SELF-DIRECTED ADULT LEARNING IN A UBIQUITOUS LEARNING ENVIRONMENT: A META-REVIEW

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Abstract: In our rapidly changing technological society, formal training alone cannot meet the need for development of working individuals. Self-directed learning is seen as a solution for adult learners to keep up with these changes. Therefore, the aim of this paper is to identify the essential elements of self-directed learning that should be integrated into a ubiquitous learning environment for learning in the workplace. To achieve this, a systematic review on self-directed learning was performed. This produced five elements that support self-directed learning: learner control, self-regulating learning strategies, reflection, interaction with the social world and interaction with the physical world. This study shows that the characteristics of adult learning, as well as those of ubiquitous learning, match with the elements that support self-directed learning. Still, in the development of ubiquitous learning environments some elements of self-directed learning are not used yet. Therefore, the fields of research that focus on learning (e.g. adult learning, self-directed learning) and those that focus on learning technology (e.g. ubiquitous learning) should work towards a more integrated approach in the design of learning environments.

Keywords: technology-enhanced workplace learning, self-directed learning, self-managed learning, self-regulated learning, student centered learning, adult learning, ubiquitous learning

1 Introduction

The world is changing, and it is changing fast. Knowledge is becoming obsolete in this rapidly changing technological society the moment it is learned (Du Bois & Staley, 1997). Apart from the practical issues that accompany formal training, like time away from the job and our rapidly changing society, this is one more reason to support adult learning in the work-situation. In their workplace, working adults face new challenges every day, challenges they cannot meet if they do not keep on learning and

developing on the job continuously. These challenges can be seen in terms of the new knowledge, skills and attitudes they need to act appropriately in new situations and in the way they use these. Beckett, Agashae & Oliver (2002) speak of 'practical wisdom' when describing the need for adults to achieve 'understanding' and not mere skill-acquisition or technical expertise for its own sake. This 'practical wisdom' should be structured in workplace learning, where it requires real worksites, real problems and real peers (Beckett, Agashae, & Oliver, 2002; Percival, 1996; Vann, 1996b). Individuals can learn from experience when they can effectively see what changes are involved and how they can be accomplished (Collins, 2004; Karakowsky & McBey, 1999). To do this, they must put their experiences into perspective. This implies that they do gain experience in the real world (external events) and are able to understand what they can do to improve their own performance in similar situations (internal events). The employees should learn to evaluate their self in the role of performing for the organization and to evaluate the required behaviours in the workplace. Development, therefore, grows out of the interaction of both internal/psychological events and external/social events (Karakowsky et al., 1999) and is based on change rather than on stability.

Beckett carefully proposes that technology can be used to support workplace learning. He does fear, however, that the learner may 'end up alone with the computer' when using technology. This would not match with his earlier statement that adult learning should take place within a social and physical environment. Looking at articles on ubiquitous learning environments (Hwang, 2006; Liao, Yang, Sun & Chen, 2005) he does seem to have a point: the approach is mainly technological. Looking at the average working place today, it becomes clear that technology is very much part of everyday life and work. Information and knowledge is nowadays handled and shared by using ubiquitous technology; modern information and communication technology that makes it possible to access information 'anytime, anywhere' (Adkins, Kruse, & Younger, 2002). A learning environment that makes use of the ubiquitous technology that is already available, would support the learning process that is needed to keep up with new developments (Dieterle, 2005). Working and learning become intertwined, set in the social and physical work-situation.

The technological approach of ubiquitous learning environments assumes that learners are able to learn and will develop themselves in a well-designed learning environment. Exposing learners to meaningful experiences would in this view be enough to stimulate development. As such, this approach only takes one element into account that leads to

development: external/social events (Karakowsky et al., 1999). At the same time it ignores the internal/psychological events. A learner can only learn from experience if he can compare these events to his/her experience, see what changes are involved and how they can be accomplished. Some individuals may not need to be stimulated in this internal process, but others may; some people are learners for life on their own accord. They could be supported in their learning by a ubiquitous learning environment, but they would keep on developing even if it was not there. Others do not initiate learning automatically themselves. It might be too ambitious to assume they will develop this way of learning spontaneously when presented with a ubiquitous learning environment. The ability to manage one's own learning is becoming increasingly important. Apart from content-based learning goals, one of the goals of education should, therefore, be to create learners for life (Du Bois et al., 1997).

Learners for life can be described as (mostly) adults who have a flexible and pro-active attitude towards learning and developing themselves. In this context the concept of self-directed learning is often mentioned: the learner is in control of his/her own development and education (Collins, 2004). In relation to this, Collins states that the optimal role of the adult learner is that of a self-directed, self-motivated manager of personal learning who collaborates as an active participant in the learning process and who takes responsibility for learning. Self-directed learning is a method of learning that some adults use in some situations, usually work or hobby-related (Collins, 2004). The question remains if this is something that (some) people develop as they grow older, or if self-directedness can be learned by all learners. At school or university, most students are not taught self-regulating strategies explicitly, so the fact that they are not self-directed learners does not mean they cannot learn to become so. Presuming that there are many elements used in relation to self-directed learning, a classification is needed in organizing the analysis and discussion in this meta-review.

To our knowledge, there is no real classification of elements supporting self-directed learning available yet. Therefore, the primary objective of this study is to gain a comprehensive view on these elements. To achieve this, a systematic meta-review on self-directed learning was done to define the elements that stimulate self-directedness. A secondary aim is to identify the essential elements of self-directed learning that should be integrated into a ubiquitous learning environment for adult learners in their workplace. To do so, the elements essential for a ubiquitous learning environment were identified using a literature study. Subsequently, these elements were matched with the elements of self-directed learning.

2 Data collection

For the systematic meta-review on self-directed learning, a computer search was conducted using the internet database Ovid-PsycInfo, for the period of 1967 to 2007. To identify educational studies, search terms like training and education were used. To find studies about self-organization and self-management terms like self-organized, self-structured, self-regulated, self-initiated, self-managed, self-directed and student-centred, student-driven, learner-driven, learner-organized, learner-initiated, learner-regulated and out of classroom were used. The search resulted in 5287 hits in PsycInfo. Because such a large number of references were found, the terms literature review and meta-analysis were used to narrow down the selection. This resulted in 63 hits.

The search hits were imported into the computer database Reference Manager. Three double hits were removed from the database. The following criteria for selecting studies were used: the objective should be self-directedness in relation to education. Therefore, studies about self-management in relation to illnesses (physical illnesses but also learning disabilities or hyperactivity) were excluded. Furthermore, self-management should be a method of learning, studies in which self-management was a result of training were excluded. On the basis of the abstracts of these 63 references only 18 met the selection criteria. Consensus was reached about the final selection of references. They were studied in full in order to conclude whether they fit the selection criteria. Fifteen of these were used in this study (Henderson & Cunningham, 1994; Meece, 1994; Percival, 1996; Schunk & Zimmerman, 1994; Vann, 1996a; Vann, 1996b; Wexley, 1984) (Hannafin & Land, 1997; Kirschenbaum & Perri, 1982; Oddi, 1983) (Hattie, Biggs, & Purdie, 1996; Hughes, Korinek, & Gorman, 1991; Pereira & Winton, 1991; Risemberg & Zimmerman, 1992; Zimmerman, Greenberg, & Weinstein, 1994). The selection did not include any publications after 1997. To ensure that the literature reviews found are in line with more recent literature on self-directed and self-managed learning, two more recent reviews were included that had not been found in the systematic search (Azevedo, 2007; Schraw, 2007). In retrospect, it was not possible to use better search terms when conducting the computer search.

For the literature study on ubiquitous learning, it was not possible to perform a systematic review. At the start of the study (2007) Ovid-PsycInfo did not include publications on this subject. Therefore, a search alert was placed in Scopus using the terms ‘ubiquitous learning’, ‘u-learning’, or the combination of ‘ubiquitous computing’ with ‘education’ or ‘learning’. In this way, 15 publications (mostly proceedings) were found that provided the essential elements of ubiquitous learning

environments (Cho & Kim, 2007; Dieterle, 2005; El Bishouty, Ogata, & Yano, 2006; Hwang, 2006; Klopfer, Yoon, & Perry, 2005; Li, Zheng, Ogata, & Yano, 2004; Liao, Yang, Sun, & Chen, 2005; Mitchell & Race, 2005; Nino et al., 2007; Sakamura & Koshizuka, 2005; Verdejo, Celorrio, Lorenzo, & Sastre, 2006; Williamson & Iliopoulos, 2001; Yang, 2006; Yang, Huang, Chen, Tseng, & Shen, 2006; Zhang, Jin, & Lin, 2005)

3 Results

3.1 General characteristics of the reviews on self-directed learning

Table 1 presents an overview of the outcomes obtained in the recent literature on self-directed and self-managed learning. The years of publication of the reviews lie between 1982 and 2007. This means that self-directed or self-managed learning has been a subject of interest for a long time. The average number of studies reviewed was 46. Nine out of the 17 reviews took ‘adults’ as subjects (Henderson et al., 1994; Kirschenbaum et al., 1982; Meece, 1994; Oddi, 1983; Percival, 1996; Schunk et al., 1994; Vann, 1996a; Vann, 1996b; Wexley, 1984). The other eight looked at students: primary school, secondary school or university. (Azevedo, 2007; Hannafin et al., 1997; Hattie et al., 1996; Hughes et al., 1991; Pereira et al., 1991; Risemberg et al., 1992; Schraw, 2007; Zimmerman et al., 1994). The studies were set in formal training situations. Three reviews (Percival, 1996; Vann, 1996a; Vann, 1996b) discussed self-directedness from a theoretical point of view. The other 14 reviews described experiments.

Vann (1996a) states that self-directedness is something that can be learned by imitating and interacting with others. Good mentors are the role models from whom the novice can learn. The learner can then experiment with behaviours and attitudes which are in turn assessed against his/her reaction and reflection (Vann, 1996b). Percival (1996) objects to the term ‘imitate’. As a constructivist she feels that the word ‘imitating’ gives the impression that the learner is passive. In her opinion self-directed learning is a method of learning in which control by the learner is the central theme. A learner, from her point of view, is an active constructor of knowledge by interacting with his/her social and physical environment. Both authors mention the interaction with the social environment and the active role the learner has, either when trying out new behaviours and attitudes or when constructing new knowledge. Furthermore, they both stress the importance of reflection. According to them reflection is needed to assess the new

(learned and performed) behaviour, attitude or knowledge to be able to learn from experience.
The experiments described in the other 14 reviews involve training which was given on one or more element(s), described as indicators of self-directed or self-managed learning. All reviews show that performance improved and learners became more active and in control of their own learning process; they became more strategic and effective learners.
Table 1. Systematic meta-review self-directed learning

1th author & publ.year	No. of studies reviewed	Learning concept	Definition	Elements
		ADULTS		
Vann 1996b	4	Self-directed learning	The learner's interaction with others sets the stage for many of her/his experimental behaviors and attitudes, which are in turn tested (assessed) against the individual's reaction and reflection.	Learner control Reflection Social environment
Vann 1996a	33	Self-direction	A person's being open to new learning and develops a love of learning, independence in learning, informed acceptance of responsibility, creativity, an orientation towards the future and the ability to use basic study and problem-solving skills.	Learner control Social environment
Percival 1996	55	Self-directed learning	A method of learning in which control by the learner is the central theme.	Learner control Self-regulating learning strategies Reflection Social environment Physical environment
Schunk 1994	20	Self-regulation	Strategy use, goal setting, help seeking, self-evaluation, experiences in live social settings	Self-regulating learning strategies Reflection Social environment Physical environment
Henderson 1994	54	Self-regulation	Active participation at metacognitive, motivational and behavioral levels, in one's learning processes.	Social environment
Meece 1994	54	Student-centered: Achievement goal theory	Achievement goal theory emphasizes the active role of the individual in choosing, structuring and interpreting his or her achievement experiences.	Social environment Physical environment

Wexley 1984	150	Self-management	Stimulus and reward management	Learner control Self-regulating learning strategies Physical environment
Oddi 1983	17	Self-directed learning	Self-directed use of teacher designed learning modules	Learner control Self-regulating learning strategies
Kirschen-baum 1982	20	Self control Self-regulatory study skills	Perceived control Planning, problem solving, self-monitoring, self-evaluation	Learner control Self-regulating learning strategies
		STUDENTS		
Schraw 2007	5	Self-regulation	Metacognition: knowledge of oneself as a learner, as well as the conditions that constrain learning (goal setting, planning, implementing strategies, monitoring, evaluating one's learning)	Self-regulating learning strategies Reflection
Azevedo 2007	6	Self-regulation	Set goals, monitor, regulate and control cognition, motivation and behavior; guided and constrained by goals and contextual features in the environment	Self-regulating learning strategies Reflection Physical environment
Hannafin 1997	124	Student-centered learning	Student as designer. Learning environment should stimulate reasoning, problem solving, critical thinking and reflection	Learner control Self-regulating learning strategies Reflection Social environment Physical environment
Hattie 1996	51	Self-management: Learning or study skills	Cognitive study skills (task-related skills) Meta-cognitive study skills (self-management of learning: planning, implementing, monitoring) Affective study skills (motivation, self-concept)	Self-regulating learning strategies Physical environment
Zimmer-man 1994	57	Self-regulation	Student's awareness of and strategic efforts enhance student's personal perceptions of self-efficacy and intrinsic interest (and thus academic motivation).	Learner control Self-regulating learning strategies Social environment Physical environment
Risemberg 1992	18	Self-regulation	The degree to which individuals are metacognitively, motivationally and behaviorally proactive participants in their own learning process.	Learner control Self-regulating learning strategies

Pereira 1991	55	Self-management	Student-initiated procedures: self-instruction, self-verbalizing	Learner control Self-regulating learning strategies
Hughes 1991	69	Self-management	Self-instruction: students provide their own verbal prompts Self-monitoring: individual's systematically observing his/her own behavior and recording in some way the occurrence or non-occurrence of specific responses	Learner control Self-regulating learning strategies Reflection

Note:
Learner control: Control over educational decisions and learning process.
Self-regulating learning strategies: setting goals, planning, self-instruction, self-monitoring, problem solving, strategy use.
Reflection: self-evaluation of performance and learning process.
Social environment (interaction with): cooperation, collaboration, experiment with new behavior and attitudes.
Physical environment (interaction with): explore in real world, authentic problems, manipulate.

3.2 Definitions of self-directed learning

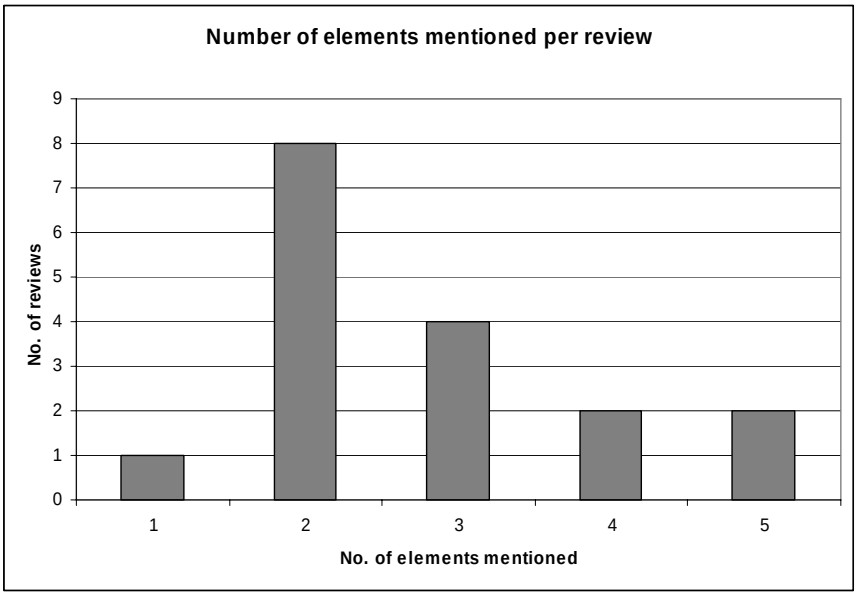
The systematic search was performed on a number of terms. Eleven of the reviews in this study used the term 'self-regulation' or 'self-management' (Azevedo, 2007; Hattie et al., 1996; Henderson et al., 1994; Hughes et al., 1991; Kirschenbaum et al., 1982; Pereira et al., 1991; Risemberg et al., 1992; Schraw, 2007; Schunk et al., 1994; Wexley, 1984; Zimmerman et al., 1994), four used 'self-directed learning' (Oddi, 1983; Percival, 1996; Vann, 1996a; Vann, 1996b) and the last two were 'student-centred' (Hannafin et al., 1997; Meece, 1994). The definitions of self-regulation or self-management, in these reviews, stress the active role of the learner and mention the use of learning strategies, problem solving, goal setting, self-monitoring, self-assessment, self-instruction and, sometimes, reflection. The reviews using these terms all assume that these indicators can be isolated and taught in training. By being able to apply self-managing learning strategies, learners can increase the control over their own learning process. Student-centred approaches emphasize the active role of individuals in choosing, structuring and interpreting their own achievements (Meece, 1994). The learning environment should stimulate reasoning, problem solving, critical thinking and reflection (Hannafin et al., 1997).
In self-directed learning, the heart of all definitions is that the control over all educational decisions is in the hands of the learner (Percival, 1996). In interaction with the environment, social and physical, the learner decides what he needs to learn and how he can achieve this. Not all learners can make these decisions by themselves. To make informed decisions about his/her educational process, the learner needs to develop skills like goal

setting, planning, evaluation and reflection. As such, the term self-directed covers both the students-centred approach and self-regulation or self-management and more. Therefore, the term 'self-directed learning' is used throughout this paper.

3.3 Classification of elements of self-directed learning

Five elements of self-directed learning could be identified from the reviews studied: *learner control*, *self-regulating learning strategies*, *reflection*, *interaction with the social environment* and *interaction with the physical environment*. In interaction with each other, these elements stimulate self-directed learning. Only two reviews mentioned all five elements (Hannafin et al., 1997; Percival, 1996), the others limit their study to one or a few of the elements found. This implies that the implementation of self-directed learning can only have been one-sided. Figure 1 shows the number of elements mentioned per reviewed study.

Figure 1: Number of elements that support Self-Directed Learning mentioned in reviews



(1) *Learner control* means that the learner is in control of his/her own learning process. This control works on two levels: on the one hand, the learner has control over all educational decisions; on the other hand the learner can manage his/her own learning.

(2) *Self-regulating learning strategies* are a number of skills that support the learner to manage and monitor his/her own learning process. Examples of these are: setting goals, planning, self-monitoring, self-instruction, self-assessment, problem solving and learning strategies.
(3) *Reflection* is the combination of self-assessment and self-evaluation on both the performance and the learning process that gives the learner insight in his/her own development. By assessing their individual performance, learners can determine if they have reached their own learning goals. This assessment provides input for future learning. Apart from this, the learners can also reflect on the way in which they have achieved their goals. The results of this can also be used when deciding on the direction of future learning. In some studies, reflection is seen as one of the self-managing learning skills, in others it is referred to as an isolated element. The reason for this is that reflection is used at two different levels. On the one hand, students can reflect on cognitive level. On the other hand, they can reflect on meta-cognitive level. Therefore, in this study the choice has been made to identify reflection as an element on its own.
(4) *Interaction with the social environment* can be described as the interaction with others, learners and teacher/coaches, in order to determine what goal should be set, discuss in what way this goal can be achieved, cooperate and collaborate during the learning process and ask for help.
(5) *Interaction with the physical world* is the last element mentioned. This element implies that the learning experience should be set in the 'real world', or a virtual world that is real enough to evoke the real world. The problem, which is the basis for the learning process, should be a 'real-life problem', something the learner could come across in the work situation. Furthermore the learner should be allowed to manipulate the problem and try out possible solutions.

3.4 Classification of elements in relation to reviewed studies

3.4.1 Learner control

Eleven reviews mention the importance of learner control; to develop self-directed learning it is important to activate the learner to make educational decisions and to monitor and manage his/her own learning. Ideally, a self-directed learner has control over all educational decisions (Percival, 1996). This even includes the development of learning activities or the training itself. This is not something that learners are used to: most formal training settings offer little space for learners to be in control; most so-called self-

directed training is still '*directed*-self-directed training' (Percival, 1996). It is only in the informal learning situations that learners, usually adults, have control over their own learning process. That might be the reason that self-directed learning is often associated with adults. Gradually, however, the characteristics that were first seen as unique of adult learners are now more viewed as innate tendencies of all human beings that emerge as people mature. The idea behind the experiments described in the reviews is that with the right support (in the right environment), all learners can become self-directed. By teaching self-managing learning strategies, the learner is supported in his/her control over educational decisions because he can then make informed decisions. There is, however, a contrast in the perception of the concept learner control: Percival (1996) states that the learner needs to be in control to be(come) self-directed where the other reviews argue that a learner needs to develop self-directedness in order to be in control of his/her learning process. Another discrepancy is the assumed level of control: the experiments described in the reviews allow only limited levels of control; they are based on formal training in which the subject of training, the content and the period in which these have to be studied have been decided upon beforehand. Percival (1996) supports an interpretation of the concept control in which the learner can exert real influence on his/her education.

3.4.2 Self-regulating learning strategies

As mentioned above, learners should be stimulated to make educational decisions. But in order to make informed educational decisions, learners should be aware of their own learning process, performance and the related learning goals. This awareness is conditional to being in control. In order to develop this awareness, learners require access to adequate learning resources (Percival, 1996). A study on gifted students shows that they, on the whole, use more and more-advanced self-regulatory strategies and carry them out more effectively (Risemberg et al., 1992). Thirteen studies show that when trained in these skills, learners become even better. This implies that supporting learners in the skills of planning, setting goals, use of learning strategies and problem-solving makes their learning more effective (Azevedo, 2007; Hughes et al., 1991; Pereira et al., 1991; Schraw, 2007; Schunk et al., 1994; Wexley, 1984; Zimmerman et al., 1994). They conclude that instructional interventions that increase awareness and self-regulatory strategy-use, help students to become more strategic and effective learners: they can learn to take control of their own learning process, and thus become self-directed learners. The use of hypermedia stresses the need for students to regulate their learning. It greatly increases task demands and requires the learner to stretch limited processing resources across two major constraints: to-be-learned

information and the hypermedia environment (Schraw, 2007). Self-management or self-regulation is something that is acquired in stages. These skills are not developed overnight, but rather become refined through repeated instruction and practice (Schunk et al., 1994).

3.4.3 Reflection

Seven of the reviews state that reflection is a critical component to learn from experience (Azevedo, 2007; Hannafin et al., 1997; Hughes et al., 1991; Percival, 1996; Schraw, 2007; Schunk et al., 1994; Vann, 1996b). In this respect, learning can be described as a dynamic process of 'reflection-in-action' where action is used to extend thinking and reflection is governed by the results of action (Hannafin et al., 1997). According to the reviews, reflection contains two aspects: on the one hand, learners should be able to assess their own performance in relation to their goals. On the other hand they should be able to evaluate the learning process itself: the use of self-regulating learning strategies and the cooperation with others.

3.4.4 Interaction with social environment

Eight reviews (Hannafin et al., 1997; Henderson et al., 1994; Meece, 1994; Percival, 1996; Schunk et al., 1994; Vann, 1996a; Vann, 1996b; Zimmerman et al., 1994) explicitly mention the social environment when describing the learning process. Percival (1996) points out that although the word 'self-directed' seems to indicate that learners are on their own, the actual meaning is that they are in control of their learning process (Percival, 1996). In the process of making informed decisions on their own learning process, learners can and do seek varying degrees of assistance from others (Percival, 1996).

Some reviews mention that working with peers has a positive effect on the motivation of learners. Furthermore, they state that cooperation and collaboration also enhance the learning process itself (Henderson et al., 1994; Meece, 1994; Schunk et al., 1994; Vann, 1996a; Vann, 1996b). From a behaviourist point of view (Vann, 1996a) the learner's interaction with others sets the stage for many of his/her experimental behaviours and attitudes: experiences serve as catalysts for the learning process that leads to self-directedness. Constructivists (Percival, 1996), on the other hand, stress the need for cooperation and collaboration during the learning process. In their view it is the dynamic social interaction with others that makes it possible for higher mental functions, like self-regulation, to develop. Apart from these differences, during the learning process, all learners experiment with new behaviour and attitudes. They need live social settings to do this. Self-directed learning should, therefore, be a social activity in a 'natural setting'.

3.4.5 Interaction with the physical environment

Eight reviews (Hannafin et al., 1997; Meece, 1994; Percival, 1996; Schunk et al., 1994) (Azevedo, 2007; Hattie et al., 1996; Wexley, 1984; Zimmerman et al., 1994) mention the interaction with the physical world when discussing self-directed learning. Two of these reviews (Hannafin et al., 1997; Meece, 1994) focuses on student-centered learning in which the learning environment should stimulate reasoning, problem solving, critical thinking and reflection. Schunk (Schunk et al., 1994) stresses the fact that it should be possible for learners to experiment and gain experiences in live settings. The interaction with the physical world serves as a stimulant and a possibility to practise and experiment. A more theoretical approach is that self-directed learning only occurs when there is a felt discrepancy between the self and the real world (Percival, 1996). In an effort to make sense out of their experiences, self-regulating individuals actively construct meaning and transform their understandings of the world. As such, they are active participants in their own learning processes. If they do not feel a 'sense of urgency' to learn, they will not take action. The 'real world' will give them this sense of urgency. If looked at from this view-point, it is essential to take the interaction with the physical world into account when trying to determine the elements of self-directed learning. A learner cannot become self-directed without becoming engaged in a curriculum that allows it to happen. Scenarios, cases or problems should present the learner with a situation in which he/she feels he/she needs more information, knowledge or communication to solve the problem (sense of urgency). This problem should be realistic enough for him/her to want to solve it (Meece, 1994). The learning environment should, therefore, be meaningful and relevant.

3.5 Elements of ubiquitous learning

As stated in the introduction, information and knowledge in the workplace is handled and shared by using ubiquitous technology; modern technology that makes it possible to access information anytime and anywhere. Most articles on ubiquitous learning environments approach this subject from a technological point of view (Cho et al., 2007; El Bishouty et al., 2006; Hwang, 2006; Klopfer et al., 2005; Li et al., 2004; Liao et al., 2005; Mitchell et al., 2005; Nino et al., 2007; Sakamura et al., 2005; Verdejo et al., 2006; Williamson et al., 2001). This probably stems from the need for advanced technological know-how to create such an environment. They primarily describe the technical requirements such a system should meet. Thus, most definitions of a content-centred ubiquitous learning environment come down to the fact that learning can take place 'anytime and anywhere'; the learner and the way in which he can learn are not taken

into account. A more learner-centred definition of ubiquitous learning states that it is a learning style in which the learner can completely concentrate on the learning process, irrespective of location and time restrictions, computers, contents, interface and communication and forget that there is a computer (Zhang et al., 2005). The learning-process-centred idea of ubiquitous learning is that a network of devices, people and situation must be created that allows learning experiences to play out (Nino et al., 2007). Yang (2006) combined these views when defining ubiquitous learning as 'characterized by providing intuitive ways for identifying right learning collaborators, right learning contents and right learning services in the right place at the right time'. In this definition, the embedding of learning in a social and physical environment is recognized as important to learning.

Studying these articles on ubiquitous learning, the following six elements could be identified:
(a) *Permanency* in a u-learning environment implies for instance that the work is recorded continuously and saved until deleted
(b) *Accessibility* implies anytime, anywhere availability of the learning environment
(c) *Immediacy* implies learning environments with immediate access to information
(d) *Interactivity* implies that the learning environment supports both synchronous and a-synchronous interaction with experts, teachers or peers
(e) *Situating of instructional activities* implies that the learning is embedded in real life situations.
(f) *Adaptability* implies access to the right information, at the right time, right place and right way.

4 Discussion and conclusion

4.1 The meta-review

The systematic literature review produced a large number of studies on self-directed learning. This shows that self-directed learning has been discussed intensively for a long period of time. It is, therefore, striking that only two of the reviews were based on all five elements that support self-directed learning. This seems to indicate that the theoretical discussion on self-directed learning has not yet found its way to the practical level Experiments were performed on a selection of elements, thus taking a one-sided view.

The literature shows that self-directed learners are more strategic and effective learners. They take control of their own learning process and make their own educational choices. Knowing this, one would like all learners to be self-directed. Reality shows that this is not the case: some people develop a self-directed attitude towards learning, especially in relation to work or a hobby, others do not. This resulted in the question that was raised in the introduction of this article: Is self-directed learning a skill that can be learned or is it a trait that some adults have. Explicitly offering self-regulating learning strategies or tools for reflection and stimulating (perceived) learner control helps learners to become more self-directed. It must, therefore, be the interaction between the elements of self-directed learning that support the learner to develop this skill. The explicit knowledge of learning strategies gives the learner insight in his/her own performance and learning process. On the basis of this insight it becomes possible for the learner to make educational decisions. In other words, this insight is conditional to benefit from being in control.

4.2 The classification

On the basis of the reviews, five elements of self-directed learning were identified: (1) learner control, (2) self-regulating learning strategies, (3) reflection, (4) interaction with the social environment and (5) interaction with the physical environment. The interaction of the elements described above follows from their descriptions. Learner control and self-regulating learning strategies interact because a learner cannot make informed educational decisions without being able to use these strategies. As learning is not an isolated process, being in control of the learning process means that the learner decides when and how he seeks assistance of others. This shows that there is an interaction between learner control and the social environment. The physical world provides the situations and problems that a learner can choose for practice. Therefore, there is an interaction between learner control and the physical world. As mentioned above, reflection is often seen as one of the self-regulating learning strategies. Obviously, they are strongly connected. Reflection can take the form of self-reflection, but others often play a role in reflection as well. Thus, the social environment and reflection often interact. Both the social and physical environment offer input for reflection as well. In this way they also interact. There is a strong connection between the social environment and the physical environment. Often, when the term ‘real world’ is used, a combination of these two environments is meant.
The theoretical reviews (Percival, 1996; Vann, 1996a; Vann, 1996b) discuss that these elements, in interaction with each other, can support a learner to become a self-directed learner. The other reviews describe

experiments in which one or two of the elements were isolated. The learners were then explicitly trained in relation with this element, mostly self-regulating learning strategies and / or reflection. As a result, the learners improved their performance and became more strategic and effective learners. This proves that the elements described above support self-directed learning. In this way the classification is a useful step in describing learning environments that support self-directed learning.
A learning environment that stimulates self-directed learning should, therefore, give the learner control over all educational decisions, support the learner to make informed decisions by explicitly stimulating self-regulating learning strategies and reflection and provide possibilities for interaction with the social and physical world.

4.3 Self-directed learning in a ubiquitous learning environment

Having determined the requirements a learning environment should meet in order to stimulate self-directed learning, it is possible to assess if ubiquitous learning can be used for this purpose. The question that needs to be answered is: Can a ubiquitous learning environment, based on the ubiquitous technology already present in the workplace, stimulate self-directed learning?

Comparing the characteristics of the elements of self-directed learning to those of ubiquitous learning shows that there are many similarities between the two. In Table 2, the elements of ubiquitous learning are presented next to the elements that support self-directed learning. These ubiquitous learning elements were found in the articles on ubiquitous learning environments mentioned before. Most elements that support self-directed learning are present in ubiquitous learning environments. Only the explicit teaching of self-regulated learning strategies and reflection cannot be found in the described characteristics of ubiquitous learning. Furthermore, the concept learner control is limited to ‘anywhere & anytime’, which has little to do with a learner who can decide what and how he/she wants to learn. Ubiquitous learning environments can be used as learning environment to stimulate self-directed learning with adults, if attention is given to the incorporation of the elements: learner control, self-regulating study skills and reflection.

Table 2. Combination of the characteristics of self-directed learning and Ubiquitous Learning Environment

Characteristics of elements of Self-Directed learning	**Elements of Self-Directed learning**	**Elements of Ubiquitous Learning**	**Characteristics of elements Ubiquitous Learning**
Control over all educational decisions Control over own learning process	Learner control	Permanency Accessibility Immediacy	Work is recorded continuously, saved until deleted Anytime, anywhere Immediate access to information
Setting goals, planning, self-instruction, self-monitoring, problem solving, strategy use	Self-regulating learning strategies	-	-
Self-evaluation of performance and learning process	Reflection	-	-
Cooperation and collaboration with peers	Interaction with social environment	Interactivity	Synchronous and a-synchronous interaction with experts, teachers and peers
Learner should be allowed to explore and manipulate in the real world, authentic problems	Interaction with physical environment	Situating of instructional activities	Learning embedded in real life
-	-	Adaptability	Right information, right time, right place, right way

The control over all educational decisions which lies at the basis of self-directed learning is also the most important characteristic of ubiquitous learning. When learning can be done ‘anytime, anywhere’, it is the learner who decides, so she/he is in control. Sometimes the learner can choose between different ways of training to reach the same learning goal, but this is not very common. Ubiquitous learning does not by definition give the learner the possibility to choose what or how he wants to learn. The concept of self-directedness does explicitly include this choice. A ubiquitous learning environment for working adults reflects the workplace and is preferably part of it. It should, within these boundaries, provide the learner with the possibility to choose what and how he/she wants to learn. This can be achieved by creating an environment in which many, different assignments, databases with information, and possibilities for cooperation help the learner to reach his/her own learning goals. The assignments should differ in their degree of complexity, the learning goal they specifically support, and the kind of activities that follow from them. In this way, the learner is truly in control: he/she can phrase his/her own learning goal(s), decide when he/she wants to do an assignment, what kind of assignments he/she wants to do, and what degree of complexity suits him/her most.

The interaction with the social environment as described in self-directed learning is exactly the same as the characteristic interactivity used in ubiquitous learning. Both state that learning is a social activity: learning with others is a source of motivation, but cooperation during the learning process also improves the performance. The social environment can be incorporated into the ubiquitous learning environment by stimulating learners to do assignments in pairs (or teams) or by facilitating virtual cooperation. Again, ideally, the learner should be able to choose between the two. Virtual cooperation should be supported in two ways: first of all, learners should be able to communicate with other learners, who happen to be on-line at the same moment, through phone, chat or e-mail. Apart from that a database of profiles of learners as well as experts should be provided. These profiles should include background information, expertise, contact details and a picture or photo. On the basis of this database, learners can decide who they would like to contact.

The last element of self-directed learning that is described is the interaction with the physical environment. This element means the same as the situating of instructional activity used in ubiquitous learning. Both characteristics imply that learning should take place in the real (or virtual-real) world, with authentic problems. The learning environment as well as the assignments within it, should be integrated in the work-context or resemble it enough.

The two elements that are not mentioned in ubiquitous learning: self-regulating learning strategies and reflection, should be incorporated into the ubiquitous learning environment (Azevedo, 2007; Schraw, 2007). This could be done within the learning environment: the use of learning strategies and reflection can be stimulated by the (virtual) collaboration and cooperation with peers or by leading questions the learner is confronted with during the learning process (virtual teacher). Apart from that, explicit information on learning strategies and their use should be made available in the learning environment. In the example of learning goals, this means that the learning environment should explain what learning goals are, support the learner to choose of phrase a learning goal, and stimulate the learner to reflect on his/her development regarding the chosen learning goal. The same method can be applied for planning, virtual cooperation, self-monitoring reflection and self-assessment. To stimulate self-assessment learners should be able to compare their own solutions with those of other learners and experts.
Because the learner is assumed to be in control of his/her learning process, he/she should be able to decide for him/herself whether and when he/she wants to use this support.

One characteristic of ubiquitous learning is not mentioned in self-directed learning: adaptability. This characteristic is typical of a context-aware ubiquitous learning environment. For the design of adaptive learning environments it is crucial to understand the characteristics, experiences, attitudes, and needs of the learners (Laak, Veldhuis, & Veerman, 2002; Wang & Newlin, 2000) However, it is unclear how they can be used to engage learners in specific instructional contexts in a ubiquitous learning environment. By indicating his/her own interests and expertise, a learner can structure the information and the contacts that are available to him. The technical environment should also provide supportive information on the location of the learner. In this way a learner has control over the information that reaches him. Future research needs to identify how an adaptive learning environment can contribute to self-directed learning.

The interaction with the physical world is mentioned as one of the five elements that support self-directed learning. In the case of working adults, what better real world can there be than their own work-situation (Beckett et al., 2002; Collins, 2004; Karakowsky et al., 1999). The reviews studied, however, were all set in formal training situations. Furthermore, it was interesting to notice that, although self-directed learning has been an important topic in the educational field for quite some time, no reviews on adult learning in the workplace or technology-enhanced learning for adults could be found. The search was limited to reviews; it is, therefore, unclear whether the reviews were representative for all studies on self-directed learning. Because the focus of the reviews studied is on formal training situations, they do not provide information on the integration of learning and working. Looking at the characteristics of adult learning as described in the introduction: learning should take place in a social and physical environment and learners should be able to assess their own performance as well as the demands made by the organization, it can be concluded that adult learning can be supported by self-directed learning; this should lead to more motivated learners. They will recognize the problems they are asked to solve and will be able to try out solutions. In situations where this would be too dangerous or expensive, a virtual world could be used. The advantage of using a ubiquitous learning environment is that learning can take place anywhere and anytime. It is a more flexible way of learning, and the learner is much more in control. But genuine control follows from the freedom to make educational decisions. So, a ubiquitous learning environment that integrates learning and working and allows for this freedom to choose should have a short-term positive effect on performance and a long-term positive effect on self-directed learning.

4.4 In conclusion

This study shows that the characteristics of adult learning, as well as those of ubiquitous learning, match with the elements that support self-directed learning. It seems, however, that in the development of ubiquitous learning environments only a limited number of the elements that support self-directed learning are incorporated (in various combinations). Especially the element learner control should be exposed. Therefore, the fields of research that focus on learning (e.g. adult learning, self-directed learning) and those that focus on learning technology (e.g. ubiquitous learning) should work towards a more integrated approach in the design of learning environments. Key aspects from both research areas are complimentary and a more complete integration of the two would lead to ubiquitous learning environments that suit (adult) learners better. As we see it, it will be a challenge to try and build a ubiquitous learning environment that really incorporates all the elements that support self-directed learning and the characteristics of adult learning.

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