individual students to remind them of deadlines (instructors B6, A12, A18, A19), (4) giving students opportunities to send a draft version of an assignment before the final version (instructors A18, A19), and (5) building in monthly supervision between (individual) students and the instructor about the content of the course and students’ learning process (instructors A14, A19). Other actions were: personalizing the structure (i.e., ill-structured vs. structured) of assignments (instructor A14), replace English texts (instructor A18), provide a manual or guidebook when students need to watch videos (instructor A18), be accessible as instructor, for instance, by responding to emails every two days (instructor A18), offer variation in online exercises (instructor A17), and provide both online and face-to-face opportunities for interaction (instructor A17).

4.2.3 Transformation

Ten instructors remarked that the blend should not be the same for students with a degree of vocational or technical secondary education, and students with a degree of higher education. Depending on the student group, they proposed to design instructional activities in a totally different way, or provide other kinds of blends. Yet, at least eight of them (B1, B3, B4, B5, A11, A13 A15, A16) also emphasized that the instructor will always play a central role in students' learning of the content (during face-to-face meetings). For instance, instructor A11 explained that: "Blended learning needs to take place in another way, and the instructor will always play a central role in the introduction of theories. We need to provide other kinds of blends, for example [one that combines] a preparatory assignment outside the classroom, a face-to-face moment to explain and interpret the theory, and an online assignment to deal with the theory." Often, these instructors additionally reported several smaller adjustments that were also mentioned by instructors with an *adaptation* profile, such as: the provision of direct and individual feedback (instructors B2, B4, A15), scaffolding students' self-regulatory skills (instructors B3, A16), or the provision of a clear structure, expectations, and an overview of the deadlines and assignments (instructors B4, B5, A11).

4.3 Explaining differences between instructors

To shed more light on the extent to which *individual factors* may explain differences between instructors, Figure 1 plots their repertoire of strategies for differentiated instruction in blended learning against their beliefs about the design of blended learning for addressing student diversity. Overall, there seems to be a trend toward more deliberate design of blended learning for instructors possessing a more extensive repertoire of strategies for differentiated instruction. However, this finding does not apply to all instructors. For example, even though instructor A9 reported more strategies for differentiated instruction than the average, she still held a *disregard* profile. The opposite also occurred, as instructors A13 and A15 indicated fewer strategies for differentiated instruction than the average, but actually hold a *transformation* profile. Further analyses suggest that these unexpected differences are the result of *organizational factors*.

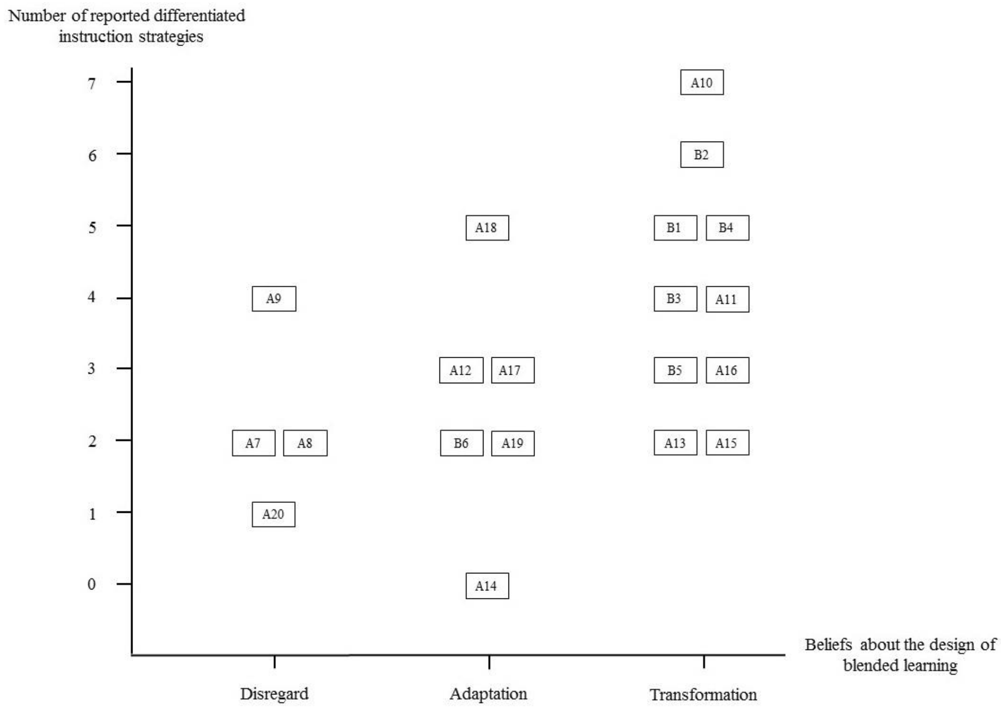

Figure 1.Relation between instructors' repertoire of strategies for differentiated instruction in blended learning and their beliefs about the design of blended learning for addressing student diversity.

Note. Every numbered symbol (1-20) represents an instructor, and the letter (A-B) refers to the center where they work.

Figure 2 adds the organization in which the instructors work into the equation. For instructors working in center A, it also indicates in which specific trajectory the instructors work. Since there were some instructors rather new to the e-learning trajectory, a distinction was made between instructors with less than one year of experience and instructors with more than one year of experience in the e-learning trajectory. Looking at instructors' use of differentiated instruction strategies, the average number of reported strategies in center B (M=4.17, SD=1.47) was higher than that in center A (M=2.86, SD=1.75). Figure 2 further shows that the center in which instructors worked, seemed also strongly connected to their beliefs about the design of blended learning to address student diversity. In line with their more extensive repertoire of differentiated instruction strategies, instructors in center B also advocate a more deliberate design of blended learning for addressing student diversity, compared to many of the instructors working in center A. To be more specific, five of the six instructors working in center B were identified as holding a *transformation* profile, and consequently believe that, to match the needs of students with a degree of technical or vocational secondary education in blended learning arrangements, not only additional support, but also a redesign of learning arrangements was needed. In center A, instructors' beliefs seemed to be associated with the trajectory in which they worked (for more information on these trajectories, see section 3.1 research setting). There appears to be a trend toward a more deliberate design, described here as a *transformation* profile, for instructors working already more than one year in the e-learning trajectory, while instructors working in the modular or non-modular trajectory often held a *disregard* or *adaptation* profile.

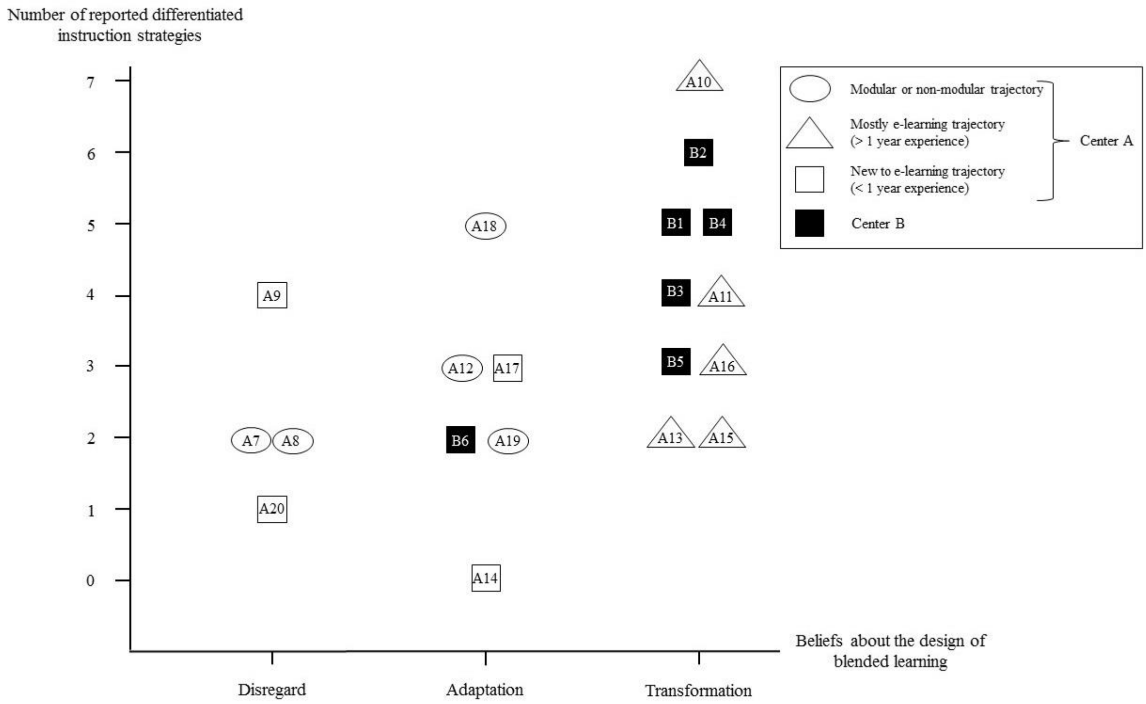

Figure 2. Relation between instructors' repertoire of strategies for differentiated instruction in blended learning and their beliefs about the design of blended learning for addressing student diversity.

Note. Every numbered symbol (1-20) represents an instructor, and the letter (A-B) refers to the center where they work. For more information on the trajectories in center A, see section 3.1 research setting.

5. Discussion

5.1 Summary of findings and discussion

In this section, we highlight the three major findings from our study: (1) some strategies for differentiated instruction were mentioned more than others, (2) half of the instructors considered a transformation of the blended learning arrangements, while the other half considered no or limited changes to existing blended learning arrangements, and (3) the organization appeared to be connected to instructors' views and use of differentiated instruction in blended learning.

5.1.1 Strategies for differentiated instruction

A first major finding is that some strategies for differentiated instruction are mentioned more frequently than others. Previous research identified four main categories of differentiated instruction, respectively focusing on: (1) *content*, or the information and ideas that students need to acquire to reach learning, (2) *process*, or how students process the content and acquire new skills, (3) *product*, or how students demonstrate what they have learned, and (4) *affect*, or how students feel about the classroom environment (Tomlinson, 2001; Tomlinson & Imbeau, 2013). The findings of the present study point out that instructors more often put forward adjustments to the product and process level, than to the content or affect level. A likely explanation for these results may be that instructors are more familiar with strategies related to the product and process level, or that these strategies are easier to organize than differentiation at the content and affect level. When looking at specific strategies, the results reveal a number of differences compared to previous research. For instance, instructors in the present study frequently mentioned the importance of adequate assistance throughout product development, while earlier studies report that there is usually less attention to this strategy for differentiated instruction (Smit & Humpert, 2012). Likewise, flexible grouping methods are hardly reported by the instructors in this study, while Humphrey et al. (2006) found that group work was often used by instructors to organize responsive teaching. A possible explanation for these differences is that the previous studies were situated in a more traditional context, whereas the present study is situated in a blended learning context. It might be easier to organize formative assessments in the latter, as learning platforms can provide the instructor with additional opportunities to provide (automated) feedback to students (see e.g., Boelens, De Wever, & Voet, 2017; McKenzie et al., 2013), while, on the other hand, the online component might be less suited to group work, since interaction and dialogue are easier to arrange in face-to-face meetings (Kember, McNaught, Chong, Lam, & Cheng, 2010).

5.1.2 Beliefs about designing blended learning to address student diversity

A second major finding is the typology of beliefs about designing blended learning to address student diversity, which emerged from the data. In particular, three profiles were discovered: a disregard, an adaptation, and a transformation profile. Instructors with a *disregard* profile either thought that additional support was not necessary, or did not seem to consider such support, even though they were aware of possible challenges to some students. For instructors with an *adaptation* profile, the proposed support remained limited to adjustments to existing learning arrangements. Instructors with a *transformation* profile believed that blended learning arrangements should be designed in a completely different way, and be tailored to the characteristics of the specific student group. This typology is consistent with other studies, indicating that not all instructors think about the design of blended learning arrangements in the same way (Bliuc et al., 2012; Ellis et al., 2009). However, it also nuances previous studies (e.g., Bliuc et al., 2012) which have considered tailored instruction in blended learning as a one-dimensional concept, rather than considering gradations in its execution.

Looking at the results, it becomes clear that half of the instructors had a *transformation* profile, while the other half had either a *disregard* or an *adaptation* profile. On the one hand, this finding echoes that of previous studies, which have noted that most instructors are led by practical considerations when designing blended learning, and pay limited attention to individual students' needs (Bliuc et al., 2012; Davies et al., 2013; Ellis et al., 2009; C. Kim et al., 2013). On the other hand, it also indicates that a relatively large number of instructors are already particularly attentive to differences between students in their design of blended learning. While the findings clearly distinguish three types of instructors regarding their beliefs on how blended learning should be designed in response to student diversity, it is less clear how these differences can be explained.

5.1.3 Explaining differences between instructors

A third major finding is that the organization and trajectory in which instructors work seem to be associated with their repertoire of differentiated instruction strategies and most of the differences in their beliefs about designing blended learning to address student diversity. The results indicate that, in line with their more extensive repertoire of differentiated instruction strategies, most instructors of center B advocate a more deliberate design of blended learning, compared to many of the instructors in center A. Previous research suggests that this is likely the result of a clear stance of the organization with respect to differentiated instruction in a blended learning context (González, 2012). This is illustrated by the way differentiated instruction is handled at the institutional level, with students in center B being grouped based on their educational degree, whereas center A does not group students based on their educational background. As previous research has also shown, a clear and supportive strategy and vision in the organization has an impact on the decisions that individual instructors make (De Neve et al., 2015; González, 2012; Smith, 2011).

The results further reveal that instructors' beliefs about the design of blended learning in response to student diversity may also vary within an organization, depending on the specific trajectories in which they work. The results from center A show that instructors who are responsible for a trajectory with mainly online activities, are more likely to say that a redesign of the blended learning arrangements is needed from the ground up (i.e., *transformation* profile), while instructors who are responsible for a trajectory with more face-to-face meetings or who just started teaching in a trajectory with mainly online activities are more likely to say that adjustments to the existing blended learning arrangements are sufficient (i.e., *adaptation* profile). There are two plausible explanations for these different types of instructor beliefs within the organization.

The first is that there may exist several subcultures in the organization, related to the specific trajectory in which instructors work. This may explain why most instructors in the e-learning trajectory had a *transformation* profile, whereas those in other trajectories had an *adaptation* or *disregard* profile. This could also explain why instructors with less than one year of experience in the e-learning trajectory did not have a *transformation* profile, as they likely need more time to adopt the organizational subculture and establish shared views with colleagues.

The second possible explanation is that the differences between trajectories may be due to the size of their online components. As the online activities provide increased autonomy for students, a certain amount of self-regulation is required (Barnard, Lan, To, Paton, & Lai, 2009; Lynch & Dembo, 2004).

Previous research has shown that students without higher education degree may be less able to self-regulate their learning (Owston et al., 2013; Räisänen et al., 2016), and thus often encounter more difficulties in blended learning contexts. This was also indicated by the instructors in the present study. With this in mind, it seems logical that instructors working in a trajectory with mainly online activities propose more profound changes in the way blended learning is designed for students without higher education degree.

5.2 Limitations and suggestions for further research

A first limitation of this study is that the small sample size limits the ability to generalize some of the results, such as the most frequently used strategies for differentiated instruction. Even though these results are useful indications, they have yet to be confirmed by more large-scale studies. Still, these results are not the only contribution that the present study offers to the field, as it also introduces a typology for beliefs about the design of blended learning for responding to student diversity, while also pointing out that the organization plays an important role in the development of these beliefs. A second limitation of this study is that the strategies for differentiated instruction of the instructors are based on self-reports, and there were no direct observations to assess the accuracy of these self-reports. However, using self-reports is a common approach in similar studies (e.g., De Neve et al., 2015), and previous research has demonstrated that self-reports are a valid way to measure instructional outcomes (Dumont & Troelstrup, 1980). Still, future research could investigate whether observations and self-reports would also be similar in this particular case. Finally, a third limitation is that, although the findings suggest that the organization is related to the instructors' profile, the question remains whether tracking students at institutional level is the cause or the consequence of instructors' beliefs. As such, further research in organizations that are adopting blended learning could provide more insight in this causality.

5.3 Implications

The present study explored instructors’ strategies for differentiated instruction in blended learning and their beliefs about designing blended learning to address student diversity. To further investigate the differences between instructors, both were compared to one another, as well as the organization and trajectory in which they work. The results hold two important implications to both theory and practice.

First of all, the finding that half of the instructors believed that student diversity required no, or only limited, adaptations to their blended learning arrangements, suggests that professional support focusing on these beliefs is of crucial importance for instructors to unlock blended learning’s full potential. In light of this, the present study’s framework of strategies for differentiated instruction could be used as a starting point for expanding instructors’ strategies for coping with student diversity in blended learning contexts. In addition, the three profiles concerning beliefs about developing blended learning arrangements to address student diversity can be used by organizations and instructors to reflect on their own practice, to become more aware of their own beliefs, and to adjust their teaching approach.

Second, differences in instructors’ beliefs about the design of blended learning were, according to the present study, mainly attributable to the organizational level, or the center and trajectories where instructors work. As such, it is important for organizations to develop a clear stance on this issue, which pays explicit attention to proactively planning differentiated instruction and responding to students’ needs in blended learning contexts. Recent work on institutional adoption (e.g., Graham, Woodfield, & Harrison, 2013) could serve as a framework for this kind of endeavor. This is also an important issue for future research, which should investigate exactly how organizations can contribute to the development of instructors’ beliefs about the design of blended learning to address student diversity. A possible starting point for such research can be found in the literature on differentiated instruction, which suggests that organizations should create a collective responsibility, by offering opportunities for instructors to share knowledge, ideas, and experiences, to enhance professional learning related to differentiated instruction (De Neve et al., 2015; Smith, 2011).

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Appendix A: Interview protocol

1. **Introduction**

- Thank the participant for participating in the study
- Explain the goals of the study: investigate instructors' experiences in working with and responding to student diversity (and more specific: students with a degree of vocational or technical secondary educations versus students with a degree of higher education), and perceived challenges when designing blended learning arrangements in general and with respect to learner diversity
- Explain the three parts of the interview
- Emphasize that the focus is on their experiences and opinions, and that there are no right or wrong answers
- Ask permission to record the interview, and explain that all data will be treated confidentially
- Sign informed consent

2. **Background information**

- What is your year of birth?
- What higher education program did you follow?
- Can you provide a description of your career?
    - How long have you been teaching in this center for adult education?
    - In which programs or trajectories do you currently teach?
    - Which courses/subjects do you teach?
    - How long have you been teaching these courses/subjects?
- Have you been enrolled in a blended learning course as a student?
    - If yes, in which program(s) or course(s)?
    - How much experience do you have with blended/distance learning? (one lesson, an entire course,…)
    - What are your experiences? Both positive and negative?
- Do you have experience with blended/distance learning as an instructor?
    - If yes, in which program(s) or course(s)?
    - How much experience do you have with blended/distance learning? (one lesson, whole course,…)
    - What are your experiences? Both positive and negative?

3. **Experiences in working with and responding to student diversity**

What are, according to you, the most important differences between students with a degree of vocational or technical secondary education and students with a degree of higher education? (open question)

- For every difference:
    - Can you provide a concrete example?
    - How is this related to your teaching? How do you cope with these differences during your lessons?
- When instructors have responded to the question, prompts were provided about the themes that were not spontaneously discussed during the open question (to stimulate the discussion, based on literature). Again, when participants further discussed about a theme, they were asked to provide a concrete example and how this was related to their teaching.
    - Do you see differences with respect to students'…
        - self-efficacy, that students feel confident in solving tasks and to believe in their own abilities *(Klug, Krause, Schober, Finsterwald, & Spiel, 2014)*
        - planning skills, or how students plan their own learning activities? *(Klug et al., 2014)*
        - use of study methods and learning strategies? *(Klug et al., 2014)*
        - self-reflection, as students' ability to monitor and evaluate their own learning process *(Klug et al., 2014)*
        - reasoning/attribution, as to which reasons students assume led to their performance? *(Klug et al., 2014)*
        - ICT skills or ICT competencies?
        - motivation?
        - feelings about the classroom environment, as students feel safe in the learning environment?
        - attitude toward education?
        - attitude toward peers?
        - prior knowledge?
        - sense of belonging, relation with other students in the group? *(McDonald, 2014)*
        - relation and attitude toward the instructor *(McDonald, 2014)*
        - written language skills
        - oral language skills

4. Beliefs and perceptions about the design of blended learning arrangements in general, and with respect to learner diversity

In general

- How does the distance/online learning take part in your lessons?
    - Which learning activities are expected of students?

    - How do you provide support to students during the online or distance part? E.g., can students reach you by email?
- How is the online part connected to the face-to-face meetings?
- Are there certain skills necessary to successfully complete a blended learning course or program? *(based on McDonald, 2014)*
- What can we, according to you, achieve with the concept blended learning? What is the power of blended learning?
- What can we certainly not achieve with the concept blended learning?
- What are the most essential components in a blended learning arrangement? What advice would you give to design an effective blended learning arrangement?

<u>Students with a degree of vocational or technical secondary education</u>

- Do students with a degree of vocational or technical secondary education encounter challenges during blended learning courses or problems to successfully complete a blended learning course? If yes, what are these challenges? Provide a concrete example.
- What do you want to change, or what needs to be modified to overcome these challenges or problems?
- With regard to students with a degree of vocational or technical secondary education: what is going well in the blended learning arrangements?
- To summarize, can you indicate what components should be emphasized to design a suitable blended learning arrangement for this target group?

5. End

- Ask whether the instructor has additional comments related to the themes of the interview
- Thank the participant for participating in the study

Appendix B: coding scheme

DIFF: strategies that adult educators put forward to differentiate between students with a degree of (a) vocational or technical secondary education and (b) higher education

<table>
<tr><th colspan="2">Instructors can differentiate instruction through…
(Tomlinson & Imbeau, 2013)</th><th colspan="2">Underlying categories and examples of strategies
Based on Lawrence-Brown (2004), Tomlinson & Kalbfleisch (1998), Tomlinson et al. (2003), Tomlinson (2001), Santangelo & Tomlinson (2009)</th><th>Code</th></tr>
<tr><td rowspan="3">Content</td><td rowspan="3">(1) What students learn / what we teach (curricula)

(2) How content is presented to students: resources and material students need to use to acquire the content and reach the learning goals</td><td colspan="2">Modify curricula (what we teach): match learning content to students' needs</td><td>01DIFF_Curriculum</td></tr>
<tr><td colspan="2">More varied lesson/instructional material, for example:
- match materials to the specific instructional needs of groups
- present information in varied ways: orally, visually, through demonstration, part to whole, and whole to part
- provide text materials at varied reading levels and levels of complexity</td><td>02DIFF_LessonMaterial</td></tr>
<tr><td colspan="2">Additional support, for example:
- provide advanced organisers, highlighted print materials, key ideas, visual aids, outlines, summaries
- add structure
- provide connections with prior knowledge or experiences
- provide clear expectations and examples, using examples and illustrations that represent varied ways of thinking, or clarify the final goals with examples of successful work from other students</td><td>03DIFF_ContentSupport</td></tr>
<tr><td>Process / activity</td><td>How students process the content</td><td>How the instructor modifies his/her teaching methods, instructional strategies, and learning activities based on student diversity. How he or she applies the content.</td><td>Whole class instruction, adjust teaching methods and instructional strategies to the entire class. Flexibility in whole class instruction can be achieved when students are tracked in rather homogeneous class groups, or when instructors carefully select instructional strategies that attend to a specific group of students in the classroom and which is in addition beneficial for all students</td><td>04DIFF_WholeClass</td></tr>
</table>

		- different degrees of difficulty, complexity, or specificity - varying the pace of work - connections between learning activities and personal interests	(Flexible) **grouping**: use a variety of grouping strategies to match students and tasks (mixed or similar readiness/interests/learning profile)	05DIFF_Grouping
			Individualized activities, for example: offer assignments on the same topic at varying degrees of difficulty, let students work at their own pace, give learners choices about topics in which to specialize, give students choices about ways of learning, provide additional instruction to the individual student	06DIFF_IndividAct
Product	How students demonstrate what they have learned (i.e., know, understand, and can do) **at certain points** in a unit of study (formative and summative)	Provide **additional support**: adequate scaffolding and support **throughout product development**. For example: - additional feedback (during product development) - divide assignments into smaller steps - peer- and self-evaluation		07DIFF_ProductSupport
		Provide **varied assessment options**, for example: - portfolios, authentic problems to solve,… - provide varied modes of expression (e.g., written paper vs oral presentation) to show mastery of common learning goals - give students choices about modes of expression		08DIFF_Product_AssOpt
Affect / learning environment	The climate or tone of the classroom. How students feel about or respond to learning and the classroom environment (students feelings impact their learning)	The instuctor stimulates… - that everyone feels welcomed and contributes to everyone else feeling welcomed - mutual respect, to accept and appreciate one another's similarities and differences - that students feel safe in the classroom (students feel accepted and valued, students dare to say they don't know or dare to make mistakes) - every learner grow as much as he/she can in general ability and specific talents		09DIFF_Affect
Additional ICT support		The instructor provides additional ICT support in and outside the classroom, e.g., how to use the learning management system, or how to edit and format a Word document		10_DIFF_Ict

BLE: Adult educators' beliefs about designing blended learning arrangements for students with a degree of technical or vocational secondary education

- **BLE_CHALL(SE)**: Perceived challenges that blended learning arrangements may pose for students with a degree of vocational or technical secondary education
- **BLE_DEVEL(SE)**: Ways to design blended learning arrangements for students with a degree of vocational or technical secondary education to overcome these challenges
    - This code consisted of three sub codes, derived from the data:
        - Adaptation: Participants who believed that more and adapted guidance and support is necessary
            - They indicate several actions to provide more guidance and support to students with a degree of vocational or technical secondary education, but did not explicitly stated that the whole design of a course or the learning activities should be changed or transformed
        - Transformation: Participants who believed that the design of other blends or different learning arrangements is needed
            - They indicate that the blend should not or cannot be the same for students with a degree of (a) vocational or technical secondary education, and (b) higher education. They propose to design different instructional activities or other kinds of blends
        - Disregard: Participants with no clear beliefs about how to design blended learning arrangements for students with a degree of vocational or technical secondary education

For further information on these studies please contact the corresponding authors:

An Instrumentalized Framework for Supporting Learners' Self-regulation in Blended Learning Environments.

Uncovering the Relation Between Learners' Characteristics and Their Self-Regulatory Behaviour Patterns in Blended Learning Environments.

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The design of blended learning in response to student diversity in higher education: Instructors' views and use of differentiated instruction in blended learning.

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