Reflection amplifiers in self-regulated learning

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The research reported here was carried out at the Open University in the Netherlands in the

and in the context of the Dutch Research School for Information Knowledge Systems.

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Reflection amplifiers in self-regulated learning

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door

Dominique Verpoorten
geboren op 15 mei 1969 te Verviers, België

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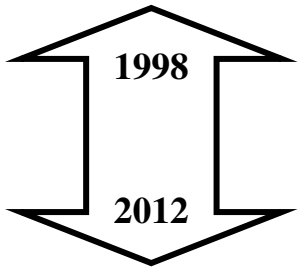
Foreword

"*As a secondary-school teacher, I am used to asking my pupils around January, how many courses we had together. I am year after year fascinated by the answers. It is bewildering to discover that even hard working and well performing pupils in my class are largely incapable to refer to the what, how, when, where, and why of learning. Also, I sometimes raise the question "why do you go to school?" or, interrupting a lecture, "why do we study this?", causing a mix of surprise and interest, reflected in the debates that follow. It is also my habit from time to time to defer a lesson by asking students to write down what they have experienced so far. Most of the time the answers are rather poor and only a very modicum mention procedural elements of learning. In addition, I have noticed that the below-average students are usually those who finish this assignment the fastest, some of them asking, before giving back their account, whether this is "the good answer". In an action-research also conducted at my school, students were asked to use a personal learning environment to bookmark resources about historical characters. In their report of what they learnt, pupils mentioned only that they had acquired academic knowledge and no one that they got acquainted with a new tool organising knowledge and resources. Methodologically unsafe, these grassroots experiences nevertheless anchored the idea that pupils hardly conceptualise the learning situation they are committed to and their own identity as learners.*"

Dominique Verpoorten, teacher at the European School Mol, Belgium.



"*This dissertation was undertaken to confront two premises to empirical data. The first premise was that reflection-in-action requested a specific type of tool to be trained: compact, structured, and repeated "reflection amplifiers". The second premise was that these structured reflective episodes, devised to be practised in a "zapping-like" manner, did not have to be long to reap benefits. One main benefit could be for students to realise that they are learners and that constant mental moves between action and reflection should steadily become the key feature of their inner intellectual life."*

Dominique Verpoorten, researcher at the Open University in the Netherlands.

Contents

Chapter 1

General introduction

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General introduction

"Perhaps if we can sharpen our consciousness of what reflection in learning can involve and how it can be influenced, then we may be able to improve our own practice of learning and help those who learn with us." (Boud, Keogh, & Walker, 1985, p. 8)

Reflection is an influential factor of learning both in regular classrooms and in eLearning settings (Heargraves, 2005; Higgins, 2011). Meta-analyses enduringly rank reflective practice among the strongest levers for learning (Hattie, 2009; Higgins, Kokotsaki, & Coe, 2011; Lai, 2011; Marzano, 1998; Wang, Haertel, & Walberg, 1990).
As a typically human negotiation process between the self and the experience of the world, reflection is not just an "add-on" to instruction, but an essential component of a deep approach to learning (Marton, Dall'Alba, & Beaty, 1993). Its practice before, during and after action helps gradually develop learners' awareness of what supports or hampers a consistent orchestration of the various dimensions of their learning, so that they can evolve into expert learners (Ertmer & Newby, 1996).
Research on reflection and adjacent concepts is highly topical and linked with urgent and worldwide needs relating to:

- education itself: making sense of the act of learning (Blais, Gauchet, & Ottavi, 2008; Race, 2002), fostering dispositions for learning (Claxton & Carr, 2004; Perkins, Tishman, Ritchhart, Donis, & Andrade, 2000), promoting ownership of learning (National College, 2005);
- labour market and economy (Andrews & Higson, 2008; Boud, Cressey, & Docherty, 2006; Heijke & Meng, 2006; Moon, 2004);
- human development (Ghaye, 2010).

THIS PHD-WORK TARGETS AND INVESTIGATES THE CONCEPT AND THE APPLICATION OF "REFLECTION AMPLIFIERS", THAT IS DELIBERATE AND WELL-CONSIDERED PROMPTING APPROACHES WHICH OFFER STUDENTS COMPACT, STRUCTURED AND FREQUENT OPPORTUNITIES TO DEVELOP OBSERVATIONS ABOUT ASPECTS OF THEIR LEARNING EXPERIENCE. THE GOAL OF THIS DISSERTATION IS TO ESTABLISH ATTRIBUTES AND USAGE OF THESE ARTEFACTS AND TO PROBE THEIR EFFECTS ON LEARNING AND LEARNERS.

The societal context of this study

At the beginning of the 21st century, formal education systems face radical changes (Aviram, 2008; Facer, 2011; Miller, Shapiro, & Hilding-Hamann, 2008; Specht, 2009). Lifelong learning has become an essential part of life. Learning never stops. The number of years spent at school has increased and the labour market demands sustained personal development of its workers because of the ongoing evolutions of knowledge and skills required. Learning to learn

becomes critical for both individuals and organisations (Fredriksson & Hoskins, 2007).

Learning to learn goes along with intensified reflective practice: it requires from learners that they amplify reflection around the personal internalization of their learning experience and are capable of steadily witnessing their own intellectual growth as the product of intentions and choices rather than incidental or externally-imposed entities (Carnell, 2005; Deed, 2008).

The European Commission (2006, p. 9) heralded "Learning to learn" as one of the eight key competencies for lifelong learning, labelled as "the ability to pursue and organise one's own learning, either individually or in groups, in accordance with one's own needs and awareness of methods and opportunities". It is generally acknowledged that if schools and universities confine themselves to passing on specific competencies, they will not provide enough preparation in self-sufficiency to their audience (Brown, Lauder, & Ashton, 2008; Peters, 2004). Educating tomorrow's knowledge workers requires to simultaneously fostering the mastery of domain content and the development of transversal (domain-independent) skills (Egan, 2010).

For providers of initial instruction, this responsibility of preparing pupils to become mindful, engaged and responsible learners in a lifelong learning society is not a trivial one (Davis, Sumara, & Luce-Kapler, 2000; Brockbank & McGill, 1998; Laurillard, 2001). It implies *finding ways to help pupils to learn how to already act as "reflective practitioners" (Schön, 1983) in their classes, that is, developing the habit of taking their own scholastic activities as an object of reflection.* Inviting students to contemplate and deliberate about what learning is and how it unfolds – in other words: inviting them to professionalise as learners – can contribute to the breeding of efficient reflective practitioners. If learning becomes an ineluctable part of life, it is expected that those who practise it can qualify, describe, and distinguish it as a specific activity (Clift, Houston, & Pugach, 1990).

Providing education for the 21st century requests first and foremost that students acquire relevant domain knowledge and secondly that they are provided with reflective insights about what a professional learning of this domain knowledge encompasses. Since *the practice of learning is not the same as learning to practice learning*, the development of enhanced awareness and insights on one's learning experience demands specific approaches. These should combine cognition (what is being learnt?), meta-cognition (how is it being learnt?), sense-making (why is it being learnt?), and attitudinal dimensions like persistence, self-efficacy, positiveness towards thinking, etc. *Besides the growth of the self-as-a-performer, opportunities to reflect must cater for the training of the self-as-a-learner.*

Reflection amplifiers - Reinvesting the moment of learning

The confluence of experience (action) and thought (reflection) creates learning (e.g., Freire, 1973; Kolb, 1984). Learning is both an active and a reflective process. It is difficult to extricate one from the other since they operate often in "parallel processing" (Burns, Dimock, & Martinez, 2000). Furthermore reflection interacts often subconsciously in the midst of doing (Koriat & Levy-Sadot, 2000). However, in order to foster pupils' development as learners, it is useful, as will be argued in this dissertation, *to trigger and externalize reflection*. Finding concrete ways to make learning and thinking processes "visible" (Bell, 2002; Hattie, 2009) and deliberately practised remains a challenge for researchers and practitioners. This dissertation conceptualises and tests *one* possible method in this respect: the insertion of artefacts called "reflection amplifiers" into the instructional design of learning tasks.

Definition

Reflection amplifiers (*RAs*) are aids designed to prompt intelligible and concise thoughts. Embedded within the process of learning, RAs signal learners to perform an inner process of reflection and they support it with a clear and appropriate interface. The interaction of the learner with RAs is deemed to materialise the process of reflection.
The word "amplifier" is used intentionally to convey the idea that enacting opportunities for reflection in the course of learning expands the mental context of the task at hand and discloses aspects of it that would otherwise be left unthought. Lemon (2004, p. 2) argues that: "an important aspect of learning includes awareness of the larger context in which teaching-learning occurs, that is, the development of the ability to go beyond merely content and skills but to understand how one perceives them to be". Eliciting the relationship between self-awareness and learning (Marton & Booth, 1997) is a major purpose of the RAs.

Function

The promotion of reflective practice while learning assumes that thinking is something else than just dealing with content. Even if both processes are interlinked, dealing with content is different from thinking about learning and from refining conceptions of the relationship between the activity system, own thoughts, own actions, and learning (Elen & Lowyck, 1998).
RAs are intended to support students at examining aspects of their learning experience in the moment of learning. They induce regular mental tinglings for evaluating "what is going on" (Salmon & al. 2007) and for nurturing internal feedback (Butler & Winne, 1995). They invite learners to think about what they are doing while they are doing it.

These reflective episodes are purposed to stimulate students to consciously appraise their "common life" (De Certeau, 1984; Lasch, 1997) as learners and to make discernible some processes characterising intellectual activity. Devising RAs able to prompt support, and train reflective skills is a way to *raise the awareness of intrinsic academic attitudes* and to ultimately promote the development of an inherent reflective mindset of lifelong learner. As emphasised by Bereiter and Scardamalia (1989, p. 361), the "lifelong learner"

> refers to more than the obvious fact that people continue to learn throughout their lives. It seems to refer to someone who has a lifelong commitment to learning, that is, someone whose top-level goals, the goals that govern major life plans, include learning goals. Thus, the lifelong learner appears to have more than a lively curiosity and a willingness to study, more even than a serious involvement in some subject matter. The lifelong learner treats learning itself as a valued part of life and structures other activities in life so that they will serve learning.

Context of use

Through establishing a practice of reflection during learning, RAs provide students with an opportunity to develop a habit of and a positive attitude towards thinking about learning. Promotion of reflection can be activated in many learning contexts. However, for manageability, consistency, institutional and personal interest reasons, the study of RAs in this dissertation is restricted to:

- formal learning: Merrill, Drake, Lacey, and Pratt (1996, p. 2) define a major difference between formal and informal learning as follows:
  > Students are persons who submit themselves to the acquisition of specific knowledge and skills from instruction, learners are persons who derive meaning and change their behaviour based on their experiences. All of us are learners, but only those who submit themselves to deliberate instructional situations are students.

  The dissertation focuses on learning activities organised around a curriculum, designed by an instructor, and based on compelling tasks with predefined learning resources, goals and outcomes. Even if students are granted a certain level of self-regulation and autonomous coordination in the studies presented in this PhD-work, they are nevertheless acting in a system of external constraints;
- eLearning: the dissertation investigates the extent to which eLearning technologies may open up new affordances to support reflection and impart learning behaviours different from those in regular classrooms;
- self-instructed contexts: the dissertation targets situations wherein learners cannot rely upon an instructor or a peer to directly inform and stimulate their thinking about learning content and processes. Such contexts are very common in distance education. This PhD-work explores whether individual learners can be empowered by the provision of spe-

cific prompts allowing them to take ownership and responsibility through structured reflective processes;
- reading tasks: the dissertation bundles RAs with a traditional academic duty: to study appropriate written learning material, occasionally enriched with still visuals. Rationale for this is that, despite a diversification of learning methods both in regular and distance education, confronting to text understanding and internalization remains an irreducible dimension of learning;
- reflection-in-action: in contrast with post-practice reflection, which is covered by an abundance of studies, the dissertation deals with reflection processes during the learning phase, which have so far received only limited attention from researchers and practitioners.

Theoretical background and scientific relevance

Reflection – Definitional issues

According to common sense, reflection lies somewhere around the notion of learning and thinking. People reflect in order to learn. Reflection is therefore practised for the sake of considering an object in more details (Amulya, 2004; Bengtsson, 1995; Moon, 2001). Objects to reflect on are innumerable. One can reflect on life, space, love, germs, fossils, butterflies or any content topic. *This dissertation addresses one specific sub-domain of reflection, linked with meta-cognition: oneself as a learner.*

Beyond the intuitive grasp, reflection turns quickly into a complex construct. The notion of reflection is akin to constructs like meta-cognitive instruction and development (Gama, 2004a), learning to learn (Hoskins & Fredriksson, 2008), learning about learning (Watkins, 2001), learning/study skills (Hattie, Biggs, & Purdie, 1996; Higgins, Baumfield, & Hall, 2007; Tabberer, 1984), self-regulated learning (Isaacson & Fujita, 2006; Ridley, Schutz, Glanz, & Weinstein, 1992) and, more recently, situation awareness (Salmon et al., 2007).

This proximity has lead to a variety of different interpretations and understandings of the word “reflection” among educational researchers and practitioners (Zeichner, 1984). This ill-defined nature of reflection has triggered fierce incriminations (Eraut, 2002; Ixer, 1999). Despite this invigorating criticism, reflection is a term which is often used in education and it is difficult to deny any legitimacy to it. References to a self-reflective consciousness can be traced as far back as Socrates’ “inner voice”.

The idea of a self-reflective mind has been given a new impetus by Flavell (1979), who attempts to generate a formal model of meta-cognition in the realm of educational psychology, and by Schön (1983, 1987) who grants a major importance to reflection, in his effort to elucidate the inner working of professional practice and learning organisations.

The notions of meta-cognition and reflection are strongly interwoven, if not overlapping or interchangeable (Georghiades, 2004; Scharp, 2008). Both for practical reasons and for readability, the remainder of this dissertation uses "reflection" as its main reference term. Reflection is defined here as an active process of witnessing one's own learning experience and evaluating its different aspects. Reflection is considered as a means by which learners can build and evolve a mental model of the learning process they are committed to and of their position inside this process (Seel, Al-Diban, & Blumschein, 2002), so that appropriate directions and actions can be procured.

Reflection-in-action - Obstacles

Thinking about a completed action is different from actively reflecting during action. While a large body of literature is available on the training of reflective skills through post-practice introspection assignments, like portfolios or learning blogs or diaries (Aalderink & Veugelers, 2005; Cimer, 2011; Fernsten & Fernsten, 2005; Jay, 2004; Wilson-Medhurst & Turner, 2010), research targeting practical ways to trigger and support reflection-in-action remains scanty. Gill and Halim (2006) give three factors (1-2-3, hereafter) to explain that educators have generally avoided weaving explicit reflection tasks to their everyday teaching practice. Three additional factors (4-5-6, hereafter) can be added to this inventory to explain the modicum of research investigating the value of making reflection a natural or significant aspect of student learning.

Factor 1 – Lack of time

Training reflection in the midst of learning implies to attend to its unfolding processes with increased time, attention and resources. This additional effort is needed to stimulate students to make what they are doing a deliberate object of attention. Despite the long-term advantages of awakening intellectual habits of self-awareness during the study time, dealing with thinking skills is readily perceived by educators as consuming the time available to "cover the material".

Factor 2 – Lack of empirical evidence

Insufficient empirical evidence of studies that decisively show the benefits of reflection in student learning prevents educators to gravitate in that direction. To address scepticism over the effectiveness of reflectivity, it is necessary to document instructional practice involving the use of student reflection.

Factor 3 – Competing demands

Even in case of substantiated positive effects of reflection-in-action training, these gains in quality learning and intellectual development might be of a different order than what the institutions – and the individuals themselves!–usually pay attention to and value in formal learning systems. This situation of competing demands generally leads to the elimination of reflective activities whose

utility might not be straightforwardly related to curriculum and examination concerns.

Factor 4 – A swampy concept

Some conceptions of reflection tend to be confined to individualistic dimensions, making it a purely introspective process with no real possible external grip, positive guidance (Kirschner, Sweller, & Clark, 2006) or quality assessment. This may have deterred researchers and practitioners who rightly think that reflection can be structured, complementary to an existing pedagogy, and practised selectively. All things considered, it remains notwithstanding true that higher-order thinking skills are difficult to define, to train and to assess. However, if they make a difference for the preparation of qualified workers (Heijke & Meng, 2006) and the sense of fulfilment of learners, issues related to their enhancement cannot be parked "until further notice".

Factor 5 – A concept for adults only

The influential books by Schön (1983, 1987) or Mezirow (1990) target reflection in adulthood and professional situations. The call they convey to breed reflective and critical practitioners has firstly been relayed in the field of teacher education (Hatton & Smith, 1995) and medical tuition (Kinsella, 2010; Kuiper & Pesut, 2004), two domains that maintain a tight connection between reflection and clear-cut professional practices. This theoretical and field application conjunction might have prevented the migration of reflective training to initial instruction and to younger audiences.

Factor 6 – A foreign learning goal

Learning to think is a concept which can be perceived by teachers as outside of their area of subject expertise and weird, compared to the regular way of delivering content (O'Connor, 2006).

The scientific relevance of this dissertation is to be found in the efforts it undertakes *to give a face value to reflection-in-action in scholarly activities* (tackling Factor 5). To this end, it brings to the forefront a type of tool, the RAs, which operates brief (tackling Factor 1), structured (tackling Factor 4) and repeated episodes of reflection interspersed in the learning material and activated during the first-order learning task at hand, whose precedence is kept intact (tackling Factor 6). These built-in opportunities for reflection are purposed to arrange stop-and-think intervals in ongoing self-learning. This dissertation puts at the test (tackling Factor 2) the potential of RAs to cue for a reflection that simultaneously (tackling Factor 3): (a) strengthens learners' engagement with the content, and (b) sharpens the visibility and the awareness of mental processes entailed by the learning activity.

Theoretical models

This section introduces a selected sample of theoretical models that address reflection as their core concern and which played a role in the shaping of the conceptual and applied research found in this PhD-work. Right from the start, it must however be stated that this dissertation made an eclectic use of these models because:

- research presented in the next chapters pertains to the "information systems" discipline. It is characterised by a design-science paradigm which seeks to extend the boundaries of human and organisational capabilities by creating new and innovative artefacts, here the RAs. Such artefacts are not exempt from educational references. To the contrary, their creation is informed by existing theories and bodies of literature that they instantiate and put at test (Hevner, March, Park, & Ram, 2004). Nonetheless, the theoretical stance does not come first;
- all models encountered during the making of this dissertation somehow address reflection but none of them (Schön excepted) presents explicitly as a "reflection-in-action" model. It means that an adequate theory of knowledge in practice is still a pending need for instruction. However to derive such a new or aggregated framework suited to reflection-in-action research and training goes beyond the scope of this dissertation.

A range of models and frameworks is available in the literature on reflection. Those encountered since the beginning of this dissertation have been elaborated by Boud, Keogh, and Walker (1985), Gibbs (1988), Johns (1995), Kolb (1984), Le Cornu (2009), Lemon (2006), Mezirow (1991), Moon (1999a), Peters (1991), Rolfe, Freshwater, and Jasper (2001) and Roth (1989). Despite worthwhile contributions many of these models failed to retain attention because they were not generic enough (in that they addressed reflection in a defined profession) or because they were presented as frameworks of questions designed to guide a post-practice reflection (significantly using verbs in the past tense: "what happened?" while reflection-in-action is concerned with the present: "what happens?").

Some of the models nevertheless present as refined conceptual works of a fair level of generality. These models are now briefly explained. They provide the interpretative background in which RAs can be approached, discussed and contrasted. For each model, convergence and divergence with the approach to reflection instantiated by the RAs are outlined.

Boud, Keogh and Walker's model of the reflective process

Boud, Keogh and Walker state that reflection is:

> 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. (…) Reflection is an important human activity in which people recapture their experience, think about it, mull

> over it and evaluate it. It is this working with experience that is important in learning (1985, p. 19).

The authors define a model dedicated to this reflective process. The model (Fig. 1.1) introduces steps to reflection, which encompass returning to the experience and re-evaluating it. The scheme is not that far from Kolb's model of experiential learning (1984). It could be seen as a zoom on Kolb's quadrants of "concrete experience - reflective observation - active experimentation".

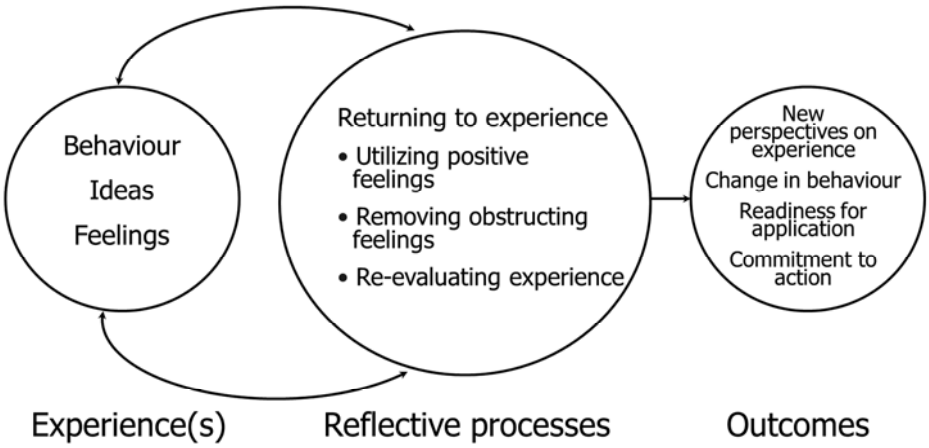

Figure 1.1. Boud, Keogh, and Walker's model of reflection (1985).

Convergence and divergence with the present work are:

a) the model introduces a link between reflection and feelings. RAs have nothing incompatible with the emotional aspects of the learning experience but the ones used in this dissertation do not take these aspects as a target.
b) the proponents of this model do not specify how "returning to experience" concretely occurs. Also, the "experience" tend to be considered as a given, salient and obvious reality. In contrast, this dissertation never presumes that learners apprehend that they "had an experience" to which to return to. Realising this entails already (oriented) thinking. The most basic level of awareness that RAs try to enact is precisely that a specific experience called "learning" is taking course.
c) on the whole, the introspective process of recapturing experience links this model mainly to reflection on action. And it is no surprise that it has become a reference in the literature on portfolios, which gained momentum in the '90s.
d) a strong point of the model is its identification of four possible "Outcomes" (Fig. 1.1, right side) of reflection that differ from performance (test score) enhancement. This dissertation will refer to them in the study described in Chapter 10.

Mezirow's model of critical reflection

Mezirow (1991, p. 104) defines reflection as "the process of critically assessing the content, process, or premise(s) of our efforts to interpret and give meaning to an experience". The author elevates critical reflection to the major objective of adult education because its practice leads to "transformative learning", coined as "the process of becoming critically aware of how and why our presuppositions have come to constrain the way we perceive, understand, and feel about our world" (idem, p. 30). Mezirow distinguishes reflective action from non-reflective action (Fig. 1.2).

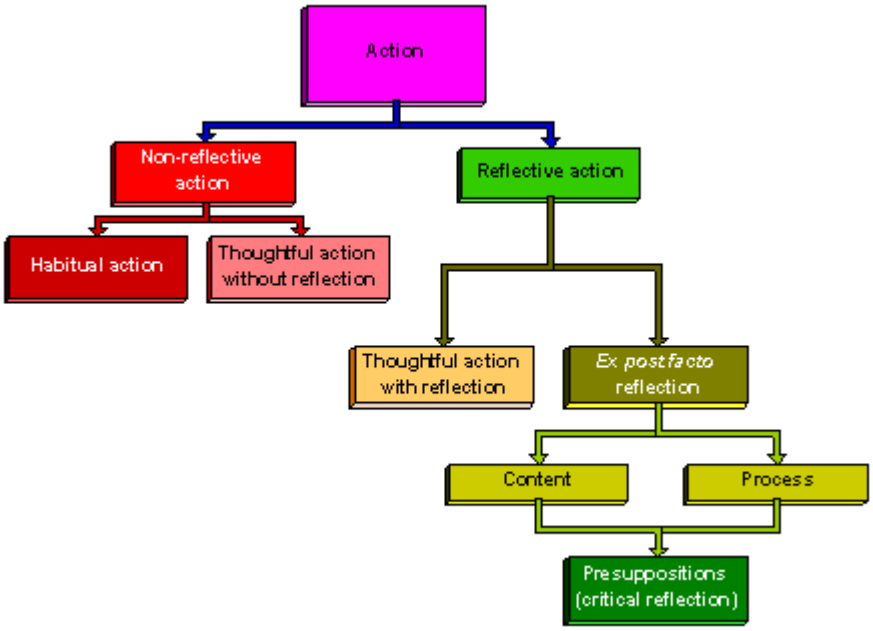

Figure 1.2. Mezirow's model of transformative learning (1991, as cited by Atherton, 2011a).

Non-reflective action can be habitual action. Learnt through frequent use, non-reflective action is performed automatically or with little conscious thought (typing on a keyboard). Thoughtful action without reflection is also possible. It makes use of existing knowledge, without attempting to appraise that knowledge, so learning remains within pre-existing meaning schemes and perspectives. Thoughtful action without reflection can be described as a cognitive process. It differs from habitual action in that the latter does not require thinking about the action while performing it. Much of the "book learning" which takes place in schools and universities could be categorised as thoughtful action without reflection in this model.

In contrast, thoughtful action with reflection involves a pause to reassess by asking: "What am I doing now?" The pause may be only a split second. In such

case, reflection is part of a thoughtful action but it is not yet acting reflectively to critically examine the justification for one's beliefs. This is the realm of "ex post facto reflection", which may focus on assumptions either about the content of the problem or the procedures followed in problem solving. The culmination of reflection is achieved when the presupposition on the basis of which the problem has been posed is questioned (critical reflection).
Convergence and divergence with the present work are:

a) RAs do not strictly have any critical dimension and, that being the case, are not really concerned by the core concern of Mezirow's model. Brookfield (2005) also points that reflection is not, by definition, critical. RAs do not put into question the learning situation itself, neither its process nor its content, like in Mezirow's truly critical reflection. On the contrary, RAs are supposed to illuminate the learning activity system (Engeström, 2005) as it is provided by sharpening the consciousness that learning is occurring and demands a certain type of mental engagement. RAs are therefore more on the side of compliance than on the side of criticism (except maybe the criticism that students can address to themselves with an increased self-awareness of themselves as learners). In Fig. 1.2, RAs can be seen as a tentative bridge between "thoughtful action without reflection" and "thoughtful action with reflection". The RAs do not question the learning activity at hand but try to make it tangible to the students; what RAs question actually is "sleepwalking learning".
b) Mezirow does not say anything about how to go from a "thoughtful action without reflection" to "thoughtful action with reflection". The swap seems to relate to a "disorienting dilemma" (Mezirow, 1991, p. 94), namely a significant stimulus that leads the individual to undergo a meaning perspective transformation. RAs, while aiming at contributing to this transition, do not proceed through any critical incident (although initiating a reflection on what they are doing as learners may be for some students a puzzling event). RAs intend to make regular learning situations thoughtful.

Le Cornu's working model of the process of reflection

Le Cornu (2009) offers the richest model of reflection so far (Fig. 1.3). Her efforts to analyse the relationships between reflection, learning and the development of the self lead her, through revisiting Christian education literature, to define two types of reflection (receptive and appreciative) besides critical reflection, while stressing the necessity of a partnership between all. The processes of internalization and externalization provide the basic structure for the model.

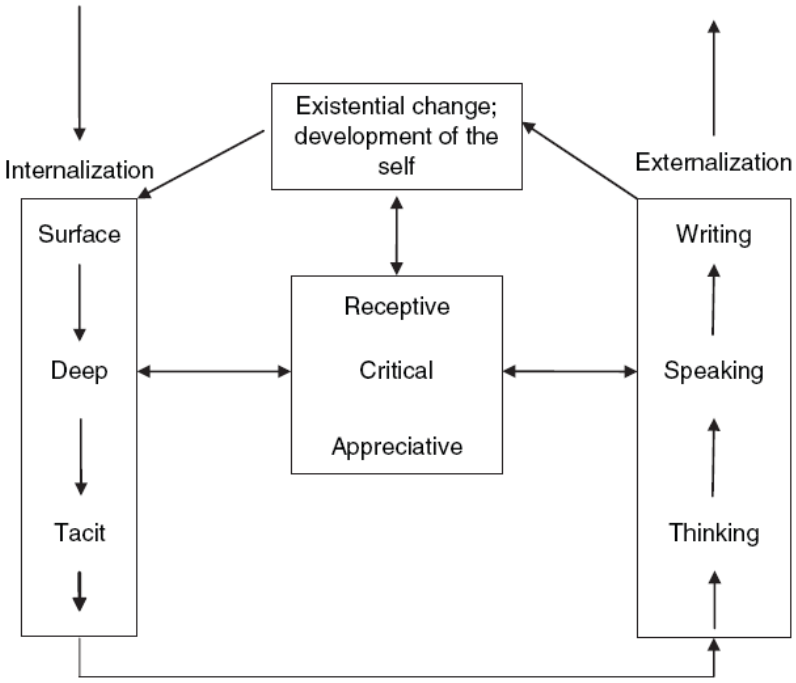

Figure 1.3. Le Cornu's model of reflection based on internalization/externalization (2009, p. 295).

"Internalization" highlights a gradual transformation of external social knowledge into personal knowledge. The author assigns different levels to this internalization by embedding Marton and Säljö's theory of deep and superficial learning (1976, a, b). The model also includes concerns for principal modalities by which people may begin to reconstruct assimilated knowledge: thinking, speaking, and writing, although thinking generally accompanies each of the others.

Convergences with the present work are:

a) this dissertation shares with Le Cornu's model a concern for the possible interactions between reflection and personalisation of learning. The author suggests that the task becomes "personal" to the extent that students become aware of what constitutes their learning experiences. In this way, the essence of personalisation is the reflection that allows learners to understand themselves as learners and, therefore, to increasingly discern/take the responsibility of their learning. This orientation assumes that personalised learning is related to active sense-making (Verpoorten, Glahn, Kravcik, Ternier, & Specht, 2009).
b) RAs, by enlightening dimensions of the learning experience at hand, by revealing its complexities, seek also intersections with appreciative reflection.

c) Le Cornu's model does not presuppose, in contrast with Schön (1983) or Mezirow (1991), and in agreement with the RAs' approach, any type of disruption to launch reflection.
d) the question of making explicit ("externalizing", as reported by Le Cornu) the product of reflection is of central concern in the present research.

Schön's model of reflective practice

Schön (1983) defines reflective practice as the practice by which professionals become aware of their implicit knowledge base and learn from their experience. He coins the notions of reflection-in-action (reflection on behaviour as it happens, so as to optimize the immediately following action) and reflection on action (reflection after the event, to review, analyse, and evaluate the situation, so as to gain insight for improved practice in future). This dissertation frequently refers to the basic distinction between reflection-in-action and reflection on action.

In his analysis of the chain of reciprocal actions and reflections forming the dialogue between supervisor and apprentice in professional contexts, Schön visualises the coaching process as a "ladder of reflection" (Fig. 1.4).

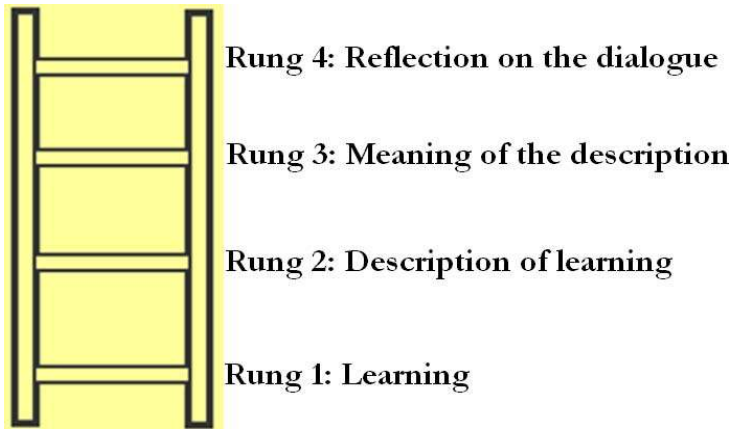

Figure 1.4. Schön's ladder of reflection (1987).

Schön's metaphor (1987, p.114) introduces:

> a vertical dimension according to which higher levels of activity are "meta" to those at a level below. To move "up", in this sense, is to move from an activity to reflection on that activity; to move "down" is to move from reflection to an action that is informed by reflection. The various levels of action and the reflection on the actions can be seen as the rungs of a ladder. Climbing up the ladder, one makes what has happened at the rung below an object of reflection.

This ladder has more than two rungs because it is also possible to reflect on the process of reflection. Schön posits that the mental habit of reflection, that is the ability to move along the ladder, is central to professionals' approach to their work.

Convergence and divergence with the present work are:

a) in the temporal flow of learning, their contiguity to student's doings commits RAs to reflection-in-action more than to reflection on action, though Schön's distinction is relative: even a reflection that takes place "in-action" bears on a pre-existing context. But in the case of RAs the interval is supposed to be a matter of seconds or minutes rather than hours.
b) the metaphor of the ladder helps to instil movement into the world of reflection, which is sometimes reduced to something static, intangible or metaphysical. The function of RAs is to infuse these up and down dynamics in the learning activity. Frequent reflective episodes and the timely internal feedback they convey are seen as ingredients of a learning model that promote the moves along Schön's ladder.
c) a small reservation towards Schön's model is that reflection seems to be activated only when the agent experiments a surprise or something going wrong. RAs, as already mentioned, do not presuppose any critical incident.

Interestingly, Bateson (1941) also uses the "Ladder metaphor" to distinguish a number of learning levels, in which each superior level is the class of its subordinates. Learning 0 is direct experience. Learning I is what is routinely referred to as "learning": generalisation from basic experiences. Learning II (which he sometimes calls "Deutero-Learning") introduces a reflective aspect to learning in that the learner learns the pattern of the context in which Learning I experiences take place. Learning III contextualises Learning II by deploying meaning-making at an existential (or spiritual) level (Atherton, 2011b; Visser, 2003). Because it takes place in complex thinking about hierarchic learning both in man and animal, and because it is not specifically centred on reflection, it is difficult to use Bateson's model straight. It notwithstanding points at the importance of a qualitative shift from Learning I to Learning II, from the cognitive to the meta-cognitive landscape. Most importantly, Bateson, like Schön, suggests that this "upgrading" of learning occurs only with a deliberate and conscious intention on the part of the learner. RAs intend to activate this intentional (meta-)learning.

Nelson and Narens' framework of meta-memory

In general, meta-cognition is seen as thinking about thinking. More specifically, it can be defined as:

> an appreciation of what one already knows, together with a correct apprehension of the learning task and what knowledge and skills it requires, combined with the agility to make correct inferences about how

to apply one's strategic knowledge to a particular situation, and to do so efficiently and reliably" (Taylor, 1999, as cited by Pierce 2004).

In their seminal publication, Nelson and Narens (1994) provide a conceptual framework that serves to guide subsequent research on meta-cognitive processes (Fig. 1.5).

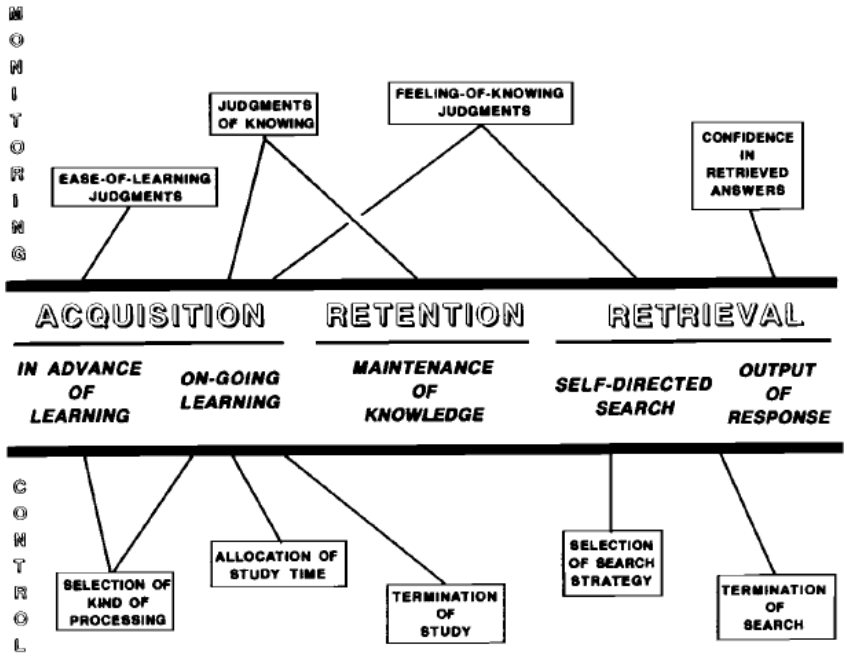

Figure 1.5. Nelson and Narens' framework of meta-memory (1994, p. 21).

Although the focus of the model is on the meta-cognitive aspects of memory, both its overall approach and many of its components apply to cognition at large. The three major stages of memory (acquisition, retention, and retrieval), along with several substages, are listed between the two horizontal lines. The model introduces monitoring processes, as listed above the time line, and control processes, listed below the time line. Disregarding the details, these monitoring and control processes are relatively concrete and suggest down-to-earth distinct reflective episodes. The convergence with the RAs lies in the effort to identify thinking processes inherently at work when learning. Some of these processes visible in Fig. 1.5 (confidence in answers, judgments of learning) have been the target of RAs devised for this dissertation (see Chapter 4, 7, and10).

Endsley's three-level model of situational awareness

Endsley offers a modelisation of situational awareness (Fig. 1.6). At a very simple level, situational awareness is an appropriate awareness of a situation (Smith

& Hancock, 1995). Bedny and Meister (1999, as cited in Salmon, Stanton, & Walker, 2009, p. 8) propose an elaborated definition which operates a bridge between awareness and reflection:

> Situational awareness is the conscious dynamic reflection on the situation by an individual. It provides dynamic orientation to the situation, the opportunity to reflect not only the past, present and future, but the potential features of the situation. The dynamic reflection contains logical-conceptual, imaginative, conscious and unconscious components which enable individuals to develop mental models of external events.

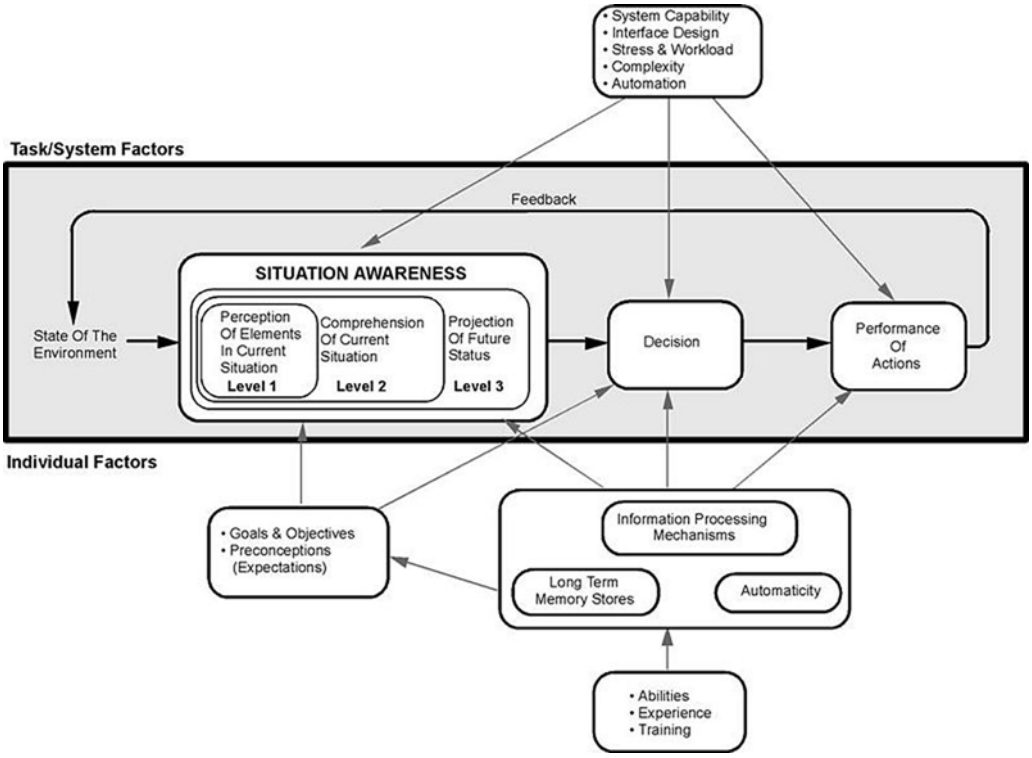

Figure 1.6. Endsley's three-level model of situational awareness (1995, p. 35).

Convergences with the present work are twofold:

a) the awareness process is usually depicted as a dynamic reflection deploying *several* mental operations. RAs attempt to increase the number of operative processes revolving around a learning task in order to enable the subject to discover its different aspects and to intensify the mental adherence to it.
b) the focus of RAs is to make salient the tenets of a "learning situation". This awareness requires "changes in the relationship between conscious and unconscious" (Bedny, Karwowski, & Jeng, 2004, p. 276). A coor-

dinating idea of this dissertation is that this increased consciousness is as pre-condition to obtain (more) relevant learning behaviours, namely behaviours suited to situations that learners precisely understand as ones where learning is sought.

Ryan and Deci's taxonomy of human motivation

Ryan & Deci (2000a) rightly note at the start of their conceptual work that, although intrinsic motivation is clearly an important type of motivation, most of the activities people do are not, strictly speaking, intrinsically motivated. This is all the more so true for educational activities prescribed in schools. Since they are not necessarily designed to be intrinsically interesting, the authors raise a central question: how to motivate students to value and self-regulate such activities, and to carry them out on their own. Unlike some radical perspectives that view extrinsically motivated behaviour as invariantly non-autonomous and negative, the authors, within the overarching framework of their self-determination theory (Ryan & Deci, 2000b), propose that extrinsic motivation can greatly vary in the degree to which it is autonomous (Fig. 1.7).

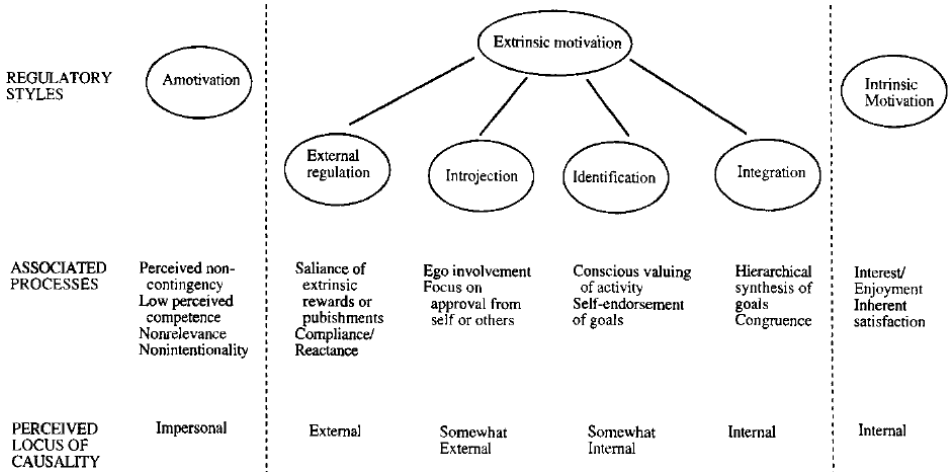

Figure 1.7. Ryan and Deci's taxonomy of human motivation (2000a, p. 61).

RAs are purposed to contribute to the inception by learners that externally imposed activities can begin to make sense when they are personally invested with mindfulness. By exposing aspects of this mindful attitude, it is hoped that students, even though they are locked in the pursuit of learning goals under external conditions, can receive from the RAs occasions to progress towards more intrinsic motives. The RAs, by impulsing an amplified awareness of the conditions of quality learning might help students to acquaint with less extreme forms of extrinsic motivation. On the Ryan and Deci's "taxonomy" (or continuum?) of

human motivation, RAs might play a role in transitions towards “introjection” or “identification”.

Institutional background and practical relevance

The author works with the Centre for Learning Sciences and Technologies (CELSTEC) of the Open Universiteit. The study takes place in a research program dedicated to prompts for meta-learning support, in regular, adaptive, game-based and mobile eLearning. Three features of the educational and research context of the Open University in the Netherlands nurtured the inspiration, opportunities and questions prevailing in this dissertation.

Interactive content

The present research on reflection is informed by the requirements of continuous education and professional development as promoted by the Open University in the Netherlands and open education in general (Commonwealth, 2005; Open University, 1994; Van den Boom & Schlusmans, 1989). Traditionally, distant learning institutes have seen themselves as content providers in priority. However, the way a student is going to thoughtfully work through the study material can imply the mastery – or learning – of specific reflective skills. By embedding student’s support devices in distance-learning course material, *this dissertation questions the practical conditions for reflective processes to become in themselves part of the learning experience.*
When support to individual engagement and reflection on the content is expressly incorporated within the content to study, the learning material tends to evolve into some kind of personal interactive learning space. RAs quietly espouse this rising orientation (Moedritscher & Wild, 2009) in distance education.

Web application framework

This work exploits advances in institutional technology-enhanced learning (Wilson, Sharples, & Griffiths, 2008). Some of the RAs have been developed for the free and open source portal “Liferay” that has recently equipped the Open University in the Netherlands. In contrast to monolithic learning management systems of before, the Web application framework of Liferay favours a pick-and-mix approach to the design of online courses. This approach, based on the combination of functional pedagogically-safe units called “portlets”, materialises some promises of the learning objects movement (McAndrew, 2009; Verpoorten, 2007; Weller, Pegler, & Mason, 2003; Wiley, 2006) by conveying added value with regard to the flexibility, localisation, personalisation, repurpose and exchange of content and components.
In this context, the RAs on note-taking, self-assessment, reflection counting and mini-dashboards, as designed for this dissertation, are contributions to the port-

lets library of the university. Albeit not reported in this dissertation, the insertion of RAs has also been tested in prototypes of units of learning (Verpoorten, 2010a, 2010b; Verpoorten & Kelle, 2010) developed with the IMS-LD authoring tool ReCourse (http://www.softpedia.com/get/Office-tools/Other-Office-Tools/ReCourse.shtml). IMS-Learning Design is a specification for a metalanguage which enables the modelling of learning processes. It has its origins in the Educational Modelling Language (Hummel, Manderveld, Tattersall, & Koper, 2004) developed at the Open University in the Netherlands.

Open Educational Resources

Lastly, this dissertation involved developers, students, contents, and courses of the institution. For instance, some of the studies took advantage of the OpenER project launched by the Open Universiteit (Schuwer, 2008). Like similar initiatives over the world (MIT OpenCourseWare, MERLOT, OPENLEARN, etc.), this project targets an expansion of the higher education learning opportunities by making available a variety of academic eLearning content free of charge. The Open University in the Netherlands has defined a program aimed at enhancing its offer of Open Educational Resources, not only in terms of quantity of available courses but also in terms of instructional support tools, what the RAs intend to be.

Technological relevance – Harnessing Web 2.0 to education

Recent years have seen the uptake of Web-based systems for educational purpose. A rich variety of eLearning systems for the creation and delivery of online content have become widely available. In recent years, so-called Web-2.0 or social Web (Brown, 2008; O'Reilly, 2007) gained momentum on the Internet. Web 2.0 aims at empowering users to create, manipulate and share resources and components (sometimes called "widgets"). These new dimensions of the digital life have been suggested to offer useful new opportunities when linked with institutional learning management systems.

So far, widgets that claim to have a link with the realm of school have been far less numerous than widgets conceived for other domains. *This dissertation contributes to technology development by providing concrete instances of widgets harnessed to clear instructional endeavours in formal learning contexts*.

Given that each of the widgets tested in the following chapters has taken between 2 and 7 days of development and is reusable, one contribution of this dissertation bears upon the assessment of minimal, feasible and affordable interventions fostering self-awareness and meta-cognitive development.

A third technology-oriented contribution relates to learning analytics and the visualisation of tracked data. Yet, this dissertation peripherally explores the potential of the mirroring of personal interaction footprints (Jermann, Soller, &

Mühlenbrock, 2001) as RAs (see Chapter 4, 5, and 10). It also elaborates the idea of "learning dashboards" (see Chapter 9) which is based on data visualisation and mash-up techniques.

In sum, the existing knowledge that specifically targets reflective practice is useful to shed light on various aspects of the practical approach to reflection taken in this dissertation. Actually, *RAs are at the cross-section of cognitive/meta-cognitive investigations (Nelson & Narens, 1994), experiential learning current (Boud, Keogh, Walker, 1985; Le Cornu, 2009), professional learning (Schön, 1983) and recent technological development.* By raising the awareness of the mental processes during learning, these technological artefacts intend to illuminate learning in the eyes of the students and doing so to contribute to professionalise their self-as-learners.

Overview of the dissertation

In a lifelong learning society, lifting up transversal abilities to learn becomes a concurrent duty for individuals and institutions. Compared to the importance of reflection training, Claxton (2006) or Csapó (1999) note that the actual situation is a shortage of clear theoretical approaches and tested practices. This dissertation was undertaken to probe the potential of a possible training approach of these thinking skills: the insertion of tidy reflective breaks in the content to be learnt.
The dissertation comprises 11 chapters[1]. Each of them – to the exception of this introductory one and the closing discussion – reflects a scientific peer-reviewed journal/conference paper either accepted or submitted and thus can be read as a separate study, epitomized by its own abstract (efforts have been made to prevent redundancies *as much as possible*). However, in the overview offered below, the links between the chapters are provided.

Chapter 2 presents a conceptual classification framework of 35 RAs reported in scientific literature. In order to be able to study this type of affordances in a systematic way, an overview of current practices and evidence was needed. The chapter identifies practical examples, each displaying variegated traits. By de-

[1] Information to the reader: (a) the introductory page of each chapter indicates whether it presents a study central to the dissertation topic ("prime" studies) or whether it refers to extension work ("collateral" studies), (b) the dissertation did its very best to comply to the APA-style guidelines (American Psychological Association, 2010) and to the British English standards of language, (c) despite the use of high resolution formats for the visuals, some of them remain difficult to read on the screen. A better readability can be obtained by magnifying the digital document by 150/200%, (d) the digital pre-print version of this dissertation can be downloaded from http://dspace.ou.nl, (e) any comment on this PhD-work is gladly received at dv@skynet.be

fining different forms of interaction and reflectivity characterising RAs, the reasoned inventory lays the groundwork for the subsequent studies.

Chapter 3 provides an evaluation by eight higher education experts and instructors of the RAs identified in Chapter 2. It also investigates, on a conceptual mode, the potential of widget technology to instantiate RAs.

Chapter 4 reports on a pilot experiment (54 participants). The purpose is to populate a small-scale course with concrete instances of RAs and to submit these to an early validation. The RAs are a note-taking tool, a rating tool, and an indicator tool.

Chapter 5 describes an empirical study (137 participants) putting a RA in the service of a real-world and full-fledged online course. The RA is a note-taking tool, based on a prototype tested in Chapter 4.

Chapter 6 updates/upgrades the dry-run literature review done in Chapter 2 to identify existing RAs. It recaps in a systematic way the existing work on RAs and locates the studies released in Chapter 4 and 5 in a broader research context.

Chapter 7 describes the results of using a RA in an online serious game. Games are suspect of neglecting reflection because of their primary focus on action and performance. The chapter discusses this assumption based on an early validation of the game conducted with 28 participants.

Chapter 8 exposes an exploratory study using pupils' personal mobile phone to reflect on own learning. The experiment, conducted with 37 participants, allows to investigate the use of RAs beyond the boundaries of classroom and school.

Chapter 9 explores how learning analytics open up new possibilities to support reflection by mirroring back to learners their personal tracked data. The chapter introduces the notion of "Learning Dashboard", links it to reflection training, presents examples and pinpoints convergent features of this interface type.

Chapter 10 communicates the results of an empirical study (40 participants) leaving some initiative to students in the choice of RAs. This study was intended to settle two opposite findings (see Chapter 4 and 5) concerning the effect of reflection on time on task. The study also makes a limited use of biofeedback sensors in an attempt to bridge cognition and physiology.

Chapter 11 offers a general discussion of the topic in the light of the conducted experiments. It synthesises the progress made and outlines strands for future research.

Chapter 2

Study 1 (prime): Reflection amplifiers in online courses – A classification framework

Chapter 2
Reflection amplifiers: a classification framework

Abstract

This chapter identifies, in literature, a sample of 35 "reflection amplifiers". This reveals in today's education a variety of intervention techniques that aim at provoking reflective practice, in order to enhance learning effectiveness and to promote meta-cognition. For the support of research into this topic, a theoretical classification framework is devised and structured along two relevant attributes of the reflection amplifiers: (a) the type of interaction they request, and (b) the educational objective they pursue. This concrete and ordered expression is used to create a mapping of the 35 inventoried techniques, enabling their detailed positioning, qualification and comparison. The whole work is intended to guide future research activities and to create awareness among online course developers about the different approaches available.

This chapter is based on: Verpoorten, D., Westera, W., & Specht, M. (2011b). Reflection amplifiers in online courses: a classification framework. *Journal of Interactive Learning Research, 22*(2), 167-190.

"Too much reflection is the minimum quantity of reflection." (Besson, 2011)

"Only the shallow know themselves." (Wilde, 1894/2001)

For many years, both teachers and researchers have been stressing the importance of reflection for learning (Aviram, 2008; Peters, 2004). Reflection is claimed to promote deeper and more effective learning both in regular classrooms (Watkins, 2001) and in eLearning settings (Means, Toyama, Murphy, Bakia, & Jones, 2009). It is generally acknowledged that stimulating reflective skills will prepare knowledge workers to cope with requests for new knowledge acquisition and ongoing personal development in the information society (European Commission, 2006; Rychen & Salganik, 2003).

Today's learning environments offer many new opportunities for reinforcing reflection by prompting learners about their own learning. The survey in this chapter identifies 35 of these applied techniques. These may vary from simple informative prompts which summarise the learning goals to more complex and interactive tools that invoke learners to verbalise certain aspects of their learning.

This chapter introduces the term "reflection amplifiers" (*RAs*) for these techniques: *RAs are deliberate and well-considered prompting approaches, which offer learners structured opportunities to examine and evaluate their own learning*.

Although a variety of RAs can be observed in face-to-face and online courses (see the Appendix), there is only little research evidence available about the assumed effects and usage. Importantly, theoretical foundation is lacking as to what type of RAs should be used to procure or support particular learning outcomes. As a first contribution to this investigation, this chapter provides a theoretical framework that identifies the relevant attributes of RAs.

First, the chapter elaborates the underlying rationale of the work by summarising the main research findings about the role of reflection in learning. Next, it inventories 35 RAs found in the literature. Then it introduces and explains the classification framework for these techniques. Subsequently, it makes use of the framework and its principles for a systematic mapping of the 35 aforementioned RAs. In conclusion, it outlines a research agenda with respect to promoting learner reflection in teaching and learning practice.

Existing reflection amplifiers

A literature survey has been carried out to identify existing approaches for promoting reflection in learning. This survey has yielded a sample of 35 RAs that: (a) embody different approaches, (b) are well-documented, and (c) have actually been used by learners. A detailed analysis of these RAs is beyond the purpose of the chapter. The appendix (p. 47) supplies the gathered RAs along with a tex-

tual label, an extremely compact definition and associated references for extended explanations. Although the sample of RAs is limited in size, it is assumed to represent the diversity of current teaching practice adequately.
An initial observation flowing from the literature survey is that RAs are being used in online and face-to-face courses without any co-ordinating framework or theoretical basis to build on. Such basis will be presented in the next section.

A general classification framework for reflection amplifiers

When considering RAs as instruments that foster the process of reflection, both the inputs and outputs of this reflection process are supposed to be important determinants.
The inputs of the process can simply be conceived as the various modes of interaction that occur when the learner is confronted with a RA. The outputs of the process essentially correspond with the particular objectives that are pursued by the RA, viz. the skills involved and trained. By their nature, the inputs and the outputs of the reflection process are the principal candidates for devising a classification. Fig. 2.1 displays the general lay-out of this two-dimensional framework.

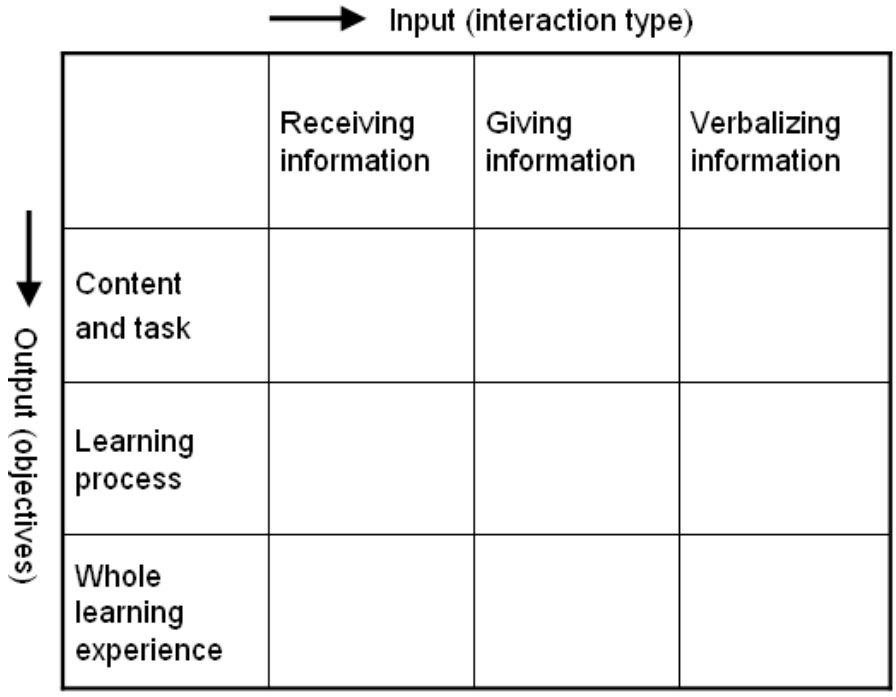

Figure 2.1. A two-dimensional (input/output) classification framework for RAs.

Relevant attribute 1 – The Interaction type

The horizontal dimension of the framework complies with the inputs of the reflection process. It depicts the kind of *action requested from learners to enact a RA*. Based on the analysis of the inventoried techniques, three major subcategories of inputs (Interaction types) have been identified.

Interaction type 1: Receiving information

This category of interaction induces the reflective experience by requesting learners to look at or ponder upon externally provided cues or information related to the learning context and the learners' positioning within it. RAs in this category do not imply any observable action of the learner, except, possibly, the time spent in the contemplation process. From the system perspective, this category most often requires that some personal data are tracked, recorded and shown.

Interaction type 2: Giving information (Responding)

This category of interaction induces the reflective experience by asking learners to give a quick insight into their behaviours or performances through the use of a scale. From the system perspective, this category requests the presentation of scoring/rating/ticking artefacts to the learner.

Interaction type 3: Verbalising information

This category of RAs induces a reflective experience by asking learners to produce a mental or written discourse about certain aspects of their learning. From the system perspective, this category may involve making available an annotation tool or prompts for reflective pauses.

Relevant attribute 2 – The Instructional purpose (target of reflection)

The vertical dimension corresponds with the *outputs or targets of the reflection process*, that is the pedagogical effects that the RAs are supposed to procure. This dimension has been subdivided into three outputs that are likely to be achieved through the use of RAs.

Instructional purpose a: Training reflection on content and task

The benefit expected from RAs harnessed to this instructional purpose is an enhanced awareness and understanding of the nature of the learning content and the associated tasks. The awareness of these elements is considered a crucial contextual determinant of learning (Pilgerstorfer, 2005). What is at stake with this category of RAs is the way students will mix and coordinate externally regulated elements (assignment, material, assessment) with the possibilities of self-regulated action.

Instructional purpose b: Training reflection on learning processes

The benefit expected from RAs harnessed to this instructional purpose is an enhanced awareness and understanding of processes of learning while they are unfolding. By fostering an externalization of selected mental activities, RAs illuminate the ongoing learning task. RAs can evenly help to externalize processes that take place anyway but on a non-conscious mode or processes that are specifically triggered by the affordance to reflect (Koriat & Levy-Sadot, 2000).

Instructional purpose c: Training reflection on the whole learning experience

The benefit expected from RAs harnessed to this instructional purpose is an enhanced awareness and understanding of the global learning experience through integration and restructuration of several dimensions thereof. In this case, RAs stimulate learners to express, explain, assess, and discuss cognitive/emotional/motivational state and other attitudinal aspects in relation to what has been learnt. This holistic restructuring process is usually done post-practice. The output of the process is a comprehensive narrative or judgment of what components of the process have effectively contributed to the learning. From there, a diagnostic can be drawn by the learner and advice for enhanced future self-regulation can be derived.

Clearly, it would have been possible to arrange RAs along other dimensions (e.g., Leclercq, 2008, p. 12): according to the line of inquiry they come from (self-regulated learning, meta-cognition, learning to learn), the level of complexity of their implementation, or their location in the learning process (before the action, during the action, after the action), etc. However, the two selected clustering keys are consistent with the aforementioned motives that underpin this research: (a) to tackle pedagogical concerns: rows are centred on the training of reflective abilities, and (b) to take into account the multimedia aspects of RAs: columns relate to the interactions learners have with the reflection support tools. The principal dimensions realise a connection between the how (input) and the why (objectives) of the reflection process.

Reflection amplifiers classes defined by the framework

The two axes and their sub-categories now define nine cells in the framework, each of which denoting a *specific class of reflective experience prompted by a subset of RAs* (Fig. 2.2).

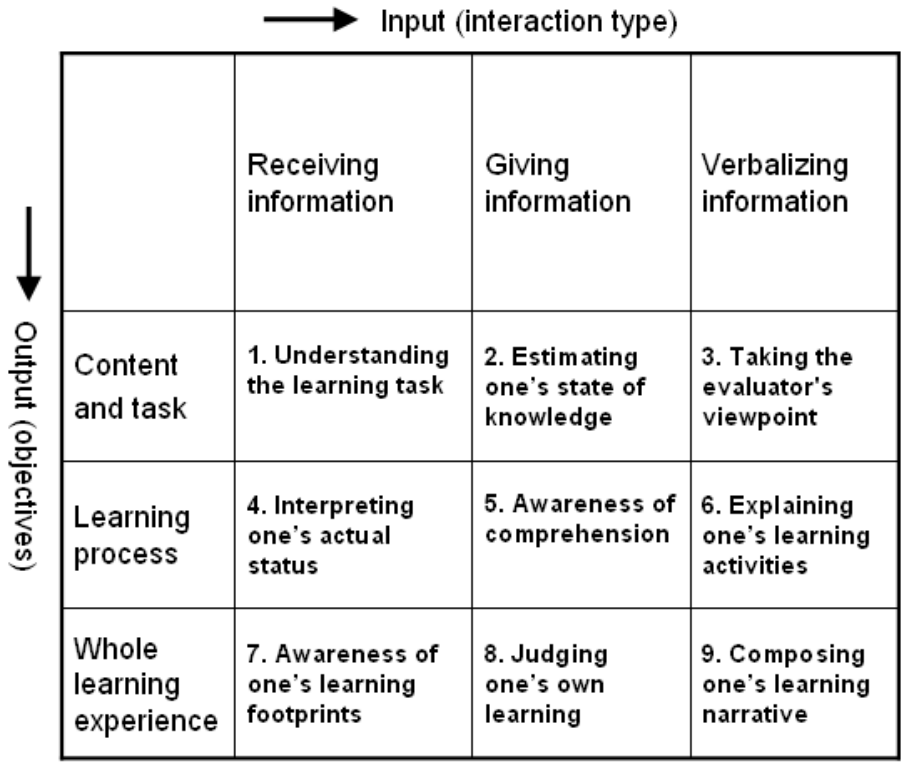

Figure 2.2. Cells define different types of experiences of reflection.

Below, a brief explanation of the experiences of reflection that are covered by the separate cells is provided.

1. Understanding the learning task: RAs in this class provide information or hints for students to internalize the rationale, the objectives, the success criteria or the associated resources tied to a learning task.
2. Estimating one's state of knowledge: this class covers reflection throughout the engagement of learners in a rating episode of one's strengths towards the task at hand.
3. Taking the evaluator's viewpoint: this class triggers reflection about the nature of the learning task by asking learners to evaluate its significance from the instructor's viewpoint.
4. Interpreting one's actual status: this class collates RAs that give learners cues likely to help them developing informed choices and orienting actions. Cues can be static, like a help-seeking behaviour guide, or dynamic, like providing an updated status of the learner's position in the learning process.
5. Awareness of comprehension: this class gathers RAs that promote reflection through a (periodic) process of self-evaluation while learning. This self-assessment habit is intricately linked to self-management.

6. Explaining one's learning activities: this class presupposes that learners engage in the production of text, speech, annotations or schemes, while interacting with the course contents.
7. Awareness of one's learning footprints: this class induces reflection through the replay of a record of their learning actions or the access to traces of past performance.
8. Judging one's own learning: this class fosters reflection through the learners' rating or report of the progress they believe having made in the learning areas as a consequence of the course they were taking.
9. Composing one's learning narrative: this class gathers RAs that foster comprehensive evaluation and debriefing of the learning experience. Tools like learning diaries, reflective journal, thinking book, personal portfolio or blog imply the coordination and the restructuring of personal information in a meaningful and self-critical account, which operates genuine reflection (and not "rumination", Morin, 2002, 2005).

The purpose of the framework is not to freeze set-in-stone boundaries but to furbish some order and key characteristics (Rosch, 1978) of useful techniques that foster a reflective approach to teaching and learning. *Abstract descriptions of categories and classes are mainly there to provide a way to start conversations about reflection (and associated constructs) in the practice of education.*
The framework intends to deliver two types of help. As *a descriptive aid*, it can be used to analyse an existing artefact or technique. As *a prescriptive aid*, the model can suggest the creation of new reflection affordances or the enhancement of existing ones. Doing so, it acts as a support to educational creativity. The framework represents thereby a common ground and an exploratory territory for practitioners. On the one hand, instructors might have already designed some of the reflective experiences composing it. On the other hand, by seeing alternatives, they are invited to commit to new approaches.

Mapping RAs to the classification framework

In this section, the explained classification framework is used to sort out and organise the set of RAs that have emerged from the literature survey. Locating any RA in the classification framework inherently involves attaching a formal description to it. For instance, the identified type "Permanent reflecting tool" (Fig. 2.3, cell 9) denotes an artefact which is supposed to support reflection on the whole learning experience (output) while using verbalisation as its requested action (input).

Input (interaction type) →

Output (reflection target) ↓

	Receiving information	Giving information	Verbalising information
Content and task	**•Transparent pedagogical rationale (1)** **•Objectives/criteria of a task (2)** •Room for choice (3) •Annotation sharing mechanisms (4) **Graphical presentation of content (5)**	**•Enhanced multiple choice questions (13)** •Ease-of-learning/self-efficacy judgments (14) **•Indicators of understanding (15)** •Formative assessment (16)	**•Where and why is it wrong? (23)** **•Students set the test (24)** **•Writing on the reading (25)** •Practice of evocation (26) **•Questions generation (27)**
Learning process	•Structure for regulative support (6) **•Growing mastery visualization (7)** •Mirroring of personal tracked data (8) **•Meta-cognitive modelling (9)** **•Help seeking behaviour guide (10)** •Compare with yardstick (11)	**•Interruptive monitoring (17)** •On-demand assessment (18) •Choosing the difficulty of questions (19) •Confidence-Based Learning (20) •Profiling questionnaire (21)	•Self-explanations (28) **•Justify your choice (29)** •Eliciting intentions before beginning a task (30)
Whole learning experience	•Records of marks/remarks (12)	**•Judgment of learning (22)**	•Learning footprints (31) **•Permanent reflecting tools (32)** •Explicit reflective activities (33) •Comments on comments (34) **•Test debriefing (35)**

Figure 2.3. Mapping of the RAs onto the proposed classification framework. Figures in brackets refer to their description in the Appendix. Bold face relates to the validation (see below).

A first validation

A validation process of the mapping was carried out. Eight eLearning experts from three institutions were asked to locate the 35 RAs in the framework. Only the very short descriptions (see the Appendix, p. 48) were available to them. On the basis of this compact piece of information, experts usually located the RAs in the same column (a different column was chosen only 17 times out of 280) but could diverge as to the line.

It means that the output dimension (instructional objective) left more room for different interpretations than the input dimension (interaction type). This was especially noticeable when it came to the distinction between reflection targeting external elements (Row 1: Content and task) or personal elements (Row 2: Personal learning processes). Follow-up interview sessions with experts confirmed that the natural interplay between these two skills could lead to hesitations regarding the positioning of a RA in the first or in the second line. When provided with additional explanation, ambiguities were usually elucidated and experts agreed that the initial location was appropriate or acceptable. However, talking in terms of "dominant" target of reflection instead of exclusive target

appeared opportune in the light of the discussions. All in all, the location of 17 RAs was confirmed with a level of inter-subjective agreement of 5/8 or more. These RAs are given in bold face in Fig. 2.3.

Further lines of inquiry

Part of the meta-learning activity consists in building a mental model of the learning context and of oneself inside this context, so that thoughts and actions can be tuned to it. The purpose of this chapter has therefore been to review and categorise a selection of instruments fostering students' reflection about task-related and self-related aspects of their learning activity. RAs materialise a "reflective learning" orientation. The last part of this chapter elaborates on three challenges bound to the investigation of this orientation.

Challenge 1 – Acceptance of the idea

An obvious condition to the acceptance of reflective practice is a better understanding of its core ideas (Leat, Thomas, & Reid, 2012). Despite growing evidence that investing efforts in developing students' ability to reflect on how they are learning has a positive impact on what they learn (Watkins, 2001), systematic articulation between learning and meta-learning is sparingly deployed in courses. A broader acceptance of reflection in learning claims for a demonstration to teachers and learners of the pay-offs and benefits of this articulation. This can be obtained only through the empirical validation of sensible patterns for simultaneous or sequential combination of RAs in courses.

Challenge 2 – Exploration of the value of tracked data for instruction

Some RAs found in the literature are based on the mirroring of personal tracked data. It is plausible that self-analytic behaviours could be trained by exploiting the unique tracking facilities of electronic environments. Indeed mining learners' interactions is a common concern of adaptive system improvement. Yet, it is usually undertaken as a back-office task and not in view to mirror their actions to students.

Some authors have expressed interest for the exploitation of different kinds of interaction "footprints". However, the targeted stakeholders have seldom been the students themselves but rather researchers (Leclercq, Fernandez, & Prendez, 1992; Perry & Winne, 2006) or instructors (Diagne, 2009; Mazza & Dimitrova, 2004; Nagi & Suesawaluk, 2008; Scheuer & Zinn, 2007; Zhang, Almeroth, Knight, Bulger, & Mayer, 2007). These works are based on information visualisation techniques. They take the data collected by learning management systems and generate graphical representations that can be used by tutors to gain understanding of what is happening in distance learning classes and to better regulate their courses.

A few researchers tried to place learning traces in learners' hands in attempts to prompt them to become agents and researchers in their own learning processes (Kostons, Van Gog, & Paas, 2009; Narciss, Proske, & Koerndle, 2007; Specht, Kravcik, Pesin, & Klemke, 2001; Van Gog, Jarodzka, Scheiter, Gerjets, & Paas, 2009). A systematic investigation of the RAs based on the feedback to learners of their personal tracked data deserves further attention.

In straight line with the mirroring of personal tracked data is the creation of "Learning Dashboards" (see Chapter 9), conceived as information and communication spaces condensing, combining and explaining situation-related (targeted learning goals, available learning resources, mandatory/optional tasks, needed/trained skills, time allocation, marks, etc.), self-related (tasks completed, achieved learning goals, resources consulted, etc.), and social-related (yardsticks) learning cues. Learning dashboards would simultaneously be a place for answers and for questions regarding personal learner information and fixed/imposed learning situation components.

Such a research agenda dedicated to mirroring issues could be grounded, among others, on Azevedo's work (2005). The author suggests a new way of thinking about computers as meta-cognitive tools designed to detect, trace, monitor, and foster learners' self-regulated learning of conceptually challenging topics. Making learning traces (beyond the marks at the tests) available has a potential to steer learner's attention towards meta-learning levels, which is an essential condition to the efficient and meaningful execution of professional learning. (This dissertation sometimes refers to "meta-learning" preferably to "meta-cognition", because the term encompasses more than cognition, embracing aspects of the learning experience like semantic intensity, affective dimensions, social relations or context appraisal (Jackson, 2004; Watkins, 2006). Also, the term "meta-learning" might be more easily understood by teachers and students).

Challenge 3 – Inquiry into the links between reflection and personalisation

There is very few research available (Waldeck, 2006, 2007) about what makes a teacher (Verpoorten, Renson, Westera, & Specht, 2010) or a student feel that a unit of learning is personalised, and about the impact of this feeling. What makes learning personal? What fosters its ownership? It should be investigated whether the promotion of meta-learning, through the use of RAs, might influence this inner perception of personalised learning. The relationship between reflective practice and sense of personalisation merits additional surveys.

Conclusion

With a classification framework and the mapping of 35 RAs onto it, this chapter provides a synthetic and synoptic view of techniques to stimulate reflection. The kind of interaction implied and the object targeted by the reflection can profita-

bly be used as descriptors of these techniques. Even when hesitations occur, the framework and its controlled vocabulary help to engage discussion over the roles and significance of the RAs. As a descriptive aid, the model can be used to analyse an existing opportunity for reflection. As a prescriptive aid, it can help choosing the most appropriate technique for new training sequences or for the enhancement of existing ones. To educators and instructional designers who ponder over possibilities to infuse reflective practice in a course, this offers a means to evaluate and compare different RAs within the same category and across categories.

In a context of investigation into the conditions and effects of learning with explicit reflective thinking affordances, this chapter outlined a systematised way of looking at and talking about reflection amplifiers. It is considered as an entry point for tackling the challenges raised by the funnelling of online courses into a reflective approach to learning.

Appendix: Compact definition of 35 RAs

In the tables below, all RAs are provided with a textual label, and explained with an extremely compact definition. The literature review sometimes provided more than one reference for each RA. The one considered as the most illustrative is given in the right column. RAs are clustered into separate tables according the type of interaction involved (receiving/giving/verbalising information), that is the most obvious descriptor according to the eight eLearning experts (see section "A first validation").

Table A.1 – *RAs enacted by receiving information*

	Label	Description	References
1	Transparent pedagogical rationale	The learners get informed about why this learning activity has been designed for them and how completing it will affect them.	Kay, 2006
2	Objectives/criteria of a task	The learners are periodically reminded of the conditions under which they will succeed.	Bilodeau, 1999
3	Room for choice	The course gives opportunities to choose learning activities (order, number, type) according to interest or learning needs.	Pegler, 2006
4	Annotation sharing mechanisms	The annotations (reflections on the material, notes, summaries) a learner adds to learning materials are made available to other learners.	Van der Baaren, Schuwer, Kirschner, & Hendriks, 2008
5	Graphical presentation of contents	Graphic organisers are presented as alternative or complement to textual structure: mind-maps, heuristic schemas, spider webs, contrast matrices,	Plaisant, 2004

		etc.	
6	Structure for regulative support	The course includes a "dashboard", viz. a page that bundles personal indicators allowing the learners to keep an updated status of their situation in the course and to better control it.	Bull & Mabbott, 2006
7	Growing progress visualisation tool	Visual displays (progress sliders, understanding meters, etc.) enable learners to determine their progress (actions and mastery) towards the learning goals.	Glahn, Specht, & Koper, 2007
8	Mirroring of personal tracked data	Different kinds of learner interactions with the course are tracked and recorded to make personal learning traces available.	Narciss, Proske, & Koerndle, 2007
9	Meta-cognitive modelling	The teacher or a subject-matter expert displays modelling behaviour, showing how to think about the material (knowledge, skills, procedures, etc.)	Sanchez-Alonso & Vovides, 2007
10	Help seeking behaviour guide	The course provides guidelines for using help at the right moment.	Roll, Aleven, McLaren, & Koedinger, 2007
11	Compare with yardstick	Learners get opportunities for comparing aspects of their learning experience (time spent, exercises completed, estimation of knowledge, own performance) to some external yardstick (teacher, peer, expert, classroom average, oneself in similar circumstances, compliance ratio, etc.).	Todorovich, Wirth, Zhang, Tillman, & Fleming, 2004
12	Records of marks/remarks	The marks and the remarks received from the instructor(s) are stored and can be consulted by the student.	Ruelland & Brisebois, 2002

Table A.2 – *RAs enacted by giving information*

	Label	Description	References
13	Enhanced Multiple Choice Question	Learners answer enriched Multiple Choice Questions. The proposed answers include meta-level options like "All answers correct", "None of the answers correct", "The question is absurd", "The terms of the problem are too ill-defined for giving a correct answer", etc.	Diaz, Rifqui, Bouchon-Meunier, Jhean-Larose, & Denhière, 2008
14	Ease-of-learning/self-efficacy judgments	Learners engage in a self-assessment of their perceived ability for the task.	Ruelland & Brisebois, 2002
15	Indicators of understanding	Learners are asked to qualify their understanding with simple indicators like "lost/foggy/got it" or equivalent.	Stadtler & Bromme, 2008

16	Formative assessment	The course offers assessment intended to generate feedback on performance to improve, helping learners to assess their own learning.	Nicol & MacFarlane-Dick, 2006
17	Interruptive monitoring	Periodically questions appear about perceived performance. Learners provide a score on an appropriate scale.	Van den Boom, Paas, Van Merriënboer, & Van Gog, 2004
18	On-demand assessment	Learners can summon the examination when they feel that their mastery is sufficient.	Quellmalz & Hoskyn, 1997
19	Choosing the difficulty of questions	In the course, the learners can request easier or harder questions.	Robison & Tanimoto, 2008
20	Confidence-Based Learning	Learners are asked to answer questions and express their confidence in the correctness of their answers.	Leclercq, 1982
21	Profiling questionnaire	The course encourages learners to reflect about themselves by filling in a learning profile questionnaire.	Coffield, Moseley, Hall, & Ecclestone, 2004
22	Judgment of learning	Learners are asked to report the progress they believe they made in the learning area as a consequence of having taken the course.	Richmond, McCroskey, Kearney, & Plax, 1987

Table A.3 – *RAs enacted by verbalising information*

	Label	Description	References
23	Where and why is it wrong?	Learners receive pieces of work for which they are asked to say what is wrong and why.	Brdarevic, 1998
24	Students set the test	Learners are asked to make up the questions they might get for their exam.	Baird & Mitchell, 1986
25	Writing on the reading	The course provides annotation tool(s) along with the electronic learning material.	Cobine, 1995
26	Practice of evocation (pausing to reflect)	Learners are requested to recall important or puzzling facts/ideas/concepts from the learning episode.	La Garanderie, 1989
27	Questions generation	Learners are invited to post questions about the material for which they receive a feedback.	Verpoorten, Poumay, Delcomminette, & Leclercq, 2006
28	Self-explanations	The course trains the learners to generate explanations about the content of an exercise, a strategy, a text, a learning goal, an example, etc.	McNamara, O'Reilly, Rowe, Boonthum, & Levinstein, 2007
29	Justify your choice	Learners are asked to justify choices they made in the course.	Baird & Mitchell, 1986
30	Eliciting intentions before a task	The course makes room for learners to reflect about how to handle the task and their expectations to encounter any problems through it.	Ausubel, 1960

31	Comments on "learning footprints"	The course includes assignment(s) requesting learners to ponder upon their tracked traces of a learning episode.	Johnson & Sherlock, 2008
32	Permanent reflecting tools	The course asks learners to verbalise and record their thinking activities related to learning tasks in a learning diary or a similar tool (e.g., blog, portfolio)	Attwell, Chrzaszcz, Hilzensauer, Hornung-Prahauser, & Pallister, 2007
33	Explicit reflective activities	The course includes self-reflective activities encouraging students to analyse various aspects of their performance.	Gummesson & Nordmark, 2007
34	Comments on Comments	The learner is asked to write a comment in response to the instructor's comments.	Baird & Mitchell, 1986
35	Test debriefing	Learners are formally invited to question their own results and to analyse successes/failures, strengths/weaknesses, areas to review, errors or misconceptions, etc.	Mitchell & Mitchell, 2008

Chapter 3

Study 2 (collateral): Infusing reflective practice in eLearning courses – Can widgets help?

Chapter 3
Infusing reflective practice with widgets

Abstract

This chapter reports the results of a survey that asked Open Educational Resources course creators about their opinion on different types of reflection amplifiers. Reflection amplifiers are structured opportunities for students to examine and evaluate aspects of their learning experience. The chapter deliberately adopts a non technical perspective; it takes voices from the field as a starting point. The outcomes demonstrate that several reflective techniques are recognised and acknowledged by the practitioners as being of relevance. Yet, applications in their courses are limited. Results of the survey are subsequently used to inspect possible contributions of widget technology to the implementation and dissemination of a selection of reflective techniques. The chapter ends up by outlining research avenues related to the development of such widget-based reflection amplifiers.

This chapter is based on: Verpoorten, D., Westera, W., & Specht, M. (2011a). Infusing reflective practice in eLearning courses – can widgets help? *Int. J. Technology Enhanced Learning, 3*(1), 93–109. doi: 10.1504/IJTEL.2011.039066

"*Reflection is indicative of deep learning, and where teaching and learning activities such as reflection are missing… only surface learning can result*." (Biggs, 1999, p.55)

This chapter is positioned at the cross-section of an emerging Internet technology (Web 2.0) and a pedagogical trend (the promotion of reflection and meta-learning). It precisely questions the educational potential of a junction between a new breed of application software named "widget" and the call for more reflection in learning.

Widgets for reflection

Reflection

Reflection is an active process of witnessing one's own learning experience and evaluating it on different aspects. Reflective practice (and akin notions like "learning to learn", "meta-learning" and "meta-cognitive development") is a significant topic in education and training (Schön, 1983). Meta-analyses (Hattie, 2009; Marzano, 1998; Wang, Haertel, & Walberg, 1990) rank reflection among the strongest influential factors of learning. Its potential concurrently applies to the enhancement of the domain-specific knowledge and the knowledge about the self-as-a-learner. Reflection is claimed to promote deeper and more effective learning both in regular classrooms (Watkins, 2001) and in eLearning settings (Means, Toyama, Murphy, Bakia, & Jones, 2009). It is generally acknowledged that stimulating deliberative practice will prepare knowledge workers to cope with requests for new knowledge acquisition and ongoing personal development in the information society (European Commission, 2006; Rychen & Salganik, 2003). However, despite the alleged importance of reflection, current formal instruction shows a shortage of specific training for this generic skill (Carnell, 2005; Claxton, 2006; Csapó, 1999), while at the same time profile sites like Facebook or the expanding practice of blogging and twittering seems to open new alleys to reflectivity (Van den Beemt, 2010).

Widget

The term "widget" refers to a miniature Web application performing a single task and displaying a very clear and appropriate graphical style. A widget provides a single interaction point for the visualisation and direct manipulation of a given kind of data (Widget Concept, n.d.). Typical examples, designed for the desktop, the Web, or the mobile, would be widgets that show today's weather forecast, upcoming birthdays or information stocks. Personal learning environments (PLEs) are already taking advantage of widgets (Attwell, 2007). The widget technology seems to be available to eLearning. However, it is not yet clear how it can best be used to the benefit of instruction and what its specific

technical, pedagogical, organisational advantages could be within such a formal context.

Widgets in the service of reflection

This chapter opens a line of inquiry about "widgets for reflection", defined as eLearning artefacts designed to prompt and support clear, short and single reflection-related tasks occurring prior, during, or after a formal learning sequence. Making widgets available, which are dedicated to the support of reflection, may help increasing the quantity, quality and persistence thereof in learning. This would nicely align with the call for more reflective practice in schools. The next section states the rationale underpinning a survey meant to gather data about teachers' views on techniques for reflection. This outlook helps subsequently to identify which of the reflective techniques are feasible candidates to an implementation as specialised widgets, likely to transform a learning environment so that it can become supportive for defined types of reflection. Eventually, a set-up for an experiment deemed to empirically ascertain the potential of widgets for reflection is outlined.

The importance of teachers' voice

Personal Learning Environments, widget technology, social software, all Web 2.0 artefacts are gaining momentum (O'Reilly, 2007) and have even been designated as the future of education (Attwell, 2007; Jones, 2008). Whilst these innovations hold out likelihood of enhanced flexibility, aggregation, interoperability, personalisation, how they can be exploited in the concrete by today's educators is still a severe challenge, as it will now be shown with observations grabbed both from the Web and in the literature.

Widgets for education, really?

On the Web, that is on the side of free-access widgets' producers, the development of Web 2.0 artefacts for formal instruction contexts has not retained much attention so far. Widgets that claim to have just a link with the realm of school are far less numerous than widgets conceived for other domains. A quick search, conducted on April 5, 2012, on Yahoo Widgets Web site (discontinued since then) with the keywords "school", "education" and "learning" returns respectively 19, 47 and 70 results while "games", "calendar", "finance" or "news" return 641, 105, 93 and 812 results. Neither in Google Gadgets (http://www.google.com/ig/directory) nor in Apple Dashboard Widgets (http://www.apple.com/downloads/dashboard) is education listed in the categories. Furthermore, a closer qualitative look shows that many widgets retrieved for the three keywords (school, education, learning) are actually foreign to regu-

lar classroom or e-learning courses, to say nothing of the recalcitrant "Last day of school countdown" widget.

Discussions saturated with technical concerns

As for the academic literature, lots of articles remain focused on the description of requirements and architecture or testing prototypes, all of which usually being highly technical and often impenetrable, if not incomprehensible, for the non-expert educator. For example, at the Mupple (Mashup Personal Learning Environments) Workshop 2009, it turned out that only 3 out of the 14 accepted contributions (http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-506) made some substantial effort to relate Web 2.0 tools to pedagogical core concerns and concepts.
This gap between technological development and grassroots practice is not necessarily new. In 2004, Wieringa and Heerkens concluded, from their analysis of a sample submissions to international conferences on engineering, that most submitted papers presented a solution and illustrated it with a problem, rather than searched for a solution to a given problem class or to a clearly identified need coming from the field. In order to prevent certain blindness to real-world conditions of use, the discussions on education-oriented widgets would benefit from being tuned to practitioners' expressed needs and interests. This is why the present investigation of the potential of widgets for reflection intentionally opens up with a glimpse into practitioners' opinion on reflective techniques.

Method

This section describes the set-up of a survey in which senior instructional designers were asked to ascertain the value of a series of reflective techniques for their course.

Aim of the survey

The survey was carried out in order:

- to gain insight about the relevance of reflection in the eyes of instructors;
- to investigate the state of affairs of reflection amplifiers (see section "Procedure and measure instrument") in Open Educational Resources (OER) courses offered by the Open University in the Netherlands;
- to hook future discussions about harnessing widgets technology to reflective practice onto data coming from practitioners;
- to take forward the understanding of concrete ways in which widgets could be used within online learning.

Participants characteristics

The survey was carried out among instructors who partook in the Open Educational Resources (OpenER) project launched by the Open University in the Netherlands (Schuwer, 2008). The OpenER project makes available, free of charge, a variety of higher education eLearning content. Like similar initiatives over the world (MIT OpenCourseWare, MERLOT, OPENLEARN, etc.), it targets an expansion of the higher education learning opportunities. The choice of OER courses for the survey has three reasons. First, the Open University in the Netherlands has defined a program aimed at enhancing its offer of OER. Second, the course creators are experienced developers of eLearning content. Third, the research has been conducted in the context of the i-Coper project, dedicated to OER.

Procedure and measure instrument

Twenty-two creators of an OpenER course received an invitation to an online questionnaire presenting the description of 35 existing techniques meant to stimulate reflection. These techniques come from an inventory established by Verpoorten, Westera, and Specht (2011b) who subsume them under the vocable of "reflection amplifiers" (*RAs*). For each of these reflective techniques[2] respondents were asked to tick one of the following options:

- I do not understand this technique.
- This technique is not relevant for my course.
- This technique would be relevant for my course but is not implemented.
- This technique is implemented in my course.

This type of investigation was chosen in order to find what concrete reflective techniques eLearning course creators considered as relevant. The research was exclusively based on participants' answers. No reality check was done in the courses.

Results

The exploratory and qualitative stance of the survey, as well as its restricted sample size, accounted for omitting advanced statistical calculations. Instead, the descriptive statistics provided should be regarded as indications likely to inform further research into widget-supported reflective practice and to safeguard it from disconnection with practitioners' concerns.

[2] All reflective techniques were presented to the practitioners with the compact descriptions given for this dissertation in the Appendix, p. 47.

Response rate

Overall, 13 course creators out of 22 completed the questionnaire. In view of the 35 techniques for reflection that were presented, this means that the study collected 455 (13 x 35) practitioners' qualifications over RAs.

Understanding of RAs

RAs seem to be well understood. Only 23 occurrences of the "I do not understand this technique" item were collected out of 455 answers. The least understood RAs, that is the RAs for which the option "I do not understand this technique" has been the most often ticked, are Formative assessment (4/13), Structure for regulative support (3/13), On-demand assessment (3/13), Confidence-Based marking (3/13).

Relevance of specific RAs

Respondents, 75 times out of 455, claim that a specific RA would be relevant for their course but is not implemented. RAs with the most potential in this respect are: Help seeking behaviour guide (4/13), Graphical presentation of contents (4/13), Students set the test (4/13), Indicators of understanding (4/13). When grouping the answer categories "this technique would be relevant for my course but is not implemented" (75) and "This technique is implemented in my course" (82) versus "This technique is not relevant for my course", it gives 157 claims of relevance versus 275 claims of non-relevance. (The 23 "I do not understand this technique" are not taken into account). So, 36% of the answers (157 out of 432) qualify a reflective technique – implemented or not – as being of relevance for an eLearning course.

Existing practice

According to respondents, 82 RAs are implemented in the courses. Highest occurrences are: Making pedagogical rationale transparent (9/13), Meta-cognitive modelling (8/13), Self-explanations (6/13), Practice of evocation (4/13), Justify your choice (4/13), Room for choice (4/13). The implementation of RAs is unevenly spread in the courses (Fig. 3.1.).

The small sample made it possible to look for patterns of aggregation of RAs but no significant one could be identified, not even at the level of one-one combinations. It means that practitioners use very varied compounds of reflective techniques.

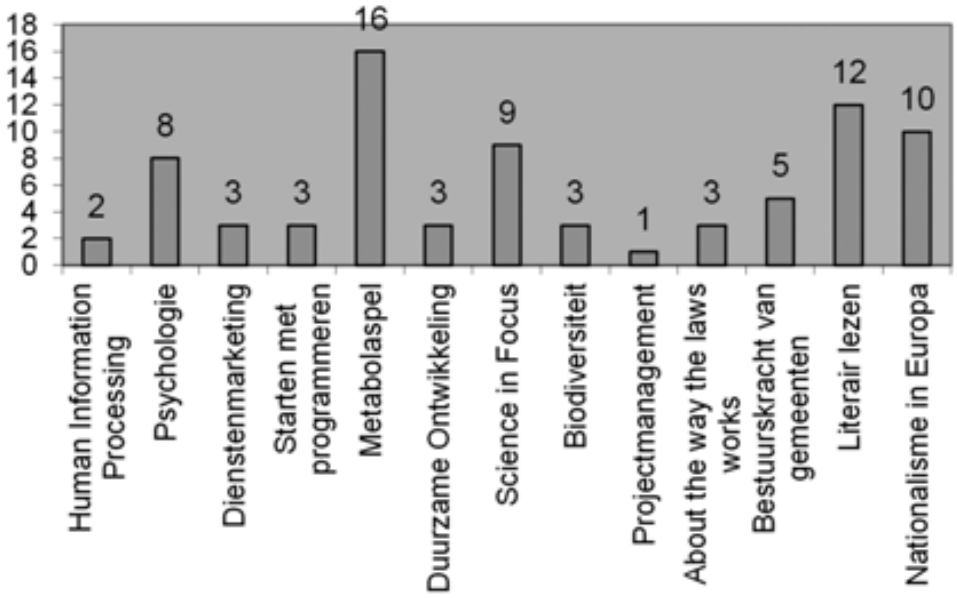

Figure 3.1. The number of RAs greatly varies among courses.

Focus on the exploitation of tracked data

Several RAs are based on the mirroring of personal tracked data. The study reveals that 7 out of 13 course creators do not know whether the eLearning platform on which they have developed the course provides any tracking facility. Overall, three respondents state that they use tracked data as teachers. One respondent says that the tracked data is used by the students. When asked whether they (would) give their students access to their learning traces as a RA, 4 teachers out of 13 answer positively (Fig. 3.2).

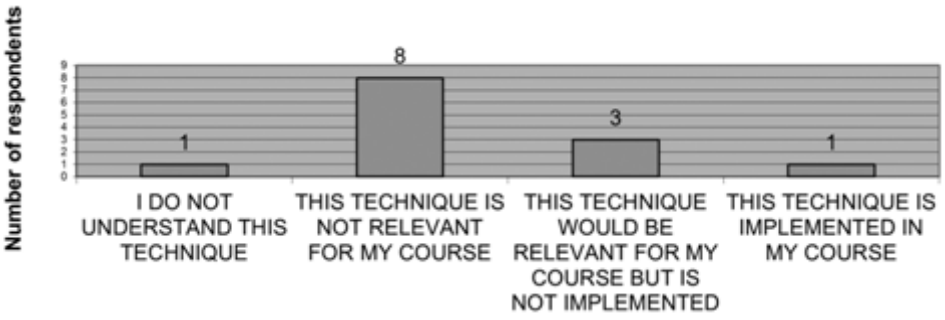

Figure 3.2. Answers' allotment regarding the exploitation of student's personal tracked data as a lever for reflection.

Designing Widgets as RAs

A key assumption of this chapter is that widget technology can fruitfully be harnessed to the facilitation of a reflective approach to learning which, according to the results of the survey, sounds interesting to more than one third of practitioners. Two coupled questions arise at this stage: (a) which techniques of reflection can reasonably be "widgetised"?, and (b) why does widget technology seem especially relevant, compared to previous research that has addressed the issue of promoting reflective skills with other technologies? Extrapolating from the survey, some lines of answer are now made.

Candidates to "widgetisation"

Teachers gave their opinion about 35 reflective techniques. Most of these techniques are too complex to be used as widgets, according to the definition given in the introduction, which combines two key features: a clear single task to execute and a very recognisable graphical style. Among others, it seems difficult to stick to these characteristics for the support of reflective techniques like "Permanent reflective tools", "Self-explanation", "Formative assessment", "Profiling questionnaire" or "Help seeking behaviour guide". However, a "widgetisation" seems feasible for the following techniques:

a) Growing progress visualisation tool: the widget would offer visual displays (e.g., progress sliders, understanding gauges) enabling learners to determine their progress (actions and mastery) towards the learning goals. Three respondents out of 13 consider this feature as relevant for their course;
b) Comparison with yardstick: the widget would specialise in comparing certain aspects of the learning process (time spent, exercises completed, estimation of knowledge, own performance, etc.) with some yardstick (teacher, peer, expert, classroom average, oneself in similar circumstances, compliance ratio, etc.). Seven respondents out of 13 consider this feature as relevant for their course;
c) Indicators of understanding: the widget would prompt learners to qualify their understanding of the course with simple indicators like "lost/not fully clear/got it" or similar labels. Seven respondents out of 13 consider this feature as relevant for their course;
d) Judgement of learning: the widget would allow students to report the progress they believe they made in the learning domain as a consequence of doing the course. Seven respondents out of 13 consider this feature as relevant for their course;
e) Self-efficacy judgments: the widget would engage students in self-assessments of their perceived level of knowledge or ability for a task. Seven respondents out of 13 consider this feature as relevant for their course;

f) Mirroring of personal tracked data: the widget would allow a visualisation by learners of different interactions they had with the course. Three respondents out of 13 consider this feature as relevant for their course.

When carefully examined, the above candidates to widgetisation fall into two categories. The first one elicits reflection by visualising personal tracked data (a, f), possibly enriched with social data (b) used as a yardstick. The second induces reflection by offering to learners an opportunity to give a quick insight into their learning processes (c, d, e) thanks to scoring/rating/ticking widgets. These categories are now further elaborated.

Category 1 – Widgets for the mirroring of interaction footprints

This category of widgets for reflection induces the reflective experience by requesting the learners to look at or ponder upon externally provided cues or information related to the learning context and their position within. RAs in this category do not imply any observable action of the learner, except, possibly, the time spent in the contemplation process. From the system perspective, this category most often demands that some personal data are tracked, recorded and shown. Hence, the survey delivers ambiguous answers regarding contemplation of personal tracked data as a lever for student's reflection. On the one hand, having students pondering upon their interaction footprints is granted some potential by practitioners (Fig 3.2). On the other hand, 7/13 of the course creators do not know whether their eLearning platform provides any tracking facility. They do not use the traces themselves and do not know whether students do. Several studies indicate that teachers (Jovanović, 2008; Mazza & Dimitrova, 2004; Scheuer & Zinn, 2007), students (Johnson & Sherlock, 2008) and learners (Glahn, 2009) can reap meta-learning benefits from the observation of learning traces. Making this data available through specialised tracking and tracing widgets is likely to boost the extent of this practice. From an application viewpoint, such mirroring widgets would remain single objects but their semantics, visual appearance, dependencies and overall development could become very complex and demanding, as already observed in a very early article on the topic (Swick & Ackerman, 1988, p. 3).

Category 2 – Widgets for student-driven evaluation

This category of widgets for reflection induces the reflective experience by asking learners to give a quick insight into their behaviours or performances through the use of a scale. From the system perspective, this category requests the presentation of scoring/rating/ticking artefacts to the learner in order to get insight into mental processes.

Borders between the two categories are not rigid. Yet, they can be combined and mutually supportive. For instance, a student can be asked to rate his progressive mastery of a content while studying. And a post-practice reflective activity can consist in commenting the evolution of mastery, based on the mirroring of the self-evaluation history.

Once developed and embedded in the courses, specialised widgets from both categories would represent self-contained meta-learning activities. Following a suggestion by Moedritscher and Wild (2009, p. 3), each of them could be formalised as a triplet of:

- one tool. Example: “I use the widget "Understanding indicators"”;
- one action. Example: “With the widget, I rate my understanding of this content”;
- one outcome. Example: “Thanks to this widget, and through the clear, small and single action it allows, I train my meta-learning skill for self-assessment”.

Reasons to give a trial to widgets for reflection

This section elaborates on reasons why widget technology is considered particularly relevant for infusion of opportunities for reflection in distance education. Again, this rationale must be considered as tentative. It is used for the derivation of hypotheses for further improvement in a research cycle concerned with the enhancement of reflective thinking and with the implementation of subservient technologies.

Reason 1 – Contextualisation of reflection

Literature on reflection demonstrates the importance of training thinking skills in the context of learning (Resnick & Klopfer, 1989). From this request ensues the need to closely relate opportunities for reflection with the learning tasks and domains of knowledge. Due to their small size and their agility, widgets seem to be a technique worth investigating for an increased localisation of student’s reflection. (In this respect, the new possibilities to insert – for instance through the Wookie server (Wilson, 2008) – widgets, and possibly widgets for reflection, within a learning design conceived with the Recourse IMS-LD authoring tool is a move in that direction). Real scenarios should be tested in order to document this nesting of widget-based reflective activities within concrete courses.

Reason 2 – Cockpits for learning

At the opposite side of the widget capacity to isolate both graphically and cognitively specific actions, the possibility to aggregate widgets is a possible second added value of this technology. Personal Learning Environments and mashups form a new type of interface that has so far mostly been investigated in informal learning contexts. The potential of an aggregated use of widgets – selected by teachers and/or learners – to compose “Learning dashboards” as a support of formal learning should be ascertained. Hence, it may be possible to conceive learning dashboards as contextual collections of widgets for reflection (see Chapter 9). Reflection would take place at the single-widget level but the dashboard itself would be a source of reflection at an upper level. Different con-

figurations of widgets for reflection might help building appropriate and personal learning dashboards.

Reason 3 – Pick-and-mix and progressive approach

No single outstanding RA emerges from faculty's answers and no preferred combination either (Fig. 3.1). It means that teachers pick up one or the other technique according to their needs. The modular approach conveyed by widget technology, and more broadly by Web 2.0, looks suitable to cater for these variations. Individual teachers could select/aggregate widgets for reflection according to their courses, their students' needs or the level of reflection to be pursued. In such a pick-and-mix approach, the inclusion of tiny, pluggable and not much disruptive opportunities for reflection might be tailored and progressive. This widget-driven evolution of already existing courses shields users (teachers, learners) against the need to get acquainted with completely new systems. In addition, it is doubtful that long-term benefits of reflection can be expected from one or even a few exercises. A consistent work with reflection must probably be arranged on a longer period and throughout different courses. The agile nature of widgets for reflection might ease this multi-dimensional deployment and thereby concur to the acquisition of reflective habits.

Reason 4 – Instant opportunities for reflection

The last line of reasoning suggesting that widgets might be particularly useful in promoting reflection is related to learning culture. An objection of teachers to the implementation of RAs can be that reflection takes time and that the course coverage might suffer from an allocation of efforts to reflection. Widgetised RAs, like the ones identified in section "Candidates to widgetisation", might demonstrate that brief incentives to reflect on learning while learning can fruitfully be applied without requesting much time.

Conclusion and further work

Looking at reflection as a desirable educational goal induces the quest for instruments that are likely to foster it. This chapter has considered the possibility of harnessing widgets to the training of thinking skills, within the framework of subject matter instruction. Due to its specific features – agility, interoperability, self-contained activities, and aggregation power – widget technology seems appropriate to:

- support an extended training of auto-cognitive skills (awareness during study, self-assessment, presence-to-learning) by embedding widgets for reflection within a variety of courses and systems;

- provide teachers with ready-to-use reflective tools likely to be seamlessly activated according to the configuration they find the most pedagogically relevant;
- facilitate cognitive regulation of personal learning by providing coordinated access to a variety of personal tracked data.

The above argument should now be transformed into proper examples. An eLearning course prototype enriched with concrete instantiations of widgets for reflection is meant to provide a convenient context for research on conditions of use, impact and possible drawbacks and benefits of these artefacts. Some of the reflective techniques reviewed by Verpoorten, Westera and Specht (2011b), buttressed by teachers in this chapter (see section "Overall relevance of reflection amplifiers"), and considered as natural candidates to "widgetisation" (see section "Candidates to widgetisation") according to the definition of widgets (see section "Widgets for reflection"), have to be turned into mock-ups materialising the reflective approach suggested in this chapter.

Limitations of the study

This initial survey on RAs in eLearning courses ought to be seen as the entry point to a larger investigation concerned with meta-learning training in formal education. Yet, the reported findings are based on a restricted sample. Since they are not representative for users in general, they need to be complemented by and compared with further evaluation data. Nevertheless, the outcomes of the study are able to provide first indications on users' opinion on RAs and subsequently on the widgets capable to instantiate them.

Chapter 4

Study 3 (prime): Using reflection amplifiers while learning in an online course

Chapter 4
Using reflection amplifiers – Pilot study

Abstract

This chapter reports about a controlled experiment on the effects of three types of reflection amplifiers in an online course. Fifty-four volunteers, distributed in five groups, used these structured opportunities for reflection during learning. Results show that reflection amplifiers were extensively employed by the test persons and were perceived as quite useful to reflection and learning. Test persons in the experimental groups reported significantly more reflective prompting and more intensive reflection than those in the control group. In contrast, no positive effect on learner performance and retention could be established. This paradox elicits different possible explanations which are discussed in the light of the common pedagogical claim that more thoughtful approaches to learning should be promoted.

This chapter is based on: Verpoorten, D., Westera, W., & Specht, M. (2011c). Using reflection triggers while learning in an online course. British Journal of Educational Technology. Advance online publication. doi: 10.1111/j.1467-8535.2011.01257.x.

"The use of meta-cognitive strategies ignites one's thinking and can lead to more profound learning and improved performance, especially among learners who are struggling." (Anderson, 2002)

Meta-analyses (Hattie, 2009; Marzano, 1998) or literature reviews (Watkins, 2001) repeatedly pinpoint reflective practice as a highly influential factor in learning, if not the most influential one (Wang, Haertel, & Walberg, 1990). It is generally acknowledged that stimulating reflective skills will prepare knowledge workers to cope with requests for new knowledge acquisition and ongoing personal development in the information society (European Commission, 2006). Today's electronic learning environments offer new opportunities for reinforcing reflection, especially in self-instructed contexts, that is situations wherein learners cannot rely upon an instructor to directly inform and stimulate their thinking about learning contents and processes. This chapter describes a controlled comparative experiment about the use of "reflection amplifiers" in such a mode of learning.

Reflection amplifiers

"Reflection amplifiers" (*RAs*) refer to deliberate prompting approaches that offer learners structured opportunities to examine and evaluate their own learning (Verpoorten, Westera, & Specht, 2011b). Whereas the promotion of reflection is often associated with post-practice methods of experience recapture (Boud, Keogh, & Walker, 1985), through portfolios or learning diaries (Moon, 1999b) or with the use of dialogue and collaborative activities as levers of thinking (Brockbank & McGill, 1998), RAs are nested in the study material and offered to individuals during learning activities. They induce regular mental tingling for evaluating one's learning and nurturing internal feedback (Butler & Winne, 1995).

In the temporal flow of learning, their contiguity to student's doings commits RAs to reflection-in-action more than to reflection on action, though Schön's (1983) famous distinction is relative: even a reflection that takes place "in action" bears on a pre-existing context but, in the case of a RA, the interval is a matter of seconds.

The concise reflection which they call for further characterises RAs. To support condensed reflective processes, they operate though miniature Web applications (sometimes called "widgets") performing a single task, displaying a very clear and appropriate graphical style, and providing a single interaction point for direct visualisation or provision of a given kind of data (Verpoorten, Westera, & Specht, 2011a). The application of such compact opportunities for reflection

touches on a principal question though: *is the very idea of a "short" reflection a contradiction or can embedded reflection be brief and valuable at the same time?* Beyond theory, there is a practical stake in this question: teachers as well as learners may be reluctant to reflective approaches, since these are supposed to happen at the expense of studying course contents. It is a major challenge to establish reflective learning practice without swamping the time available.

Research questions

Two main questions guided the experiment: (a) do RAs embedded in a study task engage learners in active reflection?, and (b) does this reflection positively affect the performance?
Two secondary research questions were dealt with: (a) do multiple RAs have a greater effect than one single RA? and (b) is there any observable difference of effect between the types of RAs used?
Lastly, the study collected learners' perception and appreciation of RAs and confronted these qualitative outcomes with performance data.

Methodology

In a comparative study an online course was delivered at five different conditions. The intervention variables were the exposure to RAs (different numbers, different types). The dependent variables were performance, time spent on the course and participants' perception of RAs.

The online course

The two-hour online course "Five Web usability principles" was created for the occasion on the eLearning platform Moodle. It provided reading material (Jakob Nielsen's columns, as published on his Web site http://www.useit.com) on 20 pages that participants could freely navigate. A final test assessed the content mastery reached by learners.

Three types of RAs

The study exposed participants to RAs selected from the inventory proposed by Verpoorten, Westera, and Specht (2011b). This work classifies reflective techniques according to three distinctive types of actions requested from the learners to enact reflection: Type 1) receiving information, Type 2) giving information, and Type 3) verbalising information. Consistently with its comparative purpose, the study used one RA selected in each category. In the introductory section of the course, the offered RAs were described to participants as "support to reflection and appreciation of one's position within the learning process". Using RAs

was stated as compulsory, in a concern to be as close as possible of a formal learning activity system, which is usually organised around a curriculum (closed corpus), is teacher-controlled, and offers compelling tasks with predefined learning resources. For tracking purpose, students had to deliberately activate the RAs. When learners were about to leave a page without having used the requested RA(s), a reminder pop-up enacted.

RA 1 – Compare with yardstick

As a RA of Type 1 (Interaction type = receiving information), this artefact offered learners an opportunity to compare aspects of their learning experience to an external yardstick. A yardstick relates an individual performance to a larger context (Glahn, Specht, & Koper, 2007). In this study, learners could compare the number of actions they performed so far with a static yardstick: the number of actions performed by a previous group of peers (Fig. 4.1). Such real-time mirroring of personal tracked data was assumed to encourage a more thoughtful monitoring and calibration of actions.

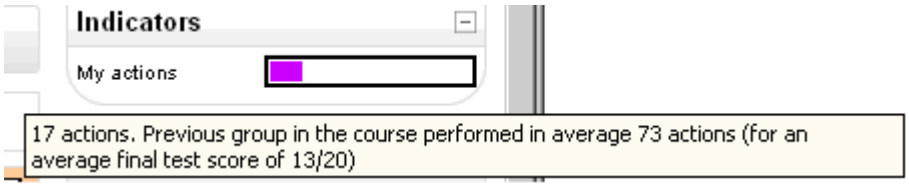

Figure 4.1. The RA (Type 1) confronted personal tracked data to a yardstick.

RA 2 – Rate your mastery of this page

As a RA of type 2 (Interaction type = giving information/responding), this artefact induced the reflective experience by asking learners to give a quick insight into their behaviours or performances through the use of a rating scale. On each page visit or revisit participants rated their perceived mastery level of the page content by selecting the appropriate number of stars (Fig. 4.2, label a). For each level a standardised explanation was given. In case of multiple visits the history (Fig. 4.2, label b) of this self-reported measure was available and steadily built a progress track.

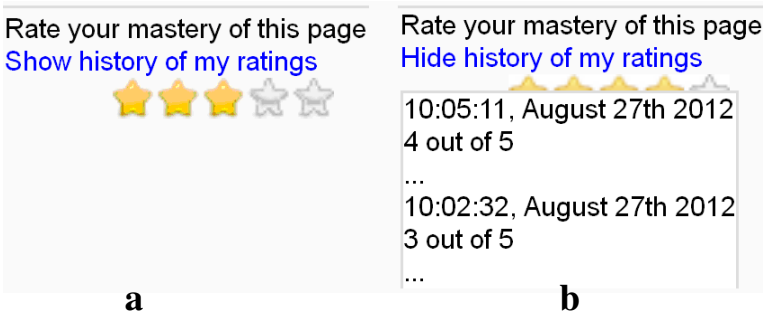

Figure 4.2. The RA (Type 2) asked for self-ratings (a), steadily building a history of mastery (b).

RA 3 – Write on the content

As a RA of Type 3 (Interaction type = verbalising information), this artefact aimed for inducing a reflective experience by asking the learners to produce a mental or written discourse about certain aspects of their learning. The online course offered the RA as a comment box available on each page. Whenever learners left a page, they first had to enter an annotation.

Sample and schedule

Invitations to participate in a three-hour experiment were displayed in four Linked' in discussion groups and spread in institutions from the authors' contact networks. Randomly, 92 volunteers were distributed over the five conditions: no RA, all RAs, RA1 (yardstick), RA2 (rating tool), and RA3 (comment box). After the completion of a 20 min background questionnaire, the subjects received the Web address of the course version matching their treatment. They had one month to complete it, take the final test and answer the 20 min post-questionnaire right after. The 54 subjects who completed the experiment received a certificate for participation and a reward. According to participants' preference, this could be a three-month premium account for the mind-mapping online application MindMeister (http://www.mindmeister.com), a 2-year valid voucher for the entrance to a one-day conference organised by the Open Universiteit, or a USB stick with educational applications (http://eduapps.org).

Measure instruments

This section depicts the three data sources exploited in this study: the returns from the questionnaires, the tests results and the logging data.

Background questionnaire

Reflective skills, and more generally meta-cognitive capacity, were critical with regard to RAs. In order to obtain learners characteristics regarding these skills, three instruments were included in the background questionnaire: the Mindful Attention Awareness Scale – MAAS (Brown & Ryan, 2003), the Need For Cognition form – NFC (Cacioppo & Petty, 1982) and the Meta-cognitive

Awareness Inventory – MAI (Schraw & Dennison, 1994). Self-reported level of mastery in the domain and of familiarity with ICT were also collected.

Feedback from learners

A second online survey, taken right after the final test, gathered participants' feedback on RAs. The questionnaire comprised:

- judgments on the intensity of reflection in the course, measured by the "Reflective Thinking" 5-item scale of the COLLES questionnaire (Taylor & Maor, 2000) that generates measure of students' perceptions about a course;
- opinions on the used RA(s): weak and strong points, contribution to learning, intention of reuse.

Short and long-term performance

A test taken after the study session measured learners' achievement. This performance test: (a) was on-demand and taken when the students felt that they had achieved the highest possible level of content mastery, (b) could be taken only once, (c) had a time limit so that the reflection took place while covering the material and not at the moment of the test, (d) was graded on 20 points, (e) could be anticipated by the participants through examples of test questions, (f) blocked access to the electronic material once launched, and (g) combined five "verbatim", five "comprehension inference" and one final integrative "knowledge inference" questions, according to the typology proposed by Chi, De Leeuw, Chiu, and Lavancher (1994). The last two types of questions requested deep understanding of the material. Six weeks after the first test, participants answered a shortened version of the questionnaire, graded on six points, in order to assess retention. By this time, they no longer could access the course.

Behavioural metrics

Log files of online sessions captured different usage patterns related to: (a) total time spent on course, (b) number of pages (re-)visited, (c) use of RAs, and (d) time spent on the final test.

Results

An alpha level of .05 was used for all statistical tests.

Usable sample

The attrition rate was stable across the groups, except one: group 5 – "comment box" condition – which suffered from a high proportion of drop-outs (questioned in the section "Discussion"). Despite its inadequate size, this group was included anyway because of the importance of qualitative data for this pilot

study. Table 4.1 gives a compact view of the five groups and their usable samples.

Table 4.1. Overview of the 5 treatments and the RAs (X = provided, – = non provided)

	Compare with yardstick (RA1)	Rate your mastery of this page (RA2)	Write on the content (RA3)	N
Group 1 (control): no RA	–	–	–	10
Group 2 – all RAs provided	**X**	**X**	**X**	16
Group 3 – RA type 1 provided (yardstick)	**X**	–	–	11
Group 4 – RA type 2 provided (rating)	–	**X**	–	11
Group 5 – RA type 3 provided (comment box)	–	–	**X**	6

Background questionnaire

To ensure equivalence between groups at baseline, one-way ANOVAs were performed on the three meta-cognitive skills questionnaires. They exhibited equivalence in the samples: MAAS: $F(4, 49) = 0.16$, $p = .95$, $\eta_p^2 = .13$, NFC: $F(4, 49) = 0.53$, $p = .70$, $\eta_p^2 = .0003$, MAI: $F(4, 49) = 0.65$, $p = .62$, $\eta_p^2 = .02$. The measures of initial self-reported familiarity with eLearning and self-reported knowledge of the domain also indicated comparable groups. Besides this even distribution, the background questionnaire revealed the high meta-cognitive agility of the sample. Only four volunteers with a lower profile enrolled in the experiment, allowing an enrichment of the observations by providing some contrast regarding usage and perceptions of the RAs (see section "Questioning learners").

Behavioural metrics

The processing of the logging data yielded the following observations:

- RAs were used as requested;
- RAs did not influence the time spent on the study phase, ANOVA: $F(4, 49) = 0.29$, $p = .87$, $\eta_p^2 = .02$;
- RAs did not impact the time spent on the test, ANOVA: $F(4, 49) = 0.31$, $p = .86$, $\eta_p^2 = .008$;
- loops between low self-ratings of mastery and further access to insufficiently mastered pages did not show up. The attention to learning brought by the RAs did not translate into tangible monitoring actions.

Feedback from learners (tackling main Research question 1)

Learners' perspective on RAs was collected in five dimensions: triggered reflection, contribution to learning, intention of reuse, appreciation and awareness of reflection affordances.

Perceived intensity of reflection

Calculations based on the "Reflective Thinking" Likert scale of the COLLES questionnaire revealed that relative frequencies for the items "I often reflect in this course" or "I almost always reflect in this course" were significantly lower in the control group than in the aggregated treatment groups, $\chi^2(4, N = 54) = 11.444$, $p = .022$. Separate chi-square tests confirmed significant differences with the control group for 3 treatment groups out of 4 (exception is group 5 – RA3 only), with regard to intensities of reflection.

Contribution to learning

In the post-questionnaire participants evaluated each RA they used (76 opinions, due to the provision of the three RAs in group 2) regarding contribution to learning. Results showed that 54% of the collected answers mentioned RAs as contributors to learning.

Intention of reuse

When asked whether they would make further use of the RAs in another learning context, 27% answered "yes", 28% "no" and 45% "it depends". Only RA 3 (comment box) obtained a clear "yes" answer (50%). RA1 (yardstick) received the lowest "yes" ratings (16%).

Pros and cons

The two corpuses of positive (83) and negative (80) comments on RAs (more than one comment per subject was allowed) were content analysed in order to obtain categories that systematically summarise and reflect the data (Table 4.2).

Table 4.2. Positive and negative learners' feedback on the RAs

Positive Answer category	Frequency	Negative Answer category	Frequency
RAs provide opportunities for comparison with others	24% (G3:91%)	Criticism on RAs' usability	28.5% (G4:52%)
RAs enhance reflection	20.5% (G4:66%)	Criticism on RAs' didactics	25%
RAs enhance monitoring	17%	Criticism on RAs' semantics	19%
RAs are usable	8%	RAs are compulsory	10% (G5:66%)
RAs make learning visible	6% (G5:76%)	RAs are useless	6%
RAs enhance attention	6%	RAs are distractors	4%
RAs enhance mental modelling of the learning situation	6%	RAs take time	4%
RAs are good for motivation	5%	RAs allow a shallow use	2.5%
RAs are good for personalisation	2.5%	RAs seem silly	1%
RAs are good for active commitment to the task	2.5%		
RAs are good for learning to learn	2.5%		
	100%		100%

Positive comments specified strong points of RAs (enhancement of reflection or monitoring, opportunities for comparison with others). The most often expressed criticism concerned usability aspects of the RAs (e.g., comment 30: "the comment box was hiding the text") or insufficient connection with instructional aspects (e.g., comment 58: "the action indicator doesn't really say anything about your real learning progress").

A look inside each category showed a few concentrations of comments. When one experimental group contributed for more than half of the comments in one category, it is indicated into brackets in Table 4.2. Despite the limited number of comments, at least in some categories, these percentages are given because they might prompt further inquiries about specific perceived effects of certain RAs.

Awareness of opportunities for reflection

Data relating to awareness of reflection affordances came from the request: "We offered, in this online course, opportunities for reflection. Give as many of them

you have noticed". Clearly, in treatment groups the awareness of available reflection opportunities was much higher: all treatment groups reported between 42 and 50% more of these than the control group. But not only the RAs were mentioned: participants also qualified of "opportunities for reflection" constitutive elements of the course like "examples in the material", "instructions before the start", "warning before taking the test", "text accessible".
The finding that reflection levers were not circumscribed to the RAs received a confirmation from the control group which, deprived of RAs, nevertheless pinpointed reflection opportunities in the course, though not to a large extent. In contrast, subjects in group 2 (all RAs condition) assimilated in a large proportion (70%) the opportunities for reflection to the offered RAs that seem, in this case, to give a face value to reflection.

Tests results (tackling main Research question b)

Despite mean scores looking substantially higher for the control group (Table 4.3), a one-way ANOVA communicated that differences were not significant, neither for the final test $F(4, 49) = 0.28$, $p = .89$, $\eta_p^2 = .02$, nor for the retention test, $F(4, 49) = 0.31$, $p = .86$, $\eta_p^2 = .11$.

Table 4.3. Results for the final test and for the retention test

Treatments	Mean Final test	SD Final test	Mean Retention test	SD Retention test	N
1	13.4	5	3.17	1.6	10
2	12.1	2.4	2.91	2.31	16
3	12.3	4.5	2.73	2.95	11
4	12	2.3	2.36	3.41	11
5	12.8	2.7	2.93	3.91	6

Discussion

Primary research questions

With regard to the first primary question – do RAs embedded in a study task engaged learners in active reflection? –, the large usage of the reflection affordances and the self-reported measures of claimed intensity of reflection point at a positive answer. However, the benefit of this reflective stimulation is not clear. One safe finding is that this benefit should not be looked for in the marks at the test: the mandatory use of compact and recurrent episodes of reflection have definitely not produced any significant effect on performance and retention (second primary research question). To evaluate this result, five different explanations are now suggested, that future research will help to disentangle.

Questioning RAs

One might propose: this kind of RA does not work. Compared to established techniques (portfolio, introspective dialogue, etc.) aiming to generate reflection on action, these featherweight techniques targeting reflection-in-action do not measure up. At best, the study results disqualify RAs as pointless, at worst as counterproductive to the performance.

Questioning learners

To preserve the RAs, it is possible to blame learners by claiming that they underestimated the amount of effort needed to properly apply the reflective introjections. The data suggests here possible nuances between high performers with a high level of prior meta-cognitive agility who discounted reflection affordances and low performers who seemed to overlook them and failed to connect them well to the tasks. The result would be in both cases a *diligent but shallow use of the RAs*, which would explain their lack of impact on performance. If confirmed, it might be said that RAs were not invested with enough reflective engagement. In this respect, the analysis of logs caused additional insight. It exhibited that RAs were not time-consuming. The qualitative data backed this observation: the time needed for reflection was seldom mentioned as a hindrance and the short time needed to enact reflection affordances may have accounted for their high level of use. But this possible strength may easily turn into a weakness since the impact of such quick insights could not be traced in students' mastery. (It can also be noticed that the comment box, viz. the most time-consuming RA when properly completed, was offered in the group where the highest level of drop-outs was observed).

Questioning the course

Hoffman and Spatariu (2008) suggest that amplifying reflection in non complex tasks is useless. In the present study however, the contents of the course were certainly not straightforward: the performance tests showed that none of the subjects achieved high levels of mastery.

The length of the course can also be questioned. Two hours may be too short for various types of RAs to produce any differentiated effect on performance (Papadopoulos, Demetriadis, Stamelos, & Tsoukalas, 2009; Van den Boom, Paas, Van Merriënboer, & Van Gog, 2004), and all the more so to suggest new reflective habits (Johnson & Sherlock, 2009).

Questioning the notion of performance

The current study confined the measure of the learning performance to domain-specific knowledge. An extended version of performance, including meta-learning achievements, might give a different picture of RAs. The qualitative data pointed in that direction: a majority of users perceived RAs as useful to reflection and learning. The influence of social desirability and Hawthorne effects might be suspected here. However, several qualitative questions converge

across groups to produce a rather neat contrast between positive subjective views on RAs and their absent or possibly adverse effect on performance. In sum, these reflective artefacts that had no impact on marks at the test were valued anyway, in relation to learning, by the largest part of the students (see similar discrepancies in Chiazzese et al., 2006 and in Thompson, 2009).

Questioning the setting

To explain why expected effects of RAs could not be traced in the students' mastery of the knowledge domain, some confounding conditions in the experimental setting may also be blamed, for instance the small size of the sample, and the absence of strict learning obligations. The enrolled voluntary learners were probably interested in reading through the course content but may have lacked the intrinsic motivation of wanting to achieve high tests scores on the topic, possibly through a thorough use of RAs. *When there is "enough learning" in the eye of a participant to an experiment remains an open question*.

(One month after the end of the survey, participants were asked in a follow-up questionnaire to select, among ten plausible reasons, the one which best explained the absence of positive effect of the RAs on the performance. The 35 received answers showed a broad dispersion among the explanations: (a) RAs offered episodes of reflection too small to be influential: 9%, (b) RAs were too repetitive and caused an over-prompting effect: 6%, (c) RAs were used superficially by participants: 11%, (d) RAs were useless for meta-cognitively agile participants: 3%, (e) RAs were useless for too easy task and content:11%, (f) RAs trained reflective habits impossible to install in a two-hour course: 17%, (g) RAs increased the cognitive load: 3%, (h) RAs created confusion in the course between a performance and a learning orientation: 11%, (i) RAs broke the learning flow: 23%, and (j) RAs trained skills that the test could not capture: 6%. The relative contribution of a single treatment group to any of these percentages never exceeded 40%).

Secondary research questions

The type and the number of offered RAs did not make any difference regarding performance and regarding the "reflective flavour" they instilled in the course. This suggests that if RAs were effective, then any RA would do.

Conclusion

How to encourage valuable reflection by learners, in a cost-effective manner, in the moment of learning? This study explored the provision of RAs as one possibility. This pilot study offers indications that: 1) in a quasi formal learning context, RAs were used as requested, 2) students of the experimental groups retrospectively reported a higher intensity of reflection (see a convergent observation

in Bannert, Hildebrand, and Mengelkamp, 2009, p. 832), 3) RAs did not enhance exam performance, 4) despite this lack of effect on performance, a fair proportion of participants qualified RAs as contributors to learning, 5) the use of RAs did not significantly extend the time spent on the course, 6) RAs instilled a higher awareness of the reflective approach applied to the course, irrespective of the type and the number of available RAs.

At this point of the inquiry, it remains uneasy to provide sound principles regarding RAs. Practitioners who would consider using such reflection affordances in a formal learning activity system should first evaluate against their audience and learning goals the relevance of giving a face value to reflection instead of assuming that this reflection will occur.

Overall, the findings of this study need to be considered with caution due to the small size of the sample. For a pilot research, observations and outcomes are nevertheless useful to inform the design of full-fledged experiments that employ larger samples and refined methodologies.

Chapter 5

Study 4 (prime): Annotations as reflection amplifiers in formal online learning

Chapter 5
Annotations as reflection amplifiers

Abstract

In a controlled experiment on the effects of frequent and local digital annotations, 137 volunteers covered a course at three conditions: no/free/structured electronic annotations. While results show no difference in performance between the conditions, analyses conducted within treatments exhibit a positive impact of different combinations of reflective actions upon achievement. This effect has however a limit, as suggested by observations related to learning efficiency. On the qualitative side, a cluster analysis processed the descriptions of the learning experience produced by participants. When related to a model of self-regulated learning, the results offer partial evidence that the insertion of frequent opportunities to reflect on the course material induces a higher awareness to own learning dynamics.

This chapter is based on: Verpoorten, D., Westera, W., Glahn, C., & Specht, M. (2012a). Annotations as reflection amplifiers in online learning. Manuscript submitted for publication.

"Deep learners know how to create knowledge; they are reflective about what they learn and how they learn. Deep learning involves the movement into meta-cognition which is the essence of personalisation: the learner understands him/herself as a learner." (West-Burnham & Coates, 2005, p. 37)

Note-taking, either when listening to lectures or reading texts, is a "totem" of teaching and learning. It seems that for centuries tutors have been expecting that students do take notes and that tutees consider note-taking as a natural activity in a scholarly life (Jackson, 2001). An annotation is conceived as a personal trace left by students on a pre-existing text or speech. Annotations record readers' efforts to shape their interaction with this content. Research on note-taking has generated debates since Crawford's early studies in this topic (1925). Promoting annotation behaviours has been a long-lasting concern in distance education. From its beginning, and long before the possibility to think about students in terms of "reflective practitioners" (Schön, 1983), it has been constantly recommended to design paper-based course material with large margins. This liberal use of white space (Open University, 1994; Commonwealth, 2005) is meant to encourage students to make analytical summary notes of what they would identify as worthy of their attention when they revise. In the 90's, a vast body of research (Dillon, 1992) discussed the many issues when moving annotation from paper-based to screen display reading. In the past few years, a renewed interest emerged for the processes of "writing on the reading" in digital activity systems, due to the novel burgeoning opportunities for searching, sharing, indexing, ordering, rating annotations in an "information enrichment" perspective (Pirolli, 2007).

Past and recent research on annotations

While the effects of note-taking are well documented for paper-based practice (Boch & Piolat, 2005; Hartley & Davies, 1978; Slotte & Lonka, 1999, 2003), the new wave of research on digital annotations develops concerns in several directions: non linear or linear annotation techniques (Makany, Kemp, & Dror, 2009), spontaneous or structured use of annotations (this chapter), annotation sharing mechanisms (Van der Baaren, Schuwer, Kirschner, & Hendriks, 2008), collaborative annotation (Kam et al., 2005; Su, Yang, Hwang, & Zhang, 2010), tagging as annotations (Glahn, 2009; Verpoorten, Glahn, Chatti, Westera, & Specht, 2011), multiple displays for annotations (Schilit, Golovchinsky, & Price, 1998). Results reveal various conditions under which Web-based annotation mechanisms are beneficial (Kawase, Papadakis, Herder, & Nejdl, NA).
Beyond their variety, the new alleys of research (for an extended view on recent work, see Hwang and Hsu, 2011) endorse to a large extent (Glover, Xu, &

Hardaker, 2007) the two faces of note-taking already identified by Hartley and Davies (1978):

- as a process, annotations help to maintain attention, apprehend the material in a mentally active way and intensify the attendance to the task. By assisting in keeping learning going, they can be tokens of reflective engagement during the study task;
- as a product, annotations are stored for the future, with possibilities to be reviewed, re-structured, and enriched.

Boch and Piolat (2005) use a similar distinction but labelled differently: "notes to aid reflection" (process) versus "notes to record information" (product).

Reflection amplifiers

In this study, the annotations are conceived as "reflection amplifiers". Following the definition by Verpoorten, Westera, and Specht (2011b), reflection amplifiers (*RAs*) refer to deliberate prompting approaches that offer learners structured opportunities to examine and evaluate their own learning. Whereas the promotion of reflection is often associated with post-practice methods of experience recapture (Boud, Keogh, & Walker, 1985) through portfolios or learning diaries, RAs are nested in the study material and offered to individuals during learning activities. They induce regular mental tingling for evaluating own learning and nurturing internal feedback (Butler & Winne, 1995).

The concise reflection they call for further characterises RAs. As support to condensed reflective processes, RAs operate though miniature Web applications (sometimes called "widgets") performing a single task, displaying a very clear and appropriate graphical style, and providing a single interaction point for direct provision of a given kind of data (Verpoorten, Westera, & Specht, 2011a), here the personal annotations. In the way they are used in this study, the annotations meet the common internal characteristics of RAs: brevity, frequency and crisscrossing with the first-order reading activity. They promote analytical scrutiny and individual reframing of the learning material's meaning. Annotations are purposed to strip away and only focus on the heart of the content in an effort to capture within the study task the gist of what has been read.

Hypotheses

In a comparative study an online course was delivered at three conditions: without annotation tool, with annotation tool and free-style notes, with annotation tool and structured notes. The study investigated the effects of the digital annotations – conceived as multiple short episodes of analytical reflection – upon the enhancement of the quality of learning and the promotion of meta-cognition. Two main and two secondary hypotheses guided the experiment.

Hypothesis 1 (main)

"The availability of an annotation tool and the assignment to use it for frequent and local notes reflects in higher marks at the test and in an increased study time".
Short but repeated efforts of reflection are predicted beneficial to the content internalization because they are seen as a way to stay analytically engaged with the supplied learning material. It is also speculated that such a reflective approach to learning has a price with regard to time spent on the material, a price hopefully compensated by a better learning success.

Hypothesis 2 (secondary)

"The best predictor of learning performance is not the annotation behaviour alone but a compound of reflective enactments while studying".
This hypothesis questions the location of the annotation activity within *larger patterns of reflective commitment to study and knowledge*.

Hypothesis 3 (secondary)

"The structured annotation strategy induces higher marks at the test than the spontaneous way of annotating".
The study includes a concern for annotation methods by challenging conventional practice of note-taking "as a student" with a different mode wherein the learner is invited to reflect "as an instructor" (details in section "The annotation methods").

Hypothesis 4 (main)

"The provision of compact, structured and repeated opportunities for reflection – here the frequent annotations – induces a different type of description of the learning experience in the treatment groups".
It is conjectured that the intentional activation of reflection throughout the study helps students to make their learning an object of attention and instils a different flavour in the account of what they have lived as learners.

Method

Independent variables

The intervention variables were the provision of an embedded annotation tool and the exposure to a strategy for frequent local annotations.

Dependant variable

The dependent variable was the *subjects' reflective engagement with the content, broken down into seven tangible indices*:

- **Index 1**: mark at the final test (FinalTest). This index designated the score obtained at the final test taken after the study session. It measured learners' achievement through 16 multiple-choice questions assessing knowledge and comprehension;
- **Index 2**: time spent in the course (TimeSpent). This index, measured as the number of "active ten-minute periods" in the course, was an estimation. One active period was counted each time that at least one click occurred in a time span of ten min. Longer periods were left out in an attempt to correct for the time students would spend in activities foreign to the study while still being logged into the course;
- **Index 3**: learning efficiency (LearnEff). It is fair to say that the speed of learning is an important achievement (many performance tests, e.g. IQ tests, use time as one of the main indicators). In order to incorporate this temporal dimension in the measures, the marks at the final test were related to the time spent in the course: slow learners got a lower score per unit of time than fast learners. Low-efficiency students did not necessarily receive lower marks, but they needed more time to reach their mark;
- **Index 4**: number of page views (NumberPages). The browsing behaviour, and in this case the action of re-visiting pages, was considered as an index of reflective engagement because it assumed a meta-learning decision about the need of re-reading the material;
- **Index 5**: quantity of annotations (NumberAnnot). Separate annotations were counted. The study neglected the quality of the notes, because it was impossible to know, from the content of an annotation, the cognitive context that the learner had wrapped around;
- **Index 6**: total number of characters for the annotations (CharactInAnnot);
- **Index 7**: number of visits (VisitDash) to the Learning Dashboard (see section "Apparatus").

The indices FinalTest, TimeSpent, LearnEff, and NumberPages were common to the three conditions. NumberAnnot, CharactInAnnot, and VisitDash were premised upon the annotation tool, only offered in Condition 2 and 3.

A post test questionnaire allowed measuring the effects of the intervention on the following additional variables: satisfaction towards the course, sense of control, perceived intensity of reflection and description of the learning experience.

Apparatus

The online course

The learning material of the experiment was the four-hour online course "Seks en de evolutie" (Sex and the evolution), a course signed (Eshuis & Goltstein, 2007) and offered in Dutch by the Open Universiteit on the eLearning platform Moodle. It was made of 30 well illustrated pages (Fig. 5.1) of about 800 words each, and four interactive animations. It covered quite complex and interrelated notions as defined by Darwin and his followers: mutation, natural selection, genetic drift, gene flow, survival of the fittest, etc. On the whole, the course gave an in-depth account about the evolutionary theory and invited learners to use it as an interpretation grid of gender-related behaviours observable in everyday life. In the three conditions, the course was identical, introduced by a welcome video, and closed with the same multiple-question test.

The tool

The digital annotation tool was a comment box displayed on each page (Fig.5.1). It kept record of all annotations produced by the learner on this very page. The annotation tool unfolded through a click by the learner. Consistently with the length of the reading material and the action requested from learners (frequent but short notes), the surface of the tool was intentionally not large and its function deliberately restrained to the basic typing.

Figure 5.1. The annotation in its local context of a standard Web page of the course.

In order to prevent effects of fragmentation and to support the function of "annotations as products", all local annotations were in addition recorded on a sin-

gle page called "Learning Dashboard" (Fig. 5.2), accessible at any time by the student. On this dashboard, the annotations were organised by section of the course content.

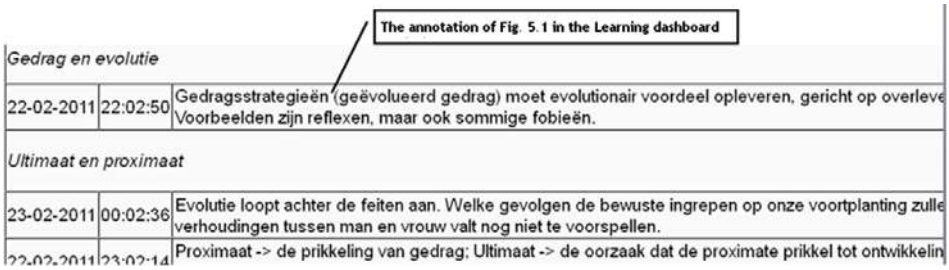

Figure 5.2. All annotations were displayed within a learning dashboard.

The annotation methods

Subjects in the treatment groups were asked to make an annotation each time they (re-)visited a page. However, participants in one treatment could encode their annotations in the way they preferred (free annotations) while those in the other treatment were requested to produce annotations as questions (structured annotations). Precisely, these participants were asked to put themselves in the shoes of the teacher and to craft questions likely to be used in a final test about the content of the page at hand. In their inventory of reflective techniques, Verpoorten et al. (2011b) labelled this reflective strategy: "Students set the test", and described it as: "Learners are asked to make up the questions they might get for their exam".

Sample and schedule

Invitations to participate to the experiment were displayed on electronic and paper communication channels of the Open University in the Netherlands, including the homepage of the used course. Dutch dailies and magazines, as well as a psychology popular publication, also received announcements of the study. The registered persons were randomly distributed over the three conditions and received credentials for one version of the online course. They had one month to fill in a background questionnaire (15 min), cover the course (4 hr), take the final test (15 min) and answer the evaluation questionnaire (20 min). Out of the 361 initial respondents, 282 entered the course at the very least once but only 137 completed all steps of the study. They composed the final sample: 34 participants in Condition 1 (control group), 54 in Condition 2 (free annotations) and 49 in Condition 3 (annotations as questions). As a reward for their cooperation, they received either an iTunes voucher of 10 euros, or a three-month premium access to a mind-mapping tool (http://www.mindmeister.com), or a USB stick containing applications dedicated to eLearning (http://eduapps.org), or a free entrance to a workshop organised by the Open Universiteit.

Quantitative results

An alpha level of .05 was used for all statistical tests.

Measures between groups

Background questionnaire

To ensure equivalence between treatments, statistical tests were performed on the data collected in the background questionnaire. (To prevent a "drowning by numbers" effect on the reader, while keeping an insight, the descriptive statistics following tests' results are given into brackets for the whole sample only, $N = 137$). The procedure exhibited an even distribution in the three conditions for:

- meta-cognitive capacities, measured with a shortened version (Bijker, Van der Klink, Boshuizen, 2010) of the Meta-cognitive Awareness Inventory (Schraw & Dennison, 1994), $F(2, 134) = .27$, $p = .76$, $\eta_p^2 = .004$ ($X = 81$, $SD = 18$);
- self-reported familiarity with the topic, measured with a 3-point Likert scale, $\chi^2(2, N = 137) = .36$, $p = .83$ ($Mdn = 2$);
- self-reported familiarity with eLearning, measured with a 3-point Likert scale, $\chi^2(2, N = 137) = 3.94$, $p = .13$ ($Mdn = 2$);
- demographics: age $F(2, 134) = .4$, $p = .92$, $\eta_p^2 = .07$ ($X = 39$, $SD = 11$), sex $\chi^2(2) = .73$, $p = .69$ (56% female, 44% male), and education level $\chi^2(2, N = 137) = 4.8$, $p = .09$ (75% of the sample ticked the category "Higher education").

Indices FinalTest, TimeSpent, LearnEff, and NumberPages

An ANOVA procedure (Table 5.1) exhibited no significant difference between conditions regarding mean marks obtained at the final test, $F(2, 134) = .44$, $p = .64$, $\eta_p^2 = .007$. Significant differences emerged between conditions with regard to the:

- total time spent on the course, $F(2, 134) = 3.49$, $p = .03$, $\eta_p^2 = .05$;
- number of page views, $F(2, 134) = 5.29$, $p = .006$, $\eta_p^2 = .07$;
- learning efficiency (mark at the test/time spent in the course), $F(2, 134) = 4.76$, $p = .01$, $\eta_p^2 = .01$.

Table 5.1. Mean and standard deviation for the indices common to the three conditions

	Mark at the test			Total time spent on course (in minutes)			Page views			Learning efficiency		
	1 (*N*=34)	2 (*N*=54)	3 (*N*=49)	1	2	3	1	2	3	1	2	3
M	6.4	6	6.4	250	320	330	57	73	84	0.032	0.024	0.022
SD	2.3	1.7	1.8	120	110	110	23	36	44	0.018	0.014	0.012

Additional contrast tests disclosed that the differences were significant only against the control group and not between the treatments. This lack of observable divergence made it reasonable and beneficial to statistical power and clarity to redefine the treatment conditions as one single group (N = 103) for the following analyses.

Within-treatment measures relating to learning *effectiveness*

Amount of reflective enactments and mark at the test

No correlation was found between the mark at the test and the absolute number of annotations (Index 5), characters (Index 6), page views (Index 4) and dashboard views (Index 7). However, a post-hoc split between (a) students who took less annotations than the average, and (b) students who took more annotations than the average indicated that marks were significantly higher for the latter: M = 6.6, SD = 1.7 versus M = 5.8, SD = 1.8, $t(101) = 2.32$, $p = .02$, $d = 0.45$.

Rate of reflective enactments and mark at the test

Beyond the mere amount of reflective actions (NumberAnnot, CharactInAnnot, NumberPages, Dashvisits), *the rates at which these enactments occur while studying might be an important aspect of the meta-cognitive activity*. For this reason, "reflection rates" were calculated to express the displayed reflection per unit of time (minute) for different indices. These rates were obtained for each individual by dividing the quantity of reflective enactments (the different indices) by the individual time spent in the course (Index: TimeSpent). Based on these ratios, post-hoc splits were applied: subjects were classified against the mean of the group as either high/low annotators (HA/LA via Index 5), high/low producers of annotation characters (HC/LC via Index 6), high/low browsers (HB/LB via Index 4) and high/low visitors of the learning dashboard (HD/LD via Index 7). Table 5.2 shows the distributions resulting from the post-hoc split taking, for each considered index, the mean rate of the group as a cut point.

Table 5.2. Sample distribution after the post-hoc split based on the reflective enactments rates

Mean rates	% of learners below mean rate	% of learners above mean rate
Annotation (.13)	57 % (LA)	43 % (HA)
Character rate (15)	59 % (LC)	41 % (HC)
Browsing (.26)	51 % (LB)	49 % (HB)
Dashboard (.009)	69 % (LD)	31 % (HD)

For instance, participant 45 took 87 annotations (against an average 43 for the whole group), produced 13958 characters (against an average 4792), visited a content page 56 times (against an average 78), and paid 2 visits to the dashboard (against an average 3). According to the ratios obtained by dividing these indi-

ces by the study time (410 minutes for participant 45 against an average 328 minutes), participant 45 was labelled: HAHCLBLD (High Annotator – High producer of Characters – Low Browser – Low Dashboarder). It was assumed that this fourfold "learning DNA" captured different facets of the participant's reflective engagement with the learning material. Assigning such a *multivariate reflective engagement profile* to the 103 participants revealed some new insights.

Isolated/combined reflection rates and mark at the test

When taken separately, the rates of annotation, character, page view and dashboard view delivered negligible correlations with the marks at the test. In contrast, observations on combined rates, for instance HA+HB (high annotation rate + high browsing rate) versus HA+LB (high annotation rate + low browsing rate) exhibited significant differences, $F(3, 99) = 3.19$, $p = .027$, $\eta p^2 = .088$. Table 5.3 shows the data for the significant cases. This significance pattern was found the same with regard to the number of characters produced per unit of time (LC/HC). Two-marker combinations of rates including the dashboard usage did not deliver significant results.

Table 5.3. Marks for two-marker profiles

Engagement profiles	Mean mark at the test	SD	N
HA+HB	7.1	1.6	23
HA+LB	6	1.7	21
LA+HB	5.6	1.9	29
LA+LB	5.9	1.6	30

The attempts made with a profile combining three reflection rates gave a significant mark advantage ($M = 7.8$, $SD = 1$) to the most reflective profile (HA+HB+HD) onto all other combinations ($M = 6$, $SD = 1.7$). However, the creation of such additional combinations induced more numerous groups and quickly created a problem of statistical power that led to stop the investigation of longer profiles.

Within-treatment measures relating to learning *efficiency*

This section analyses the links between the indices (amounts and rates) and learning efficiency (ratio between the mark obtained at test and the study time).

Amount of reflective enactments

Negative correlations surfaced between LearnEff and NumberAnnot, $r(103) = -.31$, $p = .001$, CharactInAnnot, $r(103) = -.35$, $p < .001$, NumberPages, $r(103) = -.51$, $p < .001$ and DashVisit, $r(103) = -.29$, $p = .003$, that is all reflection-related behaviours.

Rate of reflective enactments

A correlation emerged regarding the annotation rate and the learning efficiency (LearnEff). In order to sharpen this initial result, participants were grouped along intervals of .005 on a learning efficiency continuum. The mean annotation rate was calculated for each interval group. The reversed U-shape of Fig. 5.3 indicated *low annotation rates for both low efficiency and high efficiency groups*, R^2 = .734, exhuming an optimum for the note-taking activity.

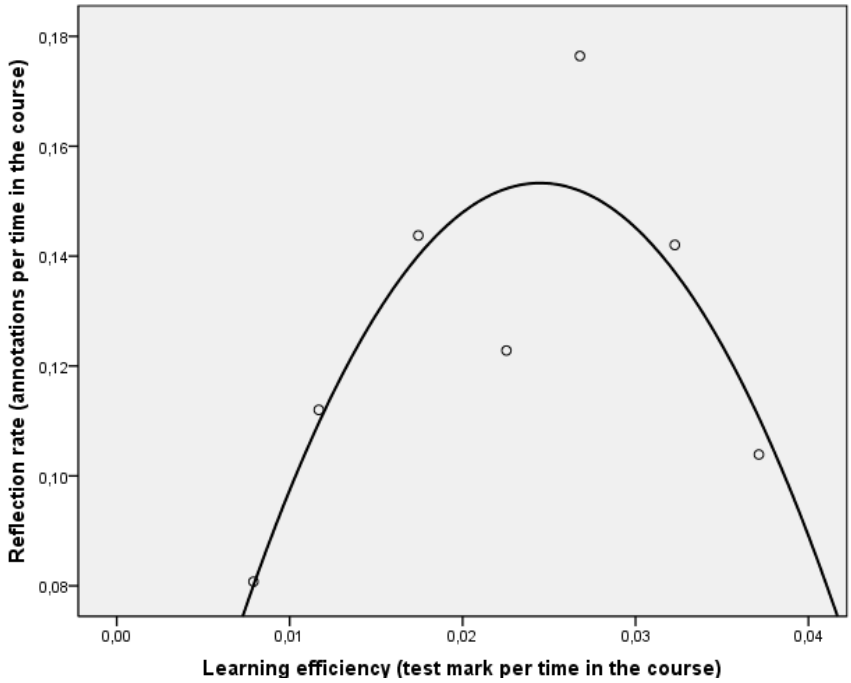

Figure 5.3. Mean annotation rate for seven distinct learning efficiency groups.

Replacing annotation rates with the character rates gave a similar shape but with a weaker goodness of fit, R^2 = .25. The rates related to the page views and the dashboard visits were also ill-fitted.

Qualitative results

The explored qualitative aspects - overall satisfaction, sense of control, perceived intensity of reflection, - were self-reported on 5-point Likert scales in the evaluation questionnaire.

Overall satisfaction

No convincing correlation was found between the groups of high and low annotators (HA/LA) and the satisfaction level. However, the analyses following a post-hoc split between unsatisfied participants (rating 1, 2 and 3 on the Likert scale, 26% of the sample) and satisfied participants (rating 4 and 5 on the Likert scale, 74% of the sample) detected a higher perceived intensity of reflection, $U = 724$, $p = .02$, $r = 05$, for the satisfied participants, $Mdn = 3$ versus $Mdn = 2$.

Sense of control

Mann-Whitney test on the sense of control of the high versus low annotation rates (HA/LA) did not disclose significant differences, $U = 1225$, $p = .61$, $r = .4$. But when the browsing rate was added in the profile, the highly engaged people (HA+HB) reported a significantly higher level of control ($Mdn = 4$) compared to HA+LB ($Mdn = 3$), LA+HB ($Mdn = 3$), LA+LB ($Mdn = 3$), $\chi^2(3, N = 103) = 7.69$, $p = .04$.

Stimulation of reflection by the annotation process

When asked about the effect of taking frequent annotations, 71.2% of the sample answered that reflection increased, 24.6% that it was not influenced and 4.2% that it diminished.

Extra annotations

In the control group, 70.6% of participants reported annotation-making on paper or on their computer. In groups 2 and 3, respectively 22.2 % and 26.5 % claimed to have taken extra paper-based annotations.

Cluster analysis

No difference in marks at the test was found between the control group and the participants equipped with an annotation tool (see section “Measures between groups”). But what about meta-cognitive benefits? In order to tackle this dimension and to test Hypothesis 4, five independent experts, specialised in self-regulated learning and reflection-related issues, categorised, in an online card sorting tool (www.websort.net), the 137 participants’ descriptions of learning experience, broken down into 257 units of meaning. The experts freely categorised these items by creating as many groups as they liked. Each item ought to be placed in one category only and each category was to contain units that were similar in meaning to each other. The experts returned 50 categories in total.
In order to spot convergences and to identify a reasonable and manageable number of clusters, they were submitted to an average linkage cluster analysis algorithm (Börner, Glahn, Stoyanov, Kalz, & Specht, 2010) which performed a

clustering based on the average distance between all pairs of objects (one member of the pair ought to be from a different cluster). Eight clusters emerged from this process (Table 5.4).
In a search for increased parsimony, the eight clusters were related to three components of the Butler and Winne's model of cognitive system in self-regulated learning (1995): Knowledge and beliefs (Clusters 1, 2, and 3, light grey in Table 5.4), Tactics and strategies (Cluster 4, 5, and 6, medium grey) and Products (Cluster 7 and 8, dark grey).

Table 5.4. Distribution of the learning experience descriptions in the eight clusters emerging from an expert mapping procedure and relations of these clusters to the Butler and Winne's model (arrows on the right)

Cluster	% of descriptions	Dominant theme of the learning experience description	
1	22%	Opinion about course components (structure, content, navigation, test) with reference to prior learning experience.	Knowledge and Beliefs
2	15%	Opinion about the visual illustrations of the course.	
3	3%	Opinion about the difficulty level of the course.	
4	17%	Application of personal study strategies in the course	Tactics And Strategies
5	13%	Application of the strategy "Students set the test"	
6	4%	Evaluation of own learning activity in the course against the score at the test.	
7	19%	Expression of satisfaction about the course completion	Products
8	7%	Expression of satisfaction about what has been learnt	

A chi-square test revealed that the descriptions stemming from the control group fed very significantly more the category "Knowledge and beliefs" while the students having used the annotation tool tended to provide accounts focused on "Tactics and strategies" and "Products", $\chi^2(2, N = 137) = 21.712$, $p < .001$.

Discussion

The goal of this study was to ascertain whether frequent and local digital annotations used as RAs during the study: (a) could be beneficial to the learning performance without extending time on task (Hypothesis 1), (b) would influence the mark on its own or in association with other reflective enactments (Hypothesis 2), (c) would yield contrasted results depending upon the use of a free

or a structured note-taking technique (Hypothesis 3), and (d) would induce a different narrative tone to the account of the learning experience (Hypothesis 4).

The *first hypothesis* is not confirmed: RAs do expand time on task without delivering benefit for learning achievement: the control group gets the same mark while using less time. From a strict performance-oriented viewpoint, frequent and local annotations are counter-productive. These results should however be nuanced by the analyses carried out within the treatment group. When applied to the 103 participants making use of the annotation tool, performance-related analyses show a somewhat differentiated picture, as recapped in Table 5.5. This helps contextualising note-taking practice. Again, to interpret Table 5.5, the difference between the absolute amount of annotation and the annotation rate must be kept in mind, along with the difference between learning efficacy and efficiency.

Table 5.5. Annotation behaviour matrix (treatment group)

Annotations	Learning efficacy (mark at the test)	Learning efficiency (speed of learning)
Amount	A. Positive effect if above average	B. Adverse effects
Rate	C. Positive effect only in combination with other reflective enactment rates	D. Optimum

Cell A: it is legitimate to encourage online learners not to spare their annotating of the learning material: subjects who made more digital annotations than the average number tended to score better at the test (section "Amount of reflective enactments and mark at the test").
Cell B: despite the benefits it brings, an above-average quantity of annotations is performed at a price: a lower learning efficiency. It is observed a first time in the comparison with the control group (see section "Indices FinalTest, TimeSpent, LearnEff, and NumberPages") and confirmed by analysis within the treatment group (see section "Amount of reflective enactments").
Cell C: the reflection rates provide insights about the way learners balance the primary activity (studying the course) and the secondary reflective activities (annotations, page re-visits, dashboard views). Here, students who write more annotations per unit of time than the average do not get a higher mark. However, combinations of this reflection rate with other reflective enactments (page views, dashboard views) have a significant positive impact on the mark at the test. *Students who interlace the first-order learning activity with repeated reflective activities perform better than those who practise this crisscrossing at a lower rate. Hypothesis 2* is confirmed: only a compound of reflective activities can make a difference with regard to performance.
(The qualitative data also seems influenced by combined reflective rates: a significant effect on student's sense of control is obtained only from blended reflective enactments (see section "Control"). On this basis, it can be advanced

that the dynamics of reflective commitment to a study task encompasses and interweaves several reflective enactments performed at a certain rhythm).
Cell D: raising the annotation rate can serve learning efficiency till a certain point where it starts conflicting with it. The curve in Fig. 5.3 suggests that suboptimal students suffer from a certain reflective passivity that might be counteracted by inviting them to accelerate the frequency of their reflective enactments on the material. At the other end, highly efficient students make a reduced use of the annotation tool since they may have developed their own reflection routines or because at a certain point the type of reflection practised through the annotations gives precedence to other forms of reflection.
As for *Hypothesis 3*, it is not confirmed: students confronted to a structured annotation strategy do not outperform their peers who use annotations as they wish. Two explanations can be put forward for this lack of difference. It is possible that free notes and structured notes conveyed onto the learning material the same analytical scrutiny, leading to similar effects. It can also be that the students did not practise correctly a structured annotation technique they were not familiar with. All things considered, the annotation strategy "Students set the test" was aligned with Hattie's meta-analyses whose superseding conclusion is that the most powerful cognitive and meta-cognitive effects on learning are induced when learners see themselves as their own teachers (2009, p. 238, Fig. II.I). The lack of effect of an exercise entirely oriented in this direction underlines the difficulty to materialise Hattie's reversed way of learning and the effort of reflection it entails.
With regard to *Hypothesis 4*, the cluster analysis brings evidence that a deliberate effort to intertwine study practice with structured reflective activities can change the focus of the accounts of learning experience, raising the chance that students take their own learning dynamics as an object of attention (Watkins, 2001) and balance content and process aspects in these descriptions (Verpoorten, Glahn, Chatti, Westera, & Specht, 2011, p. 279).

Recommendations for future research

Four main issues raised in this study call for further research.

a) Although performance tests are not the only way to measure learning, it remains a legitimate and largely-practised way to assess mastery of course content. In this perspective, final scores should reasonably be expected to reflect benefits resulting from the RAs. It has not happened here, at least in comparison with the control group. This lack of benefits from note-taking contrasts with other studies in the field (Hwang, Wang, & Sharples, 2007; Nokelainen, Miettinen, Kurhila, Floréen, & Tirri, 2005). Further empirical studies can help to sort out what the effects of annotations "ought to be" from what they actually accomplish, and most importantly, in what instructional context.

b) Besides considerations tied to exam improvement, the functional complexity of note-taking deserves further investigation. For instance, consolidation of results is needed regarding how embedded, frequent and structured stop-and-think beacons, like the annotations, influence the perception of the learning experience (sense of control, feeling of learning, narrative account). More research needs to be undertaken to see if such prompts for reflective appraisal of the study material can be related to ownership of learning and sharper feelings of personalisation. In such an approach, personalised learning might be seen as a consequence of acting and reflecting and not as the result of a decision taken by an external agent like a teacher or an adaptive system (Verpoorten, 2009; Verpoorten, Glahn, Kravcik, Ternier, & Specht, 2009).

c) On a more fundamental level, the study findings, and especially those related to the effects of combined reflective enactment rates (annotations, revision of annotations, page re-visits), highlight the intellectual dynamics at work in deep approach of study material. Similarly, when they recommend to teachers to consider incorporating various *explicit and convergent activities* (making annotations, reviewing them) that can foster meta-cognitive development into the learning process, Hwang, Chen, Shadiev, and Li (2011) also hit the interplay of several reflective behaviours. Further work is required to establish whether it could be a characteristic of high achievers and a hallmark of intellectual life in general to operate an "active study", defined as an ongoing crisscrossing, a periodic and persistent to-and-fro mental move, between a primary learning activity and secondary reflective or meta-cognitive enactments. Research in self-regulated learning points in that direction by underlining the mastery of meta-cognitive activities by high performing students. However, practical ways to evidence and sustain this interplay between cognitive and meta-cognitive landscapes must also be envisaged from an instructional design viewpoint.

d) In this study, the relationship between the average mark at the test and the annotation activity greatly varies according to how the note-taking activity is contextualised. When the mere fact of taking frequent notes is considered, the mean score at the test for the note-takers is between 6 and 6.4 (see Table 5.1). When this amount of annotation is related to the group average (contextualisation 1), the mean score for the above average note-takers is 6.6 (see section "Amount of reflective enactments and mark at the test"). When the annotation rate is linked to the browsing rate, the mean score jumps at 7.1 (contextualisation 2. See the section "Isolated/combined reflection rates and mark at the test"). When the annotation rate is coupled with the browsing and the visit to the dashboard rates (contextualisation 3), the mean score can achieve 7.8 (same section). An important issue for future research on annotations is also tied to the selection of relevant evaluation approaches.

Conclusion

A growing literature extols the importance to instil reflection and deep approaches to learning in tuition. However, practical and systematic ways to operate are not conspicuous, at least when it comes to reflection in methods of learning considered as traditional or transmissive (Terhart, 2003), in contrast to constructivist methods (problem-based learning, collaborative learning) wherein reflection is claimed to be "built-in" (Hmelo-Silver, Duncan, & Chinn, 2007; Kirschner, Sweller, & Clark, 2006; Sweller, Kirschner, & Clark, 2007). This chapter inquired the question: how to induce a more thoughtful autonomous study of learning material? To answer, the experimental setting artificially increased the number of annotations, conceptualised as frequent tinglings for reflection while reading and purposed to support a persistent dynamic mental engagement with the reading material. An assumption guided this work: that such a kind of active and reflective posture to learning, which constantly articulates the cognitive and the meta-cognitive landscapes, is a key feature of intellectual life. The experimental setting presented here was a simplified attempt to mimic and externalize such fundamental inner dynamic processes via an annotation tool. Eventually, annotations taken alone did not really measure up. However, their combination to other forms of engagement with the material provided evidence that the insertion of affordances to amplify reflection is worth considering in connection with cognitive and meta-cognitive learning benefits.

Chapter 6

Study 5 (collateral): Reflection-in-action prompts – A systematic literature review

Chapter 6
Reflection amplifiers – A systematic research review

Abstract

This chapter presents a systematic review of the research conducted in the field of reflection prompts in technology-enhanced learning. The review ultimately leads to the identification of 29 empirical experiments whose main concern is to infuse reflection-in-action affordances within a primary learning task. This state-of-the-art report inspects the theoretical background backing up the reflection prompts, exhibits their instructional settings, categorises their interaction patterns and modalities, synthesises their effects and analyses their technological foundations. Drawing on the review's findings, directions for future work are documented.

This chapter is based on: Verpoorten, D., Westera, W., & Specht, M. (2012c). Reflection amplifiers in technology-enhanced learning – A systematic research review. Manuscript submitted for publication.

"It requires gentle but firm direction to transform personal reflection into academic outputs." (Fielden, 2005, p. 469)

This chapter presents a systematic literature review on reflection in Technology-Enhanced Learning (TEL). This effort is relevant because reflection is generally assumed to be among the strongest influential factors of learning. The lens of the review is put on reflection-in-action prompts because, in contrast with techniques stimulating after-the-fact contemplation of learning situations (e.g., portfolios), they have so far received limited attention from researchers and practitioners.

Definitional issues

Reflection

For common sense, reflection lies somewhere around the notion of learning and thinking. People learn as a result of reflecting. Reflection is practised in order to consider an object in more details (Amulya, 2004; Higgins, 2011; Moon, 2001, 2004). Reflection points at a typically human negotiation process between the self and the experience of the world. It is not just an "add-on" to academic learning, but an essential component of a deeper approach to learning (Marton, Dall'Alba, & Beaty, 1993). Reflection is a term often used in education and which is difficult to deny any legitimacy to. References to a self-reflective consciousness can be traced as far back as Socrates' "inner voice".

The idea of a self-reflective mind has been given a new impetus in two different fields almost at the same time. In educational psychology, Flavell (1979) attempts to generate a formal model of meta-cognition while Schön (1983) grants to reflection a major importance in his effort to elucidate the inner working of professional practice and learning organisations.

The proximity of the notions of meta-cognition and reflection is not only temporal, it is also conceptual and the constructs are strongly interwoven, if not overlapping or interchangeable (Georghiades, 2004; Scharp, 2008). Aware of this closeness, this review includes studies on prompts for both meta-cognition and reflection while learning.

In contrast, it does not include in its main records database notions definitely akin to reflection but whose consideration would put its manageability at risk regarding time, resources and conceptual parsimony: learning to learn (e.g., Hoskins & Fredriksson, 2008), learning about learning (e.g., Watkins, 2001), learning skills (e.g., Hattie, Biggs, Purdie, 1996), and self-regulated learning (e.g., Narciss, Proske, & Koerndle, 2007).

Reflection-on-action prompts

There are a number of methods that are held to encourage reflection. These include learning diaries (Shiel & Jones, 2003), portfolios (Wilson-Medhurst & Turner, 2010), discussions of learning strategies (Hatton & Smith, 1995), use of video and observers in a learning context (Tatar, Chachra, Zastavker, & Stolk, 2010), etc. These highly valuable approaches address post-practice reflection or what Schön (1983) refers to as "reflection on action", that is a thinking episode taking place after the event and re-evaluating it so as to gain insight for improvement in the future.

In the '90s, a large and consistent body of literature settled around the portfolio, which was hauled up as the hallmark and the major lever of reflection defined as a return to experience (Boud, Keogh, & Walker, 1985). *In contrast, no equivalent emblematic tool has emerged with regard to the training of the other type of reflection discerned by Schön: reflection-in-action*, that is thinking episodes occurring in the midst of doing. Research on ways to infuse reflection in the course of a learning action remains scanty and scattered.

Reflection amplifiers

Reflection-in-action prompts are referred to with different designations in the literature. For consistency and readability reasons, the state-of-the-art report offered in this chapter subsumes the different appellations[3] under the overarching label of "reflection amplifiers", following a terminology suggested and illustrated by Verpoorten, Westera, and Specht (2011b).

Reflection amplifiers (*RAs*) point at artefacts that signal a subject to enact a process of reflection which can (or not) be somehow materialised by a specific action (an annotation, a rating, a click, etc.). Unlike experience recapture techniques, RAs are nested in the study material and offered to individuals during learning activities. In the temporal flow of learning, their contiguity to student's doings commits them to reflection-in-action more than to reflection on action, though Schön's (1983) distinction is relative: even a reflection that takes place "in-action" bears on a pre-existing context. But in the case of a RA the interval is supposed to be a matter of seconds or minutes rather than hours. A typical feature of RAs is that they focus learners' instant reflection on aspects of the learning experience they are committed to. Examples could be prompts to take a

[3] An early lesson of the review is that different names are used to label reflection-in-action support tools. In 44% of the studies included in the final sample, the word reflection or meta-cognition "prompt" is used. Remaining studies refer straight to specific techniques used to stimulate reflection (think aloud, self-explanation, questioning, visual support for the learning activity) or, on the opposite, do not individualise the reflective techniques but mention "facilities" or "features" of environments that support reflective activities. "Meta-cognitive support device", "reflection assistant" or "instructional guidance" are also among the labels found.

note, make a pause to evoke mentally the content at hand, self-assess current own mastery, look at a dashboard to realise one's position in learning, etc.
These reflective operations have in common that they are harnessed to a first-order learning assignment. They serve it but are not confused with it due to their brevity and their meta-learning dimension. By providing students with deliberate and structured opportunities to examine and evaluate their own learning while this learning unfolds, *RAs instantiate a form of "split screen teaching" (Claxton, 2005), that consists in maintaining a dual focus on the content of the lesson and the learning dispositions and processes that are in play*. This systematic literature review is in pursuit of RAs applied in the clear-cut instructional context explained in the next section.

Boundaries of the review

This review is restricted to RAs:

- in higher education: the call to breed reflective practitioners is particularly strong in higher education. However the actual situation is a shortage of clear theoretical approaches and tested practices (Claxton & Carr, 2004; Csapó, 1999). This review gathers information on RAs, considered as one possible approach to reflection training.
- in self-instructed contexts, i.e. situations wherein learners cannot rely upon an instructor or a peer to directly inform and stimulate their thinking about learning contents and processes. In such contexts, very common in TEL, individual learners might be empowered by the provision of specific prompts allowing them to take ownership and responsibility in their reflective processes.
- in technology-enhanced learning: today's electronic learning environments expand opportunities to reinforce reflection by prompting learners about the content at hand and about own ways of internalizing it. This state-of-the-art review about RAs includes concerns for technological tools and human-computer interaction (HCI) aspects.

In sum, *the lens of this review is put on empirical research on individual RAs offered to higher education students in technology-enhanced learning settings.*
The next section describes the three stages of the review process. The section after offers an in-depth analysis of the 29 empirical studies found within the settled boundaries. The chapter ends up with a discussion of the findings and the outline of further needed research.

Method

A systematic search of the literature was undertaken to identify relevant studies. It was carried out using Eppi-Reviewer 4: a Web application that enables re-

searchers to manage the entire lifecycle of a review in a single location (Thomas, Brunton, & Graziosi, 2010). A three-stage review model was followed.

Selection of articles for the main review database

First, a selection of electronic documents (chapters in books, published articles, conference papers, project reports and theses) was cautiously filtered down by applying four keywords – with truncations and synonyms – to bibliographic databases (Fig. 6.1). Queries were limited to abstracts to sharpen the results. In order to include all potentially relevant studies, educational and multidisciplinary electronic bibliographic databases were harvested: Academic Search Elite (EBSCO), ERIC, Psychology & Behavioral Sciences Collection and PsycINFO.

	Key concept 1	**Key concept 2**	**Key concept 3**	**Key concept 4**
	reflection	AND metacognition	AND prompts	AND learning
Synonyms Different spellings Controlled keywords (EBSCO Thesaurus)	OR↓ reflect* critical thinking theory of self-knowledge	OR↓ metacognit* meta-cognit* self-control self-monitoring self perception	OR↓ prompt* trigger*	OR↓ learn*

Figure 6.1. Keywords issued for the first stage of the review.

The online journals of Sage Publications, Elsevier (ScienceDirect), Springer Verlag (including the journal "Metacognition and learning"), Taylor & Francis Group (including the journal "Reflective practice") and Wiley Online Library were also crawled, along with the technology-oriented database of the "Lecture Notes in Computer Science". To the best awareness of the author, no important publishing source was missed. Not limitation was settled regarding publication date. Only documents in English were considered. In total, 328 citations were retrieved, of which 63 duplicates and 27 deceptive records (e.g., about reflection in optics).

Specific criteria and mapping of the domain

Following the elimination of duplicates and outliers, 238 abstracts underwent a stepwise inclusion/exclusion process based on the criteria announced in the sec-

tion “Boundaries of the review”. These criteria are now reviewed in details. The numbers into brackets and preceded by a minus sign (“-”) show the gradual reduction of the main review database due to the application of the inclusion/exclusion criteria. Some excluded high quality articles are mentioned by, in order to illustrate the different steps of the process and because of their contribution to the field, albeit they do not fit the perimeter of the review.

- **Inclusion criteria 1**: the document had to be an empirical study (- 49 records). Several rejected documents were of a high value for the study of RAs (e.g., Brown, 2009; Ge & Land, 2004; Lin, 2001; Lin, Hmelo, Kinzer, & Secules, 1999). However, they could not be included because they presented as general considerations, recommendations or conceptual frameworks about reflection.
- **Inclusion criteria 2**: the document had to target reflection-in-action prompts (- 44 records). Most of the discarded records (e.g., Wopereis, Sloep, & Poortman, 2010) bore upon reflection on action training techniques (portfolio, learning journal, diary, blog, retrospective report, etc.).
- **Inclusion criteria 3**: the document had to bear upon RAs used by individual students (- 14 records). The left out records dealt with the promotion of reflection in computer supported collaborative activities (e.g., Phielix, Prins, Kirschner, Erkens, & Jaspers, 2011).
- **Inclusion criteria 4**: the document had to address the higher education level (- 74 records). Despite the obvious contribution of studies carried out in elementary (e.g., De Vries, 2004), secondary, (e.g., Davis, 2003) or special/adult education (e.g., Rawson, O'Neil, & Dunlosky, 2011) the experiments conducted at these tuition levels were excluded.
- **Inclusion criteria 5**: the document had to refer to a TEL setting (- 22 records). The criterion retrieved studies, some of great value (e.g., Hoffman & Spatariu, 2008; Thompson, 2009), but taking place in face-to-face settings. It is worth mentioning that some of the excluded records tapped into promising ways to trigger reflection while learning, like response systems clickers (Bachman & Bachman, 2011), or prompts implemented with experience sampling methods (Intille, Kukla, & Ma, 2002) and sensor technologies (Back, Furniss, Attfield, Hassard, & Blandford, 2009).
- **Inclusion criteria 6**: the full-text of the document had to be accessible (- 6 records). In the case of six dissertations, the full text could not be procured and the records were removed accordingly.

In-depth review

In total, 29 records entered the final sample (see the list in Table 6.1). Each of them underwent an in-depth analysis – based on a full-text reading – carried out

in four directions: instructional context, human-computer interaction, instructional effects and technology.

Results

All findings depicted hereafter stem exclusively from the 29 experimental studies matching all inclusion criteria.

Instructional context

This section characterises contexts wherein RAs have been implemented and their stated instructional purposes.

RAs' domains of application

RAs were tested in 10 domains: psychology (28%), sciences (23%), information and multimedia (13%), mathematics and statistics (10%), medical (7%), education (7%), informatics (3%), information literacy (3%), practical training (3%), economy (3%).

RAs' deployment contexts and exposure times

Fifty-seven percent of the studies took place in a laboratory context, usually with learning material and tasks designed for the purpose of the empirical research. In this experimental context, RAs were practised during a time varying between 30 min (Bannert, Hildebrand, & Mengelkamp, 2009) to 130 min (Gama, 2004b).

As for real-world settings, 73% were fully-online courses. The remainder meshed face-to-face sessions with TEL components, usually applied for practical exercises or Lab sessions. All experiments in the final sample articles made the use of the reflection prompts mandatory.

Types of learning supported by RAs

RAs were almost evenly fastened to learning activities that could be qualified as "constructivist" (Terhart, 2003) like problem/inquiry-based learning (43%) or as "instructivist" like learning by studying multimedia resources (47%). The remainder was composed of drill-and-practice activities (10%).

RAs' instructional goals

The pedagogical scope of RAs did not present as very unified. The learning or meta-learning processes that they were supposed to assist and deepen were varied. Corliss (2006) for instance offered "meta-cognitive" and "transfer" prompts, meaning that the RAs she used aimed at meta-cognitive development and enhancement of knowledge transfer. Kramarski and Michalsky (2009) used "strategic/comprehension/metacognitive" question prompts. Ge and Land

(2003) tested "problem representation/solution generation/justification/ monitoring/evaluation" prompts. Kaufmann (2004) and Kaufmann, Ge, Xie, and Chen (2008) worked on "problem-solving" and "reflection" prompts.

Human-Computer Interaction aspects

It was found that, to a very large extent, researchers categorised the RAs they used in reference to their intended effect (see above). No concern was found for a classification based on HCI aspects. In order to gain insight anyway in these aspects, a refined version of an existing framework (Verpoorten et al. 2011b) was elaborated and the RAs found in the review mapped onto it.

Interaction with RAs

The taxonomy of Verpoorten et al. (2011b) takes as its main organising principle the Interaction pattern requested from learners to enact their reflection:

- Interaction pattern 1 – The learner receives information: this pattern induces the reflective experience by requesting the learners to look at or ponder upon externally provided cues related to the learning context and their positioning within it. RAs in this category do not imply any observable action of the learner, except, possibly, the time spent in the contemplation process (for an archetypal example, see the "Reflectometer" in Gama, 2004b).
- Interaction pattern 2 – The learner gives information: this pattern induces the reflective experience by asking learners to give a quick insight into their behaviours or performances. In contrast with Pattern 3 (verbalising information, see below), RAs in this category arrange a "thinking slot" to indicate a non-verbal judgement about aspects of learning, usually through the presentation of some scoring/rating/ticking/drag-and-drop artefacts supporting a persistent reflection while causing a minimal disruption (for an archetypal example, see Stadtler and Bromme, 2008).
- Interaction pattern 3 – The learner verbalises information: this pattern induces the reflective experience by asking learners to produce a discourse about certain aspects of their learning. Compared to Pattern 2, learners' input is more elaborated and expressive in nature (for an archetypal example, see Papadopoulos, Demetriadis, Stamelos, and Tsoulakas, 2009, 2011).

Modality type

A new level of complexity surfaced when the RAs found through the systematic literature review were mapped on the framework: *the Interaction patterns afforded different modalities*. For instance, it appeared that, in the case of Interaction pattern 1 ("Receiving"), students could be prompted to reflect by receiving either visual (e.g., Gamma 2004b; Verpoorten, Westera, & Specht, 2011c) or

textual material. A clear illustration of the latter modality was found in Ge and Land (2003, p. 37) where questions were displayed close to the learning material with this assignment: "Something to Think about… As you work through the problem, please read and think about the following questions".
With regard to the second Interaction pattern ("Responding"), a unique modality was found: ticking an option in a list. It is in line with the core feature of the pattern which is the provision by the student of compact answers during the learning process.
The third Interaction pattern ("Verbalising") had two modalities. Written reflection was the most often practised way of verbalising. It was usually implemented by interspersing digital material with text-entry fields. But in rare cases, the reflection prompt triggered a contextual think-aloud procedure.
The pinpointed modalities were combined to the Interaction patterns in the classification framework for an enriched view on learner's way to practise reflection (Table 6.1).

Table 6.1. Interaction patterns (columns) and modalities (boxes) of the RAs

Study	**Interaction type 1** Reflection induced by receiving info	**Interaction type 2** Reflection induced by giving info	**Interaction type 3** Reflection induced by verbalising info
Bannert (2006)			Talking
Bannert & Mengelkamp (2008)			Talking
Bannert, Hildebrand, & Mengelkamp (2009)	Reading		
Bartholomé & Bromme (2009)	Reading		
Bixler (2011)			Writing
Chen, Wei, Wu, & Uden (2009)			Writing
Corliss (2006)			Writing
Gama (2004b)	Watching (pictures/schemes)	Ticking	
Ge & Land (2003)	Reading		
Ge & Er (2005)			Writing
Graesser et al. (2007)			Writing
Johnson & Sherlock (2008)		Ticking	Writing
Kauffman (2004)	Reading		
Kauffman, Ge, Xie, & Chen (2008)	Reading	Ticking	
Kim (2006)		Ticking	Writing
Kramarski & Michalsky (2009)			Writing
Krause & Stark (2010)			Writing
Mayer & Johnson (2010)		Ticking	Writing
Papadopoulos, Demetriadis, Stamelos, & Tsoulakas	Reading		Writing

(2009)			
Papadopoulos, Demetriadis, Stamelos, & Tsoulakas (2011)	Reading		Writing
Saito & Miwa (2007)	Watching (pictures/schemes)		Writing
Sitzmann, Bell, Kraiger, & Kanar (2009)			Writing
Stadtler & Bromme (2008)		Ticking	
Stark & Krause (2009)			Writing
Van den Boom, Paas, Van Merriënboer, & Van Gog (2004)			Writing
Van den Boom, Paas, & Van Merriënboer (2007)			Writing
Verpoorten, Westera, Glahn, & Specht (2012a)			Writing
Verpoorten, Westera, & Specht (2011c)	Watching (pictures/schemes)	Ticking	Writing
Yamashiro & Dwyer (2006)			Writing

Location of RAs

The review additionally exhumed three modes of embedment of the RAs in the first-order learning task (Fig. 6.2). A very modicum authors (Chen et al., 2009; Verpoorten et al., 2011c) justified their decision regarding the proximity level of the prompt to the content at hand.

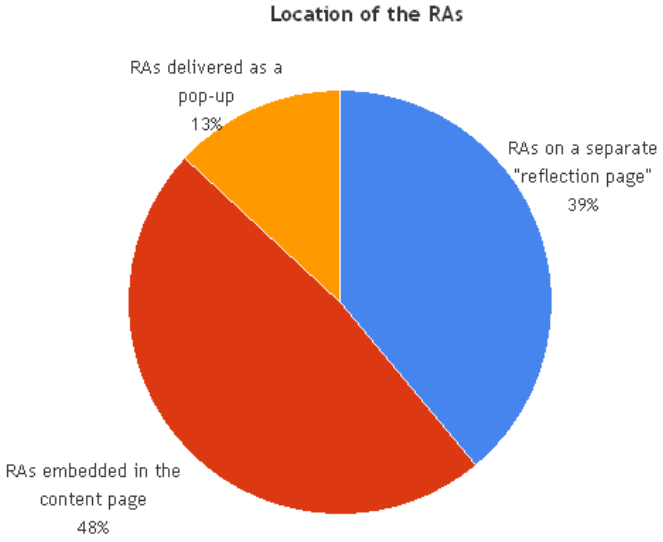

Figure 6.2. Integration modes of the RAs with the learning tasks.

Effects of RAs

The review explored to what extent the empirical studies revealed a general trend in favour of the reflection-in-action affordances. A first observation was that, with two exceptions (Chen et al., 2009; Johnson & Sherlock, 2008), all studies included some sort of final "exam" deemed to measure the learning performance. In total, the 27 studies delivered 35 such measures of achievement. The difference came from experiments displaying RAs in several modalities (Mayer & Johnson, 2010; Papadopoulos et al., 2009, 2011; Verpoorten et al., 2011c). In 57% of these measures, RAs had a significant positive effect on the learning performance compared to a control group.

Thirty percent of the selected studies did not limit their measurements to performance and supplied in addition measures of the effects of RAs on the actual development of reflective skills, usually obtained through dedicated questionnaires on meta-cognitive abilities or rubrics to ascertain the quantity or the quality of the prompted reflection. Seventeen measures of this kind were identified, with in 65% a significant positive influence on reflective skills.

Other less frequent measures were observed. One study (Bixler, 2008) found significant positive effect of the RAs on motivation. Verpoorten et al. (2012a) brought evidence that being prompted increased the overall quality of students' narrative account of their learning experience. Bartholomé and Bromme (2009) investigated effects of RAs on cognitive load. Some studies explored RAs' perceived helpfulness or contribution to learning.

Bartholomé and Bromme (2009) highlighted a paradoxical effect: while the activated RAs were deemed to produce a deeper learning, the authors brought evidence that they could reduce engagement with the material. It happened when RAs did too much work for learners and released them from personal processing (Van Nimwegen, Van Oostendorp, Burgos, & Koper, 2006).

Lastly, measurements of the effect of the RAs on the study time delivered contrasted results. In Gama's experiment (2004b), students who performed the reflective activities spent significantly more time on tasks and gave up on fewer problems. An extension of time-on-task was also found by Graesser et al. (2007) and Verpoorten et al. (2012a). Several authors (Krause & Stark, 2010; Papadopoulos et al., 2009, 2011; Van den Boom et al., 2007; Verpoorten et al., 2011) found no significant effect of reflection prompts on the study time while displaying diverging results regarding effects on performance.

Regarding statistical procedures found in the selection: only Sitzmann et al., (2006) – decidedly – and Kaufman (2004) – marginally – used within-subjects measurements to examine the potential for gradual, intra-individual changes, as learners were prompted to amplify reflection. However, the strongly dominant statistical paradigm in the 29 records was the between-subjects one.

Technology

Concerns for technologies, delivery architectures, standardisation or reusability of the RAs were found marginal or absent in the 29 documents included in the review. It appeared that most of the artefacts were built from elementary technologies: html pages, Web forms, pop-ups, e-mail (Fig. 6.3), with also two occurrences of paper-based prompts (Bannert et al., 2009; Corliss, 2006) used simultaneously with an online activity.

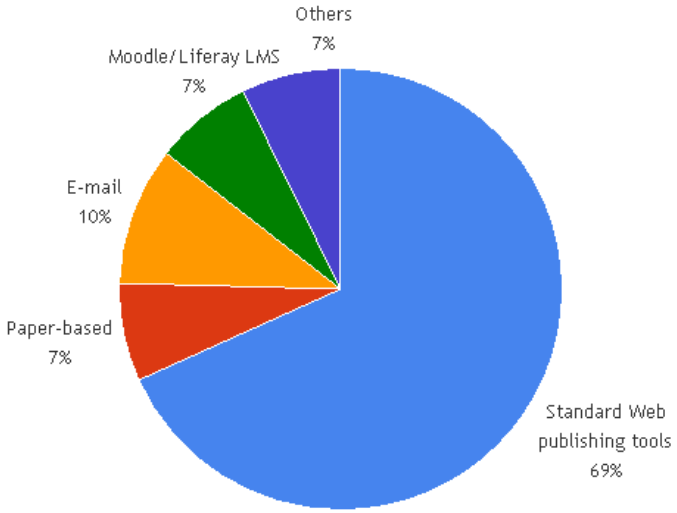

Figure 6.3. Technologies used for the implementation of RAs.

A few articles gave room to elaborated technological considerations. This was the case of Ge and Er (2005) who described the design shell of a reusable online prompting support system comprising five components directly linked with reflective practice: case library with real-world cases, question prompts, peer review, expert modelling, and self-reflection mechanisms. The system shell was designed to be reused, adapted, and generated to any specific content domain. The same ambition of an independent reflection-oriented component that could be plugged in an activity system dedicated to the learning of a specific domain also fed the work of Gama (2004b). Her "Reflection Assistant Model" was kept as general as possible so that it could be adapted according to specific domains and environments. Verpoorten et al. (2011c, 2012a) referred to 4-layer architecture (Verpoorten, Glahn, Kravcik, Ternier, and Specht, 2009) concerned with the production of RAs of Interaction pattern 1, in its Visual modality. This architecture combined a Sensor, a Semantic, a Control, and on top of these an Indicator Layer which allowed the visual mirroring to learners of their own interaction footprints, used as a vehicle for reflection.

Discussion and further work

From this review, it seems that there is more rhetoric about the value of reflectivity than there is concrete empirical data and detail about how instructional designers can help students cultivate reflection-in-action skills. This review nevertheless highlights research efforts to devise and put at the test explicit strategies and tools that encourage students to somehow deepen the moment of learning (McLoughlin & Luca, 2000).

Taken together, the 29 reviewed studies help to understand what is at stake with reflection-in-action support tools: that *fostering mindful commitment to learning requires far more than telling people to "concentrate" or "reflect" and then simply hoping for the best.* By clearly signposting reflection and hooking it to students' doings, RAs intend to pinpoint, elicit and support inner intellectual dynamics and to stimulate meta-cognitive awareness of reflective processes, which are conditions for meaningful learning.

Based on the review's finding, the next section gives an overview of the pending questions likely to guide further investigation in the field.

Where are RAs used in student learning?

The review locates research on RAs both in constructivist and instructivist learning settings (see section "Types of learning supported by RAs"). This balance attests that *reflection can never be taken for granted when learning, no regard to the kind of learning activity performed.* At one end of the continuum, reading, which could be considered as a seamless and "natural" way of learning appears as strongly invested by the research on RAs with the view that its thoughtful practice needs to be reinforced. At the other side of the continuum, so-called "active methods" also stimulate research on RAs, what can even be more striking since mindful learning might be considered as inherent to these methods. The review highlights that, in both educational philosophies, giving a face-value to reflection is considered as relevant, instead of assuming that this reflection will occur in any case, consciously or tacitly, in the course of learning.

How often to insert RAs in student learning?

Rate of the reflective episodes

The review highlights that the frequency of prompting greatly varies (see section "RAs deployment contexts and exposure times"). In an experiment of 30 min, Bannert and Mengelkamp (2008) prompt participants at a frequency of one justification per minute. Faster rates can even be found in the literature. In a study – not included in this review because addressing secondary education –, Chi, de Leeuw, Chiu, and Lavancher (1994) prompt pupils to reflect after each line they read in a text! At the other side, Van den Boom et al. (2007) prompt

reflection 9 times over a 9 months course of 120 hr. There is an issue in providing guidelines with regard to the suitable frequency and point in time to prompt successfully. Beyond specific timing decisions, an overarching question relates to the intensity of exposure to RAs. Johnson and Sherlock (2008) emphasise how deeply challenging the acquisition of "habits of reflection" is, which leaves open the question of the training time needed to establish such habits. Given the relatively low average exposure time deployed in the 29 studies, the observed benefits (see section "Effects of RAs") might be seen as a good surprise although they are in agreement with a recent meta-analysis (Higgins, Kokotsaki, & Coe, 2011) which credits the training of meta-cognitive strategies of a high level of efficiency (high impact/low spending).

Length of the reflective episodes

Another time-related issue concerns the adequate time to allocate to thinking episodes themselves. Beyond research, there is a practical stake in this further research theme. Teachers as well as learners may be reluctant to reflective approaches, since these are supposed to happen at the expense of studying course contents. While favouring compact opportunities for reflection makes sense – also because these stop-and-think beacons cannot take precedence upon the primary learning task – it raises a critical question for future research: is the very idea of a "short" reflection a contradiction or can embedded reflection be brief and valuable at the same time? Further work is needed to explore the trade-offs between reflective approaches to learning and learning efficiency.

Advanced definitions of suitable attributes of reflection prompts will also have to take into account phenomenon like expertise reversal (Kalyuga, Ayres, Chandler, & Sweller, 2003), over-prompting (Holliday, 1983; Nückles, Hübner, & Renkl, 2006), and over-reliance effects (Bartholomé & Bromme, 2009; Van Nimwegen et al., 2006).

How to design RAs?

The pedagogical decisions regarding the amount of RAs to incorporate in a study task, their timing, their frequency, their length, and their needed exposure time are closely related to human-computer interaction issues (Lin et al. 1999). For instance, a think-aloud procedure will usually be shorter to use than writing reflection down, but ticking a box will be even shorter. The topological location (see section "Location of RAs") is also likely to influence the fluid crisscrossing of the cognitive and meta-cognitive landscapes that the insertion of RAs targets. However, the review exhibits that interface-related issues (see section "HCI aspects") are hardly problematised. As observed in the section "RA's instructional goal", existing efforts to qualify RAs lean chiefly on their pedagogical intention: to assist comprehension, transfer, monitoring, solution generation, answer justification, etc. This focus placed on the output flows probably from the fact that most of the reviewed authors conducted their research in the field of self-regulated learning or educational psychology. Such research largely focuses on

cognitive processes and outcomes of the learner. Considerations for the modes of interaction that occur when the learner is confronted with a reflection prompt, viz. the input mode, is usually beyond the scope.
Modes of prompting are notwithstanding important for the formulation of a cognitive theory of reflective learning and also for the practical guidance of instructional developers and computer scientists who are supposed to create learning activity systems conducive of reflection. This is the reason why a dedicated taxonomy, organised according RAs' Interaction patterns and modalities, was formed to inspect these dimensions. Further validation and enrichment of the classification framework would be valuable contribution to the field since it can serve as an instrument to create awareness and start discussion among online course developers about the different approaches available to externalize reflection-in-action.

Why prompting reflection?

The review reveals varied pedagogical intentions behind the provision of RAs. However, beyond this apparent diversity, one commonality is discernable: the decision to make visible the appropriate thought processes students should engage in learning. *Many educators assume students are reflective thinkers because all students certainly do think. However, this assumption can contribute to make reflective operations invisible or forgotten. By overtly displaying thinking processes, RAs make their connectedness and articulation to learning conscious or at least accessible to consciousness.* By externalizing reflection, RAs make of it a learning experience on its own. In that sense RAs make learning visible (Hattie, 2009; Ward & McCotter, 2004) in a different way than marks at tests do. This overarching goal of giving reflection a face-value should be scrutinised in future work. Its contribution to the development of the self-as-a-learner should be better assessed.

What benefits for RAs?

The review exhumes mixed results regarding the effects of RAs on learner achievements (see section "Effects of RAs"). In 43%, efforts to promote reflective thinking do not materialise in learning gains. The controlled introduction of structured opportunities for reflection does not necessarily lead to better scores at the test. Although test performance is not the only measurement of learning (Boud, 1990), it should reasonably be expected to reflect benefits resulting from the use of reflective approaches.
The review also evidences that only a minority of studies investigates effects of RAs on other dimensions of the learning experience. While the performance aspects cannot be neglected, future research should give follow-ups to these pioneering studies (see section "Effects of RAs") that have started to explore relationships between reflection and self-awareness, motivation, feeling of learning or commitment to the task.

Technological challenges

"Many tertiary institutions fall short in allowing opportunities for reflection" (Barak, 2006, as cited in Strampel & Oliver, 2007). The mere lack of availability of RAs is part of the problem. Technical affordances and implementations of RAs do exist, as evidenced by the review. However, most of them are bound to local experimental contexts that strongly hamper their diffusion. The project to make RAs more universally available is a valuable one, all the more so that reflection training often addresses transversal skills likely to be implemented in a broad variety of instructional settings.

The review also reveals that most of the RAs are implemented as lightweight solution using rather basic technologies. This is an asset, especially when development costs must be balanced with learning benefits. However, other observations suggest that the development of a reflective approach to learning demands more complex technologies. For instance, a striking result of the in-depth review is that, to the exception of the Reflection Assistant tool (Gama, 2004b), none of the reviewed prompts incorporate adaptive features. The idea that different RAs could be suited to different learners is also almost absent from the reviewed articles. Technological innovation will be needed at the crossroad of reflective training and personalised learning.

Lastly, research on technologies for reflection should also go beyond standalone RAs and tackle *the challenge of reflection-conductive/supportive global milieus that help practicing reflection beyond the provision of a single isolated tool* (Allan & Clarke, 2007; Brown, 2009; Derry & Murphy, 1986; Sirkemaa, 2001; Sumner & Taylor, 1998; Thomas, 2003).

Conclusion

This chapter focused on "reflection amplifiers". These prompts have the ambition to help improving students' reflection at the domain and meta-cognitive levels. Their presence arranges a systematic and permanent criss-cross between cognitive and meta-cognitive landscapes, as a tentative mirroring maybe of what forms the intellectual activity of competent learners.

This chapter suggests deepening the investigations in this strand of research. By making learning an explicit object of attention, reflection, conversation and learning (Watkins, 2001), RAs can help students realise the value of reflection for learning, and maybe the beauty of a mentally active engagement in technology-enhanced learning.

Chapter 7

Study 6 (collateral) – Reflecting on own answers' quality in a serious game

Chapter 7
Explicit reflection in a serious game

Abstract

This chapter describes how a short, repeated and structured opportunity to reflect (a "reflection amplifier") has been integrated in the storyline of a serious game in order to stimulate the development of a meta-cognitive skill: the ability to self-assess the degree of confidence in own answers. An empirical validation of the approach, conducted with 28 secondary school pupils, delivers an uncommon pattern: while the cognitive benefits – the acquisition of academic knowledge in optics – are negligible and mixed up, the meta-cognitive gains present a raising tendency. The experiment also demonstrates that reflection does not necessarily hamper the game flow, if certain conditions, discussed in the chapter, are met.

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"Reflection enables us to know what we are about when we act. It converts action that is merely appetitive, blind and impulsive into intelligent action. (Dewey, 1964, p 211)

Today's educational literature is prone to grant virtues to games for supporting learning (Mitchell & Savill-Smith, 2004). However, questions remain about their potential to train transferable reflective skills (Bopp, 2006; Mac Farlane, Sparrowhawk, & Heald, 2002), which are considered as key leverage points in a lifelong learning society (Claxton, 2006; European Commission, 2006; Rychen & Salganik, 2003).

Gaming and thinking

At first sight the awareness and training of these second-order mental processes seem to entail stop-and-think episodes. If taking a step backwards is the hallmark of reflection, it can sound discordant with, or even antagonistic to, the immersive characteristics of games, at least adventure games. Westera, Nadolski, Hummel, and Wopereis (2008, p. 2) rightly summarise this perceived tension: "Especially in higher education, the mental mode of learning which reflects profundity, reflection, concentration and perseverance seems to conflict with the mental mode of gaming which is commonly associated with amusement, fun and relaxation".

It is therefore not surprising that the few examples of deliberate training of reflection reported in the serious game literature are connected with logics/strategy games, to which introspective pauses are inherent. For instance, Anderson (2002) reports about accounts of 6th-grade students playing a game named "Stock Market", designed to help children become familiar with how financial transactions function. One female player says: "This game makes me think how to think". What this statement reveals is that this young learner is beginning to understand the real key to learning; she engages in meta-cognition using a game. Saldaña (2004) has enriched a "Master Mind" game to assess and exert thinking skills with three levels of assistance: support of the meta-cognitive processes internal to each step of task (planning, control, and revision), scaffolding of the main steps composing the whole task, and modelling of the task solution process.

In contrast to the aforementioned examples, this chapter depicts an attempt to harness opportunities to reflect to an educational adventure game. It also provides a first empirical evaluation of the effects of this instructional feature on both the understanding of the to-be-learnt concepts – here properties of the light – and the enhancement of a specific reflective skill: to ascertain the confidence in the quality of one's answers, as explained in the next section.

Confidence degrees

In an assessment based only on identifying correct and incorrect answers there is little information available for both teacher and learner, other than right or wrong (Kulhavy & Stock, 1989; Leclercq, 1982). Adding confidence degrees to evaluation leads to refined considerations about learning and teaching. For instance what conclusion should teachers raise when 95 % of their learners succeed answering a question? What other conclusion if those students only produce a mean confidence of 10% for their correct answer? Teachers might reconsider their teaching as not completed despite the 95% of success at the test. Corrective behaviours can also benefit from the externalization of confidence. For instance, a wrong answer given along with a confidence degree of 10% is better than the same wrong answer with 90% confidence attached. The students in the latter case convey two erroneous pieces of information: one related to their knowledge and one related to themselves (their belief in their answer's rightness). This situation may be considered as dangerous since students will trust what they think they know.

These examples suggest that learning does not move someone from total ignorance to perfect knowledge. Often people already have some knowledge or representation about what is taught, even if these representation or knowledge is misleading. So evaluation should not be limited to either knowledge (viz. correct answer) and ignorance (viz. incorrect answer). As De Finetti (1965, p. 109) puts it: "Partial information exists. To detect it is necessary and feasible. (…) It is only subjective probability that can give an objective meaning to every response and scoring method".

Fig. 7.1 follows De Finetti's intuition by associating a factual measure of knowledge (obtained through multiple choice questions, Y axis) with a subjective assessment (chosen out of a 6-item scale expressing the percentage of confidence in the answer, X axis). The output is a "spectral distribution of knowledge" (Hunt, 1993; Jans & Leclercq, 1999). On the left side, the wrong answers are distributed by the confidence degree (from -100% up to 0%) given by the learner. In the middle ("omis" bar) are the unanswered questions. On the right side are the correct answers, also distributed by confidence but ranking from left to right from 0% to 100%. Each rectangle defines a type of relation to knowledge: (a) Dangerous knowledge rectangle (wrong answer/high confidence), (b) Unawareness rectangle (wrong answer, low confidence), (c) Mid knowledge rectangle (right answer, low confidence), and (d) Usable knowledge rectangle (right answer, high confidence).

Compared to the usual "correct/not correct" feedback, such a view on students' performance allows a refined diagnosis about the relevant kind of remediation (cognitive and/or meta-cognitive)

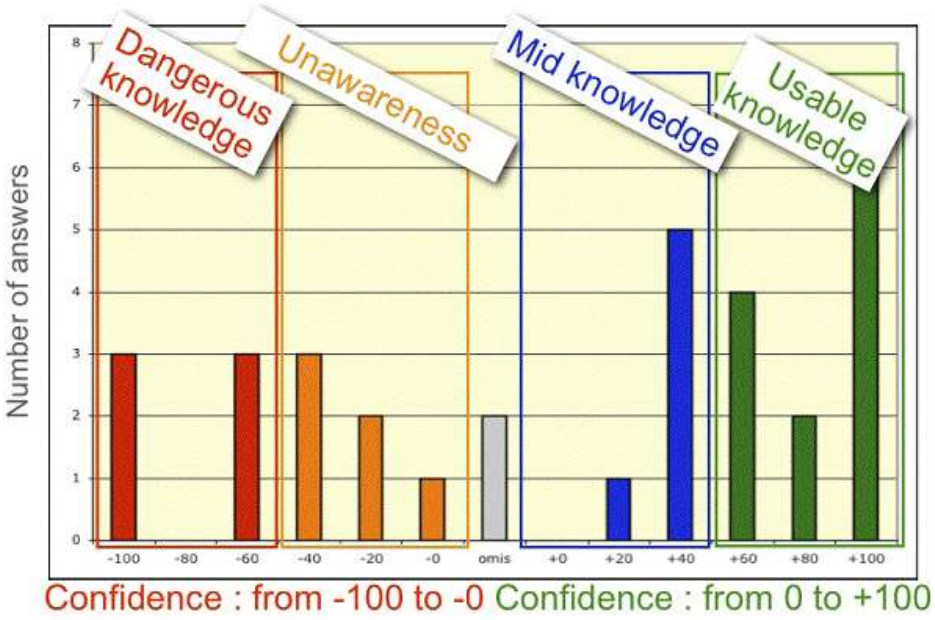

Figure 7.1. A spectral distribution of knowledge spreads student's answers in four categories of knowledge according to a cognitive dimension (right or wrong) and a meta-cognitive dimension (self-assessed confidence degree).

This study conceptualises the confidence ratings embedded in the Elektra game as "reflection amplifiers" (Verpoorten, Westera, & Specht, 2011b). The appellation refers to compact, structured and repeated reflection affordances displayed during learning in order to make aspects of it deliberate objects of attention. Reflection amplifiers (RAs) feature clear-cut reflective operations interlaced with the cognitive processes at work for the completion of a first-order learning task. The underpinning assumption tied to RAs is that, by continuously interpreting their actions in terms of personal relationship to knowledge (here, the inner confidence in own answers), learners develop an increased awareness of and an intensified presence to the learning process itself.

Research questions

In an exploratory study, 28 secondary school pupils trained cognitive (academic knowledge in optics) and meta-cognitive (confidence degrees) skills by playing a version of the game Elektra. The whole experiment was guided by two research questions: (a) how can a RA be reasonably implemented in the concrete of a learning game?, and (b) what will be the effect of such an instructional feature, respectively on the game-play and on (meta-)learning? With regard to the research question b, it must be noted that the influence of a confidence degree

rating tool was difficult to ascertain beforehand due to possible ambivalent effects.
On the one hand, RAs represent a reflective pause in the learning process. As such, they can be perceived as game-play "breakers". If explicit calls to reflection harm storytelling and immersion, there is a risk to decrease learners' motivation, one of the main levers of learning in games, according to their proponents (Egenfeldt-Nielsen, 2011). With less motivation, players may not exert sufficient effort to engage in learning.
On the other hand, RAs are designed in such a way that they minimise the disruption (they represent rather short episodes of reflection) and are integrated in the storytelling (gaining confidence in own answers is part of the hero's missions. See section "Storytelling aspect"). So, RAs can also turn to be useful to the support of the first-order learning/gaming task (for a similar dilemma with another RA – self-explanation – see Mayer & Johnson, 2010).

Method

Context

The experiment took place in the context of the European project Elektra. The goal of the project was to develop the demonstrator of a state-of-the-art 3D adventure game teaching physics according to national curricula. The demonstrator targeted 13+ students (www.elektra-project.org).

Sample

Data was collected from 28 pupils from a college in Thiais, France (mean age = 14 years old, male/female = 58/42%).

Type of game

Elektra was designed as a typical first person adventure/thriller game wherein a character named George had to rescue Lisa and her Uncle Leo, a researcher, who were kidnapped by a villain secret society. Whilst the plot was set the day of the next solar eclipse in Europe – in the year 2026 – the rescue operation undertaken by George partly immersed him in the world of the Renaissance and its scientific achievements. (The trailer of the game is available at: http://player.vimeo.com/video/24224447?title=0&byline=0&portrait=0&color=ff2e90).
To save his friends (and incidentally the earth), George had to confront with concepts from an 8th-grade physics course and to get acquainted with them. Yet, using this knowledge was a condition to move forward in his quest. Learning occurred through various modes of engagement with notions, ranging from hearing or reading to freely experimenting. After discovering a magic hour-

glass, George found himself in company of the ghost of Galileo Galilei (Fig. 7.2, label a) who observed and tutored him when confronted to the physics experimentations. Elektra developed only a demonstrator of the game, namely the opening sequence and the first secret room that George encountered on the track of the evil kidnappers.

Apparatus

Story-wise, the game element the current empirical study was concerned with was located in the basement of Uncle Leo's villa. It presented as a device that allowed balls (as an implicit reference to corpuscular premises of naïve physics) of different materials rolling down a slope (Fig. 7.2).
During the game, a ball appeared at the top of the slope (Fig. 7.2, label b). The player had to get it into the hole (Fig. 7.2, label c). In case of success, the next ball, made of a different material, was offered for play. Learners could make as many attempts as they wished with each ball. Each trial gave them an opportunity to alter the trajectory of the ball (Fig. 7.2, label d) by adjusting the magnet (Fig. 7.2, label e) and/or the fan (Fig. 7.2, label f) with the sliders (Fig. 7.2, label g, shuffled forces between 1 and 100). By contrast – and this was the chief knowledge to acquire at this experimentation table - a laser ray (Fig. 7.2, label h) could not be influenced by such external forces.

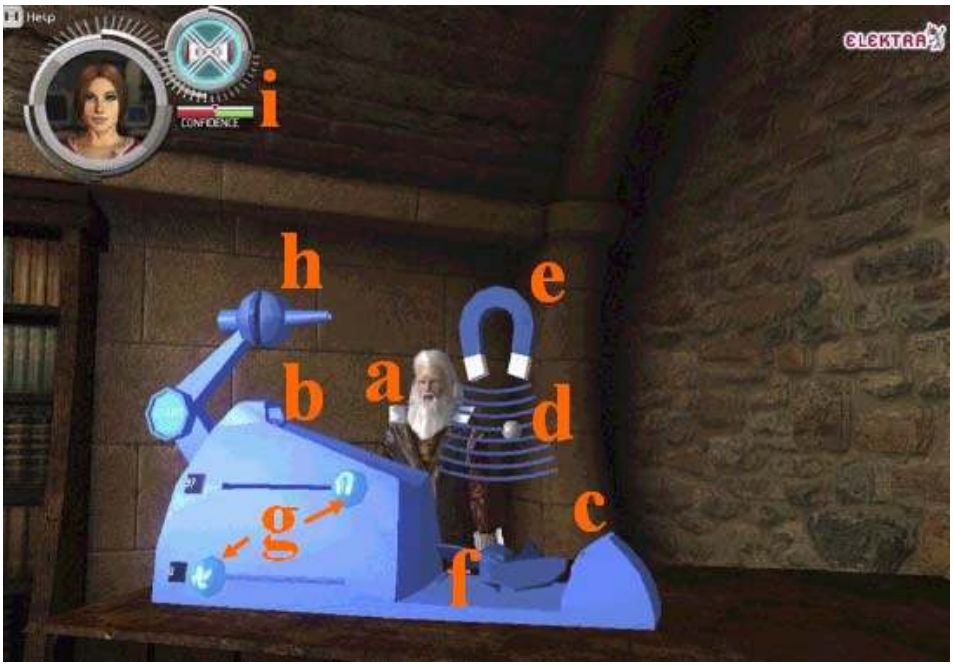

Figure 7.2. The "Slope device" was dedicated to the exploration of light properties.

With regard to the meta-cognitive instructional goal, for the ball to be released (and the effects of the magnet/fan arrangements to be observed), players had to state their degree of confidence that it would land into the hole with this configuration of forces.
A literature review and an empirical pre-study (23 participants) was carried out in order to identify the most relevant metric to express confidence on the slider (for an extensive discussion of this topic, see Castaigne, 2007). Based on the different arguments, it was decided that the Confidence slider would be graduated with the values 0, 20, 40, 60, 80, and 100% confidence.
As soon as the confidence degree was provided on the dedicated slider (not represented on Fig. 7.2), the ball started rolling the slope, then felt through the air under the influence of gravity, and if applicable, under the influence of the magnet and/or fan, as fixed by players, who then saw whether or not they managed to hit the target.
They received right after two pieces of feedback: one related to the success/failure of the task (e.g., "Well done. You noticed that the magnet had no influence on the aluminium ball and you controlled well the power of the fan") and one related to the confidence evaluation (e.g., "You did well with this ball but you indicated a confidence degree of 20%. You should trust yourself more"). In the demonstrator, both feedbacks were given as textual monitoring pop-ups.
Throughout the whole game, the status of learners' confidence in their actions was mirrored to them via a "smart indicator" (Glahn, Specht, & Koper, 2007), called "Certimeter" (for "Certitude meter") in the narrative (Fig. 7.2, label i). The Certimeter actually displayed the mean confidence degree of the successful trials, as computed real-time by the system. Colours went from red to light red between 0% and 50% mean confidence and from light green to green from 50% to 100% mean confidence (see section "Storytelling aspects" for the connection between the Certimeter and the plot).
The joint setting of the Confidence slider and the Certimeter supported a visual and systematic coordination between the game-play and the evolution of the meta-cognitive skill. The Certimeter was updated after each provision of a confidence degree. Players trained themselves with five balls made successively of iron, plastic, wood, aluminium, granite.

Learning aspects

Learning in Elektra occurred through various modes of engagement with notions, ranging from hearing or reading to freely experimenting. The instructional planning of the game was guided by the Eight Learning Events Model (8LEM). The 8LEM introduces standardisation of basic teaching and learning activities (Leclercq & Poumay, 2005; Verpoorten, Poumay, & Leclercq, 2007). It is composed of eight documented teaching/learning events, that is, ways of learning. Amongst the eight basic activity types, some are close to the instructivist or the constructivist paradigms. The model prompts teachers and instructional design-

ers to diversify the learning methods experienced by students in their courses. Elektra applied a mix of learning events. On the one hand, the game offered possibilities to explore and experiment. On the other hand, it also summoned drill-and-practise methods that it enriched by the infusion of reflective episodes. With regard to learning goals, Elektra drew on the usual distinction between specific skills (confined to a domain, here: optics) and generic skills (domain-independent, transferable, here: confidence ranking).

Cognitive goal

The main learning goal associated with the Slope device (Fig. 7.2) was to support the understanding that light propagated in straight lines, as opposed to the curved trajectories of other objects when they were under the influence of forces (wind, magnet, gravity). The selection of the cognitive goals of the game came on top of intense preparatory work: European curricula comparisons, breakdown of identified skills in various granularity levels, distribution of the retained skills in the entire game-play. This work, with its difficulties and limitations, is documented by Petit, Castaigne, and Verpoorten (2007).

Meta-cognitive goal

The setting altogether pursued a meta-cognitive objective: to develop the awareness of players regarding the confidence they had in their previsions about the trajectory of the balls and of the light.

Storytelling aspects

Cognitive and meta-cognitive learning goals harnessed to the Slope device underwent a careful integration in the storyline (Moser, 2000): the acquired knowledge about light properties was needed to move further in the adventure. In this case, learners had to use what they had learnt with the Slope device to – late on – unlock the door to the next room, by exactly hitting a small light sensor with a laser beam.

Meta-cognitive progress was also rewarded from a game-play perspective: George had to gain the trust of Galileo and this trust evolved on the basis of the good use of the confidence degrees. Indeed, George had to succeed at discovering the different influences of the fan and the magnet (and their lack of effect on the light ray) but he had concurrently to reach a green level score on the Certimeter (Fig. 7.2, label i), meaning that Galileo could trust him when he said that he was sure of his knowledge or when he said that he had doubts (a transversal skill and a pre-condition to any scientific work).

Procedure

Participants filled in the pre-questionnaire (see the next section “Measure instruments”) to assess the current state of their knowledge for the part of the cur-

riculum covered by the game. Afterwards, they received a briefing about the game, confidence degrees and the Slope device. They played it 30 min at the most and then took the post-questionnaire which evaluated their state of knowledge after the gaming session.

Measure instruments

A pre/post-test comparison and a test inserted in the game measured cognitive and meta-cognitive performance. Both tests could be taken only once.

Pre/post-test

Before and after the gaming session, pupils answered with paper and pencil to one question about the influence of wind on a ray of light and another one about the influence of magnet on a ray of light.

Intermediate test (within the game)

This test came after the players succeeded in throwing the third ball (wood) in the hole. It was designed as a formative test designed to bring a contrast to the reflection triggered by the manipulations around the previous balls. The test presented three questions (Fig. 7.3) probing successively the presumed effect of the fan, the magnet and the combination of both on the laser ray. Students gave their answer by clicking on the visual representing in their view the correct trajectory. For each answer, they were asked as usual to indicate their confidence degree. They did not receive any kind of feedback on their answers. After the test, players went on with the final two balls in an identical manner to the previous ones.

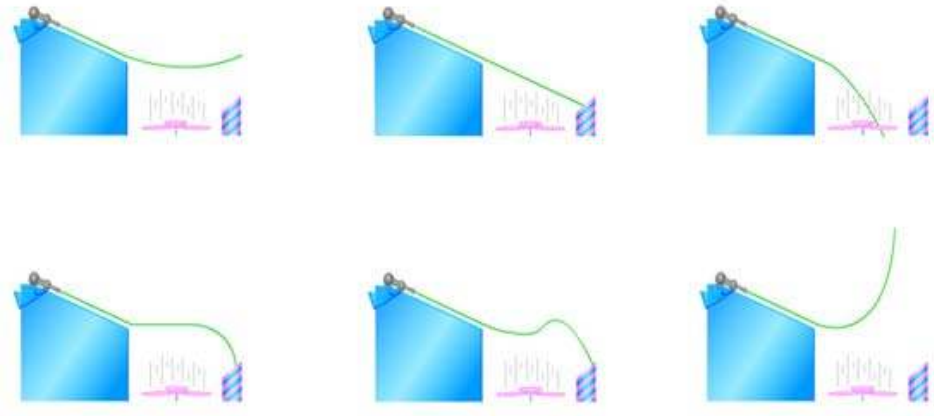

Figure 7.3. To perform the intermediate test embedded in the game, players had to click on the visual giving the correct representation of how a laser ray would propagate in a given situation (here with the fan activated).

Results

Whole game

Students performed an average of four trials with each ball before achieving success. The overall mean confidence (all attempts, all pupils, $N = 28$) was 54%.

Pre/post-test

Between the pre-test and the post-test, the group of pupils did not enhance its performance when answering if magnetism influenced trajectory of light ($t(54)= 1.65$, $p= .1$, $d = 0.44$) and if wind influenced the trajectory of light ($t(54)= 1.44$, $p= .15$, $d = 0.39$).

Intermediate test

The relationship between right answers and mean confidence degrees are summarised in Table 7.1 for the intermediate test (three questions with visuals as answers, see Fig. 7.3). Results showed a steady progression in the confidence that students had in the rightness of their answers. While the average confidence associated to the trials with the balls (54%, see the section "Whole game") and to the first multiple-choice question (MCQ#1: 55%, Table 7.1) were still in the Mid-knowledge rectangle (see Fig. 7.1 in section "Confidence degrees"), it toppled over the Usable knowledge rectangle for the two last questions.

Table 7.1. Results of the intermediate test

	MCQ#1	MCQ#2	MCQ#3
Correct answers (*N*)	19	14	22
Mean degree of confidence	55%	65%	84%

A one-way ANOVA exhumed that the differences of mean confidence degree reported for the correct answers in the three MCQs (Table 7.1) were significant, $F(2, 52) = 3.19$, $p = .49$, $\eta_p^2 = .12$. Additional Fisher contrast tests on pair-wise comparisons disclosed that the mean difference was significant between MCQ#1 and MCQ#3 ($p = .01$).

Discussion and further work

The sample of this study remains limited, as well as the extent of the assessment procedure, conducted after a rather short training period. It must also be noted that, for scientific purpose, this experiment did use a trimmed version of the Elektra demonstrator. Lastly, due to limited tracking facilities, the study had to

limit itself to between-subjects measures. These limitations considered, four main findings emerge. Each of them contributes to a specific research field.

Contribution to research on meta-cognitive development

One can ask if meta-cognition, and especially its self-assessment component, is usable as such for teenagers of this age. In brief, major works in the field consider that the components of meta-cognitive monitoring and control do not significantly differ between adults and 10 years old children. Below the age of 10, meta-cognitive processes evolve with age. For instance, Flavell, Friedrichs, and Hoyt (1970) provided evidence of significant correlation between predicted and actual memory span in children from the 4th-grade but no significant correlation was found below that age, including at nursery and kindergarten. Schneider (2008) observed unrealistic performances prediction in young children and outlined three reasons: 1) insufficient meta-cognitive knowledge: young children do not monitor their memory activities or lack in understanding about the interplay of relevant factors, 2) predominance of wishful thinking over analytical expectations: children's predictions reflect their desires, and 3) belief in the power of effort: the mere fact of spending time on a task induces the prediction of success. Duell's findings (1986) brought further evidence that as children get older they demonstrate more awareness of their thinking processes. This study comforts these previous works by providing indications that teenagers understand the idea of confidence in own answers and can practise systematic exercise based on this meta-cognitive notion.

Contribution to research on confidence degrees

Research on confidence degrees is not new. It has a respectable history based on the works of Brown and Shuford (1973), De Finetti (1965, 1970), Gardner-Medwin (1995, 1998), Kulhavy (1977) or Leclercq (1982). But, especially in game-based learning, concrete applications fostering reflection on confidence are rare, despite the pedagogical relevance they are granted. This experiment therefore presents an extension of the practice observed so far.

Previous works in the field of confidence ranking have generally noted that learners tend to overestimate the quality of their answers, especially in areas where their skills and knowledge bases are weak (Ehrlinger, Johnson, Banner, Dunning, & Kruger, 2008; Kruger & Dunning 1999; O'Hanlon & Diaz, 2010). In other words, it has been regularly observed that students do not know enough to recognise that they lack sufficient knowledge for accurate self-assessment. The pattern observed in this experiment does not fit well in this overestimation tendency. Self-assessment episodes in the Intermediate test do not show high confidence degrees but a progression towards higher levels when good answers are given (see Table 7.1). It advocates for an excipient understanding of the connection between rightness and certainty. After all, it would have been possible that pupils only focus on reaching the target with the ball, neglecting the

reflection on their actions and disregarding or using superficially the Confidence slider. On the contrary, the answers provided reflect serious meta-cognitive thinking. This fair level of engagement with reflection can be imputed to convergent factors:

- during the general introduction to the experiment, students have been briefly explained why gauging their confidence matters for learning. This may have been an important contributor to the quality of confidence rankings. Yet, it is generally acknowledged that the rationale given for the usefulness of meta-cognitive interventions is a success factor thereof (Bannert, 2006);
- from an instructional game design viewpoint, it is plausible that the encapsulation of confidence degree, both in local challenges and at the global storytelling level, contributed to their being taken seriously;
- the brevity of the reflective enactments (following a salient feature of RAs) is another aspect that probably played a positive role, challenging the idea that a reflection is necessarily a long-lasting operation.

Further investigation is needed to disentangle the respective influence of these factors.

Contribution to the integration of reflection in games

In her effort to understand the interplay and relationships between different kinds of learning environments and methods, Laurillard (1993) emphasises that standard classroom, lecture and exercise techniques can lack in context, interactivity, and the ability to experiment freely. Conversely, games offer these features but have their own shortcoming, in that they might be weak at providing students with opportunities to initiate reflection and to describe their conceptual knowledge[4]. Harteveld, Guimarães, Mayer, and Bidarra (2007, p. 132) note in a convergent way:

[4] Any learning method has its shortcomings, but well-thought aggregates can combine their strengths. The diversification of learning methods and approaches is not only a matter of students' motivation enhancement but also of epistemology (Moss, 2002; Verpoorten et al., 2007). For this reason, learning games should more often be contextualised within a larger learning sequence and not conceived as stand-alone vectors of learning, as recommended by Quinn (2005, p. 14), "I do not believe that these engaging learning experiences of games will (or should be expected to), by themselves, lead to learning. I advocate discussion around the experience, and connecting learner actions to the underlying concept. As yet, computers are not quite capable of supporting such dialogue. Self-directed learners may be capable of facilitating their own reflection, but it's not the way to bet (though I believe strongly that meta-learning, or learning to learn, is a key leverage point for the future). So although such gaming environments are not sufficient, they are necessary; we need engaging experiences to motivate learners to attend to the content, give them rich practice opportunities, and provide fodder for discussion and refinement of their understanding". De Freitas (2006, p. 11) puts a similar emphasis on embedding learning games in larger instructional learning sequences. By curiosity, the

> Games offer almost no opportunity for reflection as players are completely immersed into the game. Reflection is important to go from specific spontaneous concepts towards abstract scientific concepts. Reflection can be stimulated by an instructor, but it could be a valuable addition if it was somehow included into the game.

Elektra challenges views on game that consider this medium as inappropriate for reflective pauses. When thinking episodes are carefully crafted, when they are kept short and active and when they make sense for the next steps of the game-play, it seems that they can bring an added value without destroying the "flow of optimal experience" (Csikszentmihalyi, 1990).

How to strike the right balance between action and thought remains however a complex question. On the action side, Kiili (2004, p. 16) states that: "Ambitions to design engaging educational games have probably often failed because educational aspects have displaced game-play". But conversely, on the education side, it is legitimate to raise the question of the extent to which the game-play should take the precedence over the examination of the task at hand and the conscious internalization of conditions of success, possibly at the expense of learning and meta-learning. Effective trade-offs is a research topic that deserves additional inquiry (Kim, Park, & Baek, 2009).

Contribution to an extended definition of learning performance

What is students' learning performance in Elektra's gaming sequence? If performance is resumed to its traditional definition – enhancement of the mark at the test – the answer is "nothing". Section "Pre/post-test" highlights that learning gains do not occur.

This can probably be imputed to a poor serious game sequence. The knowledge to acquire is very limited and not strictly aligned onto possible pre-existing students' misconceptions. Furthermore, the basic optics principles to be learnt – that light propagates in straight line and is not influenced neither by the magnet nor by the fan or the gravity – may be trivial and already pre-existing in the knowledge of 14 years old students. In addition, the players do not manipulate the laser straight. Instead, visualisations of the trajectory of light are provided during the exercises with the balls in the hope that some contrast is created (see Fig. 7.3). Because of these flaws, the game is doomed to failure, at least from a cognitive performance viewpoint.

However, a similar failure is not found in the field of meta-cognition. With regard to the training of one specific kind of intellectual habit – the ability to assess one's certitude/doubt about knowledge – the study provides indications that the game produced positive effect, as attested in the progression of the mean confidence degree observable in Table 7.1. This is the interesting result of the

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young players of Elektra were asked whether they would prefer gaming before or after a lecture on light properties. Results gave a striking even proportion of "before" and "after" answers (Verpoorten, Glahn, Chatti, Westera, & Specht, 2011, p. 281).

study: given the game as it is, meta-cognitive gains can nevertheless occur. In other words, even when no academic knowledge is learnt, a learning gain takes place anyway in the realm of meta-cognition, due to the presence and the activation of a RA.

Prominent authors in metacognition (Schraw 1998; Veenman, Van Hout-Wolters, & Afflerbach, 2006) or in self-regulated learning (Zimmerman, as cited in Jackson 2004, p. 392) agree on the fact that cognition and meta-cognition often escape clear-cut distinctions. In the case of this chapter and precisely "thanks to" the (ill-fitted) background provided by the game, it is possible to suggest progress on one aspect while nothing is gained on the other.

This somewhat paradoxical finding ("nothing is learnt on a certain level but something is learnt on another one") would even be better highlighted if the same experiment could be replicated, not with "confidence degrees" (degree of confidence related to right answers), but with "prudence degrees" (degrees of confidence related to wrong answers).

"Confidence" deals only with good answers and is restricted to the evolutions in the rectangles "Mid knowledge" and "Usable knowledge" (see Fig. 7.1). In case of confidence progression, students win in both landscapes: cognitive and meta-cognitive.

A symmetric empirical study would be worth conducting on the failed answers and the confidence degrees attached to them (usually referred in the literature as "prudence"). *Evidence of gains in prudence (for instance students leaving the "Dangerous knowledge" area to enter in the "Unawareness" realm) would reveal progress being made in the face of the delivery of wrong answers! The answers would still be wrong but students would have learnt to be more prudent regarding their conviction that they are good.*

This would revamp, at the age of learning games, the invitation of Piaget (1978) to distinguish between success and understanding, between progress visible at the test (in the case of prudence, progress measured as a test score amounts to nihil) and intangible benefits (getting the grip on an essential intellectual skill: being conscious of own ignorance) which cannot be traced by the traditional modes of assessment and are not reflected into regular learning achievement measures. Such a work on prudence degrees would be a natural extension of this chapter in future research.

Conclusion

It can eventually be concluded that this experiment – which, for the first time to the best of authors' knowledge, makes use of confidence ranking as a reflection amplifier in an adventure game – points at a potential for this type of game to engage learners at meta-levels of learning.

Chapter 8

Study 7 (collateral): Fostering reflective practice with mobile technologies

Chapter 8
Reflection with mobile technologies

Abstract

During two school days and two days off, 37 secondary school pupils were offered a daily reflection and reporting exercise about how they learnt in the day (intensity and channels). This experiment had two purposes: (a) to assess the extent to which the mobile phone can be used as an instrument to develop awareness about learning, and (b) to explore how young people attend to their identity as learners when they are prompted to reflect on this theme. Results suggest that students accepted to answer questions about learning on own mobile appliances and outside school hours. The study also provides indications that getting aware of and reflecting about their identity as learners is not a common and/or understood practice for the participants.

This chapter is based on: Tabuenca, B, Verpoorten, D., Westera, W., Ternier, S, & Specht, M. (2011). Fostering reflective practice with mobile learning. Paper presented at the 2nd Workshop on Awareness and Reflection in Technology-Enhanced Learning (ARTEL) at EC-TEL conference, Saarbrücken, Germany. To be published in CEUR Workshop Proceedings - http://ceur-ws.org (ISSN 1613-0073). The first two authors contributed equally the same to the study.

"Knowledge is information combined with experience, context, interpretation and reflection." (Davenport, De Long, & Beers, 1998, p. 211)

At the end of college, European pupils have spent on average 13000 hours on the school benches (OECD, 2011), or maybe more (Goober, n.d.). There is no doubt about the quantity of content that they have been confronted with as students. Less sure and explored is how they have developed an identity as learners.

Yet, the acquisition of such an identity grows in importance in a "lifelong learning society" (European Commission, 2006), *a context precisely wherein learning attitudes and behaviours become central assets of individuals and organisations*. Research on the akin notions of "learning to learn" (Claxton, 2006) or "meta-learning" (Jackson, 2004) has put various levels of emphasis on the social and pedagogical relevance of promoting thinking about the act of learning.

Most often however this call to more thoughtful learning has centred on mechanics and methods learning, usually purposed to train the self-as-a-performer (Azevedo, 2005; Csapó, 1999). Recently, research strands like the "narrative approach to learning" (Watkins, 2006; Wagner & Watkins, 2005) or the "student's voice" (Creanor, Trinder, Gowan, & Howells, 2008; Lodge, 2005) have emerged and proposed to also question the educational needs of the self-as-a-learner. If learning becomes a critical part of life, it is expected that those who practise it can conceptualise the many hours of tuition it represents as a specific activity that they are able to qualify, describe, and distinguish from others.

Developing this kind of awareness goes along what could be called *a "student professional development"*. Its provision implies to make room for issues like the sense-making of the daily life at school (student's "common life" in the meaning given by Lasch, 1997), the personal commitment to knowledge, and students' conceptions of the relationship between elements of the environment and learning (Elen & Lowyck, 1998).

This holistic approach suggests that *a way to sharpen reflective habits about learning is to problematise the daily exposure to the learning activities*. This approach recommends that students do not simply think of their interactions with learning opportunities as a process of "performing" them but also pay attention to the personal internalization of these experience (Daudelin, 1996; Le Cornu, 2009; Lemon, 2004), in an effort to steadily see own intellectual growth as a product of intentions and choices rather than externally-imposed or incidental entities.

The current study aims at validating an instructional setting that exhorts students to think about what they live at school.

Reflection amplifiers

Training the self-as-a-learner implies to attend to learning processes with increased time, attention and resources. There is therefore a challenge in finding ways to provide pupils opportunities to mentally evoke what they have lived throughout the day with regard to learning, so that this experience can be turned into a deliberate object of attention and reflection. One possible way is offered by Verpoorten, Westera, and Specht (2011b) in their work on "reflection amplifiers" (*RAs*).

This designation refers to compact and well-considered prompting approaches that offer learners structured opportunities to examine and evaluate their own learning. While the promotion of reflection is often associated with post-practice methods of experience recapture (Boud, Keogh, & Walker, 1985), through portfolios or learning diaries, RAs are structured and repeated introspective episodes, offered in the course of action and meant to make learning visible (Hattie, 2009) and to nurture internal feedback (Butler & Winne, 1995).

RAs do not simply aim at engaging learners at the level of presenting information for understanding and use, but also at directing them at meta-levels of learning. The concise reflection they call for further characterises RAs. As support to condensed reflective processes, RAs operate though miniature applications providing a single engagement point – here, a daily SMS – with a specified theme for thought – here, the learning day.

So far, RAs have been tested in regular formal online learning. Furthermore, the "learning to think" approach enacted by RAs has concerned academic reflective skills like summarising or self-assessing. This study transposes the RAs to: (a) mobile (meta-)learning, (b) after-school setting, and (c) analytical scrutiny onto one's life as learner.

Mobile technologies

This study builds upon three core-features of mobile technologies, and of smartphones in particular:

- smartphones represent the only technology that students have permanently inside and outside the classroom. In this way, smartphones appear as possible mediations between scholarly and after-school contexts. These appliances therefore recommended themselves in a study aiming at developing awareness of learning (Marton & Booth, 1997), both formal and informal.
- smartphones are likely to promote a more personalised approach to learning because they represent a direct channel to the learner and one that is open at all time. In this study, RAs are not only received on personal devices but they intend to promote a deepening of the personal re-

lationship of the smartphone owner to knowledge and self-growth (Ranson, Boothby, Mazmanian, & Alvanzo, 2007; Santos & Ali, 2012).

- smartphones increase the chance of learning in unconventional contexts like queues, waiting times, transportation, etc., with the virtual promise of replacing some of the "lost time" associated to these periods into "productive time". If it is impossible to know beforehand where and when the participants to this study will use their smartphone for meta-learning, it is nevertheless likely that the RAs sent via SMS will offer an opportunity for learning from reflection in a non traditional context.

Research questions

This study assigns students to amplify their reflection about the learning affordances encountered throughout the day. Three main research questions have guided this pilot:

1. to what extent will students react actively to the incentives to reflect sent on their personal device and outside the school hours? This research question bears upon the mere participation to the study;
2. what insights does this sampling of experience bring regarding how learning takes place today? This research question bears upon perceived channels of learning;
3. what effects of these structured episodes of introspective reflection can be pinpointed? This research question bears upon dimensions like familiarity with reflection, appreciation thereof, perceived learning, and account of the learning experience.

Method

Sample

The study enrolled 37 students (mean age = 17 years old, 37% female, 63% male) from two colleges (Connect College, Hecht, The Netherlands and European School, Mol, Belgium). An iTunes voucher of 15 euros rewarded their participation to a series of experiments, including this one (see section "Context and assignment").

Tooling

The experiment required using both an SMS messaging system to prompt students to reflect and a response system to answer the questions raised. In a dry-run design of the experiment, the capacity of an online voting system (Votapedia, http://www.urvoting.com) to combine the two functions was evaluated. Although this system supported multiple choice questions and was free of cost,

it was discarded since it did not support long text answers. Eventually, a specific provider was selected for each function: Textmagic (http://www.textmagic.com) as the SMS broadcast system and Socrative (http://www.socrative.com) as the student personal response system.
Socrative offers facilities like multiple choice questions and short/long answers (Fig. 8.1, label a), that can easily be tuned to educational purpose. The response space can be accessed via smartphones, tablets, laptops, and personal computers, as soon as an Internet connection is available. The system also lets the teacher monitor how many students are performing the activity in every moment (Fig. 8.1, label b).

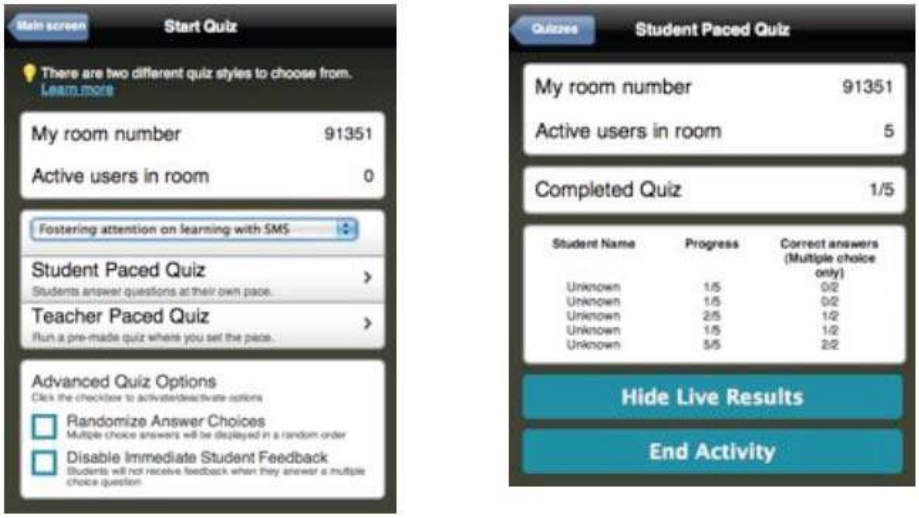


Figure 8.1. Personal response system seen from the tutor's side: a. Tutor can select various questionnaire formats, b. Tutor can monitor the exercise.

Context and assignment (daily reflection exercise)

The study took place in the context of an "Experiment Day" which offered students to discover the work at the Learning Media Laboratory (Open Universiteit) through the participation to empirical experiments. At the end of the day, a presentation provided an overview of mobile technologies for learning. Afterwards, participants were introduced to the exercise to be done in the next four days. The experiment was described to students as a reflection exercise in which they were encouraged to amplify their awareness of their daily activity as learners.
The speech of Steve Jobs (2005), whose death, close to the "Experiment Day", had received much attention from medias, was used to buttress the importance

to take a step backward and consciously attend to one's own life and personal identity (here as a learner). Yet, in his speech, Apple's manager emphasised the importance of stop-and-think episodes to question the actions of the day. An in-situ demo of the Textmagic and Socrative tools was performed. The students went back to school with a paper wrapping up the goal, the assignment and the practical information about the study.

Procedure

The daily reflection exercise was performed during the four consecutive days (Thursday, Friday, Saturday, and Sunday) following the presentation of the experiment. This setup was chosen to evenly parse the reflection exercise within two days at school and two days out of school, in a concern to deal with both formal and informal learning.
Every day, at 8 p.m. an SMS was sent to students alerting them that the student response system was ready. The sender of the SMS was "Room 91351", the identification automatically assigned by Socrative at the registration. This name had been communicated to students during the presentation. Students that had smartphone with Internet connection could follow the link contained in the SMS to perform the reflection exercise. Those who preferred to answer later on or through another medium could do it till 7 a.m. of the next day, at the latest.

Measure instruments

Pre-questionnaire

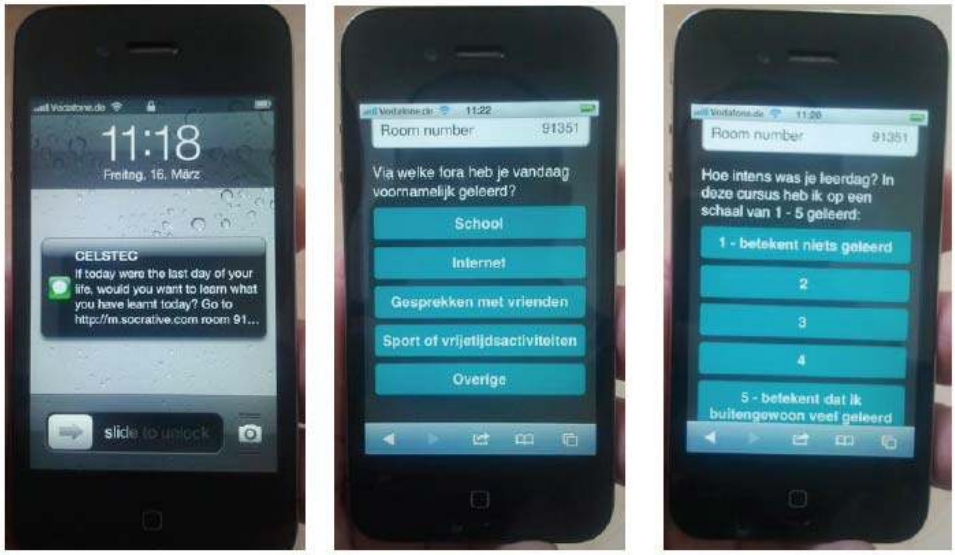
The pre-questionnaire gathered perceptions of students about the intensity of their learning in the previous week and the channels they used for learning. It provided a point of comparison to the week wherein reflection about learning was amplified.

Daily questionnaire

This questionnaire, received daily on individual smartphone (Fig. 8.2), was the reflection amplifier of the study[5]. It comprised one question about the perceived

[5] By providing an occasion of reflection which is not embedded in any specific learning moment, the study slightly diverges from the core of this dissertation which targets RAs offered in the course of action. However, the mobile questionnaire, because it is short, repeated and purposed to excipe awareness of/reflection on learning remains strongly akin to RAs. Moreover, the mobile RA tested in this study shares attributes with new methods allowing to stimulate and capture reflection in the course of action, like the ESM ("Experience sampling method"). With this method, subjects are asked to carry a beeper device that randomly sounds during fixed windows of time. Each time the beeper activates, subjects fill out a quick survey that typically includes questions asking what the subject was doing and how the subject was feeling at the time of the alarm (Intille, Kukla, & Ma, 2002; Sas & Dix, 2011). The study was also inspired by the research

intensity of the learning day and one question about the main channel of learning used in the day.



a **b** **c**

Figure 8.2. Personal response system seen from the tutee's side: a. Daily warning SMS, b. Daily reflection about channels of learning, c. Daily reflection about learning intensity of the day.

The post-test questionnaire

This questionnaire, left active during one week, had two versions:

- version a was sent to the students who performed the reflective exercise at least once: it presented the very same questions as in the pre-questionnaire, plus some questions meant to collect students' evaluative data regarding the daily reflection exercise;
- version b was sent to students who dropped out, that is students who did not complete any of the four daily reflection exercises. It raised the three same questions as in the pre-questionnaire, plus one asking them the reason why they did not participate.

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strands concerned with "measured life" (Singer, 2011) or "feedback loops" (Goetz, 2011) which have commonalities with the principle of consciously documenting daily activities.

Results

The processing of closed questions was performed with the Statistical Package for the Social Sciences (SPSS), version 20. The analysis of the questions requesting a coding of the answers was done thanks to the "Multiple Episode Protocol Analysis" (MEPA) software, version 4.10 (Erkens, 2005).

Acceptance

Question 1: "To what extent will students react actively to invitations to reflect on personal learning sent on their own device and outside the school hours (participation)?" The decrease in participation was quite visible from the first to the 4th iteration of the daily questionnaire (Fig. 8.3) but was not as severe as the drop-out rate from the pre-questionnaire to the mere entrance in the exercise. The 28 recorded post-questionnaires comprised both the participative (68% - 19 respondents) and the drop-out versions (32% - 9 respondents).

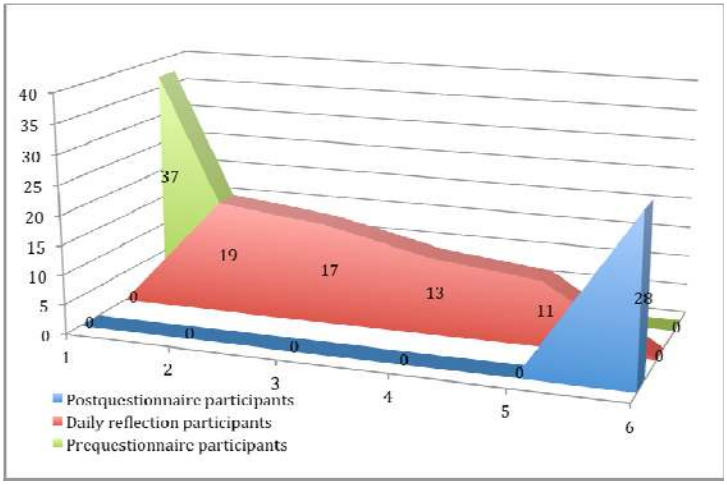

Figure 8.3. Evolution of student's participation during the experiment.

The main invoked reasons for drop-outs were for 23% "personal reasons" and for 77% technical problems or lack of facility access (mobile/internet). No respondent selected lack of interest, boredom of the intrusive character of the experiment as justifications for not participating. The Socrative monitoring tool confirmed the weight of technical failures: an average of 15% of the SMS were not delivered, a large majority thereof caused by a wrong phone number given by students at the start but also caused by malfunctions in the broadcasting (especially in Day 3 where a restart of the whole activity was necessary. Some loss also happened in Day 2).

The monitoring tool (Fig. 8.1, label b) displayed how many students were connected to the platform in every moment. This tracking feature allowed to ob-

serve that 86% of the students in average completed the questionnaire in the same moment they received the SMS.

Today's learning

Question 2: "What insights does this sampling of experience bring regarding how learning takes place in students' today common life (channels of learning)?" Table 8.1 wraps up the answers given by students in the pre-questionnaire and in the daily reflection exercises. School and Internet were the most important perceived sources of learning.

Table 8.1. Main channel of learning (in relative percentages)

	School	Internet	Conversations	Leisure	Other
Pre-questionnaire (*N* = 37)	65%	27%	3%	0%	5%
Day1 (*N* = 19)	26%	53%	11%	5%	5%
Day 2 (*N* = 17)	73%	9%	9%	9%	0%
Day 3-WE (*N* = 13)	0%	31%	7%	31%	31%
Day 4-WE (*N* = 11)	0%	46%	9%	9%	9%

Reflection

Question 3: "What effects of the structured episodes of introspective reflection can be pinpointed?"

Familiarity with reflective practice

Positive answers to the post-questionnaire question "before the start of this experiment, can you remember the last time you thought about your learning day?" amounted to 19% (*N* = 28)

Appreciation of reflective practice

When asked whether they liked the reflection ritual implemented through their smartphone, 69% (*N* = 19) answered positively. Four categories emerged from the justifications of the students valuing the experience:

- gains in meaning (18%): e.g., participant 18: "It helps you realise that your day has much value. It is eventually about my life";
- gains in self-assessment (29%): e.g. participant 5: "You look critically at what you have learnt and how you might improve. Evaluating yourself adds to the learning experience itself";
- gains in consciousness without further details (24%): e.g., participant 7: "My interest steadily grew because it made me more conscious";
- other answer (29%): e.g., participant 9: "Very interesting and well done".

Only a few students gave reason for their dislike of the experiment: "no learning comes from the reflection" (participant 6), "the reflection is quickly forgotten" (participant 20), "my reflection on learning takes place in the moment of learn-

ing and not afterwards" (participant 21), "I reflect on other things" (participant 10), "I've often asked myself before if I learnt at school and often came to this conclusion: nothing" (participant 2).

Perceived learning:
Perceived learning was rated on a 3-point Likert scale: I learnt less than usual, I learnt as usual, I learnt more than usual. A higher relative frequency of the answer "I learnt more than usual" was found for the group of students who participated to the reflection exercise and filled in the post-questionnaire (N = 19) than for the group of students who did not show up for the exercise but took the post-questionnaire (N = 9): 31% versus 7% respectively. However, a Mann-Whitney test granted no significance to this observation: $U = 79$, $p = .12$, $r = .03$

Description of learning experience:
When asked to describe their learning experience during the week, participants to the daily reflective exercise produced longer accounts: 112 characters on average versus 88 for the non participants. However, from a t-test, it turned out that these differences were not significant, $t(26) = 1.12$, $p = .26$, $d = 0.29$. The same conclusion was drawn from a chi-square test bearing upon the level of complexity of the accounts, assessed with a three-level coding rubric.

Discussion

In this study, a reflection amplifier, modelled as an evaluation questionnaire of daily learning, was relayed to the students through personal smartphones with the purpose of stimulating thinking upon learning activities, contexts and channels. The study had three objectives:

1. to check whether students would accept to talk about learning outside the school and via a personal appliance;
2. to collect first-hand information about how learning takes place today in the eyes of learners;
3. to explore if the structured educational encounters embodied by the RAs would allow students, in addition to their lived learning experiences of the day, to make these learning experiences exist in consciousness. The underpinning assumption was that "professional learning" is at the confluence of this combination of experiences of learning (action) and thought about these experiences (reflection).

This section gives an interpretation of the results and locates them in a broader educational context. The discussion and the suggestions for future research follow the order of the three guiding research questions of this study.

Use of private phones to raise awareness about learning

A proportion of pupils accepted and was able to use personal smartphone for "serious" messages coming from a researcher outside the school hours. Whilst it can seem obvious, this pre-condition does not speak for itself. Hardy et al. (2008) show that, even when undergraduates do have a good level of IT competence and confidence, they tend to be conservative in their approaches to university study, maintaining a clear separation between technologies for learning and for social networking. Based on observations revealing low levels of use of and familiarity with emergent technologies (collaborative knowledge creation tools, virtual worlds, personal Web publishing), Margaryan and Littlejohn (2009) cast doubts on the ability or the wish of students to use complex digital tools in their learning practice. In contrast, Jones, Edwards, and Reid (2008) report that, despite being unaccustomed to using their mobile phones for academic study, students willingly accepted SMS reminders – focused on time management and not on learning consolidation – from their tutor via a bulk texting service. This study suggests that it is possible to use smarphones to stimulate meta-learning about common life as a learner.

Fragmentation of the learning sources

Despite the mounting gulfs of literature stressing the emergence of a "Net Generation", "Homo Zappiens", or "Digital natives", despite the growing interest for informal learning which can go, in its extreme form of praise, till a prediction of the disappearance of physical institutions like schools (Miller, Shapiro, & Hilding-Hamann, 2008) under the pressure of the fragmentation of the traditional education landscape into thousands of personal learning environments, this study suggests that learners still perceive school as a major vector of learning. Indeed, its monopoly over learning processes is challenged by the emergence of a rich ecosystem outside school walls, as heralded by the Internet (see Table 8.1).

Acceptance and effects of reflective practice

Three findings emerge from this study regarding reflective practice in students' common life:

- there is no anchored habit in the participating students to see themselves as learners and to develop a "professional" awareness about their daily activity/job at school and the learning opportunities after school (see section "Familiarity with reflective practice");
- providing time to perform reflective activities on this topic is appreciated by about half of the sample for reasons relating to consciousness and sense-making (see section "Appreciation of reflective practice");
- the high level of drop-out combined to some students' negative feedback (see section "Appreciation of reflection") suggest that the stop-and-think beacons offered in this study are judged as useless or super-

fluous by a portion of students, even when these opportunities to reflect have been designed to be short. Further research is needed to disentangle the profile of the people ready or not to devote time to self-awareness development (Baeten, Kyndt, Struyven, & Dochy, 2010), and the reasons and consequences thereof.

Further research

As for Research question 1, the possible tensions/synergies flowing from the use of personal appliances and outside-school time for scholarly messages and activities should remain a topic for elucidation (for an example of an experimental interlace between the use of private mobile technologies and social media in relationship to the educational resources provided by a university, see Ferguson and Shum, 2012).

As for Research question 2, of particular concern for future investigation is to ascertain how school still contributes to youth's intellectual growth (Facer, 2011) when it is surrounded by and interacting with other vectors of education.

As for Research question 3, finding ways to help young people to externalize what they live day after day as learners remains a challenge for research and education. This study has tested one way to draw attention on daily learning: the provision though smartphones of short but frequent opportunities to take learning as an object of attention and to sharpen the awareness of oneself as a learner. Theoretical and empirical work is needed regarding the relationship between consciousness of learning and learning and the kind of new knowledge and attitude to school possibly conveyed by such episodes of introspection.

Limitations of the study

The sample in this study has shrunk for technical reasons but also for reasons probably tied to the limited importance granted to reflection. The small sample of students which went through the whole study, the low number of iterations of the reflection exercise (four), the fact that the invitation to reflect has not come from patented teachers but from researchers unknown to the participants concur to make the findings of this study rather fragile. Also, the effect of the reward on the participation rate is uneasy to assess because it is mixed up with the attendance to other experiments of the "Experiment Day". Another limitation is that the data has been processed according to between-subjects comparisons only, due to technical limitations of the Socrative system regarding respondents' identification.

Chapter 9

Study 8 (collateral): A first approach to "Learning Dashboards" in formal learning

Chapter 9
Learning Dashboards in formal learning contexts

Abstract

This chapter is written as a position paper that introduces to "learning dashboards", flagged as a new breed of eLearning interfaces. Following a detailed observation of three instances of these structures for regulative support, the chapter suggests possible effects their use on attention to the learning experience, reflective learning, and sense of personalisation. The chapter concludes with the identification of research challenges associated with the mirroring of tracked data, inherent to these displays.

This chapter is based on: Verpoorten, D., Westera, W., & Specht, M. (2011d, September). A first approach to "Learning Dashboards" in formal learning contexts. Paper presented at the ADVTEL Workshop (1st International Workshop on Enhancing Learning with Ambient Displays and Visualisation Techniques) at the EC-TEL 2011 Conference, Palermo, Italy.

"A defining condition of being human is that we have to understand the meaning of our experience." (Mezirow, 1997, p. 5)

The aim of this chapter is to provide a way to start talking about "Learning Dashboards". These artefacts are apprehended as reflective tools interweaving personal and contextual information about learning at hand. An argument is made that this crisscrossing between content-related and self-related dimensions, arranged within a permanent, visual, and dynamic display, is a new phenomenon in the practice of formal eLearning education. Its emergence stands at the cross-section of technological development (tracking and visualisation technologies) and pedagogical requirements (the promotion of autonomous and mindful learning, along with the call for more multidimensional students' assessment procedures).
Other metaphors like "learning cockpits", "control towers" or "control panels" could have been used since they induce similar ideas of personal control, coordination of information, and support to decision making. The denomination "Learning Dashboard" is retained for this chapter because it sounds as the most intuitive (there is a dashboard in every car).

Cognitive orchestration

Reflection – and similar constructs like "meta-cognitive development" or "learning to learn" – is assumed to be an essential factor of quality learning. Its practice in schools is supposed to gradually increase learners' awareness of what helps and hampers a consistent orchestration of the various dimensions of their learning processes (Ertmer & Newby, 1996). However, ways to initiate, train and support such an orchestration have not been systematically investigated. *This chapter holds that developing reflective behaviours could be trained by exploiting the unique tracking and visualisation facilities of electronic environments. Familiarising learners to engage with the so-called "learning dashboards" (LDs) may cultivate awareness and orchestration of the various personal and contextual dimensions of learning.*
LDs might contribute to train thinking skills, sustain self-analytic habits (Johnson & Sherlock, 2008) and build ownership of learning. By capturing more information related to learning and learners than regular tests do, LDs can also play the role of alternatives to one-dimensional assessments (Van der Vleuten, Schuwirth, Scheele, Driessen, & Hodges, 2010) into curriculum, classroom practice and class councils.

Examples of learning dashboards

In order to get acquainted with LDs and to better qualify these, a literature review was conducted. It aimed at gathering concrete examples of these displays. The review covered various connected domains: literature about reflection, tracking, visualisation of learning traces, self-monitoring skills, adaptive systems, scrutability of learner models, etc.
Instances of LDs were collected, allowing to establish early converging traits and variations. To be included in the sample, the cases had to: (a) be well-documented (a picture of the LD was a must-have), (b) address learning in formal settings, and c) be designed for use by individual students[6].
A dozen LDs matched these three conditions: Basque, Ruelland, and Lavoie (2007), Bull and Nghiem (2002), Bull, Quigley, and Mabbott (2006), Georges (2006), Kerly and Bull (2008), Mazza et al. (2009), Mitrovic and Martin (2002), Narciss, Proske, and Koerndle (2007), Stadtler and Bromme (2008), Tell Me More (n.d.), ULCC (n.d.). These instances were subsumed under the label "Learning Dashboard". However, it must be noted that their authors did not use this appellation. Three LDs are now given as tangible and representative illustrations of LDs.

CALMsystem

Developed in the context of research on intelligent tutoring system, the CALMsystem (Kerly & Bull, 2008) opened the learner model to 10-11 year-olds in a science class. This allowed them to compare the representations of their current knowledge level in different domains as assessed by the system (Fig.9.1, label 1 – "CALMsystem's belief about my knowledge") with their self-assessment of this same knowledge (Fig. 9.1, label 2 – "My belief about my knowledge"). The system also offered pupils a possibility to discuss possible divergence between both (Fig. 9.1, label 3). In both its inspectable and negotiated versions, the LD was a lever to promote meta-cognitive skills while improving the learners' model accuracy.

[6] A first lesson of the literature review was that LDs in formal learning contexts were often designed for being used by the institution (Onderwijsraad, 2011, p. 20) or instructors (Ainsworth & Fleming, 2006; Bakharia & Dawson, 2011; Diagne, 2009; Scheuer & Zinn, 2007; Tanes, Arnold, King, & Remnet; 2011). The mirroring of tracked data appeared as moderately practised to the direct benefit of students. This might be interpreted as an omen that the new instructional facilities brought about by tracking and mirroring systems are more spontaneously funnelled into the control of learners than into their empowerment (Martens, 2007, p. 59). Another reason could be that students lack capacities to interpret their own interaction history with learning, because the appropriate tools, didactical methods, managerial facilities, evaluation formats, frames of mind are not in place.

Figure 9.1. Learning Dashboard of the CALM system.

Tell Me More

Tell Me More (n.d.) is a commercial language learning software which caters for multimedia and interactive exercises covering the skills involved in learning a language: reading, writing, listening, speaking, vocabulary, and grammar. The Tell Me More LD displays the lessons (Fig. 9.2, label 1), the activities composing them (Fig. 9.2, label 2), the percentage of completion by lesson (Fig. 9.2, label 3), the percentage of completion by learning activity (blue) and the percentage of correct answers for the completed part of the activity (dark blue) (Fig. 9.2, label 4), the activities denied to the learner (Fig. 9.2, label 5), the not yet started activities (Fig. 9.2, label 4), the recommended next activity (Fig. 9.2, label 7).

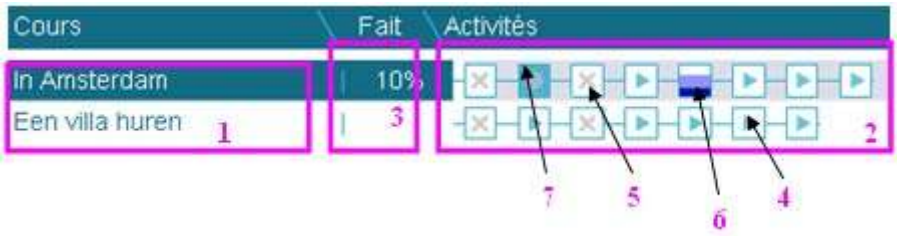

Figure 9.2. Learning Dashboard of the Tell Me More language learning software.

met.a.ware tool

The meta-cognitive tool met.a.ware was designed to support laypersons' Internet search (Stadtler & Bromme, 2008). Learners were requested to paste, under one of the six thematic tabs (Fig.9.3, label 1), the information found on the

Internet (Fig. 9.3, label 2) and to simultaneously assess and monitor their knowledge acquisition and comprehension via three rating tools: "Assess how well you have comprehended the information you have pasted" (Fig. 9.3, label 3), "Assess how much you currently know about the topic" (Fig. 9.3, label 4), "Assess how much information you still need on the topic" (Fig. 9.3, label 5). All ratings were attached permanently to the specific contents. They could be retrieved and evolved at all times during future Internet research.

Figure 9.3. Learning Dashboard of the met.a.ware tool.

Key features of learning dashboards

Based on the review, common characteristics were derived. LDs:

- add an additional layer of meta-information to learning contents and tasks. This extra layer endows learners with self-appraisal and learning-related indicators, gauges, meters, etc. (Glahn, Specht, & Koper, 2007, 2009);
- create this additional layer of meta-information by mirroring (Jermann, Soller, & Mühlenbrock, 2001) personal tracked data (*feedback by the system to the learner* in the Tell Me More LD) and/or by recording personal information proactively provided by learners (*feedback by the learner to the system* in the met.a.ware LD);
- display this additional layer of meta-information in a one-stop place (Verpoorten, 2004) from which, in return for an effort of awareness and reflection, students can keep an updated status of their situation in the course and better control it;

- seem to be designed according to three principles: *comprehension* (following a meta-learning or sense-making ambition), *condensation* (following a portal orientation) and *combination* (following a mash-up orientation);
- diversely develop the visual aspects;
- in some instances (CALMsystem's LD) offer an option to confront own mirrored data to some kind of yardstick;
- can be arranged at different levels of granularity: single pages, chapters or whole course.

Effects of learning dashboards

Based on the shared traits outlined hereunder, it does not seem extravagant at this stage to consider LDs as a distinct family of artefacts for learning. This section speculates about the cognitive and instructional effects of these affordances.

LDs and meta-learning

Although LDs look quite different across learning situations, they all organise a crisscrossing between the externally imposed context of the learning assignment and the internal context of the individual committed to it. LDs blend the content and the self. They include menus but are more than menus. They are "menus + me". This entanglement between formal and personal dimensions, between learning and meta-learning (Jackson, 2004), is obtained either through mirroring (the display of personal tracked data), or through externalization (the request made to learners to make an aspect of their learning process visible). In both cases, the relationship between the learning task and the agents becomes somehow personal and tangible in LDs (Westera, 2011). Besides the monitoring support, LDs stimulate awareness of own learning experience (Schraw, 1998) and the cognitive coordination of information about learning (Yee, Hunt, & Pellegrino, 1991). They help to realise that learning occurred and what it is made of. Such awareness can be a precondition to "learning to learn".

LDs and personalisation

The position is taken here that the mesh of cognitive and meta-cognitive landscapes, materialised in LDs, should be explored as a specific way to personalise learning (Verpoorten, Glahn, Kravcik, Ternier, & Specht, 2009). In this case, the personalisation would occur throughout the development of an inner sense of personal accountability and control of the learning material, fed by the presentation to individuals of their learning traces, deliberately produced or not. This blend of personalisation possibly offers a counterpoint to the traditional adaptive systems' approach which proceeds by automatically individualising the

learning path. In contrast, the type of personalisation conveyed by LDs relates to the steadily appropriation by a learner of externally imposed values and standards (see Fig. 1.6 in Chapter 1), which remains a typical attribute of formal education. By providing traces, histories and factual indicators of the processes fostering the internalization of these underlying values, LDs would not only work as regulative supports helping for performance achievement but would also act as a *vector of ownership*.
By recording traces and keeping track of the learning history of individuals, LDs might also inform the set up of ipsative assessments (Sluijsmans, 2008), that is procedures whereby the learning performance of individuals is not firstly compared to the average score of a group of peers but with their previous personal achievement and to progress criteria defined between them and the educator.

LDs and reflection

Another striking feature of LDs is that they can be interpreted, from a pedagogical viewpoint, as combinations of "reflection amplifiers" (RAs). An identification process of the RAs available in the three selected LDs was performed according to an inventory of reflective techniques (Verpoorten, Westera, & Specht, 2011b). It exhibited that the dashboard of the CALMsystem offered a combination of RAs called: "Indicators of understanding", "Self-efficacy judgment", "Compare with yardstick", and "Pausing to reflect". The dashboard of the Tell Me More language platform merged the RAs: "Room for choice" and "Growing mastery visualisation". Met.a.ware's LD federated the RAs: "Writing on the reading", "Indicators of understanding", "Self-efficacy judgment", and "Eliciting intentions before a task".

Further work

Whilst some early qualifications of LDs could be achieved in this chapter, most of the developed assumptions lack empirical evaluation. Many questions were thrown up in need of further investigation: what is the value of mirroring personal information for instruction?, what kind of information is relevant to be visualised in LDs and how?, what kind of LDs would be built by teachers?, which components of these LDs would be perceived as useful by learners?, and how would students appropriate their learning traces once mirrored to them?
Some plausible effects of LDs on feeling of personalisation, sense of control, ownership, relatedness (sense of acceptance) to the learning assignment, evolution of the perceived locus of control, or level of meta-learning activity were pinpointed but ought to be disentangled.
A critical question touches upon the kind of reasoning expected from a dashboard-supported reflection: while LD's monitoring function seems to fit in

with a traditional view of the self-as-performer, the exposition of learning processes that they realise along with their potential for sense-making could also put them in the service of the self-as-learner.

Conclusion

This chapter holds that LDs is an emerging phenomenon in eLearning. By mirroring/recording interaction footprints, these structures for regulative support can quickly show something of an active and personal relation of an individual learner to digital instruction. It is put forward that making visible learners' personal interaction history with a learning task is able to support attention to, reflection on and personalisation of learning.

Chapter 10

Study 9 (prime): Reflective breaks while studying online – Effects on meta-cognitive awareness, time on task, performance, and physiology

Chapter 10
Reflective breaks while studying online

Abstract

The purpose of this chapter is to gain insight into the effects of practising short, frequent, and structured reflective breaks interspersed with the learning material. The study shows that, while performance is not affected by these embedded "reflection rituals", they significantly impact time on task, perceived learning, and some learner's physiological states. The study also suggests that the exposure to such built-in opportunities for reflection modifies the engagement with the content and fosters the claimed readiness for application of a similar reflective approach to learning, in other occasions.

This paper is based on: Verpoorten, D., Qi, W, Westera, W., & Specht, M. (2011). Reflective breaks while studying online – Effects on meta-cognitive awareness, time on task, performance, and physiology. Manuscript submitted for publication.

"*Some students see meta-cognitive instruction as irrelevant because they have become comfortable with a passive, mindless approach to their education. The challenge teachers face is evident: How can we help students recognize that they need to change the way they see themselves as learners?*" (Joseph, 2003, para. 4)

Educating the knowledge workers of tomorrow demands to simultaneously foster the mastery of domain content and the development of transversal (domain-independent) skills (Egan, 2010). The latter empowers individuals to cope with requests for new knowledge acquisition and ongoing personal development (Brown, Lauder, & Ashton, 2008; Fredriksson & Hoskins, 2007). For providers of initial instruction, this responsibility to prepare students to be mindful, engaged and responsible learners in a lifelong learning society is not a trivial one (Laurillard, 1993; McGuiness, 1999). It implies finding ways to help students to learn how to become expert students (Ertmer & Newby, 1996) or to act as "reflective practitioners" (Schön, 1983) in their daily duties as learners already.
To practise "split screen teaching" (Claxton, 2006), that is maintaining a dual focus on the content of the lesson and the learning dispositions that are in play, is difficult. Tutors can perceive thinking skills training as consuming the time available to "cover the material" (Gill & Halim, 2006). Tutees are often unsure about what reflecting is, how they are expected to reflect (McKenzie, 2010), and more fundamentally why reflection is a condition for high-quality learning. For instance, Weir (1998, p. 458) describes that his students view reading as "a passive experience of running their eyes over print, then hoping that they'd 'got it' only to find, when faced with comprehension questions after reading, that they had not".
The challenge is therefore to devise reflective methods and tools which do not consume teaching time while making students cognizant of what it can mean to incorporate reflection in learning (Loughran, 1996). This chapter precisely probes *the potential of short reflective breaks to stimulate meta-cognitive awareness of reflective processes*.

Reflective breaks

Reflective breaks – also called "pausing principle" – have received attention from research when applied to face-to-face lectures (Di Vesta & Smith, 1979; Ruhl, Hughes & Schloss, 1987; Simpson, 2004) and mainly in relationship to student recall (for a systematic review, see Parker, 1994).
In contrast to the aforementioned studies, the current one: (a) took place in a context of self-instruction where no instructor was available to directly inform and stimulate students' thinking about learning contents and processes, (b) pursued a meta-cognitive training purpose by providing students with the pedagogical rationale behind each reflective break, and (c) requested to perform the

brief thinking episodes at a frequent pace in order to intensify the ongoing mental crisscrossing between learning and meta-learning, assumed to be a key feature of thoughtful learning (Verpoorten, Westera, & Specht, 2011c) and a signpost of intellectual activity and discipline (Sternberg, 1998). Four hypotheses guided this study.

Hypothesis a

"The confrontation with reflective breaks *(RBs)* enhances students' consciousness that reflection is relevant for learning."
Because RBs are purposed to arouse thinking not only on the learning material but also on the nature of the learning process itself, one main influence of the practice of these systematic and structured episodes of thinking while learning is expected to be on the global perception of the learning experience and the concern for/commitment to (Krathwohl, Bloom, & Masia, 1964) reflection.

Hypothesis b

"The time spent in the course does not differ between treatment and control groups because RBs are conceived as lightweight reflective techniques."
This hypothesis was deemed to further clarify the relationship between reflection and time on task. Hence one prior study (Verpoorten, Westera, & Specht, 2011c) showed no effect on time while a second one (Verpoorten, Westera, Glahn, & Specht, 2012a) found a significant influence.

Hypothesis c

"The treatment group gets a better score at the final test (measuring performance) compared to the control group because RBs support a quality internalization of the content."
Whilst previous experiments (Verpoorten et al., 2011c, 2012a) using RBs did not demonstrate striking effects on performance, this optimistic hypothesis was maintained here because the study addressed a different target group (see section "Sample").

Hypothesis d

"The practice of RBs impacts upon the physiological measurements of the treatment group."
The study collected physiological data for two students in order to ascertain whether parameters like skin temperature or pulse rate could serve as indicators of the reflective orientation given to the learning material.

Method

In order to put at the test the infusion of short and structured reflection affordances and to uncover their effects on the learning experience, a comparative study was set up based on an online course delivered at two conditions: with and without RBs. The intervention variable was the exposure to RBs. Consistently with the hypotheses, the dependent variables were accounts of learning experience (open and closed questions), time spent in the course, performance (score at the final test) and physiological changes and processes.

Sample

In contrast to the aforementioned studies (Verpoorten et al., 2011c, 2012a), conducted at a distance with volunteers (mainly skilled knowledge workers), the current sample consisted of 42 pre-university education students (option: informatics), physically present in computer rooms during the experiment. Hence, the context of this study was close to regular schooling practice. It sought to provide stable experimental conditions, homogeneity in the sample and a contrast regarding the target audience of RBs up to now. Pupils came from two secondary schools contacted by the author, which offered to participate to the experiment as part of a "discovery day" they organised once a year.

Course

The learning material selected for this experiment was a shortened version (1 hr) of the 4-hour online course "Seks en de evolutie" (Sex and the evolution) created (Eshuis & Goltstein, 2007) and offered in Dutch by the Open University in the Netherlands. The course covered non trivial and interrelated notions and mechanisms as defined by Darwin and his followers: reproductive value, paternity uncertainty, mating strategies, differential investment in parenthood, etc. The course invited learners to use this theory as an interpretation grid of gender-related behaviours observable in everyday life. The course was made of five chapters of five pages each, while each page contained about 200 words and one or two illustrations (Fig. 10.1).

In order not to bias the use of the different RBs by uneven levels of difficulty in the content, special attention was paid to ensure equivalence between all chapters. Each of them underwent the Flesch reading ease test (Flesch, 1948) that returned comprehension difficulty levels comprised between 48 and 52, which is comparable to the level of the "Time" news magazine. A systematic concept mapping of each chapter additionally ensured that they presented an even level of complexity regarding the number of new notions introduced.

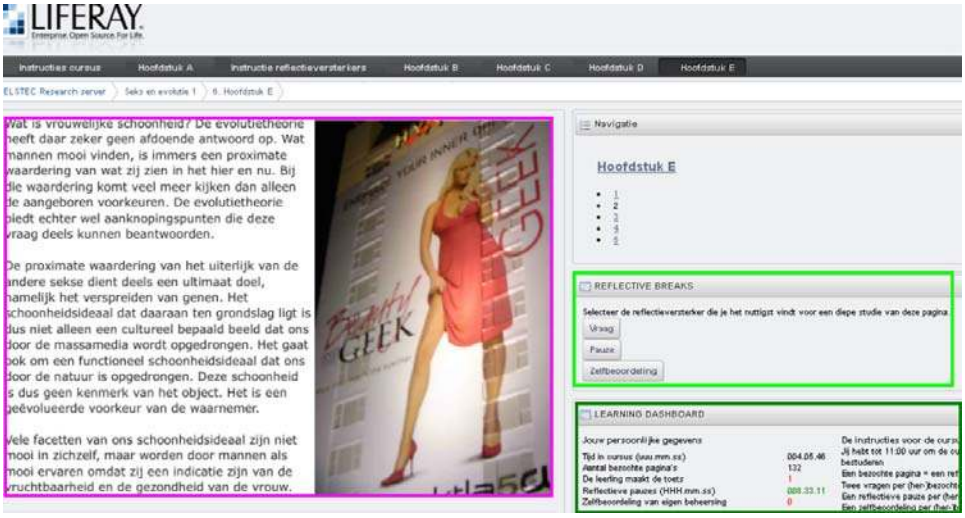

Figure 10.1. The page design bundled content (left-side overlay) and affordances to develop thinking habits: reflective breaks and learning dashboard (right-side overlays).

Tools

Technological aspect

To support and condense the reflective processes of questioning, evocating and self-assessing (see section "Pedagogical aspects"), three miniature Web applications ("portlets") were developed (Fig. 10.2). They displayed, in a clear and identified graphical style, a single interaction point with the structured reflective rituals to apply on the first-order activity (studying the content of the page).

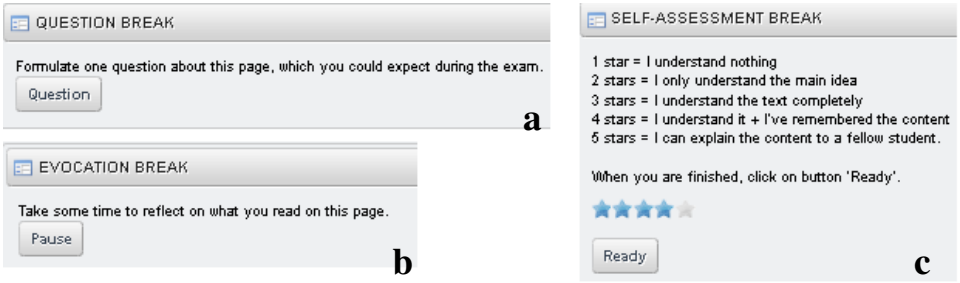

Figure 10.2: The reflection portlets used: question (a), evocation (b), self-assessment (c).

The three reflective strategies were implemented in accordance with the basic design principles for effective meta-cognitive instruction as synthesized by Bannert (2006): (1) integration in the domain-specific instruction (subject matter), (2) explanation of the application and usefulness of each instructed strategy, and (3) provision of a sufficient training time or use frequency.

Pedagogical aspects

The study exposed participants to three types of RBs meant to establish learning as an object of attention and reflection and thereby introduce students to essential components of academic literacy:

- **questioning**: previous research highlights the importance of encouraging students to generate questions about the study material (Logtenberg, Van Boxtel, & van Hout-Wolters, 2011; Marbach-Ad & Sokolove, 2000; Pedrosa de Jesus & Moreira, 2009). In this study, students deliberately and systematically exerted a questioning strategy called "Students set the test". Participants were requested to formulate questions that they might envision as questions about the content to be answered at the exam. Doing so, they put themselves metaphorically in the shoes of a teacher composing a test. The "Question break" portlet offered a note-taking tool where the students wrote down their questions (Fig. 10.2, label a). (Participants to the control group were allowed to take free-style electronic annotations in the simple text editor "Notepad").
- **evoking**: an evocation brings or recalls to the conscious mind what has been previously read. Conceptual works of the "mind management" theory (Brown-Frossard, 2012; La Garanderie, 1989) suggest that this process of mental imaging allows readers to transform what they have read into a mental object (Seel, 2001; Vermersch, 2009) and thereby anchor it in their mind. According to these authors, it is essential to do this evocation, otherwise the learning experience remains in the sensorial context of the reading and does not enter the mental realm. The "Evocation break" portlet combined an "I start the evocation" button and an "I stop the evocation" button (Fig. 10.2, label b).
- **self-assessing**: research shows that self-assessment can lead to significant enhancements in learning (Taras, 2002), by developing students' habit to evaluate the strengths and weaknesses in their own study. According to Nicol and MacFarlane-Dick (2006), in order to develop this habit and capacity, courses must offer opportunities for judging one's own level of understanding and mastery of the learning material. The "Self-assessment break" portlet presented as a 5-star visual scale (Fig. 10.2, c) that the students used to indicate their current level of mastery of a defined portion of content (for each level a standardised explanation was given).

Experimental design aspects

The treatment group studied Chapter 1 like the control group: without any RB. This arrangement opened to participants a possibility of contrast with the chapters studied with support tools. In Chapter 2, 3, and 4, students got acquainted with one single reflective technique (see the combination Chapter/RB in Table 10.1). In Chapter 5, all techniques were available. Based on their experience in

the previous chapters, students could decide which one to use after each (re)visited page.

Table 10.1. Compact view of the course chapters with RBs (X = provided, – = not provided)

Course chapter	Question breaks	Evocation breaks	Self-assessment breaks
1	–	–	–
2	**X**	–	–
3	–	**X**	–
4	–	–	**X**
5	**X**	**X**	**X**

The students had to deliberately practise the offered RBs after each page visited or re-visited. In order to consolidate this systematic reflective approach of the course content, a "Learning dashboard" (Fig. 10.3) was set up. A colour scheme indicated whether or not the number of (re-)visited pages matched the number of RBs' uses. In case of match, the number appeared in green and, in case of discrepancy, in red.

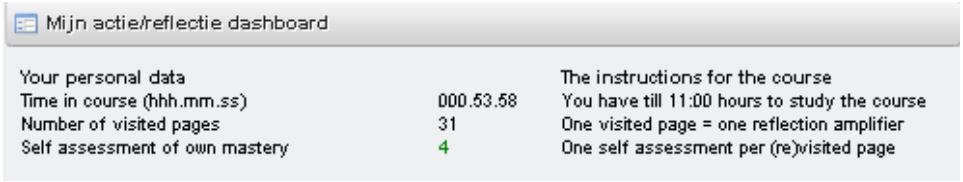

Figure 10.3. The learning dashboard for Chapter 4. The number "4" (mirrored in green) indicated that the student had practised self-assessment each time he/she had visited a page of this chapter.

Procedure

After a pre-test, the 42 participants individually studied in one version of the course (with or without RBs) according to a random distribution. Both groups were evenly invited to practise a thoughtful study freed from time pressure in view of gaining as much mastery as possible of the learning material. After the course completion, students filled in a post-test. A follow-up questionnaire was administered one month after the experiment in an attempt to evaluate possible persistent effects. Participants received an iTunes voucher of 10 euros for their participation and were debriefed before leaving.

The physiological measures were collected in a separate setting with two additional volunteers. They covered first the course with the RBs and afterwards the version without. This setting was favoured for an equipment-related reason (only one device was available for this study), a calendar-related reason (by the time of the experiment, few students were available due to exams/holydays), and a methodological reason (repeated measures allowed to better monitor individual variations).

Instruments

The data sources for this study were the returns from the questionnaires (pre, post, follow-up), the logging data, and the physiological measures.

Pre-questionnaire

Taken prior to the course study, the background questionnaire evaluated students' pre-knowledge of the course topic with six multiple-choice questions. Meta-cognitive ability was assessed for each student by their teacher on a 5-point Likert scale.

Post-questionnaire

Taken after the course completion, this questionnaire gathered:

- evaluative feed-back: open and closed questions collected student's perceptions of overall satisfaction, sense of control, and feeling of learning. Questions relating to the instructional intervention were added for the participants to the treatment group;
- performance measures: a test assessed the knowledge and comprehension of the studied topic. Ten multiple-choice questions were selected among a pool of questions tested by 137 students in a previous experiment based on the same study material (Verpoorten et al. 2012a). The mean discrimination index was of .67. This located the test at a medium-high level of difficulty (McAlpine, 2002). As a knowledge integration task, students were asked to comment three pictures with what they had learnt in the course. This was consistent with the design of the course that displayed carefully selected visuals on each page (Fig. 10.1).

Follow-up questionnaire

The follow-up questionnaire asked students to give to an imaginary friend, who ought to take the same course, advice regarding six study strategies, including the three RBs. The perceived relevance of the strategies was rated with sliders on 100-point scales, an asset available with the survey software Qualtrix (https://www.qualtrics.com).

Logging data

The tracked data was the time spent in the course (total and per chapter), the number of pages visited (total and per chapter) and the number of time a RB was used. The logs also stored the choices made by learners in Chapter 5 regarding RBs.

Biosensor

Physiological data was collected from the two students with the appliance "Biofeedback 2000" (http://www.schuhfried.com). This non-invasive biofeedback

system recorded the following physiological signals: (a) skin temperature (TEMP), (b) blood volume pulse, viz. the pulse component of the surface blood flow (BVP), (c) pulse volume amplitude, viz. the amplitude of the blood volume pulse (PVA), and (d) pulse rate (PR). The sampling rate was one measure every 25 milliseconds. The accuracies of the measures were specified as 0.01°C for TEMP and 0.004 beats per minute for PR. BVP and PVA were relative values and their accuracy was of 0.25 %.
The sessions were also screen-recorded with the software Camtasia (http://www.techsmith.com) in order to grab supplementary information about the sequencing of reading and reflecting periods.

Results

Two students who missed either the pre- or the post-questionnaire were removed from the analysis, leaving 40 test persons (mean age = 17 years old, 37% female, 63% male) in the final sample: 21 participants in Condition 1 (control) and 19 in Condition 2 (reflective breaks).

Internal validity

Students in both groups yielded a mean score of 1.5 points out of 6 (SD = 1) in the prior knowledge test. T-test showed that groups were comparable, $t(38) = 1.22$, $p = .22$, $d = 0.38$. The ability levels to reflect, as rated by the teachers, were evenly distributed in the two groups, $U = 29$, $p = .83$, $r = .09$.

Logging data

Tracked data confirmed that both groups covered the whole course. The treatment group performed the reflective assignments with diligence: the global ratio page views / RBs was close to the perfect fit ($M = 0.93$, $SD = 0.1$). Lastly, the interaction footprints revealed the choices of students in Chapter 5: the Question break and the Evocation break represented 32% of the freely-selected reflective enactments and the Self-assessment break 36%.

Feedback from learners

Follow-up questionnaire

Hypothesis a: The provision of RBs enhances students' consciousness that reflection is relevant for learning. The treatment group recommended more cheerfully ($X = 68/100$, $SD = 21$) the use of the "question break" than the control group ($X = 51/100$, $SD = 21$). This is the only significant difference, $t(28) = 4.81$, $p = .03$, $d = .15$ that emerged from the 29 answers received (14 from participants to the control group and 15 from the treatment group). However, re-

sults showed a global tendency for the treatment group to advise the two other practised RBs (evocation and self-assessment breaks) with a higher intensity.
The three other strategies sustaining a thoughtful learning that were suggested in the follow-up questionnaire (writing the keywords of the page, summarising the page, taking enough time to understand in detail) were summed up. They similarly got a slightly higher intensity level of recommendation on behalf of the control group (Fig. 10.4).

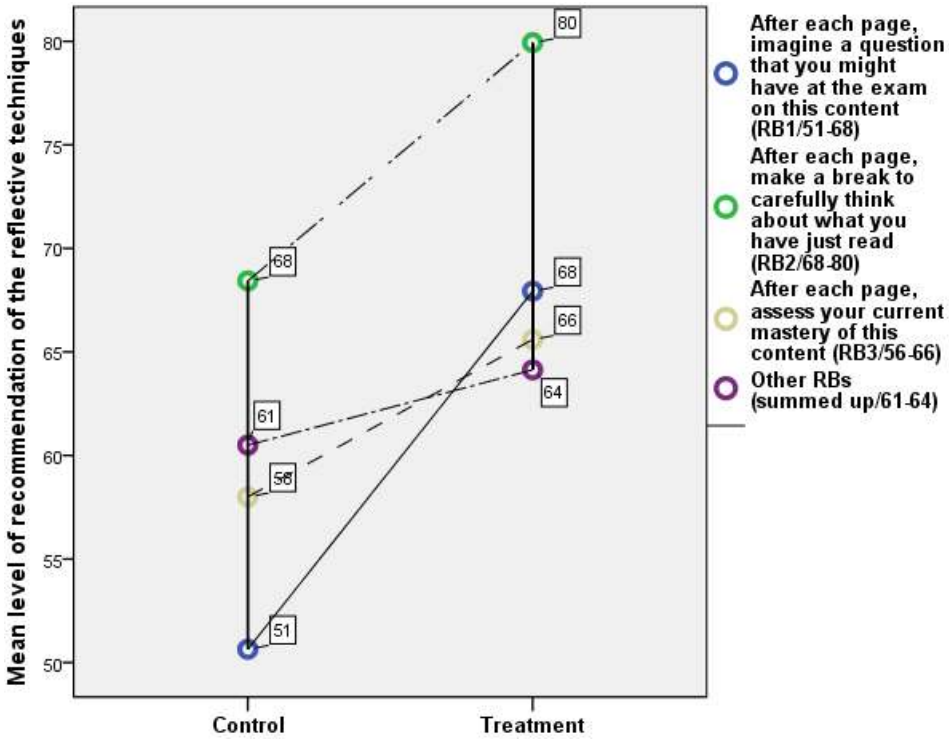

Figure 10.4. The mean level of recommendation for all reflective strategies was higher in the treatment group. The difference for the "student sets the test" strategy was significant.

Contrast with regular learning experience

Among the participants to the treatment group, 73% claimed that their learning experience in the course differed from usual, against 61% in the control group. Since these proportions seemed not to differ much, a closer look at the reasons given for this perception exhibited that 89% of the treatment group explicitly linked the impression of strangeness to the practice of reflection while the dominant reason invoked by the control group was the habit of taking handwritten annotations (46%).
The unaccustomed character of the reflective approach practised in the experiment received confirmation from another question in the pre-questionnaire probing prior familiarity with the RBs. Results showed that 16% of the respon-

dents answered having "almost never" used the three RBs; moreover, each of the RBs was unknown to about half of the sample (Fig. 10.5).

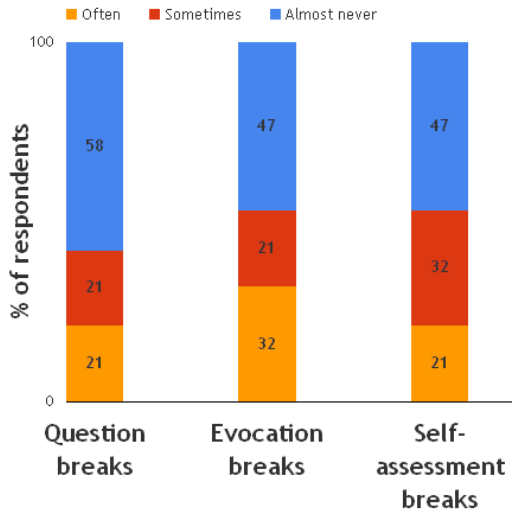

Figure 10.5. Claimed familiarity level with the three RBs prior to the experiment.

Perceived efficiency of RBs

Students rated RBs (Fig. 10.6) on a 3-point Likert scale for their contribution to their study time and study result (1 = decreased my study time/result, 2 = did not affect my study time/result, 3 = increased my study time/result). A majority of participants had the subjective impression that RBs contributed to the study quality while extending study time.

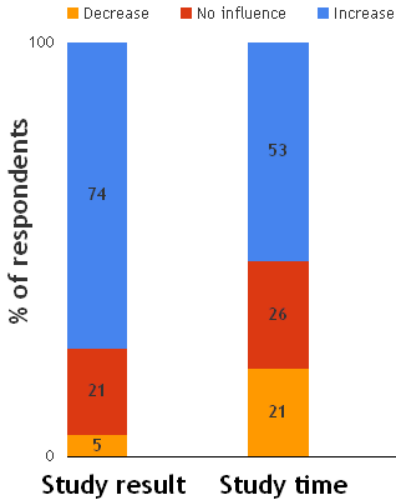

Figure 10.6. Perceived contribution of RBs to study result and study time.

In order to produce an estimate of RBs' perceived efficiency, students' answers were processed with the formula proposed by Elen and Lowyck (1998, p. 236): perceived efficiency = perceived contribution to study result – perceived contribution to study time. With this formula, a value of 0 indicates a perfect alignment between time investment and learning return. A positive value indicates efficiency of the support device, a negative value inefficiency. The greater the deviation from 0, the greater the perceived efficiency/inefficiency of the intervention. Results showed that half of the participants found RBs efficient (Fig. 10.7).

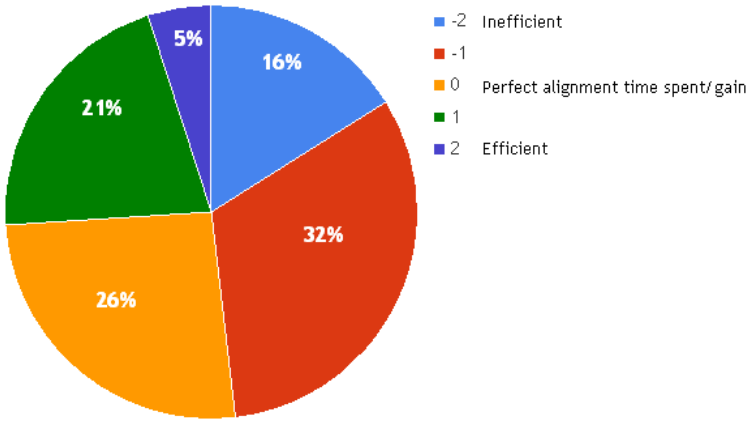

Figure 10.7. Perceived efficiency/inefficiency of RBs.

Traits of the global learning experience

On a 5-point Likert scale, students delivered a self-reported assessment of additional dimensions of the learning experience. Mann-Whitney tests detected a higher level of perceived learning, $U = 115$, $p = .01$, r = .39, in the group prompted to reflect ($Mdn = 4$) than in the control group ($Mdn = 2$). Tests conducted on the satisfaction towards the course ($Mdn = 4$ for both groups) and sense of control ($Mdn = 3$ for both groups) did not produce tangible differences between the conditions, respectively $U = 151$, $p = .13$, $r = .23$ and $U = 164$, $p = .3$, $r = .16$

Time on task

Hypothesis b: The provision of RBs does not impact total time in the course. Total time on task (Fig. 10.8) was descriptively higher in the group prompted to reflect ($M = 52$ min, $SD = 9$ min) than in the group without prompts ($X = 26$ min, $SD = 12$ min), and the difference was significant, $t(38) = 7.46$, $p < .0001$, $d = 2.45$. The treatment group records a time on task peak at Chapter 2, that is the

first chapter to request a systematic alternation between reading and reflection actions (writing down questions related to the content).

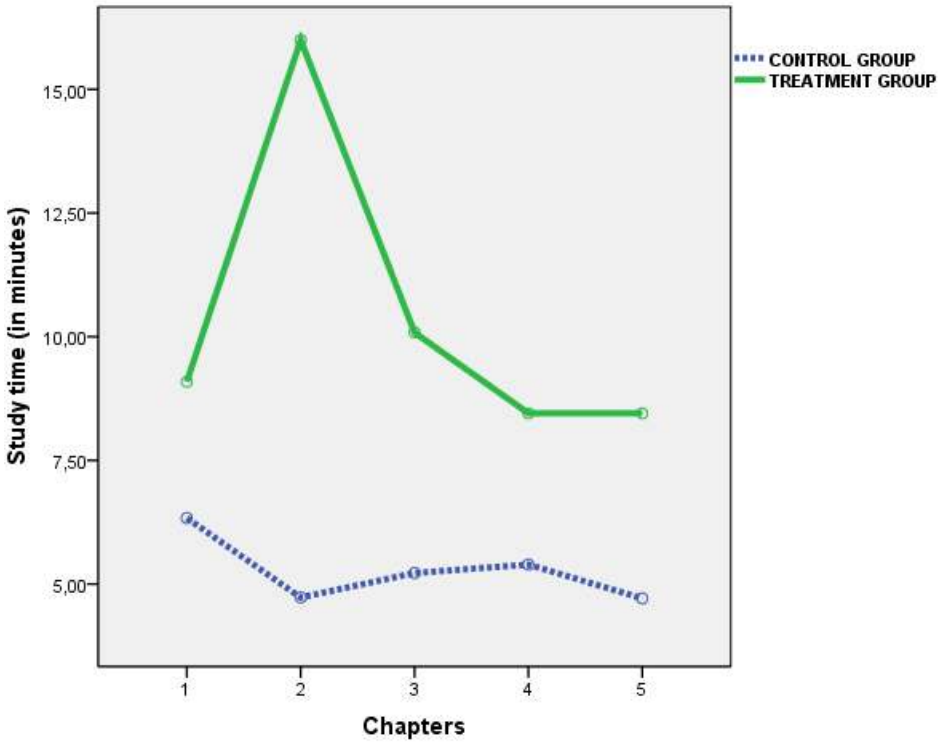

Figure 10.8. Average time (in minutes) per chapter for the control and the treatment group.

Performance

Hypothesis c: The provision of RBs improves scores at the test. Analysis of the performance scores for the multiple-choice questions revealed no significant differences between the control group (X = 4.5, SD = 2.24) and the treatment group (X = 4.7, SD = 1.59), $t(38) = .41$, $p = .67$, $d = .08$.

A 3-level scoring rubric was used to control the quality of the answers to the open questions: Level 1) trivial explanation of the picture, Level 2) explanation invocating the correct Darwinian concept, Level 3) explanation contextualising the correct Darwinian concept in the overarching evolution theory. Again, the treatment group (X = 4.5, SD = 1.6) did not significantly outperform from the control group, (X = 3.7, SD = 1.7), $t(38) = 1.54$, $p = .13$, $d = .05$.

Physiological data

Hypothesis d: The practice of RBs impacts upon the physiological measurements of the control/treatment group. Paired-samples t-tests compared TEMP,

BVP, PVA, and PR in the "with RBs" and "without RBs" conditions. This returned significant differences for each of the four physiological signals (Table 10.2): temperature and pulse rate were higher in the treatment condition, while blood volume pulse and pulse volume amplitude were lower.

Table 10.2. Physiological signals in "with/without RBs" conditions

	TEMP*		BVP*		PVA*		PR*	
	Without	With	Without	With	Without	With	Without	With
Mean	30.98	33.65	49.52	49.37	34.53	31.18	60.11	68.69
SD	3.12	1.05	13.04	12.35	24.8	19.57	12.85	12.74

* $p < .0005$

In order to refine the analyses, the screen recordings of the learning session in the course equipped with RBs were analysed. "Reading" versus "Reflection" periods (defined as the time interval between the opening and the closure of the reflection portlets) were identified and the sampled physiological measures grouped accordingly. Independent-samples t-tests also exhumed significant differences ($p < .0005$) for the four physiological signals, meaning that the physiological variations observed between the two versions of the course re-occurred in the course with RBs alone, between the periods of reading and of reflection.

Discussion

Hypothesis a (meta-cognitive awareness of reflective processes)

The experiment suggests that *the main pedagogical achievement of the RBs lies in the awakening of a different attitude to reflection* (section "Follow-up questionnaire).

The emergent consciousness that being mentally engaged makes sense while learning can be mapped onto the taxonomy of affective domains elaborated by Krathwohl, Bloom, and Macia (1964) to organise levels of commitment and concern. Five levels – receiving / responding / valuing / organisation / characterisation by value – describe the internalization process whereby a person's affect towards an object passes from unawareness of its existence to a point where the affect is "internalized" and consistently guides or controls the person's behaviour.

According to this taxonomy, the entry point to the consciousness continuum ("receiving") consists in becoming aware of or sensitive to the existence of certain ideas, material, or phenomena and being willing to tolerate them. The findings of the study presented in this chapter suggest that students in the treatment group have hit this level after a rather short exposure to RBs: they recommend them with more intensity than the control group (see section "Follow-up ques-

tionnaire"). This can be interpreted as a meta-cognitive effect of RBs: an increased awareness that compact, structured, and ongoing reflective processes can be relevant to regular study.
This finding could also be interpreted according to Boud, Keogh and Walker's theoretical model of reflection (1985). This work delineates four major outcomes (see Fig. 1.1 in Chapter 1) to the practice of reflection in education: (a) new perspectives on experiences, (b) readiness for application of these new perspectives in future experience, (c) commitment to the task, and (d) change in behaviour. The current study brings indications of benefits with regard to outputs a and b.
The study also allows questioning the place of thinking skills in regular classroom practice. Results show that the three reflective techniques offered in the course (questioning, internalizing, and evaluating oneself) are fresh to half of the students in each case (Fig. 10.5). One can appraise this percentage as low with regard to the fact that the three RBs instantiate basic operative processes of quality academic tasks and attitudes. This finding is in agreement with another experiment (Joseph, 2003) which records that 36% of the students reported a lack of cognitive activity when reading a textbook and 38% noted that they did not try to evaluate their understanding after reading a selection.
The atypical character of the systematic meta-cognitive awareness training, in the way it takes in this study, also surfaces the qualitative data (see "Contrast with regular learning experience"). *For some students, it seems possible that the confrontation with the RBs transforms reflection in a learning experience on its own.*

Hypothesis b (time on task)

Hypothesis b is not confirmed: study time is strongly affected by the presence of RBs. This confirms the findings of Verpoorten et al. (2012a). But additional questions arise. Thanks to the improved tracking facilities available in this study, *logging data reveals that all the additional time spent in the course by the participants to the treatment condition cannot be imputed to the time they spent using the RBs.* This is the most intriguing finding of this study. For instance, the logging data of Chapter 3 (evocation break) exhibits that the time spent evoking accounts for only 25% of the total time spent in this chapter. The RB applied in Chapter 4 (ticking a level of mastery) is probably even less time-consuming. A possible explanation is that RBs stimulate a different learning attitude and commitment towards the material and the study task. *The structured reflection slots arranged in a course would not per se impact the time spent studying but the reflective orientation that they infuse would.*

Hypothesis c (performance)

The controlled introduction of structured opportunities for reflection does not lead to better scores at the test, even with secondary school pupils who might be

seen as yet partially unformed regarding learning skills and likely to benefit from training. While disappointing, this result is not uncommon. In a systematic literature review (see Chapter 6), Verpoorten, Westera, and Specht (2012c) calculated that 43% of the performance measures performed in 29 empirical studies stimulating reflection-in-action returned no significant positive effect (see also Chiazzese et al., 2006; Thompson, 2009). The lack of impact sounds nevertheless as a counterintuitive finding. A large literature extols the advantages of reflection for learning. Received wisdom would be prone to say that frequent calls to reflection lead to better achievements. The results of this study remind that the theoretical benefits of various scaffolds do not necessarily match their actual impact on performance. The earnest preparation of RBs and even students' expressed perception of their usefulness (see section "Perceived efficiency of RBs") have not automatically led to higher achievements. Although test performance is not the only measurement of learning (Boud, 1990), it should still be reasonably expected to mirror benefits resulting from the use of reflective approaches.

Hypothesis d (physiological parameters)

Physiological measures differ between the conditions both at the global level of the course and when reading/reflection periods are contrasted. Interpretation of these differences is difficult: can a slowing down of some body activities be expected if reflection is assimilated to some form of meditation? On the contrary, do compulsory and unfamiliar reflective episodes reverberate on some physiological signals as a form of stress (McCraty, Atkinson, Tomasino, Goelitz, & Mayrovitz, 1999)? Answering these questions goes beyond the scope of this study. It would require further interdisciplinary discussions combining pedagogical and medical expertise. However, the observed variations (see section "Physiological data") bring extra information to the study of reflection in formal learning. So far, levels of reflective engagement with learning material attached to this context have usually been inferred from performance tests, claims of students (scales, open questions), interviews, think-aloud protocols, observations, eye-movement registration (Martens, Valcke, Poelmans, & Daal, 1996), stimulated recall (Kostons, Van Gog, & Paas, 2009), log files analysis (for a thorough discussion on these assessment methods, see Veenman, Van Hout-Wolters, & Afflerbach, 2006). *The findings of this study suggest that the mental states associated to different learning and reflection activities can also be detected in physiological parameters. The reflection externally imposed to students trigger internal answers traceable in physiological data.*

Findings related to the biofeedback in this chapter must nevertheless be taken with caution for the following reasons: (a) they bear upon two students, (b) these two students covered both versions of the course (familiarity/boredom effects might have biased the results), and (c) the comparison between reading and reflection periods is not confusion-proof: as the learning content remained available to students when using the reflection portlets, it is likely that some

reading activities took place within the reflective activities (some mouse movements observed in the screen-recording provide cues for these moving boundaries).

Conclusion

This study explored the potential of one possible method to promote reflection: reflective breaks meant to induce regular mental tingling for evaluating one's learning, nurturing internal feedback (Butler & Winne, 1995) and maintaining active commitment to the tasks at hand.

The pattern of findings suggests that the benefit of a one-hour hands-on session with these reflective tinglings is not to be found in an enhanced cognitive performance but in an increased awareness of and an intensified presence to the learning process itself. The observed effects of RBs occur in perceptions and attitudes towards reflective learning. By putting the mere action of learning under scrutiny and by rendering reflection about it more explicitly and more understandably to the students, RBs can help participants to realise that they are learners and not only students, and that learning is more than performing (Piaget, 1978). In this renewed meta-cognitive awareness of reflection (Boyd & Fales, 1983), the external learning assignment to expedite turn to be in the eye of the students a complex activity they are part of, and one which entails the steady integration of specific reflective mental activities characterising expert learners.

Chapter 11

General discussion

Chapter 11
General discussion

Abstract

By defining and investigating a series of “reflection amplifiers”, this dissertation has addressed the need for a comprehensive approach of opportunities for reflection built in learning tasks. The conclusive chapter wraps up and discusses these investigations. It highlights their key leverage points to the field. It exhibits the limitations of the accomplished work. Lastly, it frames a context for discussion by outlining pending questions and future research avenues.

"*We should remember that reflection is not an end in itself; it is the starting point of becoming a reflective practitioner*." (Scales, 1998, p.16)

For many years, many teachers, researchers and prominent authors have been stressing the importance of reflection for learning, both in regular classrooms and in eLearning settings. Reflection is seen as an indispensible aid for enhancing the effectiveness of learning and/or promoting meta-cognition or similar notions like "learning to learn" or "meta-cognitive development", all considered as essential skills for knowledge workers.
Today's electronic learning environments expand opportunities for reinforcing reflection by prompting learners about the content at hand and about own ways of dealing with it. Although a variety of reflective techniques can be observed in the literature (see Chapter 2 and 6), there has been no systematic investigation of the topic so far. Existing research remains scattered and limited to the pragmatics of concrete tools, usage, and appreciations. This dissertation has addressed the need for a more comprehensive approach of what it has referred to as "reflection amplifiers" (RAs), namely externally provided stimuli deemed to trigger and support an on-going inner reflective discourse about unfolding learning.

Main findings

This dissertation was intended to gain insight into the instructional relevance of infusing RAs in online courses. The conducted studies generally followed the same experimental procedure: asking participants, in a dedicated course enriched with RAs, to alternate cognitive activities (mainly reading) and reflective activities.

Performance gains

As for learner performance, the dissertation brings no conclusive evidence that the controlled introduction of compact, structured and repeated opportunities to reflect enhances scores at a final performance test. Attempts to engage students in an internal meta-cognitive speech targeting the learning task at hand have not promoted cognitive development.
This is somehow a counterintuitive result. A large literature extols the advantages of reflection for learning. Received wisdom would be prone to say that frequent call to reflection should lead to better achievements. The results obtained in this dissertation remind that the theoretical benefits of various innovations do not necessarily match their actual impact on learning.
After a time for hope, the final chapter is the time for humility, if not silence and resignation: the researcher must acknowledge that the earnest preparation of the RAs and even students' expressed perception of their usefulness have not

automatically led to learning gains, when conceived as an improvement of test results. This dissertation therefore concurs with the 43% of germane studies which have not detected any positive effect of reflection prompts on learning achievement (see Chapter 6).
Although succeeding at the test is not the only measurement of learning (Boud, 1990), although the educator might wish to improve people's capacities as learners, although some authors even say that a focus on performance can depress it while a focus on learning can enhance both learning and performance (Watkins, 2001), it should reasonably be expected that performance gains result from the use of the offered reflective approach. Within the limitations of this dissertation, this has not happened and the impact of RAs on examinations could not be convincingly demonstrated.

Other aspects of learning

Besides functional purposes, this dissertation also aimed at contributing to enhanced human development (Lodge, 2005) and empowerment (Aviram, 2008). Because of this concern for sustainable learning, it allowed itself to look beyond performance marking. Not only the test outcomes were measured but additional data was collected as to what extent students actually used the RAs, appreciated them, and found them unusual or not[7]. In particular, concurrently with marks at the test, the dissertation also tried to capture effects of RAs on *meta-cognitive awareness of reflection*, conceived as the attainment of a deeper understanding of the process of reflection. The next section methodically reviews the results obtained along these lines.

[7] This additional information allowed a refined appraisal of students' behaviours and perceptions with regard to learning and reflection. Such an expanded view, which does not limit itself to regular performance indicators, is especially important when the research tries to capture transversal and holistic skills, as suggested by Van der Vleuten, Schuwirth, Scheele, Driessen, and Hodges, 2010 (p. 714): "It is quite clear that a rating of 2 out of 5 on counselling skills in a patient encounter should raise some concern with the learner, but a mere numerical rating fails to disclose what the learner did and what she should do to improve. To provide richness to the assessment to a greater extent, we have an excellent tool: language. We should encourage developers to ensure that all their instruments have built-in facilities to elicit qualitative information (e.g., space for narrative comments) and we should stimulate assessors to routinely provide and document such information. This argument has even more relevance if we wish to assess difficult to define, domain independent competencies, such as professionalism. These competencies, in particular, have much to gain from enriched narrative information". See also Hodge, 2006, Langeveld, 1974 or Struyven, Dochy, Janssens, & Gielen, 2008.

Summarised research outcomes

Study 1

The first study caters for a classification framework and a first inventory of existing RAs. An early validation, conducted thanks to eight senior instructional designers, confirms the relevance of the two organising dimensions of the framework: target of reflection (content and learning task, own learning processes, whole learning experience) and type of interaction (reflection enacted by receiving information, responding, verbalising). The framework and the initial inventory allow a structured approach of RAs in this dissertation and beyond.

Study 2

Participants: 13 (Open Universiteit faculty)
Topic: reflective practice in online courses
Reflection amplifier: look back on own practice
Method: questionnaire (35 questions)

Results show that, even captured in a compact description, the 35 RAs populating the classification framework designed in Study 1 are well understood. Faculty grant a fair level of educational relevance to the reflective techniques. The overall conclusion is that the university teachers involved in this study value the idea of reflection and the use of RAs but have limited knowledge about the practicalities to create these in their online courses.

Study 3 (Pilot)

Participants: 54 (international, adults)
Course: Five Web usability principles (± 1 hr 30 min)
Reflection amplifiers: compare with yardstick / rate your mastery / write on the content
Method: controlled experimental conditions (5 groups)

Results show that RAs are extensively employed and are perceived as relevant contributors to learning by a majority of participants. Test persons in the experimental groups report significantly more intense reflection than those in the control group. Positive feedbacks from learners specify strong points of RAs (support to reflection and monitoring). One month after the course run, participants have been asked in a follow-up survey to select from 10 plausible reasons, the one which best explains the absence of positive effect of the RAs on performance. The answers show a broad dispersion among the explanations. The outcomes of this study demonstrate the delicate relation of reflection and performance and divergence between perceived and observed effects of RAs. Various explanations are suggested for dealing with these results.

Study 4

Participants: 137 (Dutch, higher education students and adults)
Course: Sex and the evolution (± 4 hr)
Reflection amplifiers: annotations (writing on the reading / students set the test)
Method: controlled experimental conditions (3 groups)

Results show significant differences between conditions with regard to the total time spent on the course and the number of page views, higher in both cases for the treatment group. Following rather convoluted statistical procedures, participants have been characterised with a multi-facetted profile based on their rate of reflective behaviours. This has allowed finer-grained insights into concatenation patterns between first-order activity (reading) and second-order activity (reflecting). The study provides evidence that an optimum exists in terms of annotations: too a low rate of annotation hampers learning efficiency and too a high rate harms it as well. The study also reveals that no single rate of reflective behaviour creates an impact on its own. In contrast, combined rates do, as shown in the post-hoc splits conducted within the treatment group. On the qualitative side, a large majority of the participants claim that taking frequent annotations increases reflection. The satisfied learners are those who perceive higher intensity of reflection. Lastly, a cluster analysis has processed the descriptions of the learning experience produced by participants. When related to a model of self-regulated learning, the results offer evidence that the insertion of frequent opportunities to reflect on the course material has induced a higher awareness to own learning dynamics.

Study 5

This study is a literature review. Through a systematic filtering process of 328 documents, it has identified 29 empirical studies dealing with RAs. This state-of-the-art report inspects the theoretical background backing up the RAs, exhibits their instructional settings, categorises their interaction patterns and modalities, synthesises their effects, and analyses their technological foundations.

Study 6

Participants: 28 (14 years old secondary school students)
Topic: Optics (± 30 min)
Reflection amplifier: rating of confidence degree
Method: embedding RAs in a learning game

Results deliver an uncommon pattern: while the cognitive benefits – the acquisition of academic knowledge in optics – are mixed up, the meta-cognitive gains present a raising tendency: students' confidence in the quality of their answers becomes more accurate. This suggests that even when no academic knowledge

is learnt, a meta-cognitive learning gain can occur if the assignment has been enriched with RAs.

Study 7

Participants: 37 (Dutch, 17 years old secondary school students)
Topic: reflection on one's learning day (4 days)
Reflection amplifier: experience sampling through a questionnaire
Method: questionnaire answered via smartphone

Results demonstrate that mobile appliances can be used to convey reflective practice about daily exposure to learning. Simultaneously, the study provides cues that looking backward at one's activity as a learner is not a deep-rooted habit in students.

Study 8

Participants: 40 (Dutch, 17 years old secondary school students)
Course: Sex and the evolution - selected pages (± 30 min for the control group and 1 hr for the treatment group)
Reflection amplifiers: students set the test / evocation / self-assessment of mastery
Method: controlled experimental conditions (2 groups)

Findings exhibit that RAs have influenced the time spent in the course, which is significantly higher in the treatment group. Qualitative feedback displays that a majority of the participants: (a) judge that the intertwine of reading and reflection activities have infused a learning experience different from the usual, (b) declare each of the three RAs unknown to them before the participation to the study, and (c) evaluate that RAs have contributed to a more thoughtful study while increasing study time. A higher level of perceived learning is recorded in the treatment group. Three weeks after the experiment, participants to the treatment group recommend the use of the three practised RAs with a higher intensity than their peers of the control group. This recommendation extends to other strategies sustaining deep learning. Lastly, the embedded reflection rituals significantly impact the physiological states recorded for two learners.

Evaluation and achievements

This section comprehensively reviews the contribution of this PhD-work to the field of reflection-in-action and adjacent research strands. Based on this evaluation, research follow-ups are outlined.

Reflection-in-action

"Put simply, reflection is about maximising deep and minimising surface approaches to learning." (Hinett, 2002, p.3). Until recently, the effort to promote deep learning has largely been associated to post-practice reflective tools such as portfolios, learning diaries or blogs, and reflective dialogues. With the so-called "reflection amplifiers", this dissertation brings in the forefront a different type of learning tool that targets reflection-in-action. RAs are brief, structured and repeated reflection affordances, interspersed in the learning material and activated during the first-order learning task at hand. These built-in opportunities for reflection are purposed to offer stop-and-think episodes in the course of learning. This dissertation has enrolled these tinglings for reflection in efforts to: (a) strengthen learners' engagement with the content, and (b) sharpen the visibility and the awareness of mental processes entailed by a learning activity performed "professionally".

The dissertation provides the field with a concrete and ordered expression of reflective techniques (see Chapter 2). The proposed classification framework supports the mapping of existing or future RAs, enabling their detailed positioning, qualification, and comparison. The framework has informed the empirical studies of this dissertation. It can also guide future research activities and create awareness among instructional designers and teachers about the different approaches available.

Widget technology

This dissertation benefits from the efforts of a vast body of literature dedicated to architecture, interoperability, reusability, mash-up integration of existing widgets with institutional learning management systems. While these technical issues are important, they remain largely incomprehensible for the committed educator who sticks to a basic concern: what does it mean to work with these new technological artefacts and how does this improve the type of educational support that is offered to students? This PhD-work provides the education sector with concrete instances of widgets harnessed to clear instructional endeavours in formal learning contexts.

The capacity of the widgets to isolate, both graphically and cognitively, specific reflective behaviours to be practised while learning is one reason why the widget technology was favoured. The other reason was the promises of this technology as for interoperability (Wilson, 2008; Wilson, Sharples, & Griffiths, 2008), flexibility, and aggregation. Widget technology allows a pick-and-mix approach that can match various needs for reflection affordances.

The reflection widgets created in the PhD-work embrace mainstream eLearning platforms (Moodle, Liferay), in order to maximize the possibility of re-use. Additionally, initiatives, not separately reported here (Verpoorten 2010a, 2010b; Verpoorten & Kelle, 2010), were undertaken to check whether RAs could be implemented with the learning technology specification IMS-Learning Design,

developed for enhancing the interoperability of learning scenarios across different eLearning systems. This approach was decided upon after the literature reviews (see Chapter 2 and 6), which revealed that most existing RAs were bound to local contexts and could not be exported to other environments. The aforementioned attempts with IMS-LD demonstrated that it was also possible to express RAs with a standard descriptive language, what might have positive consequence as for their diffusion.

Instructional design

A key feature of RAs is that they are built inside the primary study task and put at its service. Such "reflection-inside" assignments take on Scardamalia and Bereiter's prognosis about the rise of content-based approaches to reflection (1983, as cited by Watkins, 2007, p. 50):

> We do not foresee courses in meta-cognition being taught in schools. Rather we foresee that instruction in many areas of intellectual skill might be enriched by designing activities so that they bring more of the cognitive processes out into the open where teachers and students can examine and try to understand them.

A fundamental condition to induce regular mental cueing for evaluating one's learning and nurturing internal feedback is that RAs are deliberately incorporated into the instructional design of the lesson. As can be inferred from the disciplines tested in this dissertation ("Web usability" in Chapter 4, "Psychology" in Chapter 4 and 9, "Optics" in Chapter 7), RAs look like cross-domain tools. Their application to a variety of subjects (see also Section "RAs' domains of application" and "Types of learning supported by RAs" in Chapter 6) demands to educators and instructional designers to have explicit considerations for the creation of guided opportunities to practise it rather than assuming that this reflection will take place without supportive measures.

Because this dissertation provides insight in ways to orchestrate and implement reflection-in-action prompts in learning activity systems, approaching RAs from a systematic instructional design perspective would be a natural continuation of the work. For instance, a dialogue with the 4C/ID model (Van Merriënboer, Clark, & de Crook, 2002) would be worthwhile. According to Van Merriënboer, Jelsma, and Paas (1992), the 4C/ID model has been found effective for conducting training that yields reflective expertise defined as the ability to make a conscious use of cognitive schemata to solve unfamiliar aspects of the task. Several design patterns for RAs could probably be defined, in conjunction with this model. According to the type of reflective training needed, RAs could be designed differently: as learning tasks, supportive information, just-in-time information, or part-task practice, that is the four core components of the model.

Narrative approach to learning

If the knowledge economy imposes the training of reflective capabilities as a main challenge for tuition, it seems reasonable to state that *the first object on which the reflective skills could be exerted is the dominant activity of students: learning*.

> Learners should be able to tell their own story of what they have learnt, how and why, as well as being able to reel off their qualifications, the formal hurdles they have overcome. "Personalised learning" allows individual interpretations of the goals and value of education. (Leadbeater, 2004, p. 69)

Following the ideas initiated by the narrative approach to learning (Watkins, 2006a) or the student's voice movement (Creanor, Trinder, Gowan, & Howells, 2008; Lodge, 2005), the present work suggests that a way to sharpen reflective habits about learning is to imbue the daily exposure to the learning activities with structured opportunities for reflecting about them. Reflection is then materialised in spontaneous descriptions of in-situ learning experience.

Additionally, the dissertation provides the field with an attempt to accredit narratives of learning as a topic of investigation of its own. The students' *accounts of learning experience have been used both as a measure instrument of the interaction with RAs (is the interaction with RAs mirrored in the accounts?) and as a learning goal (do the accounts become richer when students are confronted to RAs?).*

Visualisation of tracked data

Learning analytics is often viewed as data processed at the level of the institution in order to ground strategies and decisions in factual evidences (Johnson, Smith, Willis, Levine, & Haywood, 2011). For the purpose of compiling aggregated community indicators, this data is usually removed from its learning context, production time and individual properties. In this PhD-work, RAs based on the visualisation of learning interaction footprints take exactly the opposite approach. They exploit the value of learning analytics in a highly situated and personal context while minimising the time span between data capture and the moment of its presentation to the stakeholders in this context.

The factual and perceived advantages, drawbacks, shortcomings, improvements of studying with real-time visualisation of own actions should be further put under scrutiny by teachers, learners, and researchers. On the one hand, indicators and dashboards provide extra information for learners to piece together a "story" of their learning by associating "what I'm doing" with evidence of the things done (Laflaquière, Mille, Ollagnier-Beldame, & Prié, 2010). In practice, these new opportunities to document learning activities could make learners uncomfortable and could be perceived by them as intrusive. Johnson and Sherlock (2009) noticed that reflection flowing from learning analytics was not necessarily used or welcomed and that learners did not really want their practices ampli-

fied in this way. As A.W. Johnson says (personal communication, March 3, 2009): "there are some things which learners are not happy exposing, even to themselves!"
Which data to track and mirror in order to stimulate learners' thinking is another challenge for future research. Since many metrics can virtually be recorded, clarity should be gained over what learner analytics should best be captured and mirrored for productive reflection in the moment of learning.

Lines of discussion centred on RAs design and use

This section puts the dissertation's findings into perspectives through *eight lines of discussion* related to the concrete design and use of RAs.

Line 1 – Frequency of RAs

This dissertation centred on short reflective tasks activated at a high frequency (typically every few minutes) during learning. But literature provides examples of higher (Chi, de Leeuw, Chiu & Lavancher, 1994) and lower frequencies (Van den Boom, Paas, & Van Merriënboer, 2007). Guidelines for assessing the amount of RAs encounters to incorporate in a study task is a research strand to develop. Its core remit will be to document appropriate balance between learning and overt reflection. In this context, expertise reversal (Kalyuga, Ayres, Chandler, & Sweller, 2003) and over-prompting (Nückles, Hübner, & Renkl, 2006; Holliday, 1983) effects will have to be dealt with.

Line 2 – Length of RAs

This dissertation was undertaken to confront two premises to empirical data. The first premise was that concrete reflection-in-action training tools were missing, in contrast to the training of reflection on action that could rely on portfolios and learning diaries. The second premise was that these training tools had to be operated without being disruptive of the first-order learning activity. Indeed, the assumption that the reflective episodes must be kept short immediately raises the issue of the concrete time given/needed to perform them. The important looming question is: can a reflection be short and useful? Beyond research, there is a practical stake in this question, closely linked to the time management in scholastic contexts. Teachers as well as learners may be reluctant to reflective approaches, since these are supposed to happen at the expense of studying course contents. It remains a major challenge for research to establish if and how RAs can prevent swamping the time available while delivering substantial positive effects.
Another critical issue is linked with the length of RAs. It is possible that the short time allowed to the RAs used in this dissertation was insufficient or that the brevity of the RAs and their "zapping-like" mode precisely led learners to

consider them as trifle. The right amount of time to allocate to reflection for it being taken seriously and for it to produce effect is an important topic of investigation.

Line 3 – Total time of exposure to RAs

This dissertation operates relatively short exposure to RAs. Typically RAs are provided in courses of 1 to 4 hr. In a performance-centred orientation, the time spent using the RAs within this period can be considered as wasted since they bring in no impact on the scores. In a learning-centred orientation, this time investment may be considered as too narrow. Johnson and Sherlock (2008) emphasise how important and deeply challenging the acquisition of "habits of reflection" is, which leaves to future work the task of ascertaining better the training time needed to establish and transfer such habits. Achieving deeply anchored reflection habits is likely to take months, if not years. Watkins for instance reports (2001, p.6) on a project (Baird, 1986) in these terms:

> A programme in science classrooms set its aim as "Increased learner awareness of the nature and process of learning". Prompts and reviews were devised to increase students' awareness and control of their own learning. Lessons often included discussions of the purposes of learning, questionnaires about learning, and discussions about the relative roles of teacher and student in learning. *After 6 months* [emphasis added], 15 and 16 year-olds showed greater understanding of content and more purposeful learning, while the teacher had changed to allow more learner control.

Csapó thinks in the same line when he writes (1999, p. 58):

> Despite conscious efforts, a curriculum that places as much emphasis on teaching general thinking skills as on teaching subject matter knowledge is still far from reality. In an ideal case, training thinking would be consistently designed for a variety of cognitive skills, carried out in several school subjects, and continued *for several years or for the whole schooling period* [emphasis added].

Line 4 – Type of RAs

This dissertation made use of a variety of RAs. No regard to their specificities, they delivered rather similar patterns: lack of effect on performance, diligent practice, global appreciation, higher perceived learning, longer time on task, and some effects on meta-cognition. This raises the question: does the type of RA matters? There is no denying that thought processes elicited by the RA's format do differ (Van der Vleuten, Schuwirth, Scheele, Driessen, & Hodges, 2010). However, this dissertation puts in debate a convergence or a combined effect of reflection stimuli. Isn't it simply their availability – whatever they are per se –, which infuses a different relationship to the learning task? Beyond the training of specific reflective skills, more research should inform the possibility that a

steady presence or RAs could promote an atmosphere of reflection that propagates through the whole learning experience.
This study does not provide detailed data about the effects of different RAs. It should be further explored whether they differ in their capacity to foster a renewed awareness of how learning can be practised. The framework devised in chapter 2 is a useful starting point for categorisation.

Line 5 – Combination of RAs

This dissertation deals with combined reflective activities in one study (see Chapter 4), without recording much difference compared to the ones used in isolation. Van den Boom et al. (2007) observe that offering a single reflection prompt is enough to bring about a significant positive effect on student's judgment of the learning task in terms of interest, importance, and utility. But they also stress that it is only when the reflection prompt is incorporated in a reflective dialogue with an instructor that its effect starts to benefit to learning outcomes. In the same vein, Chapter 5 suggests that some RAs can serve learning at one time but that beyond a certain point they hinder efficiency and might ideally be replaced by other forms of reflection. Further research should not only investigate simultaneous combinations of prompts but also combinations in a sequential order.
The issues tied to combinations of RAS are especially topical with regard to the call for reflection-conductive/supportive milieus or attention management systems (Molenaar, 2011). These integrated activity systems are deemed to help students practicing self-awareness and reflection beyond the provision of a single isolated tool (Allan & Clarke, 2007; Thomas, 2003). This new requirement advocates for an increase of the quantity, quality, and agility of reflective tools both for research and practice.

Line 6 – RAs and reflective dialogues

It was the choice of this PhD-work to study RAs as solitary practice inserted in a self-learning task (Dohn, 2011). If this boundary has secured the manageability of the dissertation, it has also left out a possible important function of the RAs: to feed an informed reflective dialogue with a tutor or with peers.
When interpreted with Watkins' taxonomy of reflection-related classroom practices (2001), it is obvious that this dissertation has probed RA's only in 2 categories out of 4. This point deserves due attention. For Watkins (2007, p. 51, 2010, pp. 8, 9, 11), there are four broad sorts of classroom practices which help learners make sense of their learning:

1. Noticing things about learning = making learning an object of attention.
2. Talking about learning = making learning an object of conversation.
3. Reflecting on learning = making learning an object of reflection[8].

[8] Watkins' arrangement of the four categories is not always the same. "Making learning an object of reflection" can either follow "Making learning an object of attention"

4. Experimenting with learning = making learning an object of learning.

RAs in this dissertation are concerned with raising attention and reflection about learning (Category 1 and 3). Further research should definitely extend to their relationships with discussion (Category 2) and learning to learn (Category 4).

Line 7 – Population targeted by RAs

This dissertation mainly worked with experienced learners. Even the enrolled secondary school pupils (see Chapter 8 and 10) studied at a fair educational level. Therefore the empirical experiments do not bring cues about how weakly, medium or strongly qualified students can benefit from RAs. More research is needed to investigate the effects of RAs according to different populations of learners. For instance, it is plausible that weak students who are already struggling with the first-order learning task perceive RAs as an additional cognitive load even though these have been conceived to help them (A.-F. Kroonen, personal communication, January 2012). This risk does exist. But, conversely, assignments deprived of structured reflection can also convey cognitive burden, possibly of another type. For under-performing students, being thrown in non examined learning activities, that is assignments that must be done without knowing their purpose (or a purpose shrunk to marks on the report) and the intellectual process to apply to might also be a form of cognitive load, a stress, or a trip in absurdity. For these, to give sense and guidance to reflection might be a "cognitive relief". Along with Smith, Moores, and Chang (2005), this dissertation suggests that all attributes low achievers are years after years lumbered with in class councils (lack of academic capacities, laziness, inability to stick to a task long enough to master it, aversion to admitting ignorance, chronic boredom, etc.) can find a better explanation in poor reflective practice than in expression of inherent arrogance or stupidity, even though these may also play a role. There are many students for whom learning activities have become so blatant that they are not questioned anymore and are tackled through automatic behaviours. To prevent that the main duty of students – learning – becomes a blind spot[9], ways must be found to increase the mindfulness revolving around this

(2001) or "Making learning an object of discussion" (2003). These differences are meaningless if the author's intention is to offer a taxonomy of reflective activity's purposes. It might have importance if some developmental/hierarchical scheme infuses the four categories. In a later article (2007, p. 51), Watkins says that: "the categories can be thought of in a cumulative sense, because in the context of the dominant picture of classrooms having little focus on learning, the attention given to this area needs to be built up progressively".

[9] Watkins (2006, p. 2) notes that learning can also become a blind spot for educators: "When we come to talk about learning, one of the curious things is that we often do not talk about learning. Instead, other themes hijack the conversation. Foremost among these are: 1) Teaching: phrases such as "teaching and learning policies" or "teaching and learning strategies" are used more and more, but closer examination suggests that they might better read "teaching and teaching", since the real attention given to learning

everyday action. *For a certain portion of students, the problem is not that questions relating to learning behaviours remain unanswered but that these questions are even unraised*. With such students, RAs might yield benefits by installing a very basic training to thinking and meaning-making skills.

Line 8 – Free use versus compulsory use of RAs

All studies presented in these pages (but also in the studies reviewed in Chapter 6) imposed the use of the RAs for experimental reasons. Despite efforts of this dissertation to favour real-world settings and to mimic as much as possible formal learning, the ecological validity remains disputable. It is unclear what would be the use of RAs in thorough real-world settings. Effects could go both ways:

- a bypass of RAs: in real life context, students show a tendency to calibrate the amount of learning time and efforts to "have their points" (Lockwood, 1995, as cited in Martens, 1998, p. 176). As the immediate benefits of the reflective activities might not be clear, they are very likely to be left out. *Another reason for dropping RAs is the effort needed to accomplish them.* On the one hand, RAs generate thoughts that would be difficult to obtain without them (Gordon, 1996). On the other hand, they equip the learning activity system with reflective episodes which require from learners – if practised seriously – to think harder about the subject matter domain being studied and about themselves as learners. This makes learning more difficult. However, it is plausible that *the opportunity for deeper learning can precisely be grabbed only by a proactive engagement with, rather than suppression of difficulty* (Nelson & Harper, 2006). Getting rid of reflection opportunities might also be getting rid of a responsible and sustainable type of learning. Arriving at the right answer quickly may sometimes deprive students of opportunities to grapple with complexity;
- an intensified use of RAs: it could be the case if the instructor puts emphasis on reflection and imports them in the realm of learning goals and learning modelling, while researchers have no authority and the learning they offer has no importance in the life of the participants.

In all cases, factors influencing the motivation to use RAs should be looked for. The right balance between too much flexibility or freedom in the practice of reflection and over-prescription should also be considered.

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is minimal. This example alerts us to the way that matters of learning are regularly attributed to features of teaching. 2) Performance: performance is not learning, though it may develop from learning. In some eyes, the goals of school have been reduced to measurable outcomes of a limited sort: performance tables, performance pay, performance management. But high levels of performance are not achieved by pressurising performance."

In sum

By making learning visible through RAs, considered as internal speech incentives and spaces of dialogue with oneself about current action (Tchetagni, Nkambou, & Bourdeau, 2007), this dissertation has looked for ways to encourage students to engage in the understanding of what they do as learners, and the sense-making of their learning experience. A main effect of RAs is to put the action of learning under scrutiny and to render reflection about it more explicit and more understandable to the students (Marton & Booth, 1996). By providing students with opportunities to think about, expand, reconsider, question, and understand differently the learning activity they are committed to, RAs were purposed to initiate habits of nurturing their self-as-learners. The expected value of the reflective approach was an enhanced consciousness about intellectual habits and frame of mind that a personal, alert, and responsible process of learning implies. Such effects have sometimes been hit: the dissertation provides cues that, by inviting learners to externalize reflection, RAs support reflective thinking. RAs therefore appear as one possible way to tackle a major research question underpinning the dissertation: how can students be stimulated to make learning a deliberate object of attention and reflection?
Conducting further empirical studies targeting the aforementioned attributes of RAs (frequency, length, exposure, type, combinations, contribution to reflective dialogue, targeted population, and mode of use) will help to sort out what this reflective approach to teaching and learning "ought to be" from what it actually accomplishes, and most importantly, under what circumstances.

Limitations

There are several limitations to the research reported in this dissertation.

Limitations related to the qualitative aspects of reflection

The studies presented here rarely touch upon the quality of reflection. When they request students to take notes and to craft questions (see Chapter 4, 5, and 10), the material they produce is not analysed in detail. Regarding the evocation break (see Chapter 10), it could have been practised as a think-aloud procedure in order to get insights into what students think during the pause (Calder & Carlson, 2002). In the self-assessment prompts of mastery or confidence (see Chapter 4, 5, 7, and 10) no justification is asked for the ratings.
Beyond the facts that think-aloud has its conceptual and practical limitations, that qualitative data is difficult to manage with a certain number of participants or that it may be hazardous to reconstruct the cognitive context around an annotation or a rating, the neglect of the fine-grained qualitative aspects was a decision flowing from the initial scope of the dissertation.

The chief postulate underpinning this PhD-work is that learning can be seen as a permanent crisscrossing between cognitive and meta-cognitive landscapes. The empirical studies attempted to reproduce this intertwine somewhat artificially with RAs. The work was therefore more acquainted with quantitative measures than with qualitative ones (Miles & Huberman, 1984). The quality of reflection was supposed to be derived from performance tests, learners' feedback or the complexity of a by-product: the description of the learning experience.
This neglect of qualitative measures has partly been disqualified by the results. The incapacity of RAs to influence the performance pleads for an increased attention to the reflection quality issues. To investigate these, RAs will have to confront to existing models concerned with attributes of reflection among which:

- Van Manen (1977): this author has proposed a progression from reflection rooted in concrete practice to the consideration of more abstract ideas: Level 1: practical, technical reflection (concentrating on ways of doing things based in using skills and technical knowledge), Level 2: using reflection to make sense of experience, putting experience into the wider context of assumptions about practice, Level 3: deeper evaluation of ethical, moral and socio-political issues.
- Bain, Packer, and Mills (1999) suggest that there are five levels of reflection: reporting, responding, relating, reasoning, and reconstructing.
- MacLeod, Butler, and Syer (1996) offer a scoring rubric to assess change in meta-cognition related to task understanding, strategy understandin, and learning management.
- Kember and Leung, (2000) have developed a questionnaire to measure the level of reflective thinking.

Other valuable inputs regarding assessment of quality reflection are provided by Lee (2005), Jay and Johnson (2002) or Sumison and Fleet (1996).
Another aspect which is not strongly addressed in this dissertation but would benefit from more qualitative inquiries relates to how students use RAs. Martens, Valcke, Poelmans, and Daal, (1996, p. 78) rightly note that research on embedded support devices (ESM) "hardly reports on what students actually "do" with ESM, the reports mainly focuses on effects in terms of learning-outcomes" (for a similar observation about the predominance of output-related concerns, see section "How to design RAs", in Chapter 6).

Limitations related to the order of events in the experiments

When handling several RAs (see Chapter 4 and 10), participants to studies encountered the artefacts in a fixed order. Such order may have produced a bias with respect to their usage and their appreciation.
The studies reported in Chapter 4 and 5 have planned the post-test questionnaire after the performance test. In case of a bad score, the answers of the participants may have been influenced. For the study presented in Chapter 10, this was cor-

rected. It is nonetheless recommended to researchers to take into account possible confounding effects caused by the order of events.

Limitations related to the measurement of reflective skills

The study dropped the use of learners' profiling questionnaires (Brown & Ryan, 2003; Cacioppo & Petty, 1982; Schraw & Dennison, 1994) after two studies, due to observations that subjects' scoring were to a very large extent comprised in the same interval and therefore not discriminative enough (see Chapter 4 and 5). This does not mean that the value of such measure instruments is denied but that the dissertation could not take these as a first-order topic of investigation.

Limitations related to data sources

Chapter 4, 5, and 9 noticed discrepancies between students' claims over the relevance, appreciation, and influence of the RAs and the objective data as provided by performance tests. Deeper investigation of these interlaces and discordances between observed and perceived effects of RAs were purposely left to future research.

The definition, the importance and the value that students grant to reflection in general was another possible research orientation that was left out of this dissertation. Despite a rather large bunch of data on these aspects, collected through the pre- and post-questionnaires of the studies, it was decided, for consistency and manageability motives, not to enter in detailed analysis. This remains nevertheless relevant to devote future resources to these issues. As soon as a learner sees no learning value in reflection, practises it to please the educator, it becomes trivial. Dealing with mental representations of reflection is therefore a critical tenet of future research on reflective practice (Van Meter, Yokoi, Pressley, 1994).

Lastly, this PhD-work was more oriented towards reflection processes deemed to make the tacit visible than by tacit knowledge and learning in themselves. In-depth analyses of phenomena like implicit strategies for behaviour (Van Hezewijk & Onderzoekcommissie Psychologie, 2010), intuitive appraisal of the learning situation (Recanati, 2002; Sperber & Wilson, 1986), or procedural knowledge aspects (Dreyfus, 1972; Tomlinson, 1999), were evaluated as beyond the scope.

Limitations related to sample size

Larger sample sizes would have provided more statistical power and firmer conclusions.

Limitations related to the static nature of RAs

The RAs used in this dissertation are neutral, static artefacts that become available in a pre-defined way. The RAs remain ignorant of the learning activities carried out by the student and hence are unable to attune their type of cue to the content issues a student may be working on. Likewise the cueing is not trig-

gered by logical rules that would enable timely presentation and a tailored type of reflective activity.

In an adaptive approach, RAs should ideally be differently matched to the reflective capacities of learners in order to act upon specific shortages. With regard to students lacking meta-cognitive competence – the so-called "mediation deficit" (Hasselorn, 1995, as cited in Bannert, Hildebrand, & Mengelkamp, 2009, p. 830) – RAs could be embedded in a training program deemed at *teaching* the meta-cognitive knowledge and skills. Such programmes, based on the provision of stand-alone instruction on higher-order thinking strategies (how to approach a given learning task, evaluating progress, monitoring comprehension, motivation management, etc.) or task-related skills (note-taking, summarising, etc.), instruct students explicitly in learning or study strategies, apart from subject matter curriculum. This is not the approach taken in this dissertation. However, for weak students, it is plausible that such an explicit awakening of the meta-cognitive awareness of what reflecting can mean may be a first step required for progress. In contrast, for students who already possess meta-cognitive skills, but do not perform them spontaneously – the so-called "production deficit", (Hasselhorn, 1995, as cited in Bannert et al. 2009, p. 830), RAs would be used according to the "content-based method" favoured in this dissertation, that is, by *training* general thinking skills while covering subject matter knowledge (Csapó, 1999; Granville & Dison, 2005; Gummesson & Nordmark, 2007).

Another limitation is that the RAs used in this dissertation are totally deprived of any kind of external feedback. The choice to address self-instructed contexts has indeed been done at baseline. However, since feedback is a powerful instrument for learning in general (Brooks, Schraw, & Crippen, 2005; Butler & Winne, 1995; Economides, 2006; Goetz, 2011; Mason & Bruning, 2001; Mory, 2004), its integration to forthcoming studies on pedagogical relevance and acceptance of RAs is strongly recommended.

Overarching issues for future work

Despite the availability of various theoretical models of reflection (Boud, Keogh, & Walker, 1985; Le Cornu, 2009; Moon, 1999a), a clear drift towards the promotion of thinking skills (European Commission, 2006; Romainville, 2007; Rychen & Salganik, 2003), finding practical ways to introduce learners to the reflective habits and dynamics of mind, needed for a continued inner intellectual life, remains a challenge for researchers (Claxton, 2006; Csapó, 1999) and practitioners (Jaschnik, 2011; Joseph, 2003). As a conclusion, this dissertation questions overarching issues that go beyond the determinants of RAs design and use (frequency, length, exposure time, type, combination, targeted population, or compulsory use) and touch upon the larger context of research on reflection.

Questioning the premise of the research on reflection

This dissertation is grounded in the assumption that advantage for instruction can flow from an increased consciousness of the learning situation and that this consciousness can be taught and trained (Russell, 2005). The approach taken with the RAs postulates that the development of reflective thinking can be fostered by the practice of reflectivity (Pallascio & Lafortune, 2000). The researchers and practitioners who promote this ideal operate on the premise that students who understand what they need to do to think and learn effectively can intentionally find meaning in learning and regulate themselves to employ specific strategies and skills and, thereby, become better learners.

This assumption is in itself disputable. For instance, Schapiro and Livingston (2000) claim that this very rational view, originating in the large body of literature concerned with self-regulation and emphasising active and strategic control of action, does not take enough into account internally-driven dispositions to learn. These dispositions - reflecting qualities such as curiosity, enthusiasm, willingness to take risks, and persistence - actually underlie and drive the strategic and self-conscious behaviour. If confirmed, this claim might partly explain the lack of effect on performance in the studies convening high achievers (see Chapter 4). If this core of internally-driven dispositions is already there, it is plausible that strategies for reflection are there also, making the RAs at best accepted but not essential for achieving better performance.

Questioning the indifference and resistance to reflection

This dissertation reports one neat example (see Chapter 4) of a diligent but shallow use of the facilities designed to help learners to deepen their reflective engagement. The experiments of Corliss (2006) and Yamashiro and Dwyer (2006) record a similar pattern: they deliver absolutely no result despite a tangible use of the prompts. There is high demand for more research into students' acceptance of and resistance to the reflective assignments given to them (Gunn, 2010). Johnson and Sherlock (2008) argue that triggering intentional reflection may be unwelcome for learners. The quotation of Watkins (2001) in the above section "Line 3 – Total time of exposure to RAs" went on like this (p.6):

> However, earlier orientations can be slow to change: for example, after eight months two students came to their science teacher: One said: "We see what all this is about. You are trying to get us to think and learn for ourselves" "Yes, yes" replied the teacher, heartened by this long-delayed breakthrough, "That's it exactly" "Well" said the student "we don't want to do that."

Reasons for active rejection, passive resistance or indifference to embedded support devices in independent learning should urgently be investigated. Are these attitudes and behaviours linked to perceptions of the quality of the support, the perceived effort needed to use them, the perceived usefulness? Do learners prefer - for good or bad reasons - to stick to their habits and their tradi-

tional roles as students and therefore neglect the attempts to learn differently? Is there any influence of what could be called the "dominant classroom culture" on learners' attitudes to reflection? If these questions go beyond the case of the specific case of RAs and reverberate on all kind of learning support (Clarebout & Elen, 2006, 2009), the study of students' positioning towards reflection is of peculiar importance in a knowledge society. A track of research focused on active and passive disregard of reflection will additionally firmly address:

- the discrepancy between claimed appreciation of the reflection and their lack of traceable effects in the exams, as observed several times in this dissertation (see Chapter 4 and 10) and elsewhere (see Chapter 6). Clarebout and Elen (2006) stress that learners' perceived benefits of learning support tools can have a strong influence on their acceptance and use;
- the pre-existing view and knowledge that students have about reflection and the importance they grant to it. This perceptual aspect of reflection needs to be addressed by future investigation because, in many cases, students may not see clearly why they should reflect and care about reflection (Scherer, 2002). Providing students with convincing reasons for the need to reflect is a though challenge. *It forces researchers and practitioners to question the model they have of learners as "needing reflective practice". The position "students may not like to reflect, but they need it" would require undisputable evidence;*
- beyond the intellectual appraisal of the nature and value of reflection, there is a challenge in finding ways to help students to experience that reflection can change a learning experience and a relationship to knowledge. How to *live* the learning benefits of a more thoughtful learning?

Questioning the components of professional learning

This dissertation assumes that the intellectual life that students are supposed to develop is made of a permanent crisscrossing of cognitive and meta-cognitive processes that the students are not necessarily aware of and that RAs try to exhume in a somewhat artificial way. Extended research is needed regarding the identification, the development, and the training of these core mental operations without which an activity cannot be reasonably qualified as "learning". *This dissertation calls for a discussion around the idea of "student professional development"* conceived as a gradual growth in the knowledge and practice of these generic and specific tenets (Lin & Lehman, 1999) of learning.

The notion coined by Elen and Lowyck (1998, p. 232) of *"instructional metacognitive knowledge"*, namely student's knowledge about the relationship between elements of the environment and learning, provides a valuable entry point in this gist of issues.

Questioning the affinity between reflection and personalisation

Definitions of personalisation vary greatly (Verpoorten, 2009), from the perfectly acceptable "antithesis of impersonal" to the technically focused "automatically structured paths to meet the needs of the learner". *This dissertation embraces an orientation that tends to equate the essence of personalisation to reflection, which allows the learner to understand him/herself as a learner and to make learning a personal matter* (Watkins, 2006b).

Daudelin (1996), for instance, suggests that reflection is the practice of thinking on material, problems, situations, experiences and their meaning and *relation to self*. This dissertation expressed interest for this relation between the learning task and the self-as-a-learner by measuring various personal dimensions of the learning experience (narratives, feeling of learning, sense of control, satisfaction, etc.).

Exploration of the interactions between reflection and personalisation should be continued. There is only scant research on what makes a student feel that a learning experience is personalised. Waldeck (2006, 2007) disclosed influential factors in face-to-face classrooms, among which a major role for the instructor. The literature surveyed in this dissertation reveals, in the field of eLearning, no research similar to Waldeck's one. *The factors that are contributing to effective personalised learning experiences in the eyes of the students are still to be elucidated.* The role that reflection could play in this perception is a topic for future investigation.

This dissertation nevertheless provides some cues. The analysis of students' learning narratives suggests that the task becomes "personal" to the extent that the learner becomes aware of what his or her learning experience is made of. In this way, the essence of personalisation is closely linked with reflection, which allows the learners to understand themselves as learners and, therefore, to take the responsibility of increasing aspects of this "personalised" learning. This orientation (Verpoorten, Glahn, Kravcik, Ternier, & Specht, 2009) assumes that personalised learning is related to active sense making and can be applied to any kind of learning task, to the condition that efforts are made to support personal ownership.

This assumption suggests a possibility to develop courses and services for personalised learning without taking the individual differences of each learner as a starting point but by providing opportunities for personalising the task by reflecting upon it. It must be noted that such a personalisation process is quite different from the one underpinning today's research in adaptive systems (for a contrasted synthesis of both approaches, see Verpoorten, 2009). In the latter case personalisation precedes the learner since the system automatically structures a learning path according to psychometrically defined learners. In a far less mechanical manner, the type of personalisation linked to reflection emerges as an outcome of the learning process and more precisely as an outcome of the steady personal appropriation of the task.

Questioning the notion of learning achievement

"Learning" versus "performance" orientations

"This is the dominant discourse of classroom life: 'get on with your work', 'what about your homework', 'have you finished your work?' But it can lead to a situation of meaningless work, as when people talk about being 'on task' without assessing the learning quality or engagement" (Watkins, 2010, p. 3). This dissertation has not challenged the dominant discourse highlighted by this quotation. It has assumed that it is possible to find ways to add reflection to traditional learning assignments, to the condition that they would be short, like the RAs are. It is however possible that dominant views on education are a large obstacle to reflection and to efforts to help students view themselves as learners and not only as performers.

While sticking to the inherent logic of the subject matter and to a mainstream view on education, RAs in two studies (see Chapter 4 and 10) induced a longer engagement with content (Pritchard, 2006). This effect could not be attributed to the length of the reflection episodes themselves. They probably emerged from a different relationship to knowledge established and sustained by frequent reflection on the content. The pattern of these studies was therefore: no impact on scores at the test (which can be seen as a failure in a performance-centred approach) and impact on time on task (which can be seen as benefit in a learning-centred approach). Trade-offs between a "learning orientation" and a "performance orientation" are consequently important issues for tomorrow's research. In a recent and broad literature review devoted to the divergence and complementarities between these orientations, Watkins (2010) found that the highest-achieving students had a healthy dose of both types of motivation (learning/performance). It is not impossible that RAs are useful for both stances since the targeted reflection they induce aims at making learners cognizant of meta-cognitive processes and also touches on the task contents.

It would be worth opening a line of investigation that would deal with problems and conflicts that the insertion of reflection affordances built in the study task can bring about in a general education system usually oriented towards tactic reflection and exams. Among other things, it should be explored if too much stance on achievement, which invites learners to see themselves firstly as performers who have to *prove* their competence ("performance orientation"), may have a negative effect on helping them to view themselves also as learners who have to *improve* their competence ("learning orientation") by developing reflective habits (Ames & Aflher, 1988; Watkins, 2001). It bounces to issues that are fundamentally organisational: how to create the conditions in the education system which enables reflection to pertain?

Hidden efficacies in the productive failure theory

One finding of this dissertation – the fact that the time spent reflecting does not show up in test results – coincide with the output of a series of comparable stud-

ies carried out in the field of computer supported collaborative learning (CSCL) and which detected "productive failures".
In one of these studies, Kapur and Kinzer (2009) show that groups which discussed more intense and actually reached a deeper understanding of the underlying concepts performed worse in a post-activity assessment than the control group. The reason invoked to explain this counterintuitive phenomenon is that learner-generated processes that may initially seem to fail vis-à-vis conventional standards like efficiency, accuracy, and performance may well have a hidden efficacy about these same notions. In other words, processes that seemingly lead to failure in the shorter term could engender a productive preparation for future learning (or a "readiness for application". See Fig. 1.1) in the longer term through, among others, the sharpening of "discernability" (Marton 2007).
This "discernability" skill would be critical to knowledge acquisition because "individuals learn well when they have generatively discerned features and structures that differentiate relevant aspects of the world" (Schwartz and Bransford 1998, p. 493). RAs, in their attempt to "make learning visible", tried to help learners to "discern features and structures that differentiate relevant aspects of learning, among which reflection in its different dimensions".
It would be an interesting research extension to see if the effects at work in productive failure cases might underlie some results obtained with reflection-in-action episodes. In all cases, the productive failure research threshold as well as findings of this dissertation can stimulate the discussion about performance measurement in learning. This brings back to a primal statement of this PhD-work (see Foreword): whilst it is questionable if a reflection on "why do I learn this?" in the classroom stimulates concrete performance assessment it can still be a matter of the instrument measuring and therefore defining what performance is.

Questioning the theoretical integration

A last major challenge for research in the coming years lays in the theoretical conversation between different frames of mind that can legitimately contribute to the discussion about RAs. It is recommended that research in the field inspects its connections to the following conceptual proposals.

Schön's model of reflection (1983)
The dialogue of RAs with Schön's seminal work must go on. Should the reflection-in-action be conceptually restricted to an immediate reflective response to a puzzling event in the practice, as suggested by Schön (1983)? Moon extends to the whole context this idea that something problematic is needed to ignite the reflective process (1999a, p. 10): "Reflection is a basic mental process with either a purpose, an outcome, or both, applied in situations in which material is unstructured or uncertain and where there is no obvious solution." In contrast to these authors, it seems that, while sharing attributes of reflection-in-action, RAs can bear upon a continuous awareness and appraisal of the act of learning itself.

This is a different conceptualisation of the link between action and thought than one based on problem-solving flashlight insights (Pearson & Santa, 1995).

Cognitive load theory (Sweller, 1994)

In what circumstances does a reflection-in-action prompt convey intrinsic, germane or extraneous load (Scott & Schwartz, 2007)? And for whom?

Awareness situation theory (Endsley, 2000)

What are the relations between awareness and reflection? Following Endsley's model it seems that by nurturing internal feedback on different aspects of learning, RAs may modify the students' awareness of the learning situation and of their position within it.

Existing models of reflection

Complex models of reflection (Boud, Keogh, & Walker, 1985; Le Cornu, 2009; Moon, 1999a) do exist. Locating reflection amplifiers within them might feed theoretical and practical advances.

Flow theory (Csikszentmihalyi, 1990)

To what extent does reflection-in-action cause unwanted disruptions of cognitive flow? For whom will reflection-in-action be helpful or disruptive? At what level does the "flow" coalesce, with or without reflective activities?
In the search for an integration process of flow theory and RAs, the recent insights offered by the psychology in workplace about the impact of work interruption (Mark, Gudith, & Klocke, 2008) and the research on multitasking issues (Kirschner & Karpinski, 2010) provide valuable input.

Testing effect theory (Roediger & Karpicke, 2006)

Research in "test-enhanced learning" or "active recall" have demonstrated that, in educational contexts, tests not only assess what students know but also directly improve long-term retention of subject matter (Butler, 2010; Karpicke & Roedinger, 2008).
The principle which underpins this body of research is that a productive learning requires to actively stimulate memory *during* the learning process (Karpicke, Butler, Roediger, 2009). It contrasts with a view on study wherein the learning material is processed passively (e.g., by reading, watching, etc.). The first experiments on this "testing effect" mainly made use of multiple-choice questions as a retrieval strategy. More recently, research extended to other forms of testing, including elaborative studying techniques like concept mapping, summaries or free recalls (Dirkx, Kester, & Kirschner, 2011; Karpicke & Blunt, 2011). The extension to such strategies - which go beyond retrieval purpose - might be interpreted as an entry of the testing effect studies in the realm of reflection support techniques. The question is raised: is the testing effect a

specific effect or a sub-category of the reflective processes to embed in school assignments in order to support quality learning? Research on testing effect shows that the stop-and-think episode that any test represents not only give an opportunity for active repetitions of what has been learnt but also reveals which items have been sufficiently learned and which ones require further study, feeding auto-cognitive skills. Producing this interlace between content-related and self-related knowledge is also a key feature of RAs. For this reason, research on RAs would greatly benefit from an increased dialogue with the testing effect theory.

Concluding remarks

This dissertation focused on artefacts aimed at improving students' reflection at the domain level and at the meta-cognitive level. It studied a series of reflection amplifiers to support these thinking activities. The core feature of this approach to learning is that it arranges a systematic and permanent intertwine of cognitive and reflective activities.

All things considered, the image of reflection emerging from this dissertation is very far from Rodin's still and contemplative sculpture, "The Thinker". It also differs from theoretical models presenting reflection as a structured progression or as well-organised cycles. On the opposite, RAs look more like the elements of a billboard, accelerating, slowing down, amplifying, guiding, bouncing the trajectory of the thought and mixing up process and product, information about content and about learner's position towards this content.

In this context, reflection appears to involve an activity and an attitude that instils dynamism and meaning to the primary learning task at hand. Indeed detecting, tracing, modelling, prompting and fostering students' reflective behaviours during learning opens theoretical, psychological design, and technical challenges.

Despite somewhat indefinite results related to performance, the findings of this dissertation suggest that it is worthwhile to tackle these challenges and to further the strand of research initiated here about reflection-in-action prompts.

By making learning an explicit object of attention, reflection, conversation and learning (Watkins, 2001), it is hoped that tomorrow's RAs can raise students' awareness of the importance of reflection and make it become a natural attitude and inseparable component of any learning initiative.

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Tables and figures

Tables and figures
Tables and figures

Index of authors

Index
Index

To avoid long enumerations and repetitions, only the main authors (or groups of co-authors) are included.

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Merci la Vie !

About the cover(s)

About the cover(s)
About the cover(s)

The selected cover

"*Reproduction interdite*" (Verboden af te beelden / Not to be reproduced) is a painting by the Belgian surrealist René Magritte. Several elements of this masterpiece can be related to this PhD.

1. In pedagogical literature, "reflection" on knowledge is sometimes presented as an antidote against "reproduction" of knowledge.
2. This PhD makes use of the two meanings of "reflection": thinking and mirroring. It is concerned with mental processes but also with the construction of a "self-as-a-learner" identity.
3. In the painting, while the man (or the student?) standing in front of a mirror surprisingly sees nothing but his own backside, the book in front of the mirror (or the content?) is correctly reflected. This book is a French copy of "The Narrative of Arthur Gordon Pym of Nantucket" by Edgar Allan Poe. Poe's novel (first published in 1837, exactly 100 years before the painting) presents as an account of an adventurous journey to the South Pole. Actually, the story is a pretext for dealing in various ways with perceptions of reality, reflexivity and self-reflexivity (Levendig, 2012).
4. Another novel by Poe kept running into my head during this PhD: "The purloined letter", wherein the most important element of the story (the letter) is not seen by the protagonists, not because it is hidden but precisely because it has been put in full view in such a careless way that it appears insignificant. Similarly, the blatant assumption that schools and universities are "places for learning and reflection" can sometimes make learning and reflection invisible or forgotten. This is why the programme contained in the title of John Hattie's book: "Visible learning" is important, with an additional emphasis on making learning visible also for the student.
5. In Magritte's painting, learner's identity is shown and hidden altogether. This is a good example of the painter's interest for the mystery that lays in everyday visible reality. Magritte had a genuine passion for mysterious objects, namely objects that still look the same just in a weird way. Reflection amplifiers tried to take learning as it is and, at the same time, make it look in a weird way.

As for the back cover, the three citations (see the last page of this file) form a wrap-up of the touchstones of this dissertation: consciousness of students that they are learners, increased awareness to their doings, and the role of the reflection amplifiers in prompting this awareness.

The discarded cover

"In 2003, officials in Garden Grove, California, set out to confront a problem that afflicts most every town in America: drivers speeding through school zones. Local authorities had tried many tactics to get people to slow down. But these efforts had only limited success, and speeding cars continued to hit bicyclists and pedestrians in the school zones with depressing regularity. So city engineers decided to take another approach. In five Garden Grove school zones, they put up what are known as dynamic speed displays, or driver feedback signs: a speed limit posting coupled with a radar sensor attached to a huge digital readout announcing "Your Speed." The signs were curious in a few ways. For one thing, they didn't tell drivers anything they didn't already know – there is, after all, a speedometer in every car. If a motorist wanted to know their speed, a glance at the dashboard would do it. For another thing, the signs used radar, which decades earlier had appeared on American roads as a talisman technology, reserved for police officers only. Now Garden Grove had scattered radar sensors along the side of the road like traffic cones. And the Your Speed signs came with no punitive follow-up—no police officer standing by ready to write a ticket. This defied decades of law-enforcement dogma, which held that most people obey speed limits only if they face some clear negative consequence for exceeding them. In other words, officials in Garden Grove were betting that giving speeders redundant information with no consequence would somehow compel them to do something few of us are inclined to do: slow down. The results fascinated and delighted the city officials. In the vicinity of the schools where the dynamic displays were installed, drivers slowed an average of 14 percent. Not only that, at three schools the average speed dipped below the posted speed limit" (Goetz, 2011, June 19).

It is difficult to find a visual for the notion of reflection and even more difficult to escape kind suggestions to take "Rodin's Thinker" (by the way, no one knows if Rodin's Thinker is bothered with content or reflection). Three reasons explain my choice for a "driver feedback sign" visual.

1. Reflection amplifiers are purposed to stimulate reflection-in-action. Driver feedback signs provide structured opportunities for reflection about driving while driving.
2. The "driver feedback sign" combines the real-time individual feedback (your speed), the indication of context (school), and the compliance ratio (speed limit). The driver compiles on its own this personal and contextual information and comes naturally to a conclusion: "I slow down" (and reflection is in itself a way to slow down). These intricacies between personal and contextual information is a core concern of the dissertation.
3. In the foreword to his PhD, my colleague Christian Glahn, evokes a friend of his: "At that time Martin was working in a clinic with depressed people. He told me about people who are caught in a vicious cycle of (mis-) interpretations of social interaction, their deep distrust in the outer world, and social isolation. These people lack of positive feedback on their endeavours to manage their malady from their social environment. As a result they assume that whatever they do, nobody else is willing to give them support, and so they cut down their social relations. By the time these people end up with my friend, they are at a stage where they see any kind of social interaction as a misinvestment. So Martin told me about a little exercise they do with their patients in order to give them the feeling that already very small social interactions pay off: on afternoon walks the care workers sometimes make a little extension to a nearby highway bridge. The actual exercise is to wave at the passing cars. Often to the surprise of the patients, many drivers or co-drivers in the cars wave back". Driver feedback signs are conceived as ways for people to wave back at themselves when driving. This dissertation, trough the reflection amplifiers but also through the idea of learning dashboards, investigates ways for students to wave back at themselves when learning.

Although I do not deny my belief that a certain level of compliance is in many contexts a condition for education, I eventually discarded this cover because it gives of reflection too a narrow and control-oriented image. Additionally, some links to the dissertation, albeit existing, were not straightforward enough.

(Picture: SpeedCheck radar speed sign, with permission from Information Display Company).

Samenvatting

Samenvatting
Samenvatting

1. HET ONDERWERP

Dit proefschrift gaat over het bevorderen van reflectie tijdens het leren. Het onderzoekt in welke mate korte, tussentijdse aansporingen tot reflectie er voor kunnen zorgen dat lerenden gaan nadenken over hun eigen leerproces en daarin meer inzicht krijgen. Die aansporingen worden weloverwogen in het studiemateriaal ingebed om tijdens de bestudering het leren en de reflectie op het leren met elkaar te verbinden. Bij deze zogeheten "reflection amplifiers" (reflectie versterkers) gaat het om compacte, gestructureerde interrupties die de bewustwording en gedachtevorming over diverse aspecten van het eigen leren pogen te bevorderen. Dit proefschrift onderzoekt de attributen en het gebruik van deze artefacten en hun effecten het op leren, op de leerervaringen en op de mate van reflectie.

2. WAT IS REFLECTIE?

Reflectie verwijst naar een mentaal discours in het denken van een individu over de samenhang tussen de leerinhouden en het eigen leerproces. Reflectie is niet slechts een extra laag die aan het leren wordt toegevoegd, maar is een essentieel onderdeel van een betekenisvol leerproces. Reflectie zorgt er voor dat het object van studie in meer detail wordt bekeken. Mensen kunnen op tal van aspecten van de wereld reflecteren, maar in dit proefschrift is het object van reflectie het eigen leerproces. Het verwijst naar metacognitie: kennis verwerven over de eigen cognitieve processen. Het woord "amplifier" (versterker) weerspiegelt de aanname dat het aanbieden van extra mogelijkheden voor reflectie de kwaliteit van het leerproces verhogen en aspecten van de leerinhoud blootleggen die anders impliciet kunnen blijven.

3. WAAROM DIT ONDERWERP?

Reflectie wordt algemeen gezien als een van de meest bepalende factoren voor het leren. In de informatiemaatschappij worden reflectieve vaardigheden van steeds groter belang. Kenniswerkers zien zich geconfronteerd met snel verouderende kennis en worden overspoeld met omvangrijke, veelal gefragmenteerde informatiestromen. Bijblijven vergt studie en een goed inzicht in het eigen leerproces. Reflectie is een noodzakelijke voorwaarde om als kenniswerker te kunnen functioneren en in staat te zijn het eigen leren organiseren. Het onderwijs kan zich niet langer beperken tot het onderwijzen van vakcompetenties en –inhouden, maar moet proberen deze te vervlechten met reflectieve processen om het leervermogen van lerenden blijvend te vergroten. Dat is wat bij de Open Universiteit gebeurt.

4. REIKWIJDTE

Dit proefschrift richt zich op reflectie-in-actie, dat wil zeggen, reflectie tijdens het leerproces. Veel studies zijn gewijd aan methoden om reflectie-na-actie te stimuleren: het nabeschouwen van leersituaties (bijvoorbeeld in portfolio's). Reflectie tijdens het leren heeft tot nu slechts beperkte aandacht van onderzoekers

en practici gekregen. Het onderzoek in dit proefschrift beperkt zich verder tot studiemateriaal in eLearning omgevingen. De ontwikkelingen van het Sociale Web, ook wel Web 2.0 genoemd, biedt nieuwe mogelijkheden om reflectie te bevorderen door gebruik te maken van widgets, kleine herbruikbare softwarecomponenten, die gemakkelijk aan eLearning omgevingen kunnen worden gekoppeld. De gekozen onderwijsvorm is die van individuele zelfstudie met online studiematerialen: lerenden kunnen geen (direct) beroep doen op een docent of een mede-leerling voor instructie, ondersteuning of terugkoppeling. Deze onderwijsvorm komt veel voor in het afstandsonderwijs van onder andere de Open Universiteit, maar raakt ook steeds meer in zwang bij andere onderwijsaanbieders. Het onderzoek richt zich in het bijzonder op formeel hoger onderwijs, waar sprake is van een tekort aan beproefde praktijken van reflectiebevordering.

5. HET ONDERZOEK

In dit onderzoek zijn diverse studies uitgevoerd naar het verband tussen de eigenschappen, het gebruik en de effecten van reflectie versterkers. Als uitgangspunt voor het onderzoek is een classificatiekader van reflectie versterkers ontworpen door middel van literatuurstudie. Dit kader is gebruikt bij de vervolgstudies. Er is gepeild hoe docenten in het hoger onderwijs denken over reflectie, in welke mate zij bekend zijn met reflectie versterkers en in welke mate zij deze gebruiken in hun onderwijs. Voorts is er een piloot-experiment uitgevoerd naar de effecten een klein aantal geselecteerde reflectie versterkers. Een van de reflectieversterkers (het maken van korte annotaties) is vervolgens uitgebreid onderzocht in de onderwijspraktijk. Ook zijn studies uitgevoerd naar reflectie versterkers in een educatieve game-omgeving, naar reflectie versterkers met gebruikmaking van mobiele technologie, en naar de voorkeuren van leerlingen voor verschillende soorten reflectie versterkers. Tot slot is ook onderzocht hoe het weergeven van statistische gegevens over het eigen leren reflectie kan versterken.

6. BEVINDINGEN

De belangrijkste bevindingen van dit onderzoek naar het gebruik van reflectie versterkers zijn:

- reflectie versterkers kunnen worden benut voor het bevorderen van academische vaardigheden en bijdragen aan de professionele ontwikkeling van lerenden;
- het classificatiekader beschreven in dit proefschrift onderscheidt reflectie versterkers op basis van twee attributen: de aard van de interactie die van de lerende wordt verlangd en het specifieke type object van reflectie;
- een direct effect van reflectie versterkers op de leerprestaties is niet aangetoond, maar wel hebben ze een positieve invloed op de leerervaring: de waargenomen intensiteit van reflectie, betere controle, besef

van het leren, besef van bestede tijd, beter inzicht in zichzelf als lerende persoon, fysiologische effecten en meer overzicht over het proces van leren;
- de waargenomen effecten rond de leerervaring zijn in alle verschillende experimentele contexten aangetoond. Daarmee levert dit proefschrift universele uitkomsten voor een reflectieve benadering van het leren.

7. OPENSTAANDE PUNTEN

Dit proefschrift leidt tot nieuwe, nog onbeantwoorde vragen, onder meer over de aangewezen frequentie, lengte, soort, en de combinaties van reflectie ingebed in online studiemateriaal en onderscheiden naar verschillende doelgroepen. Het vraagt meer onderzoek naar de duur van blootstelling en naar de juiste balans tussen vakinhouden en reflectie. Naast deze vragen en onduidelijkheden over het juiste ontwerp van reflectie versterkers, spelen er ook vragen over de mate waarin studenten en docenten bereid zijn deze reflectieve benadering van het leren over te nemen, vragen die verband houden met wijze waarop reflectie kan worden gemeten, en vragen over de subtiele samenhang tussen reflectie, leren, en de actieve betrokkenheid bij het studiemateriaal.

8. PRAKTISCHE BETEKENIS

Sommige instellingen doen pogingen om studenten niet alleen voor examens te laten leren en richten zich nadrukkelijk op het verbeteren van metacognitieve vaardigheden. Dit proefschrift verkent reflectie versterkers als mogelijkheid om leerprocessen en studiegewoonten tastbaar te maken. De widgets die voor dit proefschrift zijn ontwikkeld als voorbeelden van reflectie versterkers zijn nu als open technologie beschikbaar voor onderzoekers en practici. Zij zijn beproefd en gevalideerd in de praktijk. De empirische studies in dit proefschrift scheppen duidelijkheid over voordelen, nadelen, rollen, beperkingen en onzekerheden van deze aanpak voor reflectie.

Voor de onderwijspraktijk suggereert dit proefschrift dat:
- het stimuleren van intellectuele gedragingen tijdens het leren de cognitieve vaardigheden kan verbeteren die nodig zijn voor een levenlang leren;
- het specifiek aandacht besteden aan reflectieve praktijken die anders afwezig zouden zijn of niet bewust onderdeel zouden zijn van de taak, kan helpen expliciet te maken hoe iemand zijn of haar leerervaring kan verdiepen;
- het ontwerpen van gestructureerde mogelijkheden tot reflectie tijdens het leren kan helpen om een betere balans te vinden tussen de inhoudelijke leerprestatie en een lerende oriëntatie in online cursussen;
- er een prijs is voor de reflectieve houding: een toename van de tijd benodigd voor het leren. Docenten die reflectie versterkers zouden willen toepassen dienen een goed evenwicht te vinden tussen inspanning en efficiëntie, en tussen inhoud en reflectie.

Kortom, het proefschrift nodigt onderzoekers, educatieve ontwerpers en docenten uit de waarde van reflectie versterkers kritisch te evalueren met hun specifieke doelgroepen, leerdoelen en pedagogische context. Men mag niet voetstoots aannemen dat reflectie als vanzelf zal plaatsvinden, bewust of stilzwijgend. Voor docenten die een reflectieve benadering van leren voorstaan bieden reflectie versterkers een beloftebolle koppeling tussen cognitieve en metacognitieve denkniveau's, tussen inhoud en processen, en tussen de gerichtheid op prestaties en een gerichtheid op het leren.

Summary

Summary
Summary

1. THE TOPIC

The stimulation of reflection during learning is the core concern of this dissertation. It explores to what extent short and repeated incentives can support students to think about their learning processes while these progress. The prompts investigated in this dissertation are called "reflection amplifiers" (RAs). They are displayed to the learner as compact, structured and frequent interruptions of the learning flow. These tinglings for reflection intend to raise the consciousness of various aspects of learning. RAs are deliberately interspersed within the study material in order to operate a close connection between ongoing learning and reflection on this learning. The goal of the dissertation is to establish attributes and usage of these artefacts and to evaluate their effects on learning, learning experience, and the degree of reflection.

2. WHAT IS REFLECTION?

Reflection in the context of this study refers to the inner speech of an individual about the connections between the learning material and one's process of learning. Reflection is not just an "add-on" to academic learning, but an essential component of a deeper approach to learning. Reflection is practised for the sake of considering an object in more details. Objects to reflect on are innumerable. This dissertation addresses one specific sub-domain of reflection, linked with meta-cognition: oneself as a learner. The word "amplifier" is used to convey the idea that enacting opportunities for reflection in the course of learning expands the mental context of the task at hand and discloses aspects of it that might otherwise remain implicit.

3. WHY THIS TOPIC?

Reflection is assumed to be among the strongest influential factors of learning. Also, reflective skills gain in importance in the information society, which is characterised by an abundant and fragmented flow of information and a reduced lifecycle of knowledge. For knowledge workers, reflection thereby becomes a necessary condition for their knowledge acquisition and ongoing personal development. In the knowledge economy, schools and universities cannot confine themselves to teaching domain-specific contents and skills only. They have to find new ways to interlace their traditional mission with the building of reflective capacities, so that their audiences receive enough preparation in self-sufficiency as lifelong learners. For these reasons including reflective processes in the curriculum is a main concern at the Open Universiteit.

4. SCOPE

The lens of the dissertation is put on reflection-in-action, that is, reflection which takes place in the course of learning. Many studies are devoted to techniques purposed to stimulate reflection on action, in other words an after-the-fact contemplation of learning situations (e.g., portfolios). Reflection processes during the act of learning have so far received limited attention from researchers

and practitioners. Another restriction of this study is that it focuses on digital study material, in particular in self-instructed online contexts, i.e. situations wherein learners cannot (straightforwardly) rely upon an instructor or a peer for instruction, support, and feedback. This situation is common in distance education, as delivered among others by the Open Universiteit, but more and more also by other learning providers. Technically, the development of the Social Web, also called Web 2.0, offers new opportunities to foster reflection through the use of widgets, namely compact, agile, and reusable software components which can easily be inserted in eLearning environments. The use of such widgets is investigated. Finally, this dissertation mainly targets formal higher education wherein a shortage of tested practices regarding reflection enhancement has been reported.

5. STUDIES

This dissertation presents several studies conducted to establish the attributes, usage, and effects of RAs. The entry point of the inquiry is a classification framework of reflective techniques, elaborated through a literature review. The subsequent empirical studies are based on this reference framework. Higher education faculty are surveyed regarding their opinions on reflection and the knowledge they have of RAs. A pilot study follows, which explores the effects of some selected RAs. One of the RAs – the practice of short and frequent annotations – is afterwards put under scrutiny in a real-world instructional context. Other studies address reflection in an educative game, reflection supported with mobile technologies, and learners' preferences for different types of RAs. It is also probed how the feedback of own learning traces can support reflection.

6. FINDINGS

The main findings from this dissertation about the use of RAs in formal tuition are:

- the classification framework designed for this dissertation can differentiate RAs according to two attributes: the type of interaction requested from student to stimulate reflection and the target type of reflection;
- by conveying reflection on learning while learning, RAs can help to develop the meta-cognitive awareness of reflective academic skills and contribute to learner's "professional development";
- no direct effect of RAs on performance has been established. RAs however positively influence dimensions of the learning experience: perceived intensity of reflection, sense of control, feeling of learning, time on task, quality of insight into oneself-as-a-learner, physiological indicators and narratives of learning;
- the effects mentioned above have been observed in a variety of experimental contexts. Thereby, this dissertation pinpoints universal tenets of a reflective approach to learning.

7. OPEN ISSUES

From this dissertation, new and still unanswered questions emerge, with regard to the frequency, length, kind, combinations, and targeted population of the reflection slots embedded in content material. It calls for more research about the time exposure and the right balance between content coverage and opportunities to reflect thereupon. Beyond the issues directly linked to the instructional design of RAs, this work hits fundamental educational questions like teachers and students' acceptances of a reflective approach to learning, difficulties related to the observability and the measurement of reflection, and the intricacies between reflection, learning, and global active engagement with the study material.

8. IMPLICATIONS FOR PRACTICE

Some institutions are experimenting with efforts to teach their students more than just how to pass exams: they are looking for ways to enhance their students' meta-cognition. This study explores the provision of RAs as one possibility to make learning processes and habits more tangible. The technical impact of this dissertation is that widgets devised for clear educational reflective endeavours are now available to researchers and practitioners. Thanks to the application of these prototypes in real-world settings, one can already make up one's mind about possible advantages, downsides, moderators, limitations, and pending uncertainties of this approach to reflection.

Addressing educational practice, this dissertation suggests that:

- awakening intellectual habits during the study time can improve the thinking skills needed for lifelong learning;
- devoting specific attention to reflective practices that would otherwise be absent or not consciously integrated as part of the task allows to initiate a pedagogical deliberation about how to deepen a learning experience;
- designing structured opportunities to externalize reflection while studying may help to find a different balance between a performance and a learning orientation in the instructional design of online courses;
- there is a price for making learning processes and habits available to reflection: an increased time on task. Practitioners interested in this approach to learning have therefore to balance concerns for efficiency and mindfulness, for material coverage and thinking skills training.

In sum, the dissertation invites researchers, instructional designers, and teachers to evaluate against their audiences, their learning goals, and their teaching context the relevance of giving a face value to reflection instead of assuming that this reflection will occur in any case, consciously or tacitly. To the practitioners willing to endorse a reflective approach to learning, RAs offer, in online formal learning settings, an innovative crisscrossing between cognitive and meta-cognitive landscapes, content and processes, and between the self-as-a-performer and the self-as-a-learner.

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BACK COVER OF THE BOOKLET

> Based on her inability to recall her state of consciousness in her first three years at college, the autobiographer suspects she simply didn't have a state of consciousness. She had the sensation of being awake but in fact she must have been sleepwalking. (Franzen, 2011, p. 61)

> Although today this seems unknown, the training of the faculty of attention is the true goal and almost only value of all study. Most school exercises have a certain intrinsic value, but this is purely of secondary interest. All exercises which help to develop the power of attention are of interest, almost equally so. (…) Those who spend their formative years without developing this faculty of attending and directing mind to an object have missed a chief treasure. (Veil, 1942/1966, p. 85)

> The reflection amplifiers highlighted lots of things which I rarely give any consideration to when learning. (Participant n° 14, study 3)

This dissertation presents empirical studies concerned with the relationship between attention, reflection and learning.