Semantic Web-Enabled Interventions to Support Workplace Learning

by

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Abstract

To keep pace with today's rapidly growing knowledge-driven society, continuous learning in workplaces and being able to self-regulate one's learning processes have become essential. In this dissertation, I propose a set of interventions, developed using Semantic-Web technologies, to scaffold self-regulated learning (SRL) processes in workplaces. I integrate social embeddedness elements with harmonization components in the functionalities provided by these interventions to accentuate the social and contextual dimensions of workplace learning. To measure users' SRL processes, I developed a trace-based protocol which captures users' low-level trace data on the fly and translates them into higher level SRL events, contingencies and graphs of users' learning actions.

Findings of this research suggest that elements from both social and organizational aspects of a workplace should be integrated into the design and development of interventions which aim to support users' SRL processes in that environment. Users' perceived usefulness of the interventions show that they do consider the social context of their organization when planning their learning goals; yet, they prefer to know clearly what competences their organization expects them to achieve. Analysis of users' trace data, on the other hand, indicates a relative balance between users' reliance on both social and organizational contexts. The Social Wave intervention, which brought users updates from their social context, was the most central one during their learning actions, also the strongest determinant of users' engagement in SRL processes. The next most central intervention included the one that informed users about how various learning resources were used by their colleagues, along with the two interventions providing users with the organizational context of their workplace.

This theoretically-grounded understanding can guide researchers in intervention planning and development for workplace settings. Also, the trace-based methodology developed within this work takes promising steps toward adopting new methodological approaches in investigating SRL, and offers new ways to achieve insight into factors that promote knowledge workers' use of self-regulatory processes. Future research can gain substantially by applying social analytics on users' trace data collected using trace methodologies, merged with other quantitative and qualitative means for gathering data about users' SRL beliefs and processes.

Keywords: workplace learning; self-regulated learning; semantic web; social learning; organizational context; trace methodology

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1. Introduction

In today's rapidly growing, knowledge-driven society, organizations dynamically change their work practices in order to improve their productivity and competitiveness and respond to market opportunities. For individuals working in these environments, continual learning and agile adaptation to these societal and technological transformations is not only expected, but essential (Cairns & Malloch, 2011; Littlejohn et al., 2012). For almost three decades now, workplace learning has been a focus of research, attracting researchers in various disciplines from pedagogy, education and psychology to organizational studies and knowledge management (Fischer, 2000; Fuller & Unwin, 2004; Tynjälä, 2008). Due to this diversity, a myriad of different themes and perspectives has emerged within the research on workplace learning (Fenwick, 2008a; Lee et al., 2004; Tynjälä, 2008). One of these perspectives concerns the *mode* or *type* of learning (e.g. formal, non-formal or informal) that happens in workplaces. Frequently emphasized in the existing literature, it has been discussed that learning in workplace is mostly informal and autonomous (Ellinger, 2005; Eraut, 2004a; Hart, 2010; Kyndt, Dochy, & Nijs, 2009; Lee et al., 2004; Tynjälä, 2008). This implies that most often it is the individual worker who needs to address some knowledge or competence gap (i.e. initiating the learning process is autonomous) based on the requirements of a task at hand (learning happens in an informal mode). From an individual learning perspective, ideally, it means that individual knowledge workers are aware of their learning needs based on the requirements of a task, project, duty or any other responsibility related to them within their workplaces; are able to define relevant learning goals and engage in proper learning processes to attain them; and have the capability to reflect upon their learning process and share how they gained the required knowledge, so there will be less hassle for others in need of the same knowledge. This ideal image of informal, pro-active learning, however, rarely happens in everyday work environments. Unless provided with structured learning scenarios in formal settings, most people are not proactive enough to initiate a learning process on their own, or they simply do not know

how to learn (Margaryan et al., 2009). That is, workers often do not know where to start from, how and where to look for reliable knowledge sources, how to monitor their learning processes and ensure that they are on the right path, and more importantly, they are rather reluctant to document and share their learning experiences within the organization. Self-regulated learning (SRL) contains the potential to address this challenge (Margaryan et al., 2009; Siadaty et al., 2012). Accordingly, coupled with the new demands brought forth by socio-economic demands, the informal nature of workplace learning requires contemporary knowledge workers to be capable of deploying self-regulatory learning processes in order to identify and address their learning needs.

1.1. Statement of Problem

Recently the concept of self-regulated learning in the workplace has gained some attention (Carneiro et al., 2007; Littlejohn et al., 2009). Still, the majority of the existing body of research on the application of and support for SRL processes in learning environments has taken place in formal, educational settings, e.g. (Azevedo et al., 2010; Chen, 2002; Dabbagh & Kitsantas, 2005; Kumar et al., 2005; Winne et al., 2006; Winne, 2010a) and SRL processes in the workplace are under-researched. There are at least two important challenges that call for investigating SRL processes, in particular, in workplace environments (Littlejohn et al., 2012).

The first challenge is due to the fact that the nature and objective of learning is noticeably different between educational and workplace environments. In formal, academic settings learning is a goal in itself (Margaryan et al., 2009), and learning requirements and processes are typically well-structured and formally defined. As well, students are usually provided with information, for instance, about the objectives of a course, tasks they need to accomplish within a course, competences they are expected to gain as the outcome of a course, and the methods and standards against which their learning outcome(s) will be assessed. Accordingly, in academic environments students can utilize such information to create and direct their learning goals (Hadwin et al., 2011). Learning in workplaces, however, is usually a "by-product of work" (Margaryan et al., 2009; p.2), where the actual goal of a knowledge worker is task performance and

learning is mainly a means to achieve this goal (Illeris, 2011; Ley et al., 2010; Margaryan et al., 2009). This means that learning in workplace environments mostly happens "on demand" (Fischer, 2000); without explicit or prior training plans, in that it is triggered by learning needs and requirements of one's organizational position and duties, such as a task for which the user is responsible, or a project to which he/she belongs. This foregrounds the imperative role of the organizational context on how users recognize their learning needs, plan and define their learning goals, engage in learning strategies to attain those goals, and reflect upon their overall learning process to address their following or upcoming learning needs - these processes altogether represent the typical phases of SRL in the workplace.

The second challenge rises from the fact that the majority of conventional interpretations of and existing studies on supporting SRL processes have placed their focus rather on factors that relate to *individuals*. This is, of course, not intended to disregard the social-cognitive theories of SRL, e.g. (Zimmerman & Schunk, 1989), or the recent interest in studying co- or socially-shared regulation (Hadwin et al., 2011; Hadwin et al., 2010; Inoue, 2007); it is to point out that the existing literature on SRL (which has been mostly investigated within formal settings, as discussed above) follows an individualized perspective in that the social context and collective knowledge of a learning environment are considered to play a secondary role compared to individual-based factors (Jackson et al., 2000). Such a perspective contradicts the nature of the workplace, where individuals' work and learning activities are highly social and community centred (Hart, 2010; Margaryan et al., 2009; Marsick et al., 2011). Accordingly, learning in the workplace is not an isolated process; it is social, affects and is affected by the social context and the available collective knowledge. This implies that the social context of an organization should as well be taken into the picture when examining and aiming to support SRL processes in workplace environments. The study reported in (Margaryan et al., 2009), is the only study I could find in the literature that besides *must and should have*s, actually investigates how SRL processes happen in a real workplace setting. The findings of this study confirm that SRL in work environments is a "highly socially mediated process [rather than being solely individually based], structured by and deeply integrated within work tasks [and priorities]" (p.9). Among the findings of this study, the participating experts tended to draw heavily upon their

personal networks of trusted colleagues in the process of diagnosing and attaining their learning goals, where these goals are open-ended, and continually reviewed.

The significance of social context in learning processes is not limited to workplace environments. In the last couple of years the affordances offered by the so-called Web 2.0 paradigm have drastically changed the conventional model of the Web into a rather *participative Web* (Jovanović et al., 2009; Kane et al., 2010; Vassileva, 2008). This emergent model of the web allows for extensive social exchange and collaborative contributions, where users are no longer passive viewers or merely consumers of the existing information. Instead, they are both consumers and producers: they collaborate, communicate, and most importantly create content, share knowledge, and make use of the available social knowledge. Such promising affordances have highly affected existing learning pedagogies, bringing forth a new perspective to the concept of learning: *Social Learning* (Mcloughlin & Lee, 2010; Vassileva, 2008). An emerging conceptualization of learning, *Social Learning* expects users to be exposed to higher levels of autonomy, creativity and social embeddedness. Such a conceptualization is particularly important in the context of workplace learning, and could act as the basis of theoretical or practical attempts that target the above challenge.

These challenges highlight a need for systematic research on self-regulated learning as well as how it is best facilitated in informal workplace settings. Modern technological enhancements can lend support to address these challenges. The existing literature acknowledges and has already shown that innovative tools and software can in general deliver great benefits for studying and bootstrapping SRL processes, specifically, in formal educational settings; see for instance (Azevedo, 2010; Dabbagh & Kitsantas, 2005; Winne et al., 2006; Winters et al., 2008). In the context of workplace learning, Semantic Web (SW) technologies are the most recent stream of technology that could be very advantageous in this regard (Tochtermann & Granitzer, 2008). They bring semantics to existing knowledge; make it machine-process-able and thus ready for further inferences. Knowledge workers today often use diverse tools for their everyday working and learning practices. This presents a challenge in studying their SRL processes and providing a scaffold for these processes, as the traces and outcomes of users' (learning) activities are dispersed among different and often heterogeneous tools. Semantic Web technologies and ontologies in particular, are highly suitable for

integrating data originating from different, often dispersed and heterogeneous sources (Allemang & Hendler, 2008), and thus, represent a well-suited means to address this challenge. The goal of this dissertation is to investigate how a set of innovative interventions support individuals' different self-regulatory learning processes in the workplace; in particular, the phases of planning (of the learning goals), engagement (in learning activities and strategies) and, evaluation and reflection (over the learning process).

1.2. Research Questions

I ask the following main research question in my dissertation:

What is the effect of Semantic Web-enabled interventions on users' self-regulated learning processes including planning, engagement and, evaluation and reflection phases, in workplace environments?

More specifically, I frame my a-priori hypotheses in terms of how each of the proposed interventions assists users in performing their SRL processes, and first investigate the following research question:

How do different SW-enabled interventions support users' different SRL processes in workplace settings?

And further I investigate:

Which SW-enabled interventions are most effective in supporting users' SRL processes in workplace settings?

1.3. Research Method

I have explored the above research questions following a design-based research (DBR) approach. Pursuing this research approach, I design and refine my proposed interventions based on challenges identified in the existing literature, along with the authentic learning needs of practitioners during their day-to-day work practices. These interventions are implemented within Learn-B, a research prototype developed in the

IntelLEO[1] project. I evaluate the support provided by these interventions in their real context of use through two evaluation experiments, one with the early prototypes and one with the full prototypes of the interventions. In the first experiment, I focus on users' perceived usefulness of the proposed interventions and the associations between such perceptions and users' usage beliefs about performing SRL processes in the workplace. In the second experiment, I look into users' learning activities using the Learn-B environment during a two-month testing period. I pursue an *event*-based conceptualization of SRL processes, and employ a trace-based methodology to measure users' deployment of these processes at both macro and micro levels, plus their use of the proposed interventions. Via this methodology, users' learning actions are captured on-the-fly and in their authentic context of occurrence. One of the greatest advantages of trace-based methodologies is that they allow grounding the analysis on accurate and authentic data, where these data illustrate the deployed (learning) events in their very own context (Azevedo et al., 2010; Greene & Azevedo, 2010; Winne, 2010; Winne & Perry, 2000; Zhou et al., 2010). I analyze the trace data using descriptive and inferential statistics, plus graph-theoretic measures. In addition to these trace data, I use participants' responses to questionnaire items during the two experiments. I apply descriptive and inferential statistics to analyze the questionnaire data.

The goal of this research is to develop a theoretically-grounded understanding of the linkage between social and organizational aspects of workplaces, and knowledge workers' deployment of self-regulatory learning processes in these environments. This understanding comprises of two parts: the first part is to understand how different semantic web-enabled interventions facilitate different SRL processes in workplace settings. The second part is to identify the semantic web-enabled interventions that knowledge workers from different organizational settings commonly find beneficial to their SRL processes. Combined together, these two components can guide researchers in intervention design and development for workplace learning purposes. In addition, the developed trace-based methodology aims to open up the way for adopting new

[1] http://www.intelleo.eu/

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methodological approaches in measuring SRL and its processes, specifically in the context of workplace learning.

1.4. Organization of the Dissertation

This dissertation consists of 7 chapters. These chapters correspond to the stages of the design-based research approach that I pursued within this research. Table 1.1 shows the mapping between the chapters in this document and stages of the applied DBR approach.

Table 1.1. The four stages of the applied DBR approach mapped against chapters in this dissertation.

Stage of the applied DBR approach	Chapter in this dissertation
Stage 1: Informed Exploration and Analysis of Practical Problems	Chapter 1: Introduction
	Chapter 2: Literature Review
Stage 2: Development of Learning Interventions, based on existing literature and identified practical problems	Chapter 3: Theoretical Framework
Stage 3: Evaluation and Refinement of Interventions in the context of real Practice	Chapter 4: Method – Evaluation Experiments
Stage 4: Reflections to Produce Design Principles and broader Generalizations	Chapter 5: Results
	Chapter 6: General Discussions and Implications
	Chapter 7: Conclusions and Future Directions

In Chapters 1 and 2, I explain in detail about stage one, the analysis of practical problems (see Figure 4.1). Chapter 1 (Introduction) provides a brief prologue to my research, the key questions I am asking in this research and the methods I used to investigate them. In Chapter 2 (Literature Review), I explore the existing literature on challenges of supporting workplace learning and look at the key concepts and ideas in this regard, including the perspectives into workplace learning, the concept of self-regulated learning, and social semantic web technologies. Chapter 3 (Theoretical Framework) covers stage two of my DBR approach, in that I describe the theoretical

underpinning of my proposed interventions, discuss how it provides a sound basis for my proposed interventions, and formulate my a-priori hypotheses with regard to each intervention. In Chapter 4 (Method) first I describe the pursued DBR approach, and the micro-analytics, trace-based methodology I developed to measure and analyze SRL processes. Then, I discuss how I undertake the third stage via three iterations: a preliminary exploration using paper prototypes, plus two evaluation experiments, one using the early prototypes and one using the full prototypes of the interventions. The next three chapters pertain to the fourth stage of my DBR approach. In Chapter 5 (Results), I present the results from analysing the collected data in experiments 1 and 2, organized across my research questions. In Chapter 6 (General Discussions and Implications), I interpret and discuss these results in relation to my research questions and results of the previous research in the field. Also in this chapter, I discuss the limitations which could have affected the validity of my results, as well as several implications of these results for this research area. Finally, I conclude in Chapter 7 (Conclusions and Future Directions) with a summary of this dissertation, its main contributions, and an outline of possible avenues for future research.

2. Literature Review

In light of the challenges inherent to the nature of workplace learning, Chapter 1 identified a need for researching SRL and its processes in workplace environments. My research intends to present an understating of how a set of innovative interventions, designed in accordance to the social and organizational dimensions of a workplace, support knowledge workers' different SRL processes. Accordingly, there are three areas of research that are central to my research questions: i) learning in the workplace, ii) the concept of self-regulated learning and how it is measured, and iii) technological enhancements such as Semantic Web technologies.

I begin this literature review by looking at the main themes running throughout the existing literature on workplace learning, and identify the perspectives within each theme. Next, I review the concept of self-regulated learning, surveying the most influential theoretical models in this domain. I also examine the existing approaches to measurement of SRL and SRL processes, as they are foundational to my trace-based methodology. Finally, I look at the Web 2.0 paradigm, Semantic-Web technologies, and a combination of both (Social Semantic Web) and how their affordances can be utilized in my research. Informed by this literature review, in Chapter 3, I continue with explaining the theoretical framework of my research, which serves as the basis for the design of my proposed interventions.

2.1. Workplace Learning

Recent research, both theoretical and empirical, clearly highlights the gap between the knowledge and skills gained through formal educational settings and the knowledge needed at work (Eraut, 2004b; Sampson & Fytros, 2008; Tynjälä, 2008). In addition, the constant development of information technologies, rapid growth of available knowledge and the continuous movement toward globalization over the last

few decades have brought new challenges to organizations and their members. In this era of globalization and worldwide competitiveness, having the skills to cope with dynamic changes, plus sustaining higher levels of performance are central to productivity in the workplace. This has led employees, knowledge workers and policy makers to consider constant learning as an inseparable part of the workplace environment, through which required task and work-related knowledge could be developed and enhanced (Eraut, 2004a; Fenwick, 2008a; Lee et al., 2004). In view of this challenge, workplace learning has been a focus of research since the early 90s, and has attracted researchers from various disciplinary backgrounds such as adult education, vocational training, higher education, cognitive psychology, organizational studies and (knowledge) management research (Fuller & Unwin, 2004; Lee et al., 2004; Tynjälä, 2008). Such diversity has resulted in a set of different themes, concepts, and models running in the existing literature on workplace learning. In the following, I look at the themes that are of interest to my research questions, and present the different perspectives through which each theme has been viewed and examined in the literature.

2.1.1.   *Conceptualization of Learning in the Workplace*

There are different understandings of how learning happens in workplaces (Hager, 2005, 2011; Paavola et al., 2004; Tynjälä, 2008). The way a research community understands and defines the concept of *learning* highly affects, and is affected by, its consecutive investigation into workplace learning. These understandings stem from different conceptualizations of learning, put forward by different theoreticians and researchers in the field, and grounded in different epistemological assumptions and beliefs about knowledge and learning (Lee et al., 2004).

The first conceptualization is to view learning as a *thing* or *product* of acquiring knowledge. Theories within this category focus mostly on individuals and cognitive aspects of work performance, and less importance is given to the effect of social, organizational and cultural factors, i.e. the general context of learning. Within this conceptualization, work performance is manifested through thinking or reflection, followed by application of that thinking or reflection by an individual. Viewed from this acquisition perspective, workplace learning is considered to be of the same kind as formal learning, in that *learning* itself is taken for granted and not problematized (Hager,

2011). The *acquisition* metaphor of learning, initially introduced by (Sfard, 1998), and the *standard paradigm of learning* discussed in (Hager, 2004) fall into this category.

The second main category of workplace learning theories emphasizes that learning is an involving action, which occurs through social interactions (Hager, 2005; Lee et al., 2004; Tynjälä, 2008). Through this conceptualization, workplace learning and performance extend beyond the level of individuals and are considered to be affected by social, organizational and cultural factors (Hager, 2005). The *participation* metaphor of learning (Sfard, 1998) and the *emerging paradigm of learning* (Hager, 2004) manifest this conceptualization. It has been highlighted by many researchers that although the acquisition paradigm undeniably benefits formal education, it falls short of illustrating the nature of workplace learning; the participation metaphor has been frequently suggested in the existing literature as an answer to this concern (Fuller & Unwin, 2004; Hager, 2011; Lee et al., 2004; Tynjälä, 2008).

Still, as discussed above, the challenges of our recent knowledge-based society require organizations and their members to go beyond gaining the required knowledge in merely push (i.e. acquisition) or pull (i.e. participation) manners. Instead, they need to be creative, innovative, and capable of utilizing the available collective knowledge, and improving their knowledge building processes. Clearly, this demands a conceptualization of learning that goes beyond the acquisition and participation dichotomy (Hager, 2011; Paavola et al., 2004; Tynjälä, 2008). The *knowledge creation* metaphor of learning, a third metaphor introduced by (Paavola & Hakkarainen, 2005), views learning as creation of new knowledge via social processes. It is built upon the theory of knowledge building (Bereiter, 2002), the model of knowledge expansion (Engeström, 2001) and the widely influential model of knowledge creation of (Nonaka & Takeuchi, 1995). This metaphor, thus, is seen as capable of soundly tackling the recent shift toward a social and collective knowledge paradigm, where creativity, originality, and the capacity to gain knowledge from a sea of collective are highly expected and valued (Mcloughlin & Lee, 2010; Tynjälä, 2008).

The way learning in the workplace is recognized and conceptualized mutually affects the perspective into the mode of learning that happens in the workplace. Mode of learning here, for instance, can be formal, informal or a combination of both, intentional

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or unplanned, or blended and social. In the following, I discuss the different approaches to this theme, outline the definitions for workplace learning modes available within the current literature, and describe how they are related to each other.

2.1.2. *Modes of Learning in the Workplace*

There exists a wide body of research on definitions of, and similarities and differences between formal, informal and (partly) non-formal learning in workplaces (Kyndt et al., 2009). *Non-formal* learning is typically set somewhere between formal and informal learning (Kyndt et al., 2009), although in some existing research it is used interchangeably with the term informal learning (Colley et al., 2003; Hager & Halliday, 2007). Even less consensus is achieved in the existing literature on what exactly *formal* and *informal* learning is and should be, particularly in the context of workplace learning. (Hager & Halliday, 2007) suggest distinguishing *informal* learning through what it is *not*, that is, formal. Accordingly, agreeing upon a functional definition of formal learning can make it easier to distinguish between these two modes of learning. In their view, formal learning is recognized when three items are present in a situation: "a specified curriculum, taught by a designated teacher, [and] with the extent of the learning attained by individual learners being assessed and certified" (Hager & Halliday, 2007; p.21). To further rely on the literature, the definition of informal learning provided by (Eraut, 2004a) matches well against the above definition of formal learning, in that he characterizes informal learning by attributes such as implicit, unintended, opportunistic, unstructured learning and the absence of a teacher. Looking from a relatively different perspective, (Hodkinson & Hodkinson, 2004) present a six-fold classification for the various modes of workplace learning. They argue that learning in the workplace can be either intentional/planned or unintentional/unplanned; further at either of these two levels, learning can occur about something which is already known to others, is new to others, or is the development of an existing capability. Based on this classification, informal learning mostly happens at unintentional/unplanned level.

Being mostly informal is a key feature of workplace learning, emphasized by several researchers in the field, such as (Ellinger, 2005; Eraut, 2004a; Hart, 2010; Kyndt et al., 2009; Lee et al., 2004; Tynjälä, 2008). However, although the majority of researchers agree that informality is the most typical feature of workplace learning, it is

not and shall not be recognized as the only manner in which learning happens in the workplace. (Slotte et al., 2004) enumerate three reasons for why informal learning alone is not enough for workplaces: first, informal learning often occurs without mindful efforts and results in mainly tacit knowledge, which may not be all positive or of high quality; second, informal learning alone cannot ensure that the required knowledge and skills of organizations and their members keep pace with the dynamics of socio-economic transformations and rapid development of information technologies; third, formal education and planned learning settings can exploit informal learning in a more effective way, and turn the resulting tacit knowledge into explicit knowledge, which could shape the basis of missing or required expertise. This last reason is fairly comparable with the rationale behind *blended* learning. Blended learning has long been a halfway solution to the issue of *formal-versus-informal* learning (Collis et al., 2005). Blended learning brings the best of both worlds for most organizations: the formal aspect of learning addresses organizational needs through a *push*-wise conceptualization of learning, whilst the informal features address knowledge workers' learning needs and requirements in a *pull*-wise manner (Hart, 2010). Suggesting a more complex alternative for blended learning, (Tynjälä, 2008) argues that learning at both workplace and educational environments should contain formal as well as informal aspects, but with different weights and priorities assigned to each aspect. Referring to the existing literature, she distinguishes between three modes of workplace learning - as opposed to the dichotomy of formal - informal: i) incidental and informal learning, which takes place as a side effect of the performed work; ii) intentional, but non-formal learning activities related to work processes, where learning is usually self-initiated by the workers themselves and iii) formal, structured learning via, for instance, planned training on-the-job or off-the-job.

An important issue that can be inferred from Tynjälä's recognition is that workplace learning, as well as learning occurring in formal and educational environments, is not a unified phenomenon, distinguished via some limited labels such as informal, intentional, or implicit. Instead, depending on the many contextual factors involved in workplace learning, such as individuals' needs, their position in the workplace and the organizational requirements and priorities, it can swing from one mode into another. The *knowledge creation* metaphor of learning discussed earlier in this section is actually well-suited to conceptualize learning from such a perspective.

Another important issue here is that, although all of the above discussions focus mostly on how *individuals'* learning processes happen in the workplace, learning can and does also happen at the organizational level (Fenwick, 2008b; Hart, 2010; Tynjälä, 2008). It is the organization that should discover and utilize this level of learning in order to further support individuals' and organizational learning needs. Indeed, in today's knowledge-driven society, which is subject to rapid change, dynamic communication, and continual knowledge advancements, organizations need to ensure that firstly, the resulting learning and increased performance at the individual level is shared within the organization and secondly, the organization itself is as well utilizing the dynamic and evolving collective intelligence of its employees. In the next section, I illustrate the different levels at which workplace learning can occur, and discuss the related perspectives that exist within this theme.

2.1.3.   Levels of Learning in the Workplace

Learning processes in the workplace, regardless of how they are conceptualized according to different schools of thought or in what mode they are recognized, can take place at different levels, ranging from the level of individuals, to teams and groups, communities of practice, organization, inter-organizations and, collective and social learning (Fenwick, 2008b; Tynjälä, 2008). It is noteworthy to mention that when looking at different levels of learning, these are the learning processes that sequence and progress from one level to another; in fact they act like a glue that holds and tightens all levels together. An extended body of research exists on the concept of learning processes, where various forms of learning outcomes and processes are described by researchers coming from different disciplines. For instance, the work by (Nonaka & Takeuchi, 1995) investigates four stages of knowledge creation, namely socialization, externalization, combination and internalization, based on the transitions between the two types of explicit and implicit knowledge into each other. This perspective can be rationalized via the knowledge creation metaphor of learning. Another instance is the organizational learning framework proposed by (Crossan et al., 1999). This framework utilizes four types of learning processes including intuiting, interpreting, integrating and institutionalizing, built on the concepts of cognition and action. This framework rather follows the acquisitive and participative conceptualization of learning.

Individual learning is the most typical level where learning happens in workplaces. It usually changes the existing knowledge, beliefs, attitudes, or competences and can be defined as the process of internalizing information through knowledge building activities and relating it to that which is already known (Bereiter & Scardamalia, 2003). The research on individual learning in the workplace, in particular, seeks to investigate issues such as what users learn at work (i.e. in the form of learning outcomes and products), how they learn it (i.e. looking at learning processes) (Tynjälä, 2008), what challenges they mostly face when engaging in learning processes, and how those challenges could be addressed (Cairns & Malloch, 2011; Tochtermann & Granitzer, 2008).

Another level of learning in the workplace is group learning. Group learning allows individuals to externalize their own knowledge and share their knowledge and learning experiences with their colleagues and within their workplace. This would not only enhance workers' individual learning, but would facilitate the realization of a *learning organization* (defined below). Interesting studies exist in the literature that discuss the (positive) effect of different aspects of group learning e.g. group knowledge awareness and self-presentation on individuals' learning, performance and self-assessment, and collaboration patterns and information-sharing behaviours (Dehler et al., 2011; Kimmerle & Cress, 2007; Sangin et al., 2008). Teamwork, one of the categories mentioned in the typology of learning outcomes by (Eraut, 2004a), is a highly relevant concept here that most often emerges as the output of individuals' collaborating in groups. Studies examining group learning in workplaces typically follow a participatory conceptualization of learning. To focus solely on the enhancement of individual learning via group learning activities, however, creates a very narrow view of all the various learning processes that happen in an organization. It is widely discussed in the literature that organizations as well as individuals can learn. It is important here to notice the difference between the two concepts of *organizational learning and learning organization.* Borrowing from the extensive debate among researchers on distinguishing between these two concepts, the most common accepted definition of *organizational learning* is that it represents the process of individual and collective learning that takes place within an organization (Easterby-Smith & Malina, 1999). *Learning organization*, on the other hand, is rather perceived as a culture or ideal form for an organization to

evaluate and improve its learning processes (Senge, 1991), or as (Pedler et al., 1991) describe it, learning organization is "…an organization that facilitates the learning of all its members and continuously transforms itself." (Ang & Joseph, 1996) contrast *organizational learning* and *learning organization* in terms of processes (manifested via the former term) versus the structure (reflected by the latter term.) Such a perspective has led to observations by other researchers such as (Gorelick, 2005) who state that in order to have a dynamic and successful organization, "organizational learning and the learning organization can and should co-exist."

The above definitions highlight the important role that collective learning plays in the realization of learning at the organizational level. As well, a learning organization relies on the collective knowledge of its individual members to further transform itself and improve its existing learning processes. The notion of collective and social learning is an emerging conceptualization of learning brought forth by the affordances of social, participative web and its rapid-growing technologies (Mcloughlin & Lee, 2010; Vassileva, 2008). Recent research on workplace learning also emphasizes the importance of collective learning and other forms of social exchange for both individual learning and organizational development (Tynjälä, 2008). For instance, in her review of research on learning in the workplace, (Fenwick, 2008b) emphasizes that the relation between individual and collective learning is a particularly important topic in the literature. (Siadaty et al., 2010) further highlight the importance of collective learning from a knowledge sharing perspective. They indicate that by sharing their knowledge and learning experiences as well as using the knowledge shared by others and building on top of it, individuals can improve both their own individual learning and contribute to the collective organizational knowledge, thus, supporting the learning of the organization.

Learning in the workplace does not necessarily halt at the organizational level. Network learning, as defined by (Knight, 2002), is "learning by a group of organizations as a group." The focus of network learning is on the processes through which the network, and not merely the individuals participating in it, transforms its ways of thinking and acting. (Tynjälä, 2008) characterizes network learning via five main attributes: i) the interaction between the network's participants; ii) shared goals around which the interaction happens; iii) awareness of the available collective knowledge within the network, i.e. who owns it, how and from where it can be accessed; iv) full participation of

network members in social collaboration and sharing activities; and v) existence of a trustful and collaborative climate within the network. Another highly relevant concept here is inter-organizational learning, in that sharing of learning experiences and learning and knowledge building activities occur within two or more (collaborative) organizations (IntelLEO Consortium, 2010a).

As described in the introduction, the socio-organizational context including the organizational support that knowledge workers receive while involved in their learning processes significantly affects learning in the workplace. Not all organizations offer equal opportunities for learning (Ellinger, 2005; Hager et al., 2006; Marsick, 2009; Tynjälä, 2008). Indeed, regardless of how skillful learners are in identifying their learning needs, conducting appropriate learning processes and communicating with the collective while trying to attain their goals, if they do not receive the required contextual support from their organization, they won't be able to achieve their desired learning outcomes. In the following section, I start with describing the notion of *context* within workplace learning environments and continue with discussing *organizational support* within the broader domain of *organizational context*.

2.1.4.   Learning Context in Workplaces

As discussed earlier in this chapter, workplace learning is most often informal, indicating that knowledge workers normally learn as they perform their daily tasks and engage in the routine work life. Such informal nature of learning highlights the significant role of *context* in *learning* – a characteristic also applicable to workplace settings which is also broadly acknowledged in the existing literature, e.g. (Ellinger, 2005; Kyndt et al., 2009; Marsick, 2009; Tochtermann & Granitzer, 2008; Unwin et al., 2007).

2.1.4.1.   Definition of Context

True, there is a consensus that learning in the workplace is highly contextual, but the real challenge remains in how the concept of *context* is defined and operationalized: what factors are considered to affect workplace learning in an organization, what elements of the workplace environment are included in it, and what processes are applied to recognize and capture the *context*.

I start with the generic notion of context itself, which has been a subject of debate among researchers from varying disciplines. Each discipline has its own characteristics, leading researchers to interpret this term differently based on the domain of their research and apply different approaches to capture contextual information. The most generic and commonly accepted definition of context is "…any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves" (Dey, 2001).

In the scope of learning, like in other domains, different authors have suggested different interpretations of the term *context.* For instance, (Azouaou & Desmoulins, 2006) define learning context as meaningful properties about the entities that surround and give meaning to something else, i.e. if we define a learning context of a learner, we should only consider properties that describe the learner and his/her environment. In (Derntl & Hummel, 2005), learning context is about describing the current situation of a person related to a learning activity. (Jovanović et al., 2007) consider learning context to be about a learner, or a group of learners, interacting with some learning content by performing certain activity with a particular objective in mind. The authors stress that such unique situation-related data implicitly govern how content should be structured into a flow of interaction for a particular learner or a group. Despite this apparent diversity, researchers seem to agree that a learning context is mostly characterized by learners, learning resources and a set of learning activities that are performed in the light of a specific pedagogical approach (Siadaty et al., 2008).

The above definitions are all formulated for formal learning environments where learning processes are structured, more or less stabilized and learners have relatively clear ideas about how the learning process occurs and what objectives they should look for. In workplace environments, however, the notion of learning context needs to further extend to also cover the intertwined relationship between learning and work. Below, I examine how *context* has been defined in the current research on workplace learning.

In APOSDLE[2], an EU FP6 project, the notion of *workplace learning context* is introduced and defined as a set of relevant features of employees' working environment which influences their current work-related activities. The work environment is in turn composed of three main spaces: i) work space, including devices, tools and resources relevant for the employee's tasks; ii) learning space, including the employee's competencies; and iii) knowledge space, which is the knowledge stored in the organizational memory. This conceptualization of workplace learning context is formalized through the Workplace Learning Context Model. This model is then further used to support self-directed learning processes of knowledge workers (Ulbrich et al., 2006).

In (Maier & Thalmann, 2007), seven contextual concepts are proposed to be considered in workplace learning environments. These concepts include process, person, group, product, location, time, and technology. For each of these concepts, the authors describe how it can be captured from the systems and tools that knowledge workers interact with in their daily work tasks, as well as how it can be mapped against the elements of learning content metadata standards such as IEEE Learning Object Metadata (IEEE STD.2002.94128, 2002). Such meta-data can be further utilized in a learning system that is context-aware and delivers knowledge resources based on the user's situation.

The above two definitions are amongst the most complete ones in the current literature which try to address workplace learning context; still, none of them considers the effect of work and organizational factors on learning in workplace environments. As discussed above, supporting learning in the workplace calls for an additional set of concepts to be considered in the respective definition of *context*. That is, learning and work are intertwined and inseparable in work environments. Thus, to support learning at work, in addition to all the above concepts central to the definition of learning context, considering the concepts related to work performance in the definition of workplace

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[2] http://www.aposdle.tugraz.at/

learning context is a necessity. These concepts in general represent how work processes are organized and conducted in an organization (e.g. workflows), how roles, positions and duties are defined and distributed, how employees' knowledge and skills are assessed, and what the stance of an organization is toward learning and supporting learning processes. The last factor, for instance, can manifest how workplaces motivate users to take part in learning and knowledge building activities, how they provide users with the required knowledge, and what policies and norms users should be aware of while engaging in knowledge sharing or collaborative activities. Based on the specific domain in which workplace learning is being examined, other relevant concepts might need to be added to this list. As an example, the concept of "*ba"* introduced by (Nonaka & Konno, 1998), illustrates the collaborative space needed for thinking and learning, introduced from a knowledge management perspective. I integrate the above concepts into the generic term *organizational context*, discussed in the following subsection.

2.1.4.2. Organizational Context

Although a pivotal factor for supporting learning in the workplace as recognized by many researchers (Ashton, 2004; Kyndt et al., 2009; Lee et al., 2004; Marsick, 2009; Tynjälä, 2008; Unwin et al., 2007), there exist a limited number of studies in the current literature which have tried to define organizational context (within their specific domain of research) and examine how it affects workplace learning.

(Ashton, 2004) is one of the leading researchers who raised his concerns about the lack of research on the role of organizational structures in supporting workplace learning. In an attempt to address this concern, he conducted an empirical study (through a set of interviews), on a sample of 195 employees in a Malay organization. The results of this study indicated that hierarchical structuring of relationships, the design of jobs, and movement of employees, organizational decisions about learning and its importance, and decisions about the system of rewards were the most significant structural factors that impacted learning within that workplace.

In a similar attempt, (Ellinger, 2005) tried to explore the organizational factors that (positively or negatively) influence informal workplace learning. The results of the qualitative study he ran in a US manufacturing company indicated that the supportive culture of learning, both within the company and from the management side, work tools

and recourses, and openness and accessibility of people compose the positive factors which encourage employees to learn informally. Weak non-supportive culture (again both from the leadership and within the organization), lack of resources and work tools, and non-explicit results of learning were, on the other hand, the major organizational inhibitors (i.e. the negative factors) to informal learning in this study.

(Marsick, 2009) also enumerates concepts such as leadership, structure, culture, systems and practices, incentives and rewards as the most common organizational factors that affect workplace learning. These concepts are extracted from the results of five research studies in different disciplines such as teachers and schools, social workers, and knowledge management in academic and business settings.

In light of the above research efforts to explain workplace learning context, perhaps the most comprehensive definition so far is provided by (Braun et al., 2007). This definition encompasses a set of features that can be divided into seven categories: i) personal, including employees' competences, preferences and habits; ii) social, including the quality of social relationships with other members of the organization, which is reflected through roles, trust and intensity; iii) temporal, in terms of the date and time of the learning episode; iv) environmental, such as the worker's location; v) technical, in terms of available applications and resources; iv) organizational, including the information about users' roles and positions within the organization; and vii) operational, that include detailed information about workers' current activities. The above definition is more inclusive compared to other existing definitions. However, it still looks into workplace learning context from rather an individual-based learning perspective and organizational factors such as policies, generic objectives of the organization and incentives or rewards are not taken into account in this definition. The "organizational learning and knowledge management" module of the conceptual framework proposed in (Siadaty et al., 2010) aims to address the above concern. The proposed framework consists of two main modules: one module reflects organizational goals which, via an integrated set of ontologies, are connected to individual learning goals. The other module is used to define and apply organizational rules and policies with regard to workers' knowledge sharing activities. An underlying set of ontologies is used to model all of these concepts.

As can be seen, there is still no (commonly) agreed upon definition of workplace learning context. True, the research might consider only a subset of such contextual factors, based on its orientation and requirements. However, when aiming at supporting learning in workplaces in particular, the compelling fact that most often learning and work are inextricably interwoven, should be borne in mind. This means that firstly, workplace learning context is not merely a modified version of learning context with the addition of a few work-related concepts (e.g. tasks and positions), and removal of other concepts pertinent to academic settings (e.g. course structures.) Secondly, organizational context puts an imperative impact on how workplace learning is conducted and its goals are achieved. Thus, it cannot and should not be omitted from workplace learning *context*, whereas this is not the case with the majority of the existing research. There remains, thus, first a need to broadly examine the factors that support (or inhibit) informal workplace learning from the perspective of workplace context, and identify those that are most common in different disciplines. This aids to identify the basic concepts of workplace learning context, in the same way that the concepts of learner, learning content and learning activities are the most commonly acknowledged ones present in various definitions of learning context.

In addition to the organizational factors, the recent research on workplace learning highlights the role of collective and other forms of social exchange in both individual learning and organizational development (Eraut, 2011; Fenwick, 2008b; Hart, 2010; Tynjälä, 2008). The survey conducted by (Littlejohn et al., 2012; Margaryan et al., 2009), as described in the introduction, particularly highlights the role of the social context in users' self-regulatory learning processes. The observations of this survey are fully aligned with the *knowledge creation* metaphor of learning. According to this metaphor, discussed in previous chapters, learning is conceptualized as the creation of new knowledge through social processes. Such a perspective can soundly tackle the recent shift toward a social and collective knowledge paradigm of learning, where creativity, social-embeddedness, and the capacity to gain knowledge from a sea of collective are highly expected and valued (Mcloughlin & Lee, 2010; Vassileva, 2008). Recent enhancements in technology can augment this discovery and creation of knowledge. In the following chapters, first I look at the concept of self-regulated learning and how it is measured in the current literature, and then I describe the affordances of

recent technological enhancements such as Semantic Web technologies which can be utilized to facilitate SRL processes in workplaces.

2.2. Self-Regulated Learning

In the introduction, I discussed how the informal nature of workplace learning requires knowledge workers to be able to self-regulate their learning in these environments. In what follows, I provide an overview of the existing perspectives and models of self-regulated learning, and describe the methods commonly applied in current empirical research for measuring SRL, according to these perspectives.

2.2.1. Overview

Self-regulated Learning (SRL) ideas emerged from within educational psychology research in the 1980s, and became increasingly popular as the concept of *learning to learn* found its way through educational environments. Since then, it has been extensively a subject of study in different disciplines such as training, academic education, medical education and educational psychology. Given this diverse range of interests, a variety of *regulation*-related terms have been defined and vastly used in the literature, such as self-management, self-directed learning, self-education and self-guided learning (Steffens, 2006; Wolters, 2010). For the intent of this dissertation, however, I confine this review of the literature to the concept of *self-regulation*.

There exist a number of different models in the literature that posit alternative views on how learning is self-regulated (Boekaerts, 1997; Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman & Schunk, 1989). SRL models in general aim to understand how learners take control over and manage their learning processes (Wolters, 2010). One way to differentiate these models is through the different conceptualizations on self-regulated learning. It can be said that one perspective into SRL offers an *aptitude* or *component* conceptualization, while the second perspective conceptualizes SRL in terms of *events* or *processes* (Dettori & Persico, 2008; Klug et al., 2011; Puustinen & Pulkkinen, 2001; Steffens, 2006; Winne, 2010b). The models looking from the *component* or *aptitude* perspective are more *trait*-oriented (Klug et al., 2011); they encompass personality differences, attitudes and beliefs, and identify cognitive, meta-

cognitive, motivational, and emotional aspects of (self-regulated) learning. An important property common within this category is that aptitudes, although relatively enduring, are considered to be *adjustable*, in that learners can be taught to develop the desired aptitudes, or transfer the level or nature of an aptitude as they progress through learning events (Winne, 2010). On the other hand, the *event* or *process* perspective is more concerned with the way students approach problems and apply their learning strategies (Steffens, 2006). These models view SRL as proactive, goal-oriented processes that learners deploy to acquire academic skills and competences (Klug et al., 2011; Steffens, 2006). Such processes consist of a set of learning phases, within which learners perform their learning actions. These phases typically repeat during learning activities of self-regulated learners and influence one another.

Another way to differentiate the existing models is through their theoretical underpinnings (Greene & Azevedo, 2007; Puustinen & Pulkkinen, 2001). (Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman & Schunk, 1989) are the models that are most empirically supported in the current literature. While these models share some overlapping conceptualizations, discussed in the following section, the most differential element among them is the theoretical background in which they are grounded.

(Pintrich, 2000) and (Zimmerman & Schunk, 1989) models are based on the social-cognitive theory (Bandura, 1989), in that learning is shaped in terms of interactions between personal factors (e.g. beliefs and affects), behaviors and the environment. Although there is no universal, single definition for SRL, many recent works on SRL cite the definition provided by Pintrich (Pintrich, 2000; p.453). In Pintrich's words SRL is defined as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment." This definition reflects a goal-oriented perspective of SRL. Consistent with this perspective, in Zimmerman's view, "… students can be described as self-regulated to the degree that they are meta-cognitively, motivationally, and behaviourally active participants in their own learning process" (Zimmerman, 2001, p.15). Self-regulation in Zimmerman's social cognitive model is cyclic in nature, and occurs in a cycle of three phases: forethought, performance, and self-reflection. Pintrich's framework of self-regulation is denoted via a four-by-four grid of *phases* and

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areas. The four phases include forethought, monitoring, control and reflection. The self-regulatory activities related to each phase occur in four different *areas*, including the categories of cognitive, motivational and affective, behavioural and contextual features of the environment.

(Winne & Hadwin, 1998)'s model, on the other hand, is inspired by the information processing theory (IPT). In this model, self-regulated learning is identified in terms of events, and consists of four stages. These stages include task definition, goal setting and planning, studying tactics and meta-cognitively adapting studying techniques. The acronym COPES is used in this model to describe an IPT-based structure, in the form of *event units* (Winne et al., 2002), common within the four phases. It stands for Conditions, Operations, Products, Evaluations and Standards. Except for operations, the other four elements represent some sort of information that learners take as the input to, or produce as the output of their learning process (Greene & Azevedo, 2007). *Conditions* include internal (i.e. cognitive conditions such as beliefs, domain knowledge and motivation) and external (i.e. task conditions such as instructional cues and time available) information available to a learner that influence how the task will be engaged. *Operations* represent the cognitive processes, tactics and strategies which learners actually perform to address the task. *Products* are the information generated as a result of *operations*. *Evaluations* are internal and external feedback about *products*, while *standards* are the criteria against which products are monitored.

The diversity, as well as similarities, among the above models plainly highlights the fact that this is the underlying model of SRL which does (and should) guide how this complex phenomenon is measured, and how hypotheses and assumptions about components targeted for measurement are formulated (Azevedo, 2009; Greene & Azevedo, 2010; Winne, 2010b; Winne & Perry, 2000). In the following, I discuss the measurement methods available, and mostly applied, in the current literature.

2.2.2.   *Measurement Methods*

To provide a succinct yet inclusive overview of the available SRL measurement methods, I start with describing the taxonomy provided by (Schraw, 2010). This taxonomy is built upon the four articles in a special issue of *Educational Psychologist*

dedicated to the topic of measuring SRL constructs; still, I believe it well represents the big picture on this topic, since these articles forefront the challenges and issues raised within the work and research of the pioneer researchers in this field. In this taxonomy, Schraw divides the applied measurement strategies into online and offline methods. Online methods are defined to be applied during students' primary learning episodes, whilst offline methods are taken before or after those episodes. Online methods can be either *obtrusive* or *unobtrusive*. Online, obtrusive methods are applied in ways that require learners' "conscious attention," or being less obtrusive, in ways that learners are aware of them. Such methods, thus, consume some portion of learners' "processing resources" and might interfere with their flow of cognition (not necessarily in a negative way). Among the methods categorized under this label, *think-alouds are* perhaps the most frequently applied one. Unobtrusive methods, on the other hand, utilize indicators which do not require learners' attention and knowledge, and can run *in the background.* The most notable of these methods are *trace-logs.* In general, traces can be any type of data collected from users' actions in a learning environment such as their clicks on provided hyperlinks or selected options from a palette choice. Reading times and eye-tracking strategies are other examples of online, unobtrusive methods. Schraw categorizes offline methods into *self-reported beliefs*, *current abilities* and *expected performance. Self-reported beliefs* represent learners' perceptions of their own beliefs and abilities. These reports may concern metacognition, epistemology or self-efficacy, and might be measured in general or within a specific domain, e.g. self-efficacy for computer use. There exist a number of different self-report questionnaires in the literature that are often used in this regard (Carmen & Torres, 2004). For instance, the Motivational Strategies for Learning Questionnaire (MSLQ) is one of the most widely-used self-reporting questionnaires. This questionnaire includes 81 items, and aims to assess learners on their motivational orientation and use of different learning strategies pertained to a specific course or subject matter (Pintrich et al., 1991). Learning and Study Strategy Inventory (LASSI) is another frequently used self-reporting questionnaire, which is designed mainly to asses learning strategies used by university students. This questionnaire includes 77 questions items, which are grouped according to ten scales, including attitude, motivation, time-organization, anxiety, concentration, information processing, selection of main ideas, use of techniques and support materials, and self-assessment and testing strategies (Weinstein et al., 1987). *Current abilities* demonstrate

existing abilities and skills that learners bring with them to a learning task. These abilities might be general, such as students' intelligence or reasoning skills, or more domain-specific such as their interest and expertise in a given subject matter. *Expected performance* can be indicated through learners' pre- or post- judgement of learning (JOL) with regard to a learning task. Learners' "verbal reports of goals" are another example of this type of offline method. Such reports provide a measure on how learners plan to define and carry out their learning goals, plus an articulation of learner's criteria for successful learning.

Another useful way to examine measurement methods is to look at how SRL constructs are conceptualized in the underlying model. Winne deliberates on this approach (Winne, 2010b; Winne & Perry, 2000) by describing the protocols for measuring SRL categorized based on whether they measure SRL as *events* or as *aptitudes. Inventories* and *think-alouds* are the protocols mainly used in the existing research to measure SRL as aptitude. In *self-report* inventories learners are usually asked about some characteristic of their learning strategies (e.g. "frequency, likelihood or difficulty"), in a *loosely-defined* context (e.g. "when you study", "in this course", or "for exams"). To answer such questions users would need to rely on their memories, and previous learning experiences in similar situations, and their responses are typically limited to a pre-defined set of options, e.g. a Likert-scale of 1-5. In *think-alouds*, learners are asked to utter their thoughts and decisions as they engage in learning strategies and tactics. Contrary to self-reports, *think-alouds* do not require learners to *recall* from their memory or think in a particular way (as applied via instructions in self-reports), and can capture the dynamic aspects of SRL (Winne et al., 2010). Yet, they illustrate learners' *interpretations* about their "in-action" events, and this is the learner who decides what events are taken into account when articulating their choices and decisions. Unstructured interviews are another protocol used to measure SRL as an aptitude. They are similar to *think-alouds* in that user responses are not limited to pre-defined answers; but different from them (and rather similar to self-reports) in that users are asked about their SRL processes once the learning session has finished, or about their *typical behaviour* which could be foreseen in future learning situations. *Traces* (or trace-logs as phrased in Schraw's taxonomy) are the main protocol used (and suggested to be used) to measure SRL as event (Azevedo et al., 2010; Greene & Azevedo, 2010; Winne, 2010;

Winne & Perry, 2000). Traces allow capturing users' actions *on the fly*, in the authentic context where they happen. They are defined as the "observable indicators about cognition that students create as they engage with a task" (Winne & Perry, 2000; p.551). For instance, a trace could be that the student highlights a text because he/she finds it important, or clicks on a hyperlink to reach other related resources. Although traces are the most suited, available method to measure SRL "as the dynamic, contextual and adaptive process it is theorized to be" (Winne, 2010b; p.275), they cannot and should not be considered as the one and only method for measuring SRL constructs (Azevedo, Moos, et al., 2010; Winne, 2010b). Self-reports and *think-alouds* still provide researchers with valuable information on learners' own thoughts and perceptions about SRL. As alluded to earlier in this section, the underlying model of SRL affects how it is further measured. Besides clarifying their underlying model and conceptualization of SRL, it is important for the researcher(s) to decide which SRL constructs or processes are of most importance to their research, and determine and deploy the measurement protocol(s) most capable of measuring those processes/constructs.

The affordances of technology-enhanced learning environments can be utilized to design and implement systems that track learners' actions and query them for further inferences (Zhou et al., 2010). On top of it, such affordances can facilitate users' SRL processes in workplace environments. In the following section, I look into how Semantic Web technologies, in particular, can be used in this regard.

2.3. Social, Semantic Web Technologies

It is generally acknowledged that information technologies offer considerable opportunities for supporting learning at work environments (Tochtermann & Granitzer, 2008). The affordances of contemporary *social learning* tools, specifically, offer a remarkable opportunity for addressing the social nature of learning in workplaces (Dabbagh & Reo, 2010). For instance, knowledge workers can use a lightweight bookmarking approach to express their learning experience in using a specific work tool; or by using a commenting widget they can comment about the challenges they faced when using a specific learning strategy for a learning goal. Other members of the organization can then benefit from these comments and reviews when they are planning

their own learning goals. As another example, when expressing their learning experiences, RSS feeds can provide users with information on how their colleagues perceived and benefited from their previously shared knowledge. Such feedback can be incentive for the user to further contribute to the collective knowledge. These simple examples shed light on how the affordances of new technologies can support learning in work environments. Designing such systems that unlock the collective knowledge, and the collective intelligence in higher levels of inference for the purpose of scaffolding learning, however, is not a straightforward task (T. Gruber, 2008). For this kind of aggregation to be realized, the affordances of present-day social software (e.g. bookmarking tools and feed providers) have to be enhanced with semantic technologies (T. Gruber, 2008; Jovanović et al., 2009). Social Semantic Web Technologies are in particular the most recent stream of technology that could be of great benefit in this regard.

2.3.1.   Semantic Web Technologies

The Semantic Web (SW) refers to the evolution of the current World Wide Web into a Web of meaningfully described data, using well-defined semantics, available for automatic discovery and integration across distributed applications (Berners-Lee et al., 2001). A set of technologies, tools and standards such as RDF, SPARQL, SWRL and OWL form the building blocks of this enhanced vision of the Web (Breslin et al., 2009). Ontologies in particular are one of the fundamental building blocks of the Semantic Web. They are expressed through standard languages (such as RDF and OWL), which allow them to be combined, shared, easily extended and used to semantically annotate different kinds of resources.

In general, the Semantic Web technologies can serve as a powerful platform for bringing semantic-rich structure to data, allowing for representing machine-understandable data and thus, enabling further reasoning on the data and creation of new knowledge. Built on top of an ontological infrastructure, various collective intelligent systems can be developed and utilized in different domains (T. Gruber, 2008). Such systems typically aim to i) aggregate and collect user contributions by adding meaningful structures to them; and ii) enable reasoning and inference over the collected information,

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leading to answers, feedback, discoveries, or other beneficial results that are not visible within users' *plain* contributions.

2.3.2.   *Social Web*

Currently, one of the most visible trends on the Web is the emergence and growth of the Social Web, or the so called Web 2.0, phenomenon. It should be noted that although the term Web 2.0 resembles a new version of the Web, both Sir Tim Berners-Lee, the inventor of the Web, and Tim O'Reilly, the founder of the term Web 2.0, emphasize that it should not be positioned against the ordinary Web (or Web 1.0 to be compatible with the versioning). Instead, it should be regarded as a consequence of a more fully implemented Web resulting in newer structures and abstractions. Although it is difficult to define the exact boundaries of what structures or abstractions belong to Web 2.0, it seems there is an agreement that services and technologies such as blogs, wikis, multimedia sharing services, RSS-feeds and content syndication, podcasting, bookmarking/content tagging services and social networking sites well demonstrate the foundations of this concept (P. Anderson et al., 2007; Breslin et al., 2011). A common attribute among Social Web applications and websites, with premiers such as Flickr[3], Delicious[4], Facebook[5], YouTube[6], Twitter[7] and Wikipedia[8], is that they are highly social and participatory, promoting collaboration and contributions around an *object-of-interest* (Breslin et al., 2009). Collaborative authoring of content (e.g. in a Wiki page) or opinion expression/exchange in different forms such as blogging, tweeting, rating, annotating, commenting or *like*-ing are just a few of the many ways users can use to share their contributions toward an object of interest in the Social Web sphere. The new pedagogical affordances emerged through Social Web applications and software have

[3] http://www.flickr.com/
[4] http://www.delicious.com/
[5] http://www.facebook.com/
[6] http://www.youtube.com/
[7] http://twitter.com/
[8] http://www.wikipedia.org/

already brought new perspectives into the learning area. The emergence of concepts such as Pedagogy 2.0, PLE 2.0, Social Learning and other social-web based phrases and words (Dabbagh & Reo, 2010; Kieslinger & Gillet, 2008; Mcloughlin & Lee, 2010; Razmerita et al., 2009; Vassileva, 2008) well demonstrate the transition from conventional pedagogical approaches to more participative and social-based forms of learning.

The pedagogical weight that Social Web can bring into the learning arena is, however, more than merely all these social affordances. The (mostly hidden) value of users' contributions lies in their being collected together, re-aggregated and reasoned over to create further new knowledge which is valuable to the users of a particular domain of interest (Breslin et al., 2009; T. Gruber, 2008), be it in an educational setting or in a social networking website for music fans. Despite being very welcomed and widely adopted in different contexts ranging from education to business domains, Social Web tools and technologies commonly suffer from the problem of being isolated from the rest of the Social world (Breslin et al., 2011; Jovanović et al., 2009). True, there might be huge amounts of user contributions within each of the above applications and services, but these data mostly make sense merely within the *walls* of that very application. In other words, the Social Web creates many isolated islands of (valuable) user contributions, but these islands cannot integrate and/or interoperate with each other. The main reason for this lack of interoperation is that most Social Web applications suffer from the problems of ambiguity of meaning, i.e. they do not offer their data, if they open it up at all, in shared structures similar to those of other islands. To realize this interoperability and allow for realization of collective knowledge systems, the Social Web can benefit from the structured knowledge, brought along by standard languages used in the Semantic Web vision. Such standards will make it easier for collective knowledge to be shared across various islands, thus helping any sort of application to interoperate with other islands (Breslin et al., 2009; T. Gruber, 2008; Jovanović et al., 2007).

Table 2.1 The key features of Semantic Web, Social Web and Social Semantic Web, adapted from (Jovanović et al., 2009)

Semantic Web	Social Web	Social Semantic Web

Data Structure	Structured data	Semi-structured/ unstructured data	Structured/semi-structured data
Machine process-ability of data	Standardized and machine -understandable data representations	Provided data not standardized, not understandable by machines	Standardized and machine - understandable data representations
Data provision	Experts needed for creation and provision of data	Normal users can contribute to the system's knowledge base	Benefiting from the wealth of data inherent in Social Web
Emergent Knowledge	Reasoning mechanisms available over structured data	Inference and reasoning requires extra effort for semi-structured/non-structured data	Computation and inferences over the collected knowledge

The *Social Semantic Web* stands for a new paradigm for creating, managing and sharing information through combining the technologies and approaches from the Semantic Web and the Social Web (Breslin et al., 2009; T. Gruber, 2008; Jovanović et al., 2007; Mikroyannidis, 2007). The newly emerged concept of the Social Semantic Web can be seen as a huge graph of collective knowledge systems, in that social interactions within each system lead to the creation of explicit and semantically rich knowledge representations. These systems, thus, are capable of providing useful information based on users' contributions and, they get more productive as more users contribute to the collective knowledge stored in them. On the other hand, Semantic Web applications can benefit from the wealth of knowledge inherent in user contributions within Social Web. The synergy of Social Web and Semantic Web, thus, can lead to something greater than the sum of its parts. Table 2.1 provides a summary of key features of Semantic Web, Social Web and Social Semantic Web, adapted from (Jovanović et al., 2009).

2.3.3.   Related Studies

The affordances of Social Semantic Web paradigm have already found their way into educational and knowledge management domains (Jovanović et al., 2007; Papailiou et al., 2008; Tiropanis et al., 2009). However, they have not yet been explored from the perspective of supporting users' SRL learning processes in workplace environments.

The GroupMe! system (Abel et al, 2009) is a related and interesting research, though not specifically in the domain of workplace learning, that combines Web 2.0 and Semantic Web technologies to provide personalized content management in the context of social networking. From the *social web* perspective, it offers users intuitive user interfaces where they can create and manage groups of multimedia web resources which are of interest to them. From the *Semantic Web* perspective, all of user interactions with the GroupMe! System (e.g. creating groups and adding resources to the groups), and any other operation related to the groups are saved as RDF triples compliant with a set of ontologies that are used by the GroupMe! system. This use of Semantic Web technologies, in particular, eliminates the problems of ambiguity and improves the ranking of the discovered resources.

At a conceptual level, "Charting" is the name of a "meta-level process" introduced by Littlejohn and her colleagues, which aims to enhance self-regulated learning in workplaces (Littlejohn et al., 2009, 2012). This process is the only research that I could locate in the existing literature which explicitly discusses the challenges related to supporting SRL in workplace settings. It is based on the metaphor of *"wisdom of the crowds"* (similar to the underlying objective of the collective intelligence systems). Charting is composed of three main components, including *connect*, *consume* and *contribute*. These components represent generic activities that individuals should perform in order to find, make sense of, use and share resources while relying on the collective. As the authors also highlight, these concepts are not so novel on their own, but it is their integration into this meta-level process that aims to bring the individual and collective aspects of SRL closer together, considering the characteristics of modern work environments. Still, there exist a few research studies that explicitly use Semantic Web technologies to support some aspect of workplace learning.

The EU FP6 project APOSDLE aims at enhancing users' productivity in informal self-directed workplace learning by making individuals aware of available knowledge sources for a task at hand in the context of their everyday work processes. The system's functionality is primarily based on its knowledge base which stores an integrated representation of various kinds of knowledge (e.g. domain, task, and instructional knowledge). Knowledge integration and advanced search and retrieval capabilities

(associative information retrieval) are partly supported by the Semantic Web technologies.

MATURE[9] is another EU-funded IP FP7 project, which examines how informal knowledge matures in organizations, networks and communities of practice through collaborative activities among individuals. To provide the required support for this maturing process, the MATURE project aims to rely on the Social Semantic Web technologies, tools and services such as semantic wikis, semantic tagging and common vocabulary (i.e. ontology) building tools. For instance, SOBOLE (Social Bookmarking and Lightweight Engineering of Ontologies) is an AJAX-based (i.e. one of the commonly used technologies in Web 2.0) semantic social bookmarking application developed within this project, which aims to integrate a competence management approach with users daily work activities (Braun et al., 2010).

The above studies show how the affordances of Semantic Web technologies and Social Web tools can be utilized to design systems that facilitate SRL processes in workplace environments.

[9] http://mature-ip.eu/

3.   Theoretical Framework

As discussed in the previous chapter, theories about and perspectives of workplace learning have come a long way in the last thirty years. One of the major distinctions between these perspectives is the metaphor upon which *learning* is conceptualized and accordingly described. These metaphors represent collections of typical and important features for understanding learning (Paavola et al., 2004). The most influential metaphors in this regard include learning as *acquisition* of knowledge and skills which is closely in line with perspectives viewing learning as a *product*, learning as *participation* in communities of practice which fits with the *process* views on learning, and most recently the *knowledge creation* metaphor which views learning as creation of new knowledge via social processes (Hager, 2005; Paavola et al., 2004; Sfard, 1998; Tynjälä, 2008). The first two metaphors shape the main and most basic understandings of learning. The *acquisition* perspective has been most typically applied in formal educational settings; whilst the *participation* metaphor has been frequently used to reflect the nature of learning in the workplace, where knowledge and practices are passed from one generation to another and there are no significant changes or structural/cultural transformations (Fuller & Unwin, 2004; Hager, 2005; Lee et al., 2004; Paavola et al., 2004; Tynjälä, 2008).

To respond to the rapid changes in today's knowledge-driven society and keep pace with the increasing subsequent societal transformations, contemporary learners need to build a diverse range of competences, including the ability to adapt to work in newly structured dynamic environments, as well as detecting, approaching and resolving novel and complex problems for which, often, no previous knowledge exists (Littlejohn et al., 2012). These requirements give rise to Self-regulated learning (SRL) as an essential competence for individuals in contemporary workplaces (Carneiro et al., 2007; Littlejohn et al., 2012). In addition, these new conditions have led the human work in contemporary society to be increasingly shaped by (collective) creation of knowledge artifacts (Littlejohn et al., 2012; Paavola et al., 2004). These issues make the previous two

conceptualizations of learning fall short of capturing, in a profound way, the innovative and progressive aspects of recent knowledge advancements (Paavola et al., 2004; Tynjälä, 2008). The *knowledge creation* metaphor has been proposed to account for this recent shift toward a social and collective knowledge creation paradigm, where learning is treated as an innovative rather than reproductive or acquisitive activity (Tynjälä, 2008). According to this metaphor, learning is perceived as an aggregation of individual and social processes, in that learning does not take place independently from a social and contextual environment, yet it is the individual who is the focal point of knowledge creation (H. Gruber & Harteis, 2011). I underpin the conceptualization of *learning* in my research on this metaphor, as it very well embodies the nature of workplace learning in contemporary knowledge-driven society.

In the following section, first I describe the SRL model underpinning my theoretical framework. Then, I discuss the SW-enabled interventions that I propose within this framework in order to support users' self-regulatory processes in the workplace, as well as their everyday work practices (following a design-based research approach; see section 4.1 for more details), and describe the respective hypotheses within each of my proposed interventions.

3.1. The underpinning SRL model

The models offered by (Zimmerman, 2001), (Winne & Hadwin, 1998), and (Pintrich, 2000)'s general framework for SRL are the theoretical foundations mostly used in the current research on supporting SRL in TEL (Technology-Enhanced Learning) environments (Winters et al., 2008). Despite the terminology used, all of these theories characterize SRL as a number of phases proceeding from a forethought or preparatory phase, through a task performance or enactment phase, to a self-reflective and evaluation phase (Dettori & Persico, 2008; Puustinen & Pulkkinen, 2001; Winters et al., 2008). In my research, I explore the effect of Semantic Web-enabled interventions on users' self-regulatory processes in the workplace, explicitly looking from the *event* perspective (as opposed to the *aptitude* or *component* perspective discussed in Chapter 2). Accordingly, I base the underlying SRL model used in the theoretical framework of my research on the above three phases. These phases encompass the need of

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contemporary knowledge workers to identify and plan their learning goals, apply strategies toward performing these goals, and reflect on their learning practices which would influence their subsequent preparatory processes. These SRL phases are defined in the following sections:

3.1.1. Planning

This phase contains processes that precede acting and in particular includes activities related to analysing a task at hand, setting related goals and planning strategies for achieving those goals. Entwined with task analysis, goal setting is often the premier step of a self-regulatory learning process. Learners vary significantly in the types and effectiveness of the goals they set for themselves (Valle et al., 2009; Zimmerman, 2008). Nevertheless, it should be borne in mind that there are differences in the nature and goals of learning processes between workplace context and formal education. While in education learning is a goal in itself, in workplace settings it is mostly a by-product of work and task performance (Illeris, 2011; Ley et al., 2010; Margaryan et al., 2009). Moreover, strategic planning is also closely associated with goal setting, whereby learners identify the appropriate strategies to perform in order to achieve their desired learning goals. In short, during this phase learners analyse a specific situation and/or identify the need to enhance their competences, set their learning goals, select strategies to reach them, judge the perceived capability to reach the goals and take the expected outcomes into their consideration.

3.1.2. Engagement

The Engagement phase refers to processes occurring during task effort. This phase is considered to facilitate that which is referred to as an enacting *feedback loop* (Zimmerman & Schunk, 1989), in that learners engage in their learning strategies, observe their performance, compare it with a standard benchmark (e.g. within the organization) or a goal, and apply appropriate strategy changes in order to respond to the perceived differences (Dabbagh & Kitsantas, 2004). This phase, thus, describes learners' efforts to not only enact their plans and strategies, but to monitor, and keep track of their on-going progress and performance toward a learning goal, and apply changes in their planned strategies, if need be.

3.1.3. *Evaluation and Reflection*

This phase refers to processes occurring post-effort and after a task ends or a goal is achieved. During this phase, learners compare their self-observed performance against some standard, such as one's prior performance, another person's performance, or an absolute standard of performance (e.g. some criteria established within their organization's culture). In addition, learners review and reflect on their learning experience. One key aspect of this phase is the generation of new meta-level knowledge about the whole learning process, strategies, or self, which in turn affects subsequent SRL processes (Winters et al., 2008).

As discussed in the Introduction, two major challenges need to be taken into account in order to gain a better understanding of, and provide support for, users' SRL processes in workplace. The first challenge arises from the fact that despite the social nature of workplace learning, specifically looking from the knowledge creation perspective, the majority of the existing interpretations of SRL offer an individualistic perspective (Jackson et al., 2000) in that the social context plays a less significant role than individual-based factors. However, findings on patterns of defining goals in the workplace have shown that individuals draw from and contribute to the communal knowledge in their organization (Margaryan et al., 2009), while setting and managing their learning goals. Such findings clearly demonstrate that learning goals are not preset and immutable. Instead, they evolve through individuals' interactions with others, and their participation in knowledge creation activities. The social context plays an even more significant role when it comes to defining and evaluating learning goals, adapting one's strategies to social and organizational norms, and receiving incentives or experiencing inhibitors from the communities to which a worker belongs (Zimmerman, 1990).

In addition, the current research has shown that SRL is highly context dependent and the specific features of a learning environment can influence whether learners engage in SRL processes and the extent of their engagement (Boekaerts & Cascallar, 2006; Whipp & Chiarelli, 2004; Winne, 2010). Moreover, the contextual nature of workplace learning implies that the organizational context puts an imperative impact on how workplace learning is conducted and the desired goals are achieved. These issues

lead to the second challenge stressing that individuals need to be aware of the stance of their organization, such as the learning expectations, norms, policies, rewards and incentives, when self-regulating their learning processes at their workplace.

Looking from the perspective of advances in information technologies, technological enhancements at work environments can deliver great benefits for how each of the above challenges, as well as the interdependencies among them, are addressed. Social Semantic Web technologies, in particular, have brought along a set of new pedagogical affordances that allow for building promising collective-based knowledge systems in various domains (Tochtermann & Granitzer, 2008). However, one should not assume that only because these technologies provide the affordances, it is all that is needed for effective learning (Dabbagh & Reo, 2010; Dasgupta et al., 2009; McLoughlin & Lee, 2007). Deployment of SW-enabled tools for workplace learning must be firstly built upon an appropriate learning metaphor and informed by theories that support learners' self-regulation and knowledge creation activities. Secondly, any attempt aiming to support workplace learning should provide a solution to the challenges inherent in this particular domain, as discussed above.

To address the above challenges, I propose a set of SW-enabled interventions in order to support users' self-regulatory learning processes during their work practices, and enhance the design and implementation of the various functionalities of these interventions with i) social embeddedness elements to support the social nature of workplace learning and ii) support for the harmonization of individual learning goals with those of the organization to nurture the contextual dimension of learning in the workplace. Considering the underpinning SRL model, these enhancements imply that when planning their learning goals, knowledge workers should harmonize their goals with organizational goals and expectations (i.e. the organizational context), and be aware of how their individual learning contributions benefit the whole organization's performance at the same time. The social embeddedness, on the other hand, allows knowledge workers to be aware of the learning processes of other learners (i.e. their colleagues) and rely on their successful learning activities as guidance for their own learning process. Being aware that other users know about and make use of their learning success increases a learner's motivation to further take part in knowledge creation activities. Awareness of the utility of the shared knowledge is one of the major

factors affecting one's motivation in imparting knowledge within an organization (Siadaty et al., 2010). Finally, learners need to monitor their own progress and apply adjustments with respect to their planned learning goals, the updates from the collective, and dynamics of their organization. There is extensive evidence in the literature that encouraging learners to systematically monitor their own performance positively affects their skill acquisition, motivation, and self-efficacy (Boekaerts & Cascallar, 2006; Zimmerman & Schunk, 1989). In the following, I describe my proposed SW-enabled interventions and formulate the respective hypotheses for each intervention. Figure 3.1 depicts these interventions and the SRL model included in my theoretical framework, as well as the research hypotheses related to each intervention.
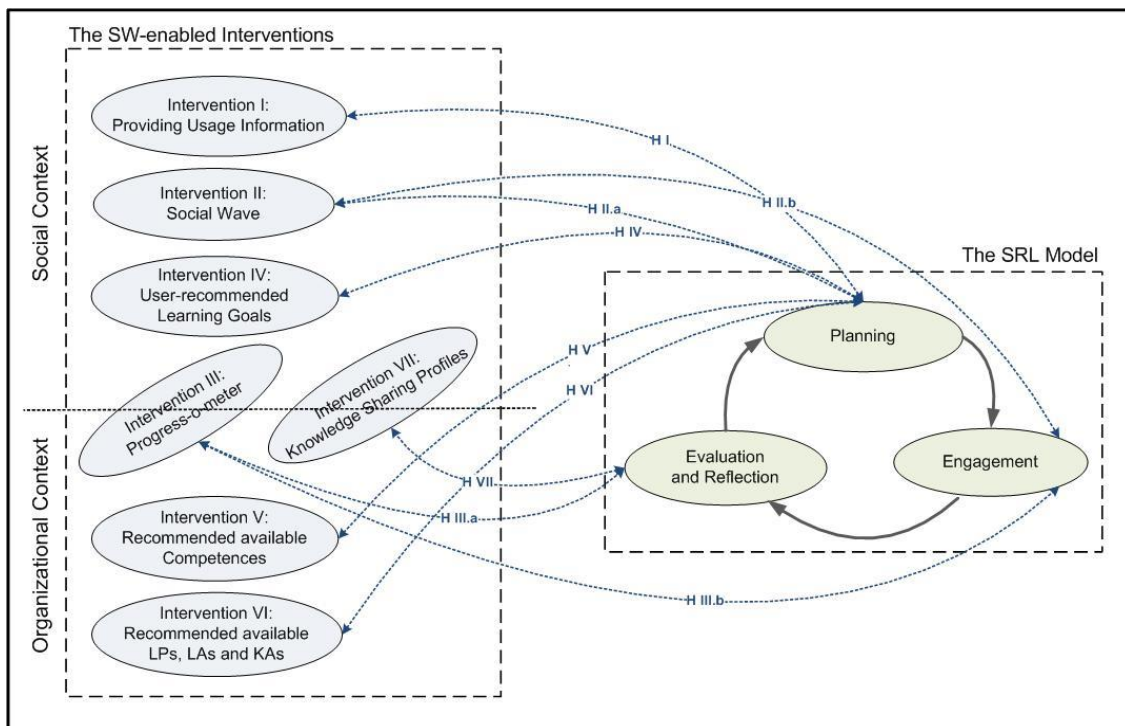
Figure 3.1. The Theoretical Framework of my research, including the underpinning SRL model, the proposed SW-enabled Interventions and the research hypotheses related to each of these interventions.

3.2. Semantic Web-enabled Interventions

There are a set of specific terms and concepts that are used in the description of my interventions, as well as within their implementation in the Learn-B environment (see

Appendix D). Thus, before describing my proposed interventions as part of my theoretical framework, their main functionalities and the formulation of the respective hypotheses, first I introduce these terms and concepts, followed by an overview of their definition in the existing literature, as well as the definition being used in this research.

Within the scope of this research, users learning goals are defined in terms of *Competences.* Utilizing the concept of *competence* in different domains related to performance management, workplace learning and human resource management has gained a lot of attention over the last couple of years. However, almost all of the existing research in this area stresses the extensive diversity of available definitions and the fact that hitherto there is no commonly agreed-upon definition of this concept. As emphasized by (Sampson & Fytros, 2008) and (van der Klink et al., 2006), some authors distinguish between the terms *Competence* and *Competency* while some use them interchangeably. According to (van der Klink et al., 2006), the term *Competency* is mostly used within the United States and refers to "behavior and personal traits that contribute to excellent performance," while the term *Competence* conforms to the UK occupational standard (Sampson & Fytros, 2008) and refers to "collectively agreed occupational standards such as national vocational qualifications." However, there exists also a third German term, *Kompetenz*, that is considered to be "more holistic than Competence or Competency, comprising not only content or subject knowledge and ability, but also core and generic abilities" (van der Klink et al., 2006, p.224). IMS RDCEO (IMS RDCEO, 2002), IEEE RCD (IEEE 1484.20.1.D8, 2007) and HR-XML Competencies (HR-XML Competencies, 2004) are the prominent efforts toward providing a standard and reusable definition of this concept. The IMS consortium RDCEO specification (Reusable Definition of Competency or Educational Objective) includes elements such as identifier, title, description (optional unstructured text of definition description), definition (optional structured text for more complete description) and metadata. The IEEE RCD (Reusable Competency Definition) is based on the existing IMS RDCEO, in that the word competency is used in a very general sense including skills, knowledge, tasks, and learning outcomes, considering this concept to be used in a learning management system (LMS) or a Competency Profile. In addition to the elements supported by these specifications, the HR-XML Competencies standard adds elements for measurable evidence and weights to the definition of Competency. A

mapping between elements of HR-XML and IMS RDCEO can be found in (Sampson & Fytros, 2008). Despite the noticeable diversity of definitions around the concept of competence, almost all of these definitions include both the soft (e.g. personal behaviours, traits and motives) and hard (e.g. technical knowledge, skills and abilities) dimensions. Evidence (proficiency) and context, however, are rarely considered in the definition of competencies. In my research, the term *competence* is considered to represent an individual's skills related to a certain domain topic; for instance being able to develop ontologies using the Protégé software. Competences are also used as the means to represent organizational objectives and learning needs.

Associated with each competence comes one or more *Learning Path(*s). A learning path is typically defined as a learning-related workflow that contains start and finish points, both defined in terms of competences at specific levels of proficiency, and a set of learning activities that lead from the start point to the finish point (Janssen et al., 2008). In the scope of my research, each learning path is comprised of one or more *Learning Activities*, and leads to the attainment of a specific competence at a specific level. Each *Learning Activity* is accompanied by a set of metadata specifying its content, process, and planning information (e.g. title, description, average time required for it and its delivery mode) and a set of *Knowledge Asset*s. Knowledge assets can be in the form of learning contents such as documents, books, weblogs, videos or presentations; or human resources such as a knowledgeable colleague who has already successfully completed this Learning Activity. Finally, a (*learning*) *resource* is the umbrella term used to refer to a Competence, Learning Path, Learning Activity or a Knowledge Asset.

3.2.1. Intervention I: Providing Usage Information

This intervention provides users with usage information about available resources. Derived from the collective knowledge within the organization, it allows users to be aware of how the collective is using and approaching various learning resources within the organization, also supporting the functionality of Interventions V and VI (described in the following). In other words, this intervention informs users of the social context of their organization around a particular learning resource.

For instance, each *available competence* (offered via Intervention V) is accompanied by analytical information such as the number of users (or their roles in the organization), who have acquired it, as well as users' feedback about this competence; recommended *learning paths* (provided by Intervention VI) are further augmented with analytical information such as the number of users (or organizational roles) who have successfully finished a certain path or a revision of it, and users' average completion times for that path. Feedback of the colleagues who have already accomplished a certain *learning activity*, plus analytical information such as their average completion time in finishing the activity are instances of the usage information that accompany learning activities. I categorize the different functionalities of this intervention into three major features: Analytics, Social Streams and Collective Stand:

- Analytics: this feature provides users with statistical information such as achievement information of the users who have worked with or used a specific learning resource holding the same or related duties/roles as the user, their average completion time for learning activities, and summaries on how many times each of the competences required for a specific duty have been added to learning goals by other members of the organization. In the implementation of this feature within the Learn-B environment, the details of the provided statistics vary per resource (for examples, see Appendix D).

- Social Streams: this feature illustrates what activities were performed on, or what events happened around a learning resource over a certain period of time. In other words, Social Streams show the *popularity* of a certain resource, and indicate whether this learning resource has been "lively" used by other members or not.

- Social Stand reflects what the collective thinks about a certain learning resource. In its implementation, it comes in diverse forms such as annotations, reflections (e.g. comments and notes), ratings and tags of other users.

My hypothesis regarding this intervention is that providing users with information on how other members of the organization have defined their learning goals, what they think of available resources in terms of achieving the desired organizational competences, how vastly they have used available resources such as learning paths and knowledge assets, and their achievement information on related competences (if shared within the organization) helps users to better know the social context of their

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organization with regard to their learning goals, and thus supports users to perform the planning phase of their SRL processes. Accordingly, the respective hypothesis is (see Figure 3.1):

Hypothesis I: *Usage Information accompanying each learning resource (i.e. Analytics, Social Streams and Collective Stand) aids users with their planning phase of their SRL processes.*

3.2.2. Intervention II: Social Wave

The Social Wave intervention brings to users *waves* of latest updates (and hence the name of this intervention) on their learning goals, and the learning resources associated with each specific goal, plus updates from the learning activities of their colleagues whom they follow. The functionality of this intervention is similar to having an RSS feed (Winer, 2005), i.e. a news feed, for each specific learning goal (or a learning resource) or colleague who the user is interested in following and receiving updates about.

Updates on learning goals allow users to track a learning goal of theirs, and each of its components (i.e. the competences the goal is comprised of, the learning paths the user has associated with each competence, and the learning activities and knowledge assets included in each learning path) in the social context of their workplace, to see how the collective makes use of that resource. Updates on colleagues enable users to track the learning activities of other members of the organization and be aware of how other employees are approaching and attaining their learning goals and the respective competences. Accordingly, this intervention enables users to stay abreast of the social context in their organization. Such awareness can significantly affect the way users plan their learning goals, or engage in learning strategies to achieve them, resulting in slight revisions or major updates to the goal, its components, or users' personal strategies. Thus, my hypothesis regarding this intervention is:

Hypothesis II: *Social Waves originating from users' learning resources or their followed colleagues support users in their planning and engagement SRL processes.*

3.2.3.　Intervention III: Progress-o-meters

The objective of this intervention is to help users monitor their own learning progress within the context of their workplace. It shows users their progress in achieving their defined learning goals, in terms of the completeness of the competence included within their goals and the completeness of learning activities performed toward achieving each of those competences. Moreover, it provides users with a comparison of their progress with their colleagues' who are working toward completing the same learning goal (e.g., a goal shared by the members of a project). My hypothesis regarding this intervention is that being aware of one's progress in achieving his/her learning goals, observing oneself within the social context of the organization and comparing personal learning progress with that of their colleagues provide users with the opportunity to gauge their learning strategies, apply the necessary changes if need be, and reflect on their learning process. I formulate my respective research hypothesis as the following:

Hypothesis III: *Showing users their progress in achieving their defined learning goals as well as a comparison of their progress with that of their colleagues assist users with the engagement and, evaluation and reflection phases of their SRL processes.*

3.2.4.　Intervention IV: User-recommended Learning Goals

This intervention enables users to recommend learning goals, along with the competences and the learning paths the goal is comprised of, to their colleagues. Accordingly, when users come across a learning goal, and consider that it could be useful to some other members of the organization, e.g. the person is working on the same task or has similar learning needs, they can recommend this goal to them. The recommended learning goal might belong to the recommender or to another colleague. The recipient can then accept this recommendation, treat the learning goal similar to their other individually defined learning goals and update or modify it accordingly - with the difference that any changes applied to it would be visible to all the involved parties (including the recommender if they recommend their own learning goals), or they can simply ignore it if they believe it does not match their learning needs.

My hypothesis regarding this intervention is that allowing users to receive recommended learning goals from their colleagues helps them with initiating their SRL

cycles, in particular to perform task analysis and goal setting processes, where they can gain some insight into how to define learning goals that target their learning needs, how such goals could be formulated and how other members of the organization have approached these goals. Thus, I hypothesize that:

Hypothesis IV: *Receiving user-recommended learning goals boosts users' planning processes.*

3.2.5.   *Intervention V: Recommended available Competences*

This intervention aims to inform users of the learning objectives and requirements of their organization, represented through a set of pre-defined and established competences. Looking from the organizational context, this intervention recommends users those competences, from the available competences in the workplace environment, which are of higher importance and relevance to each specific user based on their current level of skills as well as their position and responsibilities within the organization. For instance, the recommended competence could be related to the requirements of the organizational position a user holds, or demanded by the task the user is responsible for, considering the user's current knowledge in that domain and the related lacking competences. I categorize the functionality of this intervention into two core features: the feature informing users of their organizational context, and the feature providing users with personalized cues:

- Organizational Context: this feature allows users to explore the recommended competences, from a higher level perspective of the objectives and learning needs of their workplace, such as the competences required for and demanded by each task, duty or position available within the organization.

- Personalized Cues: this feature provides users with a rather personalized perspective on how a particular competence suits their learning needs, and why it is important for them to acquire that competence. For instance, it provides users with the priority, required level and the prerequisites for a competence. Such a competence, provided by the organizational context feature, might be required for a specific duty for which the user is responsible.

My hypothesis regarding this intervention is that it helps users to better know the learning objectives of their organization, and thus their individual learning context, to make decisions accordingly. In particular, I hypothesize that informing learners of the organizational competences that are of higher importance and relevance to users, based on their organizational positions and level of expertise, helps them to identify their learning needs, and therefore, supports them in their planning phase:

Hypothesis V: *Explicitly showing required competences by an organization to its users supports them in conducting the planning phase of their SRL processes.*

3.2.6. *Intervention VI: Recommended available Learning Paths, Learning Activities and Knowledge Assets*

This intervention provides users with recommended learning paths for the available competences. These recommended paths originate from two sources: either from the organization itself, where the recommended learning paths are built from predefined *learning templates* defined by an expert in the organization, or from the collective, in that they are the learning paths that other members of the organization used to achieve a specific competence. The learning paths from a collective source might be in three forms: i) exactly the same as the original path defined and provided by the organization, and then adopted by a user; ii) a modified version of the path originally defined and provided by the organization; or iii) a learning path created by a user from scratch.

My hypothesis regarding this intervention is that being aware of the different options (i.e. learning paths) available for a competence before committing to one for achieving the competence, allows users to ensure the availability of resources and knowledge assets, and likely, the support from the users who have already chosen that option. Moreover, it gives users the chance to explore how the collective has defined their learning paths, for the same or similar competence and what resources they have used in that regard. Users can also see how they relate with the owner of a learning path, for instance they can see that they both have the same organizational position or work in the same project. My respective hypothesis is described as:

Hypothesis VI: *Providing users with recommendations on what existing learning paths they can choose from for a potential competence assists them in the planning phase of their SRL processes.*

3.2.7. *Intervention VII: Knowledge Sharing Profiles*

Through this intervention, users can monitor the extent to which they share their learning experiences within their workplace in terms of owned learning resources (such as defined learning goals, acquired competences, finished learning paths and performed learning activities), and also compare their sharing activities with those of other users within the same group, project, or the entire organization. My hypothesis is that the Knowledge Sharing Profiles intervention informs users of the social context of the organization in terms of their sharing activities and contributing to the collective, and thus supports the reflection phase of their SRL processes:

Hypothesis VII: *Providing users with their Knowledge Sharing Profiles helps them to align their reflections and sharing of their learning resources.*

In the following chapter, first I discuss the research methodology that I pursued, i.e. the design-based research approach, to evaluate the above propositions, including a detailed explanation of the approach I followed to measure the SRL processes aimed at within the theoretical framework of my research. Subsequently, I present the details of the research methods applied within the two evaluation experiments performed to investigate my research hypotheses, under the light of the respective design-based research approach.

4.   Method

As alluded to in the previous chapter, to date very little research has been conducted to study and provide support for self-regulatory learning in workplace settings. To gain an understanding of how knowledge workers can be supported in performing SRL processes in their workplace settings, I proposed a set of semantic web-enabled interventions, underpinned by my theoretical framework (see the Theoretical Framework chapter for more details). Built upon this framework, I enhanced the design and implementation of my proposed interventions with social embeddedness elements and support for harmonization of individuals' learning goals with those of their organization. These interventions were then developed within the Learn-B environment as part of the IntelLEO project[10] (see Appendix D). However, I did not intend to solely design and evaluate a set of particular innovative interventions within my research. Contrary to what is currently pursued by many researchers in the field (Amiel & Reeves, 2008), the purpose of my research is to *improve*, not to *prove* (Herrington et al., 2007).

To explore the effect of the provided functionalities, I believe they should undergo a continuous cycle of design-reflection-design in close collaboration with practitioners, in the context for which they were designed. Accordingly, I followed a Design-based Research (DBR) approach. Through this research approach, the proposed interventions are viewed holistically, i.e., they are evaluated by real knowledge workers through actual interactions in everyday work practices (The Design-Based Research Collective, 2003). Only in such a way the integrity and effectiveness of the proposed interventions can be fully aligned with the nature of workplace learning.

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[10] http://intelleo.eu/

I begin this chapter with describing the design-based research as my research approach, its appropriateness and a discussion on the trace methodology that I designed and used to measure users' SRL processes. Next, I describe the details of the evaluation experiments that were conducted, following the design-based research approach, including the research questions and respective research hypotheses addressed within each experiment, as well as the main components of, and the processes used in the preparation and execution of each experiment.

4.1. Research Design

Evolving since the early 90s, Design-based Research (DBR) has been increasingly used for designing learning interventions in real-world settings. Different authors in the field have used various terms to describe design-based research, such as Design Experiments, Design Research, Design Studies, Developmental Research, Formative Research and Formative Evaluation (van den Akker et al., 2006). Nevertheless, DBR, as the umbrella term used for the above research approaches, has recently received considerable attention by researchers in learning sciences as a flexible methodology which aims to improve educational practices. DBR, in general, is recognized as an approach that is based on theory, requires collaboration among researchers and practitioners in real-world settings, and results in the production of contextual principles and theories (Amiel & Reeves, 2008; Barab & Squire, 2004; Wang & Hannafin, 2005). One of the major challenges in current research on learning environments is that the proposed solutions and interventions are often separated from the problems and issues of everyday practice. The promise of the design-based research approach is that learning interventions are viewed holistically, via interactions with end-users in real practices (The Design-Based Research Collective, 2003). Such an *in-action* perspective helps to better understand the effect of the designed interventions and solutions. In addition, it can lead to contextualized design principles and theories (Amiel & Reeves, 2008; Barab & Squire, 2004).

There exist a set of major characteristics commonly attributed to design-based research (The Design-Based Research Collective, 2003; Wang & Hannafin, 2005; van den Akker et al., 2006), emphasizing that DBR is i) not only grounded in related research

and theoretical propositions, but contributes to advancing the theoretical knowledge of the field, where besides examining *whether* a theory works, the researcher applying this methodology further investigates *how well* it works; ii) iterative and based upon a cyclic approach of design, evaluation and revision, via interactions between the researchers and the practitioners throughout the whole process (see Figure 4.1); iii) contextual, in that it aims to design an intervention in its authentic context where the research results are linked with both the design process, through which results are generated, and the settings, within which the results are generated.

The above characteristics clearly show that design-based research not only incorporates some conventional evaluation approaches, but actually expands them (Barab & Squire, 2004; The Design-Based Research Collective, 2003). Similar to evaluation research, DBR draws on many of the approaches used in quantitative and qualitative research methods, such as surveys, expert reviews or comparative analyses, to examine the results of an intervention and revise it accordingly. However, unlike evaluation research, it goes beyond merely evaluating a particular (learning) intervention or product. From a design-based research perspective, a successful innovation is viewed as a mutual product of the designed intervention and the (real-world) context in which it is used, with an emphasis on the applied iterative research process. The aim here is to systematically produce design principles and models (and not just particular interventions) of the successful innovation, that can contribute to a broader field of knowledge and research.

Figure 4.1 illustrates the four stages of a typical DBR approach (T. Anderson, 2005; Reeves, 2006). In the first stage, the existing literature is reviewed, theoretical foundations are explored, and communication between the researchers and practitioners are conducted in order to analyze the practical problems, discuss the research goals in collaboration and design the intervention(s) and solutions. During the second stage, the researchers rely on consultation and collaboration with practitioners, and use the relevant literature, existing theories and design principles to develop and propose (learning) intervention(s) and solutions to address the analyzed problems. The proposed intervention(s) goes through iterative cycles of evaluation and refinement in the third stage of a design-based research approach, where usually a variety of qualitative and quantitative measures are used to assess the effects of the proposed intervention(s) in

their real context of use. The fourth stage begins from within the third stage, where researchers thoroughly collect and analyze evaluation data in order to redefine the practical problems, and refine and revise the proposed solutions based on the new observations. As evaluation data is collected, examined and reflected upon, the proposed intervention(s) will be enhanced and design principles will be developed and refined, resulting in a continuous cycle of design-reflection-design.
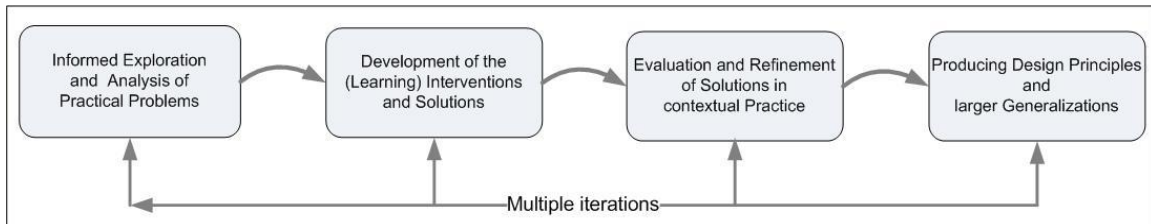
Figure 4.1. The four typical stages of design-based research (DBR) approach

A design-based research methodology is pursued in this research. Considering the contextual and social nature of workplace learning, one of the major advantages that DBR brings to my research is that by extending current methodologies, it allows me to go beyond just designing and testing particular interventions (e.g. in immutable laboratory settings), and integrate design, research *and* practice concurrently. This enables me to design, refine and evaluate my proposed interventions based on the real learning needs of practitioners in their every-day work practices.

In addition to the reviewed literature, which initially gave rise to the research questions that I investigated in this dissertation, the practical problems observed in real practices also played a significant role in the formulation of the research questions and the initial design of my proposed interventions. Through my participation in the IntelLEO project during my research, I was in close collaboration with practitioners of real-world organizations. Accordingly, the practical problems observed from these real practices were highly considered in the design and refinement of my proposed interventions (for more details see section 4.3 and (IntelLEO Consortium, 2010b)).

As can be seen in Figure 4.1, the iterative nature of a DBR approach implies that a single implementation of the proposed interventions is rarely adequate to gather enough data and evidence on its effect and (theorized) success in real practices (Amiel & Reeves, 2008). After the initial implementation and evaluation of the proposed interventions, a design-based research study usually contains two or more cycles of evaluation and refinement in its third stage, through which required additions and revisions are applied to improve and further the affordances of the proposed interventions (Herringto et al., 2007). To investigate how my proposed interventions support users in performing self-regulatory learning processes in workplace environments, I evaluated and refined them within three iterations, including a preliminary exploration using paper prototypes of my interventions, plus two evaluation experiments. The first experiment was conducted using the early prototypes of the interventions, while the full prototypes were used in the second experiment. The full prototypes were developed based on the additions and revisions resulted from the previous (early prototype) evaluation. These two experiments were conducted following a non-experimental research design. Non-experimental research involves observing and measuring pre-existing scenarios and variables of interest as they happen (or exist) in their authentic context, as opposed to being manipulated by the researcher - such as in experimental research where, typically, the researcher manipulates one or more variables, and controls and measures changes in other variables (Johnson & Christensen, 2007; McMillan & Schumacher, 2001).

In the following sections, first I describe the trace methodology that I used to measure users' SRL processes, and then provide the details about the two evaluation experiments (section 4.3).

4.2. Trace Methodology for SRL Measurement

As discussed in the Literature Review, different approaches have been used in and suggested by the contemporary research to measure features and elements of self-regulated learning. The applied measurement method reflects how SRL is modeled in a research. Thus, to reach valid measurement results and generalizable inferences, the selection, development and deployment of a measurement method (or a combination of

methods) should undoubtedly be aligned with the underpinning SRL model or theory (Greene & Azevedo, 2010; Klug et al., 2011; Winne, 2010b; Winne & Perry, 2000).

In my research, I consider self-regulated learning in the workplace as a dynamic and contextual process, i.e. a series of *event*s, which unfolds during users' learning episodes (for a detailed discussion on the theoretical framework underpinning my research see Chapter 3). Measuring SRL as a sequence of events in the real context where it happens, although challenging (Winne, 2010b), brings the advantage of grounding the measurement on precise and authentic data which represent users' deployed (learning) tactics and strategies in response to that very context (Azevedo et al., 2010; Greene & Azevedo, 2010; Winne, 2010; Winne & Perry, 2000; Zhou et al., 2010). This is a boon to understanding SRL in the workplace, considering the informal and contextual nature of learning in such environments.

Affordances of technology-enhanced learning environments provide the opportunity for measuring SRL processes as events (Greene & Azevedo, 2010; Winne, 2010b; Zhou et al., 2010). They allow for automatically writing event records to log files and thus, empowering researchers to trace learners' choices, interactions with learning content, learning actions and applied tactics on the fly, as they happen within the learning environment and in their authentic context. This method is often referred to as *Trace Methodology* in the contemporary research on measuring SRL features (Nesbit et al., 2007; Winne & Perry, 2000; Zhou et al., 2010). Winne (Winne, 2010b; Winne & Perry, 2000) defines traces as "records of behaviour, a form of performance assessment, that provide grounds for inferring a learner's cognitive and metacognitive activities." In other words, while the cognitive and metacognitive states of learners might not be visible to researchers, traces are the "observable indicators about cognition that students create as they engage with a task" (Winne & Perry, 2000, p.551). Moreover, unlike inventories and *think-aloud* methods (see Chapter 2), which are commonly applied in research on SRL, trace methodologies enable researchers to unobtrusively track users' learning experiences through actual, in-action evidences of their cognitive and metacognitive states, and not based on users' perceptions of their use of these processes, sampled from memory (e.g. in self-reports), or a portion of user's interpretation of these states which they decide to share with the researcher (e.g. in think-aloud or unstructured interviews).

To investigate my research hypotheses, I employed a trace-based methodology using the affordances of the Learn-B environment. In the following I describe in detail the steps of my measurement protocol following this methodology.

4.2.1.   Capturing Users' Traces in the Learn-B environment as raw Learning Logs

Perhaps the most straightforward way to trace users' learning processes in the Learn-B environment is to write all their actions in a log file, as they interact with and operate on different modules and components in this environment. However, one of the main challenges in analysing log data for measurement purposes, especially in learning environments, is the complexity and excessiveness of the details captured in raw logs. Log files can contain an abundance of low level events, such as mouse clicks on different components, which do not necessarily correspond to the learning variables and constructs of interest to a researcher (Zhou et al., 2010). In addition, capturing and storing every action performed by every user in the form of low-level event records requires substantial amounts of memory and processing power. This can raise additional technical issues with regard to the design and implementation of the log tracking component, which could also jeopardize the main purpose of a learning system.

To address the above challenges, thus, I aimed to trace and log only those events which were of interest and use to my research questions and the retrospective hypotheses (discussed in section 3.2). I categorize these events into two sets: Intervention events and SRL events. *Intervention events* represent the activation or usage of any of the proposed interventions; while *SRL events* indicate that the user has enacted an SRL process.

To identify these events and have the log tracking module capture and record them into log files accordingly, I thoroughly examined the Learn-B environment to document all the different ways that users could trigger any of the proposed interventions or enact an SRL process within this environment. For instance usage of Intervention I: Providing Usage Information could be represented by users clicking on the Achievement Visualization tabs of an available (i.e. recommended by the organization) Competence or Learning Path, or on the Social Wave tabs of an available Competence, Learning Path or an Activity (see Appendix D).

To identify the SRL events, I defined a set of specific self-regulatory activities commonly recognized by the existing literature as the processes that users could enact within each of the three phases of the SRL model in my theoretical framework (Dettori & Persico, 2008; Greene & Azevedo, 2009; Puustinen & Pulkkinen, 2001). I call the three phases "macro-level", and the specific activities within each phase "micro-level" SRL processes, as coined by (Greene & Azevedo, 2009). To locate and determine how users' actions within the Learn-B environment could represent their enactment of the various micro-level SRL processes, I again carefully explored all the functionalities available, and attempted to be as inclusive as possible during this process (Hadwin et al., 2007). For instance, I considered the event "Adding a new competence to an existing learning goal" as a traceable action for both *Applying appropriate Strategy Changes* and *Goal Setting* micro-level SRL processes, categorized respectively under *Engagement* and *Planning* macro-level phases. The macro and micro level SRL processes, their description, and one example event for each micro-level SRL process are provided in Table 4.1. Appendix A shows the full list of SRL and Intervention events in the Learn-B environment, according to each micro-level SRL process or intervention feature. It should be noted that although such an operational categorization of the (macro-level) SRL phases into more specific (micro-level) activities allows for a much more thorough investigation of the many ways users can perform SRL processes in the Learn-B environment, it is neither limited to nor affected by the specifics of Learn-B. Such a macro-level analysis of SRL processes could be equally applied to different contexts and learning systems built upon the same or similar underpinning theoretical framework.

I aimed to limit tracking of users' actions to only these two sets of events (i.e. *SRL* and *Intervention* events, Appendix A). Still, there exists a rich set of functionalities provided by Learn-B, equally available for the various learning resources within this environment. For instance, users could click on the Social Wave tab, Comments tab, Data tab, or Achievement tab of an available competence, a learning path, or a learning activity (see Figure 7.1). This made it almost impossible in terms of maintenance and extensibility to design and implement each of these user actions as a stand-alone and track-able event.

Table 4.1. Macro- and Micro-level SRL processes and examples of indicator SRL
events from the Learn-B environment

Macro-Level SRL Process	Micro-Level SRL Process	Description	Example SRL Event
Planning	Task Analysis	To become familiar with the learning context and the definition and requirements of a (learning) task at hand	Clicking on different competences under duties or projects related to the user
	Goal Setting	To explicitly set, define or update learning goals	Drag and dropping an available competence to a new or an existing learning goal
	Making Personal Plans	To create plans and select strategies for achieving a set learning goal	Choosing an available learning path as the path for a competence
Engagement	Working on the Task	To consistently engage with a learning task and using tactics and strategies	Request collaboration for a competence, learning path or learning activity
	Applying appropriate Strategy Changes	To revise learning strategies, or apply change in tactics	Adding a new activity to an existing learning path
Evaluation & Reflection	Evaluation	Evaluating one's learning process and comparing one's work with the others	Rating a learning path, learning activity or knowledge asset
	Reflection	Reflecting on individual learning and sharing learning experiences	Adding a comment for a competence, learning path or learning activity

To address this issue, the layered architecture and modular design of the Learn-B environment was used to develop a rather generic and structured framework for tracking users' interactions within this environment. Using this framework, the system was able to capture and store users' interactions as a series of basic lower-level *event types*. Additional information specific to each event as well as the learning resource on which the event was performed were also stored separately. For instance, when users clicked on a Social Wave tab, a Comments tab, a Data tab or any other intervention-related tab within Learn-B, two basic events were always fired: a *SelectNodeEvent* and an *OpenTabEvent*. As another example, creating a learning goal, a user-defined competence, learning path, learning activity or knowledge asset were all represented through the *Create* event. Figure 4.2 shows a snapshot of the trace data (the basic event types plus the specific details about each individual event), collected by the system on the fly.

Figure 4.2. A snapshot of log files generated within Learn-B.

When capturing the *SRL* and *Intervention* events in their authentic settings, however, it was important that users' actions be captured in their full context of occurrence containing all the events involved, as well as the detailed information related to each event. Thus, as users interacted with the different tools within the Learn-B environment, data was logged at the level of the above-mentioned event types, accompanied by additional information (if any), and written to the respective database tables which were set up in advance for this purpose. For instance, when a user added a new keyword to a knowledge asset, the system recorded that a *TaggingEvent* was performed by this specific user, on this learning resource, time-stamped to the full date and time of its occurrence, followed by an *Edit* event. Further information in the case of this example includes the type of the tag (e.g. keyword), text of the tag itself (e.g. "documentation"), the type and title of the learning resource being tagged (e.g. "Knowledge Asset" and "Basics of SW documentation – standards", respectively), as well as the URIs (Uniform Resource Identifier, which indicates where a resource is stored in the underlying ontologies) of all the entities involved, i.e. the user, the knowledge asset and the user-added tag (see the blue box in Figure 4.2).

4.2.2. Extracting Occurrences of Intervention and SRL Events from the Collected Trace Data

The raw learning logs collected by the system during users' interactions within the Learn-B environment often contained two or more *event types* per mouse click. This meant that the collected data were at a lower granularity than the intended *SRL* and *Intervention* events, also resulting in an extensive amount of events to be written to the log files. To analyze the collected trace data at the desired granularity level (i.e. at the level of *SRL* and *Intervention* events), I *parsed* each user's raw log file to aggregate their collected finer-grained traces into chunks of coarser-grained SRL and Intervention events. For this purpose, I developed a *pattern* library, in which I defined patterns of sequential event types corresponding to each of the SRL/Intervention events (see Appendix A). I call these patterns *Event Patterns*. To define these patterns, I systematically examined the Learn-B environment to identify sequences of lower-level events that were triggered, along with their specific details, and captured by the logging module when users performed each of the events in either sets of SRL or Intervention events. For instance, for the intervention event: "clicking on users who have already acquired an available competence" related to Intervention V (see Appendix A), first a *SelectNodeEvent* could be fired, depending on whether users clicked on the upper *Persons* folder in the tree structure, or just expanded it and then clicked on one of its child nodes i.e., a single *Colleague*; followed by another *SelectNodeEvent* (clicking on the Colleague's node) and an *OpenTabEvent* (opening the data tab for that colleague) - Figure 4.3.a.

a)

[SelectNodeEvent]*
- nodeTitle: blank
- nodeRelName:"PERSON_FOLDER"
- nodeView: "shared"
- nodeid: a pattern of 6 digits, followed by a dot; e.g. 1.1.1.1.1
- resourceType: "null"

*: Optional

SelectNodeEvent
- nodeTitle: Colleague's name
- nodeRelName: "PERSON"
- nodeView: "shared"
- nodeid: a pattern of 6 digits, followed by a dot; e.g. 1.1.1.1.1
- resourceType: "User"

OpenTabEvent
- tabName: "Person Form Data"
- nodeTitle: Colleague's name
- nodeRelName: "PERSON"
- nodeView: "shared"
- serviceName: "LPC"
- nodeid: a pattern of 6 digits, followed by a dot; e.g. 1.1.1.1.1
- resourceType: "User"

b)

```
Available.Competence.UsersHavingCompetence.click=^.*?(\w+[a-z0-9]*)
(?:\s+)(?:(\d{2}/\d{2}/\d{4}\s\d+:\d{2}:\d{2})(?:\s+)(\d+)(?:\s+)(S
electNodeEvent)(?:\s+)(?:nodeTitle)(?:\s+)(?:.*?)(?:\s+)(NULL)(?:\s
+)(?:\1)(?:\s+)(?:\2)(?:\s+)(?:\3)(?:\s+)(?:\4)(?:\s+)(?:nodeRelNam
e)(?:\s+)(?:PERSON_FOLDER)(?:\s+)(?:\5)(?:\s+)(?:\1)(?:\s+)(?:\2)(?
:\s+)(?:\3)(?:\s+)(?:\4)(?:\s+)(?:nodeView)(?:\s+)(?:shared)(?:\s+)
(?:\5)(?:\s+)(?:\1)(?:\s+)(?:\2)(?:\s+)(?:\3)(?:\s+)(?:\4)(?:\s+)(?
:nodeid)(?:\s+)(?:(?:\d+\.){7})(?:\s+)(?:\5)(?:\s+)(?:\w+[a-z0-9]*)
(?:\s+))?(\d{2}/\d{2}/\d{4}\s\d+:\d{2}:\d{2})(?:\s+)(\d+)(?:\s+)(Se
lectNodeEvent)(?:\s+)(?:nodeTitle)(?:\s+)(?:.*?)(?:\s+)(User)(?:\s+
)(?:\1)(?:\s+)(?:\2|\6)(?:\s+)(?:\3|\7)(?:\s+)(?:\4|\8)(?:\s+)(?:no
deRelName)(?:\s+)(?:PERSON)(?:\s+)(?:\5|\9)(?:\s+)(?:\1)(?:\s+)(?:\
2|\6)(?:\s+)(?:\3|\7)(?:\s+)(?:\4|\8)(?:\s+)(?:nodeView)(?:\s+)(sha
red)(?:\s+)(?:\5|\9)(?:\s+)(?:\1)(?:\s+)(?:\2|\6)(?:\s+)(?:\3|\7)(?
:\s+)(?:\4|\8)(?:\s+)(?:nodeid)(?:\s+)((?:\d+\.){6,})(?:\s+)(?:\5|\
9)(?:\s+)(?:\1)(?:\s+)(\d{2}/\d{2}/\d{4}\s\d+:\d{2}:\d{2})(?:\s+)(\
d+)(?:\s+)(OpenTabEvent)(?:\s+)(?:tabName)(?:\s+)(?:Person Form
Data)(?:\s+)(?:\5|\9)(?:\s+)(?:\1)(?:\s+)(?:\8|\12)(?:\s+)(?:\9|\13
)(?:\s+)(?:\10|\14)(?:\s+)(?:nodeTitle)(?:\s+)(?:.*?)(?:\s+)(?:\5|\
9)(?:\s+)(?:\1)(?:\s+)(?:\8|\12)(?:\s+)(?:\9|\13)(?:\s+)(?:\10|\14)
(?:\s+)(?:nodeRelName)(?:\s+)(?:PERSON)(?:\s+)(?:\5|\9)(?:\s+)(?:\1
)(?:\s+)(?:\8|\12)(?:\s+)(?:\9|\13)(?:\s+)(?:\10|\14)(?:\s+)(?:node
View)(?:\s+)(?:\5|\10)(?:\s+)(?:\5|\9)(?:\s+)(?:\1)(?:\s+)(?:\8|\12
)(?:\s+)(?:\9|\13)(?:\s+)(?:\10|\14)(?:\s+)(?:serviceName)(?:\s+)(?
:LPC)(?:\s+)(?:\5|\9)(?:\s+)(?:\1)(?:\s+)(?:\8|\12)(?:\s+)(?:\9|\13
)(?:\s+)(?:\10|\14)(?:\s+)(?:nodeid)(?:\s+)(?:\7|\11)(?:\s+)(?:\5|\
9)$
```

Figure 4.3. A sample Event Pattern in the Pattern library, denoting the Intervention event "Clicking on Users who are acquiring/have already acquired an available competence"; a) pattern specification, b) pattern implemented in REGEX.

To implement the parsing process, I developed an analyser module called *Log Parser*. This module received users' raw log files as input and matched them against the *event patterns* defined in the *pattern library* – see Figure 4.11.a. The input was in the form of textual collections of trace records across various learning sessions, retrieved from the respective data bases and aggregated into one concrete log file per user (similar to what is illustrated in Figure 4.2). I defined the *event patterns* in terms of regular expressions. Regular expressions, "*REGEX"* for short, are basically strings of characters which denote a pattern and are often used to find a particular text, replace text with other text or validate a given input (Habibi, 2004). Figure 4.3.b shows the regex implementation of a sample event pattern.
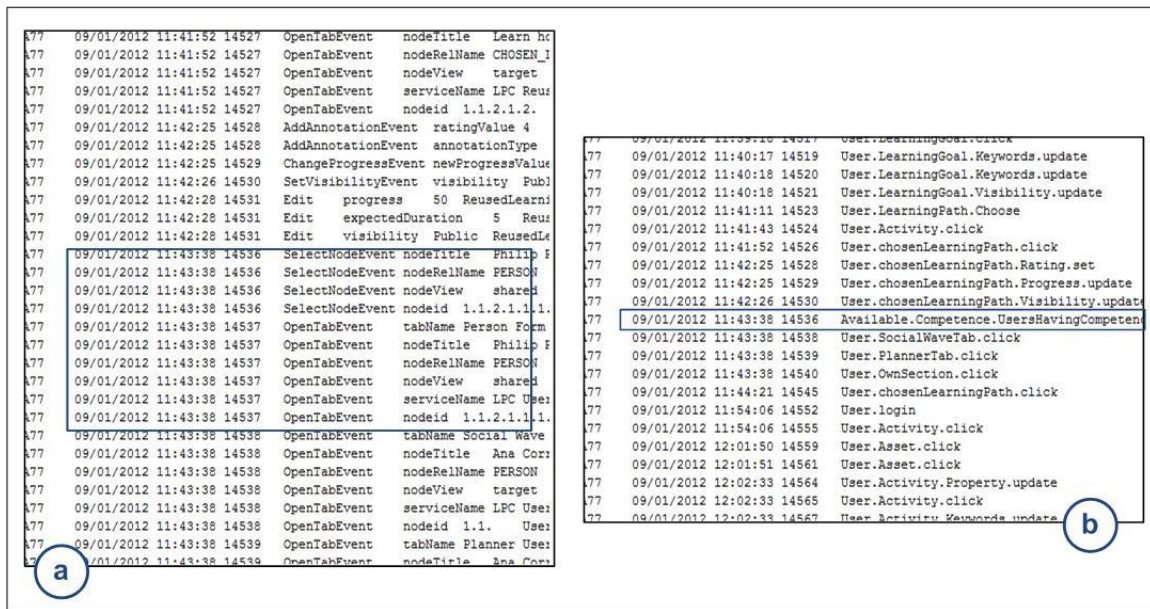
Figure 4.4. A sample user's a) raw log file, b) event-ized log file as the output of the Log Parser. The blue box shows the event records related to the event pattern in Figure 4.3.

I implemented the pattern matching algorithm in the Log Parser so that it searches for occurrence of all the available patterns defined in the *pattern library* in the users' log files, and upon success, translates the matching event records into a single record that specifies the occurrence of the intended SRL or Intervention event. Thus, the output of the Log Parser was an *event-ized* draft of each user's log file in that the extraneous events that do not have a matching pattern in the *pattern library* are removed from user's traces, and the output file contained only coarser-grained SRL and Intervention events aggregated from the lower-level traces. Figure 4.4 shows a sample user's raw log file as the input to the Log Parser, and the event-ized log file as the output of this module.

4.2.3. Extracting Contingencies and Transition Graphs from the collected Trace Data

Parsing users' raw traces into *event-ized* log files allows operationalizing the event-based conceptualization of SRL in terms of events' *occurrence* (Azevedo, Moos, et al., 2010; Winne, 2010b; Winne & Perry, 2000). An *occurrence* of an (SRL) event provides a touch-point where the researcher can observe the evidence (or product) of user cognition operations. Hence, an occurrence is merely a tally of an observable state

and does not convey any information about the context. As such, although occurrences allow for performing frequency counts of users' engagement in SRL actions (in the case of SRL events), or use of the proposed interventions (in the case of Intervention events), they fail to capture the transitions between users' actions. Such transitions represent the pattern and dynamic processes users perform in TEL environments, especially in informal workplace settings.
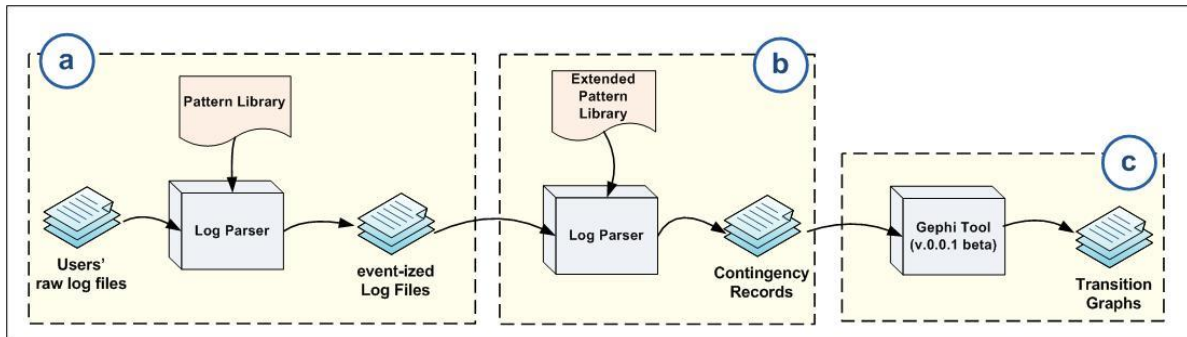
Figure 4.5. The applied SRL measurement protocol based on Trace Methodology, extracting a) SRL/Intervention events from raw log files; b) Contingencies and c) Transitions between SRL/Intervention events.

Therefore, to investigate my research question and the respective research hypotheses, I find it very important to go beyond simple frequency counts of actions and occurrences and instead, probe into the context of such occurrences, such as the states preceding a subsequent SRL event. I explored the existing *contingencies* between users' actions within the Learn-B environment and built the transition graphs of these contingencies in order to include elements of context in my analysis. Contingencies in general show what subsequent event was preceded by which prior event. Accordingly, they include some features of context in them and operationalize the event-based approach to measuring SRL at a higher level than *occurrences*. A *contingency* can be modeled in terms of a conditional *if-then* (condition-action) relationship (Winne, 2010b; Winne & Perry, 2000). For example, when we observe in the trace data of a given user that he/she performed a "creating a learning goal" event immediately after clicking on the "achievement tab of an available competence", the former event represents the condition, and the latter demonstrates the action. Here, the *condition* is an intervention event indicator of triggering Intervention I: Providing Usage Information. The action is an SRL event indicator of Goal Setting micro-level SRL process. Such a contingency

observed in user's trace data show that the SRL event was preceded by an Intervention event.

To mine the existing contingencies and build the transition graphs, I applied another level of pattern matching on users' *event-ized* log files. At this level, I translated all of the indicator events, i.e. those included in the *pattern library*, to their respective SRL and Intervention events. To this end, I extended the *pattern* library with additional sets of higher level, more general patterns that showed which *event patterns* manifest engagement in, or usage of which SRL or Intervention event. For example, the event pattern "Available.Competence.UsersHavingCompetence.click", shown in Figure 4.3, manifests the usage of Intervention V. Figure 4.6.b shows all of the event patterns in the *pattern library* that indicate enacting the *Working on the Task* micro-level SRL process. Figure 4.6.a lists the textual description of these event patterns as described in Appendix A.
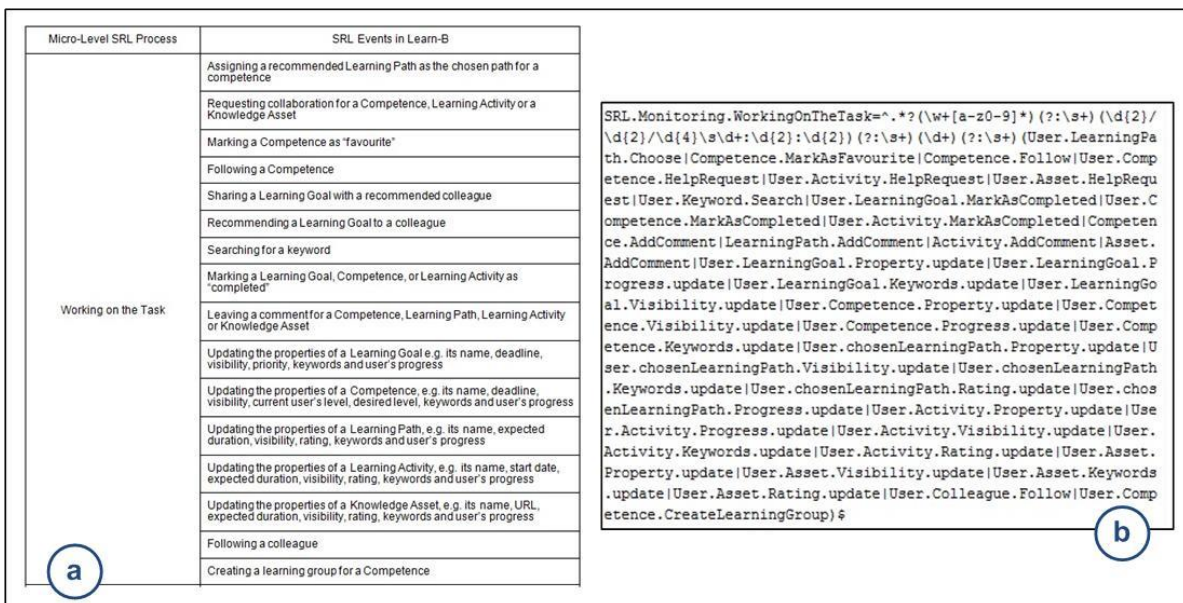
Figure 4.6. A pattern in the Pattern library which denotes all of the SRL events indicative of the "Working on the Task" micro-level SRL process; **a) list of the indicative SRL events as described in Appendix A, b) the pattern implemented in REGEX.**

I developed a pattern matching algorithm, similar to the one that I designed for extracting the *occurrences*, to scan all of the indicator events in users' *event-ized* log files, and translate the matching instances into contingency records of SRL or

Intervention events (Figure 4.6.b). An important issue here was that some of the event patterns were operationally defined as indicators of two or more SRL/Intervention events (see Appendix A). Hence, when translating such low-level events to higher level SRL or Intervention events, all of the possible matches had to be taken into account. For instance, adding a new knowledge asset to an existing learning activity (the "User.Activity.AddNewAsset" event pattern in the *pattern* library - Figure 4.7.a) was defined as an SRL event indicative of *Goal Setting* and *Making Personal Plans* micro-level planning processes, as well as the *Working on the Task* micro-level engagement process (Figure 4.7.b).

Figure 4.7. A sample user's a) event-ized log file, b) event-ized log file translated to SRL/Intervention events. The blue boxes show how one event pattern could be indicative of, and thus translated into, two or more SRL/Intervention events.

Having parsed users' log files into a time-stamped sequence of contingencies between their enactment of SRL and Intervention events, I developed the transition graphs. These graphs were created using the Gephi tool (Bastian et al., 2009), from each user's transformed log files, in order to paint a fuller picture of how users used the proposed interventions in exercising their SRL processes (Figure 4.6.c). Here, a *transition graph* is a graph of conditional contingencies, where nodes represent users' actions (e.g. performing SRL or Intervention events within the Learn-B environment) and each directional link between nodes represents a transition between two events.
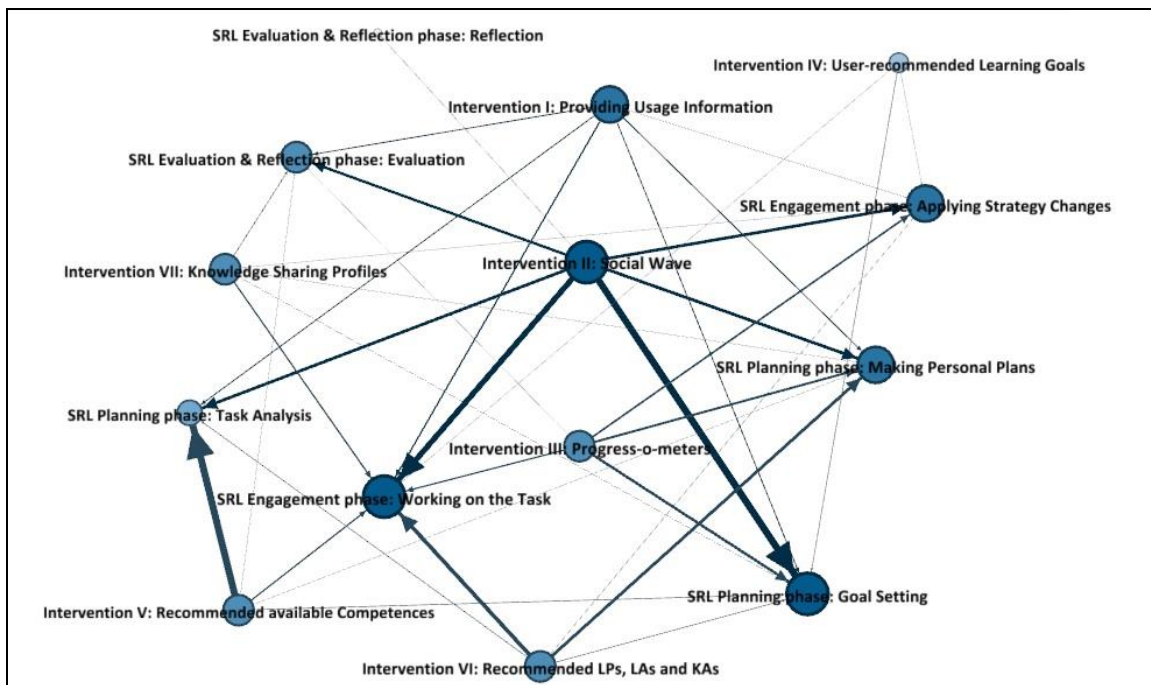
Figure 4.8. A sample transition graph from a user's log file translated into a time-stamped sequence of contingencies. Only the links starting at Intervention nodes are shown in this graph. Size of a node indicates its influence in the graph; thickness of a link shows how frequent that link occurred in user's trace data.

Figure 4.8 shows a sample transition graph. To get a less cluttered visual representation, only the links of interest to my research hypotheses, i.e. those directed from an Intervention event to other nodes (either SRL or Intervention nodes), are shown in this graph. The thicker a link, the more frequent that contingency has appeared in user's parsed trace data. Transition graphs illustrate how users' navigation between various events, e.g. their usage of proposed interventions and performing SRL processes in this example, looks like. Moreover, they can reveal a variety of quantitative measures adapted from graph theory (e.g. centrality metrics), which could be used in describing features of SRL processes (e.g. nodes of bigger size in Figure 4.8 are more influential in this graph), or exploring useful patterns such as the strategies which are more practiced by users who have a common background, organizational position, or are members of the same project. A detailed description of these measures, how they were calculated and applied to study my research hypotheses in particular is provided in section 5.2.3.1.

In the following sections, first I describe the preliminary exploration of the design and (paper-) prototyping of the proposed interventions. The details (e.g. the main components and materials, processes used in the preparation and execution of the experiments and the data analysis approach) about the two evaluation experiments conducted within the IntelLEO project are discussed subsequently.

4.3. Evaluation Experiments

A design-based research approach allows end-users to become part of the design team, be actively involved in the design process, have their specific needs and requirements identified, and be able to test and evaluate the usability of the system as it goes under iterative cycles of revision (Amiel & Reeves, 2008; The Design-Based Research Collective, 2003; Wang & Hannafin, 2005). Following this approach, I aimed to design the proposed interventions in their real context of use and in collaboration with practitioners, starting off with a preliminary exploration of the interventions' *paper prototypes*. These paper prototypes were used in sample *learning scenarios*. In the subsequent iterations of design and evaluation, I analysed the data of two evaluation experiments regarding my proposed interventions. The preliminary exploration of the paper prototypes, as well as the two evaluation experiments were conducted within the IntelLEO project, with end-users from three different business cases participating in this project. Each business case included two organizations, one from the industry side and one from the academia/research side. This allowed me to evaluate my proposed interventions in diverse organizational settings. The first business case (BC1) represented a university-industry partnership between an international enterprise (a leading car manufacturer) and a research institute; in the second business case (BC2) this partnership was between an SME (Small and Medium-sized Enterprise) and a university; and the third business case (BC3) denoted the partnership between an educational association (a professional teacher association) and a university. *Early prototypes* of my proposed interventions were developed within the Learn-B environment, considering the feedback received from the exploration of the paper prototypes. The early prototypes were evaluated in the first experiment. In the second experiment the *full prototype* of Learn-B, considering the required modifications and

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refinements observed from the first evaluation experiment, were used and evaluated by the end-users.

4.3.1. *Preliminary Exploration*

Prototypes offer a representation of design ideas, which is technically feasible and affords practical interpretation, before creation of the final product. They can range from low-fidelity sketches and paper-based mock-ups to high-fidelity working models and systems that are operational at various levels. Regardless of fidelity level of a prototype, they are all intended to explore and communicate propositions about the design and its context by inviting end-users to the design process, letting them share their experience of and feedback on using the system with the designers and developers, and clarifying information needs and requirements (Houde & Hill, 1997). *Paper* prototypes, in particular, provide the means for early usability evaluations of the design and central functionalities of the system, through collecting users' insights on the interface, as well as their overall experience of working with it (Snyder, 2003). I evaluated paper prototypes of my proposed interventions using sample *scenarios.* Scenarios are stories, i.e. informal narrative descriptions, about users, i.e. one or more persona(s), and the tasks they execute using the system to achieve their desired goals. Scenarios are commonly applied to plan and perform user training, documentation and usability tests. Avoiding the treatment of users as mere receivers or informants in the design process, scenarios allow users to be initiators in the analysis of information about their expectations of and requirements for the system, and encourage them to participate in the design process (Carroll, 1995).

Paper prototypes of the main features of Interventions III, V and VI along with other modules within the IntelLEO project, which were not related to my proposed interventions, were evaluated in the preliminary exploration. The paper prototype of Intervention III was called *Preview Learning Goals* at the time, and included features such as allowing users to preview i) their learning goals and their level of progress toward each goal, and ii) the competences a learning goal is composed of and their personal progress in achieving each competence via a progress bar.

Intervention V was called *Creating Target Competences* in the preliminary exploration, and its core functionality was to provide users with a list of available

competences (plus competence attributes such as importance and expected level of expertise). Users could browse this list and select those competences that they wished to acquire, and add them to their created learning goals. *Recommended Learning Path* was the name of the module which represented the paper prototype of Intervention VI. Using this prototype, users could choose a competence from their list of competences and view the recommended learning path(s) for it, along with its included learning activities, knowledge assets and some detailed information about these activities and assets, such as an activity's name and description, average level of skill for performing the activity, its average duration, the type of a knowledge asset (e.g. document, web page, blog post, etc.) and users' comments on it.

Representatives of the biggest business case, i.e. BC1, were asked to participate in the evaluation of the paper prototypes. In this preliminary evaluation, an open-ended (learning) scenario was used to familiarize users with the paper prototypes and collect their generic feedback and conceptual answers on the designed functionalities. The scenario included a sample employee who aimed to improve his/her competences after an appraisal interview with his/her manager. Following this scenario, the participants were asked to interact with the paper prototypes to plan their new learning goal(s), access existing learning resources, search for learning materials and share their individual learning experiences.

Focus groups with five participants per group, with different experience levels and from different sub-departments in their organization, were formed to demonstrate the paper prototypes and introduce the learning scenario to test-users. In the discussions following the demonstration of the paper prototypes, the participants were asked to think about possible supplementary scenarios where the developed interventions could fit into their working life and support their learning processes. The aim was to study the usefulness of the interventions (in their presented paper-prototype form), and the issues that could surface when deploying them in the real working context of the end-users. These in-depth discussions resulted in a list of challenges, issues and questions related to the three SRL phases, as well as several suggestions for the further development of the concept and implementation of the interventions (Holocher-Ertl et al., 2011; Siadaty et al., 2010). Users stressed the importance of a more structured access to existing knowledge and learning resources, intelligent recommendations on what to

learn considering also the learning experiences of their colleagues, as well as suggestions provided by their peers. All of these reflections were related to the *Planning* phase of users' self-regulatory processes. The former issue was addressed via a more clear design of Intervention VI in later revisions, while the latter was addressed through Intervention IV, which was not yet available in this exploration.

Users' concerns regarding the activities in the *Engagement* phase of their SRL cycles included the importance of Intervention VI as a tool to collaboratively structure and collect information about completely new topics. Users expected a tool through which new learning topics could be elaborated on in groups, the most important questions related to each topic could be specified, colleagues could contribute knowledge to answer those questions, and to bring all of these into a structure so that it could be later reused by others. These concerns were addressed in further revisions of Interventions V and VI. Additionally, the participants discussed their need to find colleagues as co-learners, and the functionality to send a request to receive assistance on a competence, a learning activity or a knowledge asset. This latter concern was addressed via Intervention IV and further revisions of Intervention V.

In the *Evaluation & Reflection* phase the most important issue was being able to track one's learning activities and thus demonstrating the completeness of one's learning goals. This issue was aimed to be solved via more detailed information and feedback contained in further revisions of Intervention III. Another topic raising the participants' concern was the issue of "time". The end-users discussed that they need to know how much time it takes, on average, to acquire a certain competence based on the estimation and experiences of other users, as well as how much time is given to them by their organization to increase their competences on a specific topic. The former functionality was made available in the later revisions of Intervention I, via its Analytics feature. The latter was supported in further revisions of Intervention V, via its Personalized Cues feature.

The preliminary exploration of the paper prototypes provided me with explicit usability concerns and issues related to the design of the proposed interventions. Moreover, users' feedback on the functionality of these interventions in their real context of use helped me to further improve and revise the conceptualization and design of the

interventions in the subsequent cycles of design and implementation, discussed in the following sections.

4.3.2. Experiment 1

I analysed the data collected from the evaluation study of an early prototype of Learn-B in the first cycle of testing and evaluation of the proposed interventions. In this experiment, the emphasis was rather on users' perceived usefulness of the proposed interventions, as well as their usage beliefs regarding performing self-regulatory learning processes in the workplace. A sample of participants from all three of the IntelLEO business cases took part in this study. Early prototypes of Interventions I (Providing Usage Information), III (Progress-o-meters), V (Recommended available Competences) and VI (Recommended available Learning Paths, Learning Activities and Knowledge Assets) were evaluated in this experiment.

4.3.2.1. Research Question and Hypotheses

In this experiment, I aimed to investigate the following two research questions derived from my main research question (stated in section 1.2):

4.3.2.1.1. RQ1- How do learners perceive the usefulness of various functionalities of Learn-B in performing SRL processes at their workplace?

The first research question in experiment 1 aimed to examine users' general usage beliefs about how the different functionalities provided by Learn-B helped them to engage in various SRL processes. Considering the functionalities available in this experiment, my a-priori assumptions, derived from my initial research hypotheses (discussed in section 3.2) and underpinned by my theoretical framework, were as follows:

- Intervention I, *Providing Usage Information*, fosters the social embeddedness dimension of workplace learning by informing users of how other members of their organization have approached their learning goals. My hypothesis is that such information (as implemented in the early prototype version of this intervention) firstly aids user to get acquainted with their learning context and plan their learning goals in view

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of that context (H1.e in Figure 4.9) and, create their personal plans accordingly (H1.f). These hypotheses contribute to *Hypothesis I*, as stated in my theoretical framework.

- The early prototype of the *Progress-o-meters* intervention (Intervention III) implemented in this experiment informed users of their progress toward their learning goals and thus brought their attention into their individual learning advancement. The feature allowing users to compare their progress with their colleagues' was not yet available in this round of evaluation. Following *Hypothesis III* in the theoretical framework, my a-priori hypothesis with regard to the available functionalities of this intervention within experiment 1 is that it supports users in pursuing and keeping track of their learning strategies in the Engagement phase of their self-regulatory processes, so that they can plan and choose learning plans according to their personal learning progress (H1.g).

- The *Recommended available Competences* intervention (Intervention V) informs users of the learning needs and expectations of their organization, and the available competences from which they can choose. This helps users to better know the learning objectives of their organization, and thus their learning context, and make decisions accordingly. My a-priori hypothesis here (related to *Hypothesis V* stated in the theoretical framework) is that this intervention supports users in performing the Planning phase, in particular the Goal Setting/Task Analysis (hypothesis H1.a) and Making Personal Plans micro-level processes (hypothesis H1.b).

- By providing users with information about the available learning paths and knowledge assets for achieving any of the available competences, the *Recommended available Learning Paths, Learning Activities and Knowledge Assets* intervention (Intervention VI) allows users to get to know their learning context in accordance to the learning objectives of their organization. Similar to Intervention V, my a-priori assumption here is that this intervention supports users to perform the Planning phase of

their SRL processes, in particular the Goal Setting/Task Analysis (H1.c)
and Making Personal Plans micro-level processes (H1.d) – these two
hypotheses are built upon *Hypothesis VI* in my theoretical framework.

To answer RQ1, I analyzed users' responses to the question items in the post-
questionnaires (see section 4.3.2.5 for more details on my data analysis approach in this
experiment), that addressed their perceived usefulness of each of the above
interventions for performing SRL processes. In the second research question, I was
interested in examining how useful users find self-regulatory processes for their
workplace learning, provided that they receive the necessary support for performing
these processes:

4.3.2.1.2. RQ2- How do users' perceptions of the usefulness of the support provided in Learn-B associate with their usage beliefs about the performed SRL processes?

There exists an extensive body of research on how and why knowledge workers
make a decision about the adoption and use of a new piece of technology in their
workplace (Holden & Karsh, 2010; Legris et al., 2003; Venkatesh & Bala, 2008).
Although subject to some serious criticisms (Benbasat & Barki, 2007), perhaps the most
widely employed model in this regard is the Technology Acceptance Model (TAM)
(Benbasat & Barki, 2007; Chuttur, 2009; Holden & Karsh, 2010; Liu, 2010; Venkatesh &
Bala, 2008). TAM is rooted in Fishbein and Ajzen's Theory of Reasoned Actions
(Fishbein & Ajzen, 1975) and has gone through a number of changes and extensions,
e.g. TAM2 and TAM3; see (Venkatesh & Bala, 2008), since it was first introduced in
(Davis, 1989). The theory of reasoned action (TRA) posits that a person's relative
strength of intention to perform a behaviour (i.e. their behavioural intention) is in part
affected by their attitude toward that behaviour. Here, attitude is defined as a set of
weighted salient beliefs about the consequences of performing that behaviour.
Subjective norms constitute the other factor included in this theory that affects a person's
intention to perform a behaviour. TAM is one of the most significant adaptations of this
theory, in the context of information systems in particular, in that use of a system
represents the intended behaviour (Davis, 1989). Davis adapted the TRA theory so that,
only the attitude factor accounts for the use of a system, and the two distinct beliefs,

perceived ease of use and *perceived usefulness,* were considered as the only beliefs predicting a user's attitude toward the use of a system (Chuttur, 2009).

In my second research question in this experiment, RQ2, I aimed to examine whether the provided support to perform SRL processes informs two key perceptual beliefs associated with the usage of these processes: i) perceived usefulness and ii) perceived ease of use. Following (Davis, 1989), we can understand perceived *usefulness* as the degree to which a user believes that a particular functionality within their learning environment (or following a learning practice) supports their learning process. My a-priori assumption regarding this research question was that if users receive the necessary support in their learning space, addressing both the contextual and social dimensions of learning in the workplace, to perform a specific SRL process, they are likely to find the process useful for their learning. Moreover, the cyclic nature of the underlying theoretical framework (see Chapter 3) and the reciprocal effect of enacting these processes on one another suggest the existence of probable associations between the perceived usefulness of the provided support and the usefulness of other SRL processes that users engage in during their learning activities.

To investigate this research question, I looked into the associations between users' perceptions of the usefulness of the support that Learn-B provides for performing their SRL processes and users' perceived usefulness of performing these processes for their personal learning. In particular, I examined the significant correlations between two sets of users' answers: one set being the items which asked users about their perceived usefulness of a particular Learn-B functionality in performing a certain SRL process, and the other set included the questions which dealt with users' perceptions of the usefulness of performing each particular SRL process for their personal learning in the workplace.

The research model shown in Figure 4.9 illustrates how the two research questions in this experiment were investigated. Specifically, the left hand side of the model is related to my first research question, RQ1. I investigated this research question by looking into users' perceptions of the usefulness of the provided support in conducting their SRL processes at their workplace. A specific set of questions were used as indicators of the perceived usefulness of different dimensions of each intervention;

these questions are listed in Table 5.1 to Table 5.3 (for more details, see the subsection on Materials and Measurement in experiment 1). The SRL processes, shown in the middle part of Figure 4.9, were manifested via the three tasks that the users performed in the study. The blue dotted arrows represent RQ1 and the respective hypotheses in my research model.
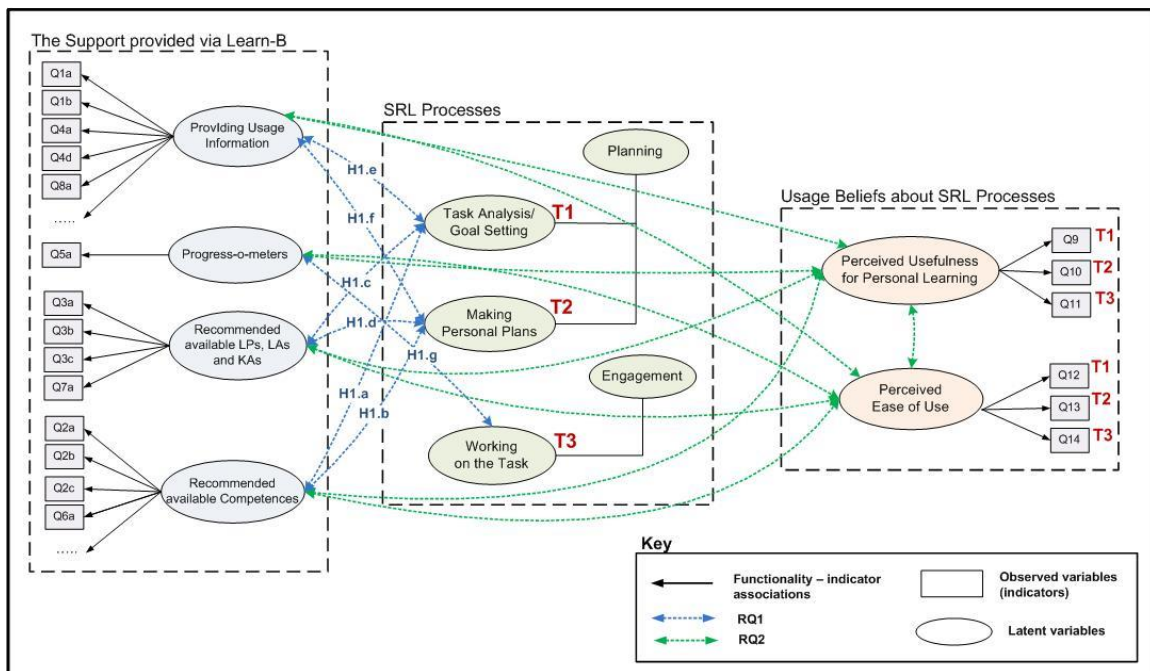
Figure 4.9. The Research Model applied in Experiment 1.

To address my second research question, RQ2, I investigated whether and to what extent the provided support is associated with users' usage beliefs about the SRL processes (i.e. usefulness for personal learning, and their ease-of-use). The green dotted arrows in Figure 4.9 represent RQ2. The observed variables on the right hand side of the research model (Figure 4.9) are the questionnaire items related to users' usage beliefs about their performed SRL processes.

4.3.2.2.   Participants

An early prototype of Learn-B was evaluated in February 2011 with end-users from the three different business cases participating in the IntelLEO project. In total, thirty users participated in the study, including eight from the first business case (the leading car manufacturer), 12 from the second (the SME) and 10 from the third business case (the professional teacher association). The majority of the participants had

university degrees (83.3%). There were 23.3% users with 10 or more years of working experience, 36.7% with 3 to 4 years' experience, 23.3% with 2 to 3 years, and the rest had less than a year of work experience in their current organizational positions.

4.3.2.3. Materials and Measurement

The materials used in the first experiment included the study scenario tailored to the organizational context of each business case (the details of the scenario are described in the next section), the Learn-B environment loaded separately with each business case data, and the questionnaires. To investigate research questions RQ1 and RQ2, three sets of constructs, namely interventions, SRL processes and usage belief constructs, were defined, operationalized and measured in this study.

The Intervention constructs consisted of the four interventions that were implemented as prototypes in the Learn-B environment and evaluated within experiment 1: Intervention I (Providing Usage Information), Intervention III (Progress-o-meters), Intervention V (Recommended available Competences) and Intervention VI (Recommended available Learning Paths, Learning Activities and Knowledge Assets). To operationalize the intervention constructs, I designed indicator questions targeting the different functionalities, those available within experiment 1, of each intervention and included them in a proper section of the questionnaires that the users filled in after each study task. For instance, Intervention I was measured on two of its available features: i) Analytics, including visualizations showing the number of people who already achieved a competence (or finished a learning path) or were working on it as well as their organizational positions; and ii) Social Stand, which reflected what other members of the organization thought about a certain resource, implemented in the form of keywords, comments and ratings of other users.

The SRL constructs, i.e. Goal Setting/Task Analysis and Making Personal Plans (both micro-level processes related to the *Planning* phase) and Working on the Task (reflecting the *Engagement* phase) were operationalized via the three tasks that users were asked to perform in the study scenario. Further details about the scenario and the learning tasks are described in the next section.

The usage belief constructs, i.e. perceived usefulness and perceived ease of use of the SRL processes, were operationalized using two distinct items in the questionnaires that users filled in after completing each study task.

Appendix B presents the list of items for all the constructs, the item identifier as it was used in the questionnaires and the specific feature (for the Intervention constructs) or SRL micro-level process (for SRL constructs) that each item manifests. The questionnaires were comprised of 5-point Likert scale items with values ranging from 1-Strongly Disagree to 5-Strongly Agree for the usefulness of the functionalities items, and 1-Not Useful at All to 5-Very Useful for the question items about usefulness of the tasks.

4.3.2.4. Procedure

The evaluation was conducted on site of each business case. The end-users were asked to complete a series of learning tasks in the context of a learning scenario, authentic to the specific organizational context of each business case. At the beginning of each evaluation session (i.e. for each business case), the participants were familiarized with the learning scenario, phrased in a manner specific to each target business case, such as "requested by the management" in case of the first business case (the leading car manufacturer), or "as part of the user's professional development plan" in the third business case (the professional teacher association). The learning tasks, however, were the same across the business cases in order to allow for the comparison of results between the three different organizational settings. For instance, all of the participants were asked to create a learning goal based on a set of recommended organizational competences, where only the recommended competences differed across business cases. Three of the learning tasks were specifically performed via Learn-B (and covered my proposed interventions), which are described in the following. Upon completing each task, the participants were asked to fill in the corresponding questionnaire.

Task 1. In this first task in the learning scenario, users were asked to create a learning goal in Learn-B, select one or more from the three available organizational competences and include them in their newly created learning goal. Each competence had a specific set of attributes that described it in more detail. For instance, one

competence had a very detailed competence description, while the second one was recommended by the colleagues. After finishing this task, the participants were asked about the functionalities that they perceived as useful in performing this task as well as their usage beliefs about the performed task. According to the SRL model underlying my research (section 3.1) and the pursued micro-level analysis approach (4.2.1), this task represents the Planning phase, and in particular the Goal Setting/Task Analysis micro-level processes.

Task 2. The second task demanded users to browse, select and adapt one of the available learning paths related to the organizational competences from Task 1. The learning paths were accompanied with different information such as comments and ratings of other users, achievement information (e.g. the number of users who already completed a given learning activity in a learning path), and various forms of knowledge asset formats (e.g. URL, text documents or videos). After finishing the task, the participants were asked to identify the functionalities that they found useful when choosing a learning path. By choosing and adapting a learning path for their created goals in this task, users engaged in the Planning phase of their SRL process, specifically the Making Personal Plans micro-level process.

Task 3. In this task, users were asked to add a knowledge asset to one of the learning paths chosen in Task 2. The knowledge asset was supposed to be defined in the form of an external URL. The participants had to link it to one of the learning activities in the respective learning path, and set its attributes such as visibility, personal rating and tags. After completion of the task, the participants were asked about the functionalities that they found useful when documenting their own learning resources, in terms of user-added knowledge assets. This task represents the Engagement phase of the SRL model (see section 3.1) – Working on the Task micro-level process.

Task 4 and Task 5 of the learning scenario were performed via the other tools developed within the IntelLEO project and did not explicitly represent my proposed interventions, thereby I do not consider them in my data analysis. In Task 4, users were asked to annotate (tag) a learning resource and share external URLs with colleagues using IntelLEO's lightweight bookmarking service. In Task 5, they were expected to initiate a learning group for the collaborative enhancement of the competence from Task

1. This task used the tools via which users could select co-learners to participate in their working group and define the settings of their desired working group.

4.3.2.5. Data Analysis

To examine my first research question within this experiment (RQ1), I analyzed the questionnaires' data using descriptive statistics including mean and standard deviation values. Using standard descriptive statistics to analyze the type of the data and research questions I had (specifically, RQ1), is a common practice (Blaikie, 2003). Also, it is noteworthy to mention that although there exist two schools of thought on analyzing Likert-scale data i.e., ordinal vs. interval (Carifio & Perla, 2008), I followed the latter. This choice is backed with a significant amount of empirical evidence indicating that Likert scales can be used as interval data (Carifio, 1987; Carifio & Perla, 2008). To gain a summative view over users' perceptual usage beliefs, the responses to questionnaire items were grouped into "Not-Agree": Likert-scale responses 1, 2 and 3, and "Agree": Likert-scale responses 4 and 5.

Additionally, I relied on inferential correlation, calculating Pearson correlation coefficients using the SPSS software (version 19), to investigate my second research question, RQ2. In particular, I looked into the significant associations between two sets of users' answers: i) the items asking users about their perceived usefulness of a particular functionality in performing a certain SRL process (Table 5.1 to Table 5.3), and ii) the questions which dealt with users' usage beliefs about performing each particular SRL process in the workplace (Table 5.4 to Table 5.9). For variables whose values were not normally distributed, I used parametric tests (i.e., Pearson's correlation) over log-transformed data. Evidence-based disciplines, such as medicine, suggest that this approach is noticeably more dominant over non-parametric tests (Keene, 1995). This is also consistent with the findings of the previous research in educational and psychological measurement (Rasmussen & Dunlap, 1991). The transformation also allowed to accommodate the seemingly outlier data points, which were actually indicative of the inherent variability in users' perceptions. The detailed discussion on the results of the data analysis is given in section 5.1.

4.3.3.   Additions and Revisions

Following the design-based research approach, the end-users participating in experiment 1 were invited to take part in a group discussion after the evaluation session to discuss about their feedback on and experiences with the early prototypes of the tools in more detail. The feedback from the users on usability and functionality as well as further functional requirements was then employed to revise and improve the functionality of the proposed interventions when developing the full prototypes.

The key usability issue of the early prototypes, frequently stated by the participants, was related to the tree-like, hierarchical structure of the interventions within the Learn-B environment. In the user interface of the early prototype, users' learning goals (and the included competences and learning paths) as well as recommended available competences and learning paths were organized in a tree structure, divided into two main sections. The upper section of this tree showed user's personal learning goals and competences and the lower section showed the available organizational resources such as competences and learning paths. By expanding a node, users could see the *children* of that node (if any), e.g. the competences included in a learning goal, or the learning activities included within a recommended learning path. Users frequently commented that they found it difficult to work with the arrows next to a node to see its hidden children, and also comprehend and remember the icons beside different types of nodes (e.g. the icon related to learning goals versus the one for competences). In addition, opening many of the nodes would result in the tree becoming very long and thus burdensome to navigate through in order to find relevant learning resources. To address this issue, in the full prototype the Learn-B team aimed to flatten this structure, and introduced a set of tabs that presented the various features and functionalities in separate frames. For instance, tabs such as the Planner, Social Wave and Portfolio were introduced in the full prototype. These tabs were always accessible and showed the respective information only when the user switched to that tab. Moreover, to make the hidden nodes more visible and accessible, the design of the full prototypes was revised in a way that the detailed information about a learning resource (e.g. the Analytics about an available competence) would appear in a separate frame on the right side of the screen when users clicked on that resource (e.g. a given competence).

A major functionality feedback received from the users, especially those from BC1, was that they were interested in an additional feature which would help them to build a learning path together with their colleagues around a certain topic. Such a learning path could act as a useful guide for the newcomers to the topic as well as the experienced employees, who needed to refresh their knowledge with certain aspects related to that topic. This functional requirement was addressed in the full prototype via Intervention IV, which allowed users to recommend learning goals to their colleagues and collaboratively work on its achievement. Accordingly, using this intervention, users could create a learning goal around a certain topic and share it with their colleagues; then, together with those colleagues interested to work on this goal, they could select and include related available competences in the goal, and finally create learning paths (along with related knowledge assets) anew or choose from the recommended existing learning paths (provided by Intervention VI) to achieve each of the included competences.

Another comment frequently stated by the participants was their need for a higher level of transparency of their colleagues' learning efforts on the learning topics and resources that were of interest to the user. In other words, users were interested in a tool which would show them how their colleagues were approaching a certain competence, learning path or learning topic that they, too, were working on. One of the main reasons behind this concern was that, especially in larger organizations, users often perceive the time and effort that they put into learning and knowledge seeking much more than what is actually necessary, plainly because they are not aware of each other's efforts. In addition, being aware of other's relevant learning activities (e.g. activities related to learning resources of interest to a given user) not only provides users with useful information and insights into approaching new or existing competences and learning paths, but offers them the opportunity to know about those colleagues who have the same interests and perhaps could be of help, if the user encounters difficulties in their learning process. The Social Wave intervention implemented within the full prototype of the Learn-B environment aimed to address this issue. It provided users with the latest updates on their learning goals, competences and learning paths, as well as any other learning resource or colleague from which the user desired to receive updates.

In addition to being aware of other users' learning activities, another frequent suggestion received from the participants was a feature showing each individual where he/she is in terms of their learning, competences and learning paths, as well as a comparison with other users regarding their achievements. The former requirement was already supported in the early prototype of the Progress-o-meters Intervention, and its design and user interface were improved for better clarity. The latter requirement clearly highlighted the social embeddedness dimension of workplace learning, and was an impetus to implement the comparison feature of this intervention in the full prototype. Via this feature, users not only could monitor their individual progress, but had the option to also compare their progress with that of their colleagues. Also, an additional feature was added to the full prototype of Intervention V, Recommended available Competences, which showed the user who else is working on a recommended competence or has already achieved it – of course, if the other colleagues had made this information visible within the organization.

Finally, the participants from the three business cases suggested, in agreement, that they prefer to receive a clearer personalisation, showing them explicitly which learning resources better fit their learning needs. Part of this concern might be due to the rather complicated hierarchical structure of the interface that, according to the feedback received from the end-users, limited them from easily finding the relevant learning resources and information. In addition to the improvement of the tree-like design of the interface, the full prototype implementation of Intervention VI was improved in a way that it provided users with a *sorted* list of top ten available learning paths. The most appropriate learning path, considering the contextual data about a user such as his/her organizational position and competence requirements, current learning goals and achieved competences, was the recommendation atop the list. To recommend the most appropriate learning paths to users, this intervention first exploited cosine similarity measure between the vector of concepts and tags representing a user's personal preferences and, the vector of concepts and tags related to a learning path to find how similar each path is to the preferences of a given user. Then, it considered users who had previously used the candidate learning paths, and checked their similarity with the current user. The rationale for this comparison, also explicitly emphasized by users in their feedback, was that those learning paths followed by users with similar interests and

backgrounds were considered very likely to be better adopted, compared to those used by users with whom a given user has no or very low similarity (Siadaty et al., 2012).

In the following section, I discuss the second evaluation (experiment 2) in detail, in which the full prototypes of all of the proposed interventions were evaluated by participants from the three business cases, during a two-month testing period. The details include discussions on the research questions and hypotheses, the participants, materials and the measurement method applied, plus the procedure and the data analysis approach applied in this experiment.

4.3.4. *Experiment 2*

To evaluate the effectiveness of my proposed interventions in supporting users' self-regulatory learning processes in the workplace, I analysed quantitative questionnaire data in the second experiment (that users filled in after the evaluation period), plus users' trace data (in terms of logged events that users performed when using the Learn-B environment). In this round of evaluation, full prototypes of all the interventions were evaluated during a two month testing period, including interventions: I (Providing usage information), II (Social Wave), III (Progress-o-meters), IV (User-recommended Learning Goals), V (Recommended available Competences), VI (Recommended available Learning Paths, Learning Activities and Knowledge Assets) and VII (Knowledge Sharing Profiles).

4.3.4.1. Research Question and Hypotheses

Following the design-based research approach, in the first experiment I used the early prototypes of interventions I, III, V and VI to examine my respective research hypotheses. In the second evaluation iteration, I aimed to paint the full picture of my research question, using the full prototypes of the proposed interventions and investigating all the three SRL phases in my underlying SRL model. Accordingly, I looked into the following research questions derived from my main research question (stated in section 1.2):

4.3.4.1.1. RQ1- How do different SW-enabled interventions support different SRL processes in workplace learning environments?

In this research question, I aimed to investigate how the different features provided within Learn-B, now implemented as fully working prototypes, assist users in conducting their self-regulatory learning processes in the workplace, including the Planning, Engagement and Evaluation & Reflection phases. Built on my theoretical framework, my a-priori assumptions were as follows:

- My a-priori assumption regarding the *Providing Usage Information* intervention remains the same as previously discussed in experiment 1 (see section 4.3.2.1.1). This intervention informs users about the social dimension of their learning context when they are planning their learning goals and accordingly, about to select a learning resource. Hence, my hypothesis here is that this intervention assists users in the Planning phase of their SRL processes, in particular with Task Analysis (hypothesis H2.a in Figure 4.10), Goal Setting (H2.b) and Making Personal Plans (H2.c) micro-level processes. These hypotheses are related to *Hypothesis I* in my theoretical framework.

- The *Social Wave* intervention enables users to i) track a learning goal of theirs and each of its components, i.e. the competences the goal is comprised of, the learning paths the user has associated with each competence, and the learning activities and knowledge assets included in those learning paths, in the social context of their workplace and ii) see how the collective makes use of a specific learning resource. My a-priori assumption here, related to *Hypothesis II* in my theoretical framework, is that such a social awareness can significantly affect the way the owner of a personal learning goal is attaining it, resulting in slight revisions or major updates to the goal or any of its components. The hypothesis is that the *Social Wave* helps users to Plan their learning goals (Goal Setting; H2.d, and Making Personal Plans; H2.e, micro-level processes) and also provides opportunities for their further efforts on the task or updates to strategic plans, i.e. the Engagement phase; H2.f, and H2.g respectively).

- The full prototype of the *Progress-o-meter* intervention was evaluated in experiment 2, which informed users of both their individual progress toward their learning goals (this feature was already available in the first experiment) plus a comparison of their progress with that of their colleagues. My a-priori hypothesis here, updated compared to the one in experiment 1, is that observing one's individual progress within the social context of the organization helps learners to monitor and assess their progress toward achieving their goals, thus also assisting them to further work on their learning tasks (H2.h) or apply the necessary strategy changes, if need be (H2.i); in addition, I hypothesize that this intervention assists users with their Evaluation & Reflection processes (H2.j and H2.k, respectively – both contributing to *Hypothesis III* in the theoretical framework).

- Users can benefit from the *User-recommended Learning Goals* intervention, in that they can initiate their learning processes starting off with a learning goal recommended by one of their colleagues. Tis colleague, for instance, can be an experienced co-worker who holds the same organizational position, or is responsible for similar tasks and thus, is quite familiar with the learning needs and requirements of that position or task(s). My a-priori hypothesis regarding this intervention, stemming from *Hypothesis IV* stated in the theoretical framework, is that it aids users with their Planning phase, in particular with task analysis (H2.l) and goal setting (H2.m) micro-level processes, where they can gain insight into how relevant learning goals are formulated, what available competences they can start from, and what learning paths the collective has chosen to achieve those competences.

- My a-priori hypotheses regarding the *Recommended available Competences* and, *Recommended available Learning Paths, Learning Activities and Knowledge Assets* interventions in experiment 2 remained the same as stated in experiment 1. That is, I hypothesize that these two interventions help users with their Planning phase, i.e. Task Analysis (H2.n; H2.q), Goal Setting (H2.o; H2.r) and Making Personal Plans micro-

level SRL processes (H2.p and H2.s respectively – *Hypotheses V and VI* in the theoretical framework).

- The *Knowledge Sharing Profiles* intervention allows users to see what percentage of each type of learning resource that they own (e.g. the competences included in their learning goals), they have shared within their organization. Also users can compare their sharing of each learning resource type with that of the average within their organization. My a-priori hypothesis regarding this intervention, related to *Hypothesis VII* in my theoretical framework, is that it helps users to align their Reflections and sharing of their learning resources (H2.t).

To investigate my first research question in experiment 2, I analyzed the quantitative data obtained from the online post-questionnaires, which users filled out after the two-month testing period, addressing my a-priori hypotheses explicitly, together with the trace data of users' actions using the Learn-B environment, also captured during the two-month evaluation period.

In my first research question, I looked from the *trees* perspective to investigate the distinct support that each of my proposed interventions provides for users' SRL processes. In my second research question, however, I was rather interested in examining the *forest* itself; i.e. to explore the interventions which were generally most effective in supporting users' self-regulatory learning processes in organizational settings.

4.3.4.1.2. *RQ2 - Which SW-enabled interventions are most effective in supporting users' self-regulated learning processes in workplace environments?*

A few studies in the existing literature examine how different affordances of TEL environments support users' SRL processes, specifically in educational settings. For instance, the study reported in (Dabbagh & Kitsantas, 2005) examined how different categories of affordances (or "web-based pedagogical tools" as called in the paper) supported different SRL processes. It was shown that according to students' perceptions of the usefulness of these tools, content creation and delivery tools supported goal setting, help seeking, self-evaluation, and task strategies; whereas collaborative and

communication tools supported goal setting, time planning and management, and help seeking processes. Although it has been emphasized that users in general and students in particular could be inaccurate in their responses to questionnaires and self-reports compared to their actual behaviour and usage of a system (Hadwin et al., 2007; Krosnick, 2000; Tourangeau et al., 2000), no trace data was used in this study to examine the actual evidence of users' usage of the tools, and to compare it with what they reported in the related questionnaires. In (Winters et al., 2008), a few more related studies are described. Besides this limited number of studies which are explicitly conducted in formal educational settings at present there is no research, to my knowledge, investigating how different technology-enabled tools support users' self-regulatory learning processes in workplace settings, where learning is contextual and greatly informal.

Thus, in the second research question in this experiment, RQ2, I aimed to explore the interventions which were the most effective in supporting users' SRL processes in their workplace. It is noteworthy to emphasize that contrary to the commonly practiced approach where investigated affordances are usually in the form of a set of tools available in an existing learning environment, (e.g. in (Dabbagh & Kitsantas, 2005) twelve of the features available in WebCT were studied), the design and implementation of my proposed interventions were primarily based on the specific challenges and requirements of workplace learning, as well as the practical needs of the end-users' in their everyday work practices – and thus, followed the design-based research approach in my research.

To investigate RQ2, I used participants' trace data which were collected as log files during the two-month evaluation period. Using the trace data, I studied the graph theoretic measures of the transition graphs built from users' log files, plus calculated inferential statistics to examine how frequencies of users' engagement in SRL processes are associated with their use of the proposed interventions.
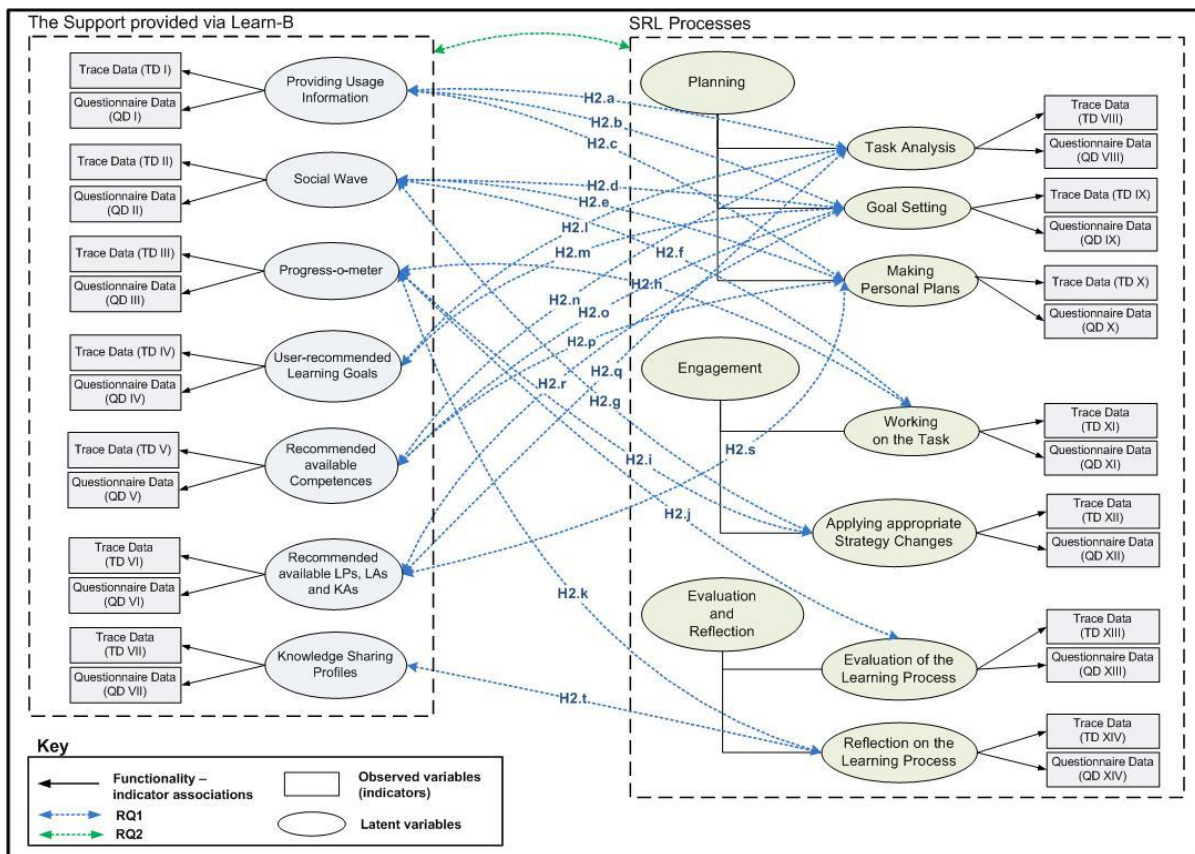
Figure 4.10. The Research Model applied in Experiment 2.

Figure 4.10 shows the research model, consistent with my analysis approach in experiment 1, that I used to investigate my two research questions in experiment 2. In this model, the blue dotted arrows indicate the research hypotheses related to my first research question, RQ1. I investigated these research hypotheses using users' responses to the post-questionnaire items, plus their trace data collected in log files. The question items are described in section 5.2.1 and their full list is given in Appendix C (see the subsection on Materials and Measurement in experiment 2 for more details). The green dotted arrow in Figure 4.10 represents RQ2. I used users' trace data to study this research question, i.e. to explore those interventions which were the most effective in supporting users' SRL processes in their workplaces. Users' trace data were manifested via a set of events that users could perform within the Learn-B environment; Appendix A shows the full list of these events, categorized into SRL and Intervention events.

4.3.4.2.   Participants

The full prototype of Learn-B was evaluated during an evaluation period of two months, depending on the availability of the end-users. 53 users participated in this evaluation iteration, including 33 users from the first business case and 20 users from the third business case. The second business case did not participate in the evaluation of the Learn-B environment in this round of experiments. 53 is the number of the users who used the Learn-B environment during the second evaluation period and we were able to collect their trace data. A smaller number of these participating users, however, provided us with their responses to the socio-demographic and post questionnaires; in particular, 13 users from the first and 10 users from the third business case. Nearly all the participating users, i.e. 95%, had university degrees. More than half of the respondents (58%) considered their computer skills to be close to excellent (levels 8 and 9, on a scale of 0-10, 0: very low and 10: excellent skills), and the rest reported higher than average computer skills (i.e. levels 5, 6 and 7). 25% of the users had between 7 to 19 years of working experience in their current position, 30% between 3 to 5 years of experience and the rest (45%) had up to two years of experience in their respective organization.

4.3.4.3. Materials and Measurement

The materials used in the second experiment included a set of study scenarios per business case, described in the next section; the full prototype of the Learn-B environment loaded separately with the data for each participating business case; the socio-demographic and post-questionnaires and the trace data collected from users' activities within the Learn-B environment during the two-month evaluation period. In order to examine my research questions within experiment 2, I defined, operationalized and measured Intervention and SRL constructs following a similar approach to that applied in the first experiment.

The Intervention constructs were operationalized via the seven SW-enabled interventions, now implemented as full prototypes in the Learn-B environment. Each of the intervention constructs was measured both in the post-questionnaire and via the trace data. In the post-questionnaire, I designed a set of specific question items, asking users about their view on the support provided by different features of an intervention,

and put them in the respective section of the post-questionnaire. The post-questionnaire was comprised of 5-point Likert scale items with values ranging from 1-Strongly Disagree to 5-Strongly Agree. For instance the *Providing Usage Information* intervention was again measured via Likert-scaled questions, as in experiment 1, according to its (now fully implemented) three dimensions: Analytics, including visualizations showing the summaries of usage and achievement information about various learning resources in an organization; Social Streams illustrating the *popularity* of a certain resource; and, Social Stand of the organization toward a resource represented via keywords, comments, and average ratings of users. The full list of these intervention questionnaire items is available in Appendix C.

On the level of trace data, I defined a set of *Intervention events* per intervention that could trigger that specific intervention, manifested via its different features, in the Learn-B environment. These events were accordingly detected, time-stamped and logged by the log-tracking tool running in the backend. Thereby, I could precisely track and measure the occurrence of each intervention and the context in which it happened. More details about these events, how they were defined, operationalized and measured are discussed in section 4.2, the Trace Methodology for SRL Measurement. In the case of the *Providing Usage Information* intervention, for instance, the set of intervention events consisted of those representing the i) *Analytics* feature: clicking on the Achievement visualizations under the Analytics section of an available competence, learning path or learning activity; or clicking on the Duties node; ii) *Social Stream* feature: clicking on the Social Wave tab under the Analytics section of an available learning resource (i.e. competence, learning path, learning activity or knowledge asset); iii) Social Stand feature: clicking on the Comments or the data tab of an available learning resource.

All the three SRL phases were to be measured in this evaluation iteration. Accordingly, the SRL constructs were also measured on the level of both post-questionnaire and trace data. Consistent with my research hypotheses, I formulated the questionnaire items targeting each intervention in a way that users could explicitly provide their perceptions on the support provided by a given intervention with regard to the specific SRL processes that I aimed to investigate in my research questions. For instance, the section about the *Providing Usage Information* intervention in the post-

questionnaire included items such as "*The summary for all the Duties helped me to plan my personal learning goals, e.g. to decide which competences to include in my personal learning goals*". This example shows a Likert-scaled question item targeting the planning phase, which was examined in my respective research hypothesis (see Figure 4.10). All of these SRL-related questionnaire items are listed in Appendix C.

To measure SRL processes on the level of trace data, I deployed an approach similar to the one for measuring intervention constructs using the trace data. In particular, I identified those sets of *non-intervention events* that users could perform via the Learn-B environment, where each set was an indicator of enacting a specific SRL micro-level process. For instance, the set of non-intervention events which were indicative of the *Task Analysis* micro-level process included events such as clicking on the Duties, Roles, Tasks or Projects folders; clicking on a single duty under the duties folder; clicking on different available competences under a specific duty, project, task or role; searching for a particular keyword; or clicking on the learning goals or competences defined by the colleagues of the user. Appendix A shows the full list of all of the SRL and Intervention events in the Learn-B environment, according to each micro-level SRL process or intervention feature.

4.3.4.4. Procedure

The full prototype of the Learn-B environment was evaluated during the final evaluation of the IntelLEO project in a two-month testing period, between October 2011 and January 2012. To allow for the evaluation of my proposed interventions as well as the other tools developed within the IntelLEO project in real-life workplace settings, each business case defined specific test scenarios authentic to its organizational context. These evaluation scenarios aimed to deliver an actual and realistic framework for the evaluation of the provided functionalities, in light of the specific learning needs and requirements of each organization.

The first business case, BC1, defined three scenarios for this purpose. The first testing scenario was designed to "Introduce and support newcomers in the department", in that newcomers (i.e. the participants with less experience in the organization) could benefit from the personalized learning resources in their Learn-B environment and

familiarize themselves with their organization's working practices, norms and expectations. The available learning resources (e.g. competences, learning paths and knowledge assets) were prepared and continually revised by the more experienced participating users from both of the involved organizations, i.e. the leading car manufacturer enterprise and the research institute.

The second evaluation scenario in BC1, "Supporting employees in their working process to develop new competences", was aimed to assist knowledge workers in further expanding their expert knowledge. Similar to the previous scenario, the available knowledge was initially generated by the more experienced participants in the form of various available learning resources. New knowledge was then contributed to the system by the collective, via Learn-B and the other tools developed within the IntelLEO project, in terms of user-defined competences, learning paths and uploaded/added knowledge assets.

The third testing scenario in BC1 was titled "Implementing new and changing working topics". The main objective of this scenario was to evaluate the provided functionalities in situations where knowledge workers face unfamiliar new working topics or topics under constant revisions and amendments. This was a very common situation users often confronted in BC1, which was also stressed by many users during the evaluation of the paper prototypes. To this end, the third testing scenario directed the participants to use the Learn-B environment to collaboratively define the most important questions on a new and/or challenging topic (e.g. via a shared learning goal); contribute their existing knowledge to answer those questions; and to bring structure to their contributed knowledge (e.g. in terms of a sequence of activities to be performed within a learning path), so that it could be reused by other users at a later stage.

The objective of the test scenario in BC3 was to represent one of the most common and important learning needs in this business case: "how to prepare for the accreditation process using e-portfolio tools". The majority of the end-users in BC3 were in-service teachers, who had worked as teachers for several years and now were interested in improving their career rank by going through the accreditation process. Accordingly, the participating end-users were asked to perform a set of assignments with regard to the accreditation process on a weekly basis during the testing period. The

assignments included: i) individual analysis of one or two of the available educational technology competence(s) in the Learn-B environment; ii) collaborative creation of individual accreditation learning paths, based on available learning paths and the learning paths defined by other end-users; iii) collaboratively analyzing and comparing the accreditation requirements (represented via pre-requisite competences in the Learn-B environment), and formulation of the results of this analysis; iv) individual learning from other participants' learning paths v) communicating, reflecting over existing and user-defined learning resources, and participating in discussions with peers and facilitators.

Experiment 2 started with an initial training session for the participants, where the tools and their functionalities were introduced and the socio-demographic questionnaire was distributed. Similar to experiment 1, the evaluation was conducted on site of each participating business case. During the evaluation period, all the participating users were provided with the same set of tools and functionalities. Users' actions in the Learn-B environment throughout the two-month testing period were traced and collected as log files. However, it is noteworthy to mention that not all possible user actions in the Learn-B environment were stored via the backend log-tracking system. Only those actions that revealed the occurrence of an SRL process or triggering of one of the proposed interventions were of interest to my research questions and thus, were identified and stored by the log-tracking module. The logging process and the applied methodology are discussed in greater detail in section 4.2.

After the two-month evaluation period, the end-users were asked to fill out a set of post-questionnaires, including the questionnaires related to the evaluation of the IntelLEO project in general, in addition to the questionnaire that I designed for my research questions. Also, two focus groups per business case were organized in order to investigate the experiences, insights and perceptions of the participants in more detail. The qualitative data resulting from these focus groups, however, were not in particular pertinent to my research questions and thus, I did not consider them in my analysis process.

4.3.4.5. Data Analysis

I used participants' responses to the post-questionnaire and their trace data to examine my first research question (RQ1) in experiment 2. I analyzed the post-questionnaire data using standard descriptive statistics, mean and standard deviation values. In line with my data analysis approach in experiment 1 (see section 4.3.2.5), I treated the Likert-scale data from the post-questionnaire as interval data during the analysis process; an approach suggested by a significant amount of empirical evidence in the literature, see for instance (Carifio, 1987; Carifio & Perla, 2008). Also, to be consistent in the analysis and to have a unified outlook on users' responses, users' responses to post-questionnaire's Likert-scale items were grouped into "Not-Agree" (including Likert-scale responses 1, 2 and 3), and "Agree" (including Likert-scale responses 4 and 5).

Using the trace data, first I examined the frequency of occurrence (use) for each of my proposed interventions, by summing the tallies of *intervention events* manifesting a given intervention, across the log files of all users. The full list of all of the intervention (and SRL) events is given in Appendix A. Second, I built users' graphs of learning actions using their parsed, sorted trace data, and explored the *contingencies* between users' use of the proposed interventions and their engagement in SRL processes. A detailed discussion is provided in section 4.2 on how users' trace data were extracted and parsed into occurrences of events, contingencies and transition graphs. The *contingencies* were in general represented via weighted, directed edges between users' SRL and intervention events (nodes) in their graph of learning actions. The contingencies related to my research hypotheses, which I call *supporting edges* hereafter, were those edges which began at an intervention node and ended in an SRL node. These SRL and intervention nodes were the ones included in their respective a-priori hypothesis. For instance, an edge directed from the "Intervention I: Providing Usage Information" node to the "SRL Planning phase: Task Analysis" node in a user's graph of learning actions (see Figure 4.8) represents a supporting edge for hypothesis *H2.a* (see Figure 4.10).

To investigate RQ1, I calculated the proportion of the existing *supporting edges* in relation to the weight of a given intervention node, where *weight* of a node is denoted

by the sum of all the edges leaving that node. More precisely, the weight of the edges manifesting each of my respective hypotheses, e.g. the edge between *Intervention I* and *SRL-Task Analysis* nodes in the case of *H2.a*, divided by the total weight of that Intervention. Interestingly, when surveying the contingencies, I noticed that there were cases where an intervention was used more than once, while its total weight was equal to zero. An in-depth screening of the data revealed that these were the situations where users had triggered an Intervention such as Intervention I, but had not performed any other action in the Learn-B environment succeeding that intervention event. In other words, triggering of that intervention was the very last event in that specific session of the user. Subsequently, this resulted in a *division-by-zero* in my calculations, which was automatically converted to a system-missing value by the SPSS software. Instead of missing cases, however, I treated these instances as cases with a value of 0, indicating the "zero-occurrence" of a *supporting edge*.

To further probe RQ1, besides the above descriptive statistics, I examined whether and to what extent the frequency counts of intervention events are associated with those SRL events addressed in my a-priori hypotheses, using the Pearson correlation coefficient (see Figure 4.11.a).

To investigate my second research question, RQ2, I calculated the centrality measures for each of my proposed interventions within the transition graph generated from all users' trace data. I used the Gephi software (v. 0.8.1 beta) to build the transition graph and calculated the centrality measures (Bastian et al., 2009). In networks theoretic, centrality denotes the relative importance of a node within a graph and could be identified via *degree*, *betweenness*, *closeness* and *eigenvector* centrality, the most popular and commonly used centrality measures in various domains (Borgatti et al., 2009; Freeman, 1979; Landherr et al., 2010; Yan & Ding, 2009). In the context of my research, I consider centrality to represent the importance of an Intervention or SRL event within the network of user's learning actions in the Learn-B environment.
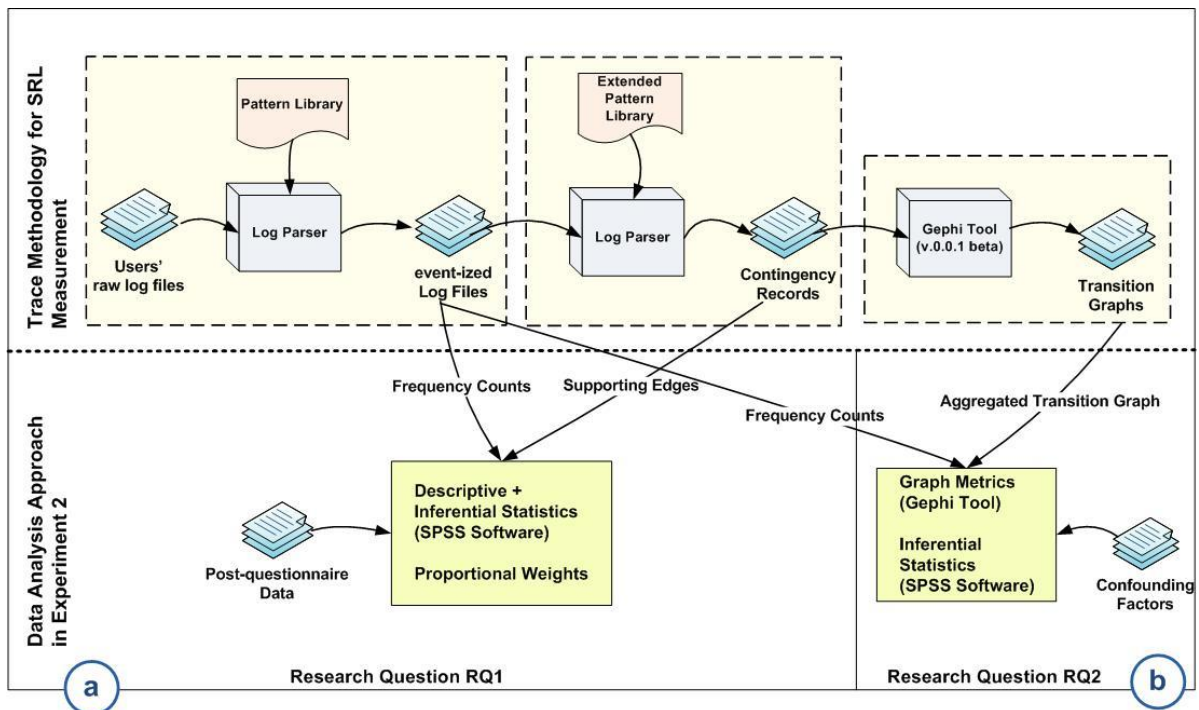
Figure 4.11. The Data Analysis Approach in Experiment 2.

In addition to graph-based metrics, I used inferential statistics to find all of the existing associations between the usage frequencies of the intervention events and the performed SRL processes, using Pearson's correlation coefficients. In RQ1, I was in particular interested in those associations that were in accordance with my a-priori hypotheses. In RQ2, however, I was interested in discovering whether my proposed interventions supported also those SRL processes which were not explicitly included in my a-priori hypotheses (i.e. within RQ1), and if so, to what extent.

Having identified the existing associations, I looked for those interventions whose usage frequencies not only were associated with users' engagement in SRL processes, but also could be *determinants* of that. Accordingly, I conducted multiple regression analyses per SRL micro-level process in order to explore whether the occurrence frequencies of my proposed interventions could significantly contribute to users' enactment of that SRL (micro-level) process. Lastly, I compared the effect of users' different levels of usage of the interventions discovered in the previous step, the *determinants,* on their engagement in SRL processes, considering also the effect of potential confounding variables in the second experiment (see Figure 4.11.b).

5. Results

5.1. Experiment 1

In this section I present the results of my statistical analysis over the collected data from evaluation experiment 1 (see section 4.3.2 for full details). The results are presented and discussed in the context of my research questions in this experiment (see the Research Question and Hypotheses section).

5.1.1. RQ1: Perceived Usefulness of Learn-B's Functionalities (i.e. the proposed SW-enabled Interventions) for performing SRL Processes

I analyzed the descriptive statistics of the respective questionnaire items to examine my first research question (RQ1): how learners perceived the functionalities of Learn-B in performing their SRL processes in the workplace. The descriptive statistics are shown in Table 5.1 and Table 5.2. The first column in these tables shows the Intervention; the second column is the indicator question item as it was presented in the questionnaire; the third column gives the number of users who agreed with the given questionnaire item and finally, the fourth column shows the descriptive statistics. For each question, I report the central tendency measure i.e., Mean (M), Standard Deviation (SD) and the number of valid responses (N).

In the following, I have organized the presentation and discussion of the results for RQ1 in accordance with the Planning (micro-level) processes: i) Task Analysis and Goal Setting, ii) Making Personal Plans and iii) Working on the Task micro-level SRL process of the Engagement phase.

5.1.1.1. Planning: Task Analysis and Goal Setting

H1.a (Figure 4.9)*:* Results from the users' answers (Table 5.1) show that almost all of the users agreed that *seeing the available competences* within their organization

(Q2c) is useful when they are creating their learning goals (M=4.62, SD=0.56, 28 out of 29 users), followed by 86% of them considering *seeing the available learning paths* for a competence (Q3c) another useful functionality when planning their learning goals (i.e., performing Task Analysis). General information about a competence such as its name, description and keywords (Q2g) was acknowledged as useful by 82% of the users (N=29, M=4.38, SD=0.86). More individualized information about a competence such as its priority with regard to the user's organizational position (Q2d; M=4.31, SD=0.81), the pre-requisites for achieving it (Q2f; M=4.17, SD=0.81), and its expected level to be acquired by the user (Q2e; M=4.03, SD=0.94) were the other factors provided by Intervention V, which users found useful when planning their learning goals (86%, 82% and 72% of the users, respectively). These results suggest that users found it important to know about the learning objectives of their organization, as well as their position with regard to these objectives (such as the priority of a certain competence for their organizational role), when planning their own learning goals.

H1.e (Figure 4.9): Amongst the *Usage Information* provided, only the comments (Social Stand) on a given competence were perceived useful for planning learning goals by a majority of the users (Q1c; M=4.14, SD=0.87); however, most of them, 83%, did not agree that having positive comments from their colleagues was the reason for them to choose a given competence (Q1a, M=2.83, SD=0.96). The Analytics information (Q1d:) number of users who already achieved a competence (M=3.10, SD=1.12) and (Q1e:) their organizational roles (M=3.28, SD=1.19) were also mostly not considered useful – i.e., 66% and 52% of the users, respectively, did not agree with the corresponding questionnaire items. In line with the results related to planning their learning goals, a noticeable number of users, 76%, also did not agree that being accomplished by many of their colleagues was a reason for them to include a certain competence in their learning goal (Q1b; M=3.05, SD=0.93).

Table 5.1. Descriptive statistics related to RQ1 - Planning: Task Analysis and Goal Setting.

Intervention	Question Description in the questionnaire	# of users in agreement	N, Mean, Std Dev.
	Q1a: I selected a specific competence, because it had positive comments from my colleagues. (Median score across all selected competences.)	5	29, 2.83, 0.957

Provision of Usage Information	Q1b: I selected a specific competence, because many colleagues successfully completed it. (Median score across all selected competences.)	7	29, 3.05, 0.929
	Q1c: When I plan my personal learning goals, I think it is useful to see comments from my colleagues concerning the competence.	24	29, 4.14, 0.875
	Q1d: When I plan my personal learning goals, I think it is useful to see how many people have already achieved and not yet achieved this competence.	10	29, 3.10, 1.012
	Q1e: When I plan my personal learning goals, I think it is useful to see the role of employees who [have] achieved this competence.	14	29, 3.28, 1.192
Recommended available Competences	Q2a: I selected a specific competence, because it was the competence I would need most urgently to increase my job performance. (Median score across all selected competences.)	21	29, 4.00, 0.973
	Q2b: In general, visual icons beside each available competence help me to pick those competences that fit my immediate learning needs.	11	29, 3.21, 0.940
	Q2c: When I plan my personal learning goals, I think it is useful to see the available competences within my organization.	28	29, 4.62, 0.561
	Q2d: When I plan my personal learning goals, I think it is useful to see the priority of the available competences for my position.	25	29, 4.31, 0.806
	Q2e: When I plan my personal learning goals, I think it is useful to see the expected level of the available competence for my position (low, medium and high level).	21	29, 4.03, 0.944
	Q2f: When I plan my personal learning goals, I think it is useful to see if I have the pre-requisites for an available competence.	24	29, 4.17. 0.805
	Q2g: When I plan my personal learning goals, I think it is useful to see the name, description and keywords of a competence.	24	29, 4.38. 0.862
Recommended available LPs, LAs and KAs	Q3a: I selected a specific competence, because... it had many available Learning Paths. (Median score across all selected competences.)	16	29, 3.55, 1.055
	Q3b: Seeing all the available and recommended learning paths for each competence help me better make a decision whether to choose a competence or not.	22	29, 3,93, 0.753
	Q3c: When I plan my personal learning goals, I think it is useful…to see the available learning paths for a competence.	25	29, 4.31, 0.806

In line with the above results, when it comes to setting their goal(s) and choosing competences to include in them, 72% of the users agreed that they picked those competences that they needed most urgently to increase their job performance (Q2a); however, only 38% of the users agreed that the visual icons accompanying available competences helped them to specifically choose the competences that fit their immediate learning needs (Q2b; M=3.21, SD=0.904) – *H1.a*. This might have been due to the unfamiliar design and lower graphical resolution of the icons in this early prototype of Learn-B. Seeing all the available and recommended learning paths (Q3b) was another factor acknowledged highly useful, by 76% of the users (M=3.93, SD=0.75), for choosing a specific competence; further endorsed by over half of the users who agreed they chose a given competence because it had many learning paths available (Q3a) – *H1.c*.

5.1.1.2.   Planning: Making Personal Plans

Having analysed the learning context and set their learning goals, the users were prompted to choose a learning path in Task 2 (i.e., perform the "Making Personal Plans" micro-level process). The users' responses to the respective questionnaire indicate that almost all of the users (96%) agreed that seeing all the matching available learning paths and their included learning activities and knowledge assets (Q7a) is useful when they want to choose a learning path (M=4.44, SD=0.583, 24 out of 25 users) – *H1.d* (Figure 4.9).

In addition to the keywords accompanying learning activities/documents a learning path is composed of (Q4b), colleagues' ratings of (Q4a) and their comments about these resources (Q4c) were the other *Usage Information - Social Stand* (Int. I) that users majorly found useful when making their personal plans; *H1.f* in Figure 4.9 (M=3.68, SD=0.90; M=3.60, SD=0.76; M=4.0, SD=0.76, respectively). However, contrary to when setting their learning goals, more than half of the users (64%) did not find *Usage Information - Analytics* such as the number of people engaged in a certain learning activity (Q4d) and their organizational roles (Q4f), useful for Making Personal Plans (M=3.00, SD=1.19; M=3.0, SD=1.55; respectively). This finding might be due to the unfamiliar look and design of, or users' difficulty in interpreting the related visualizations.

When asked about the reasons why they chose a certain learning path, good and clear descriptions of the respective activities and documents (Q6a) were the only

functions perceived useful by nearly half of the users (M=3.48, SD=1.08) – *H1.b*. Similar to the results for setting their learning goals, most of the users did not agree that positive comments (Q4e) or high ratings (Q4h) from the colleagues were necessarily the reasons for them to choose a given learning path (M=3.24, SD=0.831; M=3.04, SD=0.841, respectively). Likewise, neither being completed by many of their colleagues (Q4g), nor knowing the number of colleagues involved with/working on a learning activity (Q4d) were considered as the reasons to choose a learning path by a good number of the participants, (M=2.92, SD=0.997; M=3.00, SD=1.190, respectively). This indicates that users prefer to know clearly what options their organization is offering them, rather than relying on the achievement information or performance of their colleagues. Such results could be indicative of a poor organizational culture that does not nurture trust among employees. This early assumption offers further investigation.

Table 5.2. Descriptive statistics related to RQ1 - Planning: Making Personal Plans

Intervention	Question Description in the questionnaire	# of users in agreement	N, Mean, Std Dev
Provision of Usage Information	Q4a: I perceive the following functions as useful, when I have to select my learning path…to see my colleagues' rating of a learning activity or document.	15	25, 3.60, 0.764
	Q4b: I perceive the following functions as useful, when I have to select my learning path…to see the keywords of a learning activity or document.	16	25, 3.68, 0.900
	Q4c: I perceive the following functions as useful, when I have to select my learning path… to see the comments of my colleagues concerning the learning activity or document.	18	25, 4.00, 0.764
	Q4d: I perceive the following functions as useful, when I have to select my learning path...to see how many people completed the activity or are still actively involved in it.	9	25, 3.00. 1.19
	Q4e: I selected a specific learning path, because the learning activities and documents had positive comments from my colleagues.	9	25, 3.24, 0.831
	Q4f: I perceive the following functions as useful, when I have to select my learning path…to see the roles of the colleagues, who finished this learning activity.	9	25, 3.00, 1.155
	Q4g: I selected a specific learning path, because many colleagues were and still are involved with the related learning activity.	7	25, 2.92, 0.997
	Q4h: I selected a specific learning path, because... the learning activities and documents had a good rating from my colleagues.	7	25, 3.04, 0.841

Recommended Available Competences	Q6a: I selected a specific learning path, because the related learning activities and documents had a good and clear description.	12	25, 3.48, 1.085
Recommendation of LPs, LAs and KOs	Q7a: I perceive the following functions as useful, when I have to select my learning path… to see the available learning paths, learning activities and documents within my organization.	24	25, 4.44, 0.583

5.1.1.3.   Engagement: Working on the Task

In Task 3, users were asked about the functionalities that they found useful for adding a new knowledge asset to their learning path chosen in the previous task. This task was aimed at investigating the self-regulatory Engagement process, and specifically the Working on the Task step. Results from users' answers to the respective questions show that when choosing their learning paths, a majority of the users perceived it noticeably useful (72%) to see their personal progress in completing a learning activity (Q5a, N=25, M=3.88, SD=1.09) – *H1.g* in Figure 4.9.

In addition, setting the visibility of their newly added learning activity/document (Q8c) and adding keywords to it (Q8a), were perceived as useful functions by nearly 80% of the users (M=4.13, SD=0.741; M=4.17, SD=1.274, respectively); followed by 62% of the users asserting that being able to also rate the new learning resource(s) is useful when they aim to adapt their learning paths, Q8b (M=3.67, SD=1.007). These three questions indicate that, interestingly, users' find it useful to provide their contribution and *input* to Intervention I: Providing Usage Information when working on their learning tasks; whereas in my a-priori hypotheses regarding the functionalities provided by this intervention (see *H1.e* and *H1.f* in), the focus was rather on how the *output* of this intervention, i.e. the collected usage information in terms of analytics, social streams and social stands, supports users in their planning processes.

Table 5.3. Descriptive statistics related to RQ1 – Engagement: Working on the Task.

Intervention	Question Description in the questionnaire	# of users in agreement	N, Mean, Std Dev
Progress-o-meters	Q5a: I perceive the following functions as useful, when I have to select my learning path … to see my personal progress for a learning activity.	18	25, 3.88, 1.092

Q8a: When I want to document my own learning resources, I think it is useful....to add keywords	19	24, 4.17, 1.274
Q8b: When I want to document my own learning resources, I think it is useful...to allow the rating of my new knowledge asset.	15	24, 3,67, 1.007
Q8c: When I want to document my own learning resources, I think it is useful...to set the visibility of my learning activity and document.	19	24, 4.13, 0.741

5.1.2.   Summary of the Results for RQ1

The first research question in experiment 1 was how useful learners perceived the functionalities of Learn-B in performing their (self-regulatory) learning processes at their workplaces. In this experiment, Interventions I (Providing Usage Information), III (Progress-o-meters), V (Recommended available Competences) and VI (Recommended available LPs, LAs and KAs) were implemented in an early prototype of the Learn-B environment. To answer this research question, I analyzed users' responses to the respective questionnaire, which they filled out after completing each of their three learning tasks. These tasks were part of the learning scenario that users carried out within experiment 1, operationalizing the SRL phases Planning (including micro-level processes: Task Analysis, Goal Setting and Making Personal Plans) and Engagement; the micro-level process: working on the task.

The *Social Stand* feature of Intervention I was perceived useful by a majority of the respondents, i.e. 83%, when analysing task requirements and setting learning goals respectively. Interestingly, still an equal number of the users did not agree that knowing about the positive stand of their colleagues would be reason for them to choose a given competence. A similar pattern was observed with the *Analytics* feature of this intervention, where 41% of the users, on average, found this functionality useful for their planning processes, but only a few of them (7 out of 29) agreed that such information was the reason for selecting a specific competence (*H1.e*). When Making Personal Plans, the *Social Stand* feature was found useful by a noticeable 68% of the users; the *Analytics* feature, however, was perceived useful in this regard only by 36% of the users. Again, only a small percentage (31%) of the users agreed that knowing about the *Social Stand* or *Analytics* of the social context of their organization would be reason for them to

choose a specific learning plan (*H1.f*). These results suggest that when planning their learning goals, although users mostly benefit from the functionalities provided by Intervention I, they do not totally rely on the social context of their organization for this matter; instead, they rather seek out their organizational context and the options provided by their organization.

On average, 78% of the respondents acknowledged that the various *Personalized Cues* within Intervention V (Recommended available Competences), were useful for their planning processes. The other feature of this intervention providing users with the *Organizational Context* of the available competences was perceived useful by a larger percentage (89%) of the users in this regard (*H1.a*). Interestingly, only 48% of the users found this feature, *Organizational Context*, useful when making their personal plans-*H1.b*; (users were not asked about their perception of the other feature when making personal plans). Whilst nearly all of the users, 96%, found Intervention VI useful when making their personal plans (*H1.d*); this intervention was perceived useful for planning processes by a smaller 82% of the respondents on average, considering its different dimensions (*H1.c*). The Progress-o-meters, Intervention III, was also perceived useful when making their personal plans, by 72% of the users (*H1.g*).

5.1.3.   *RQ2: Associations between the Perceived Usefulness of the Proposed Interventions and Users' Usage Beliefs about SRL Processes*

In this section, I examine my second research question, i.e., whether and to what extent two sets of users' perceptions are associated: the first set being the perceived usefulness of the proposed interventions in performing SRL processes and the second set being the usage beliefs about these processes, including the usefulness of the performed SRL processes for personal learning in the workplace, plus their ease-of-use.

As explained previously, the SRL processes were manifested via three tasks that users performed in the study. In the respective questionnaires that users filled in after finishing each task, there was one question that asked them "how useful they perceived that specific task for their personal learning" (Q9 in Task1, Q10 in Task2, and Q11 in Task3); along with another question asking them "how easy or difficult was the solution of the described task in Learn-B" (Q12 in Task1, Q13 in Task2, and Q14 in Task3);

Appendix B. To examine the relationships, I performed Pearson's correlation analysis and analyzed the correlations between the questions in Table 5.1 and Table 5.2, and the above two sets of questions (Q9 to Q11; and Q12 to Q14). Following (Cohen, 1988)'s rule of thumb, in the following I present and discuss the significant correlations identified as strong (r>=0.5) or moderate (0.3<=r<0.5), structured according to the three performed SRL processes.

5.1.3.1. Usage Belief: the perceived usefulness of SRL processes for users' personal learning

Results from the users' answers show that more than half of the participants (17 out of 29 users) found Task 1 (i.e., planning: Task Analysis/Goal Setting) useful for their personal learning (N=29, M=3.55, SD=1.088). Task 2 (i.e., planning: Making Personal Plans) was perceived as useful by 65% of the users (N=25, M=3.60, SD=1.080), and a notable 70% of the participants stated that Task 3, indicator of engagement: working on the task, was useful for their personal learning (N=24, M=3.92, SD=0.974).

5.1.3.1.1. Planning: Task Analysis and Goal Setting

In my a-priori hypotheses, I theorized that Interventions I, V and VI support users in their Task Analysis/Goal Setting processes. Results of the Pearson correlation analysis show that there were positive moderate associations between users' perceived usefulness of Task Analysis/Goal Setting and the perceived usefulness of the support given by *Recommended available Competences – Personal Cues*, where it provided users with the pre-requisites for a competence, r(29)=0.481, p=0.008; and the priority of achieving a competence, r(29)=0.428, p=0.021 given users' organizational positions (Table 5.4). The first variables in these correlations (CR1.a and CR1.b) demonstrate the effect of organizational context in workplace learning, in that the link between organizational competences and personal learning goals i) allows organizations to direct their employees' learning process and ii) allows the individuals to know what is required from them. The correlations themselves are an indicator of the link between the perceived usefulness of Goal Setting for users' learning in the workplace, and the support provided to users in harmonizing their learning goals with those of their organization.

Table 5.4. Observed correlations between the perceived usefulness of Task1: Task Analysis and Goal Setting and the perceived usefulness of the proposed Interventions

Correlation	First Variable	Second Variable	Correlation Coefficient
CR1.a	Q2f: perceived usefulness of seeing the pre-requisites for an available competence when setting learning goals. (Recommended available Competences)		r(29)=0.481, p=0.008
CR1.b	Q2d: perceived usefulness of seeing the priority of available competences for user's organizational position when setting learning goals. (Recommended available Competences)	Q9: Perceived Usefulness of Task Analysis/Goal Setting for Personal Learning	r(29) =0.428, p=0.021
CR1.c	Q4h: selecting a learning path because of its good ratings from the colleagues (Providing Usage Information)		r(24)=0.446, p=0.029
CR1.d	Q4b: perceived usefulness of seeing the keywords of a learning activity or document when choosing a learning path (Providing Usage Information)		r(24)=0.487, p=0.016
CR1.f	Q10: perceived usefulness of making personal plans for personal learning		r(24)=0.925, p=0.000
CR1.g	Q11: perceived usefulness of working on the task for personal learning		r(24)=0.667, p=0.001

Moderate positive correlations CR1.c and CR1.d indicate that increases in the perceived usefulness of knowing about the outlook of colleagues, in terms of keywords and ratings, on a learning path when deciding which path to take, were correlated with the increases in the perceived usefulness of Task Analysis/Goal Setting processes for users' personal learning.

Not surprisingly, a strong positive correlation was observed between the usefulness perceptions of two inextricably tied SRL micro-level processes, i.e. Task Analysis/Goal Setting and Making Personal Plans, for personal learning in the workplace (CR1.f). The perceived usefulness of the Engagement process of SRL for personal learning was also positively associated with that of Task Analysis/Goal Setting (CR1.g). These results support the cyclic nature of the underlying SRL model in my research where these processes, and their subsequent perceived usefulness for personal learning, are closely coupled, whilst boosting the input to one another.

In line with the above findings, the correlation results related to the *ease-of-use* usage belief (see section 5.1.3.2) indicate that positive correlations exist not only between the perceived usefulness of Task Analysis/Goal Setting for personal learning and its perceived ease-of-use in Learn-B (CR4.f), but also with the perceived ease of performing the other two SRL processes that the users engaged in during this experiment (CR5.d and CR6.d, respectively).

5.1.3.1.2. Planning: Making Personal Plans

Significant positive correlations were observed between users' perceived usefulness of the *Making Personal Plans* process and the perceived usefulness of the support provided by *Usage Information* (Intervention I) when performing the planning processes i) Task Analysis/Goal Setting (CR2.a), and ii) Making Personal Plans (CR2.b and CR2.c).

Table 5.5. Observed correlations between the perceived usefulness of Task2: Making Personal Plans and the perceived usefulness of the proposed Interventions

Correlation	First Variable	Second Variable	Correlation Coefficient
CR2.a	Q1d: perceived usefulness of seeing achievement information on a given competence when setting learning goals. (Providing Usage Information)	Q10: Perceived Usefulness of Making Personal Plans for Personal Learning	r(24)=0.491, p=0.015
CR2.b	Q4h: selecting a learning path because of its good ratings from the colleagues. (Providing Usage Information)		r(25)=0.498, p=0.011
CR2.c	Q4b: perceived usefulness of seeing the keywords of a learning activity or document when choosing a learning path. (Providing Usage Information)		r(25)=0.578, p=0.002
CR2.e	Q2d: perceived usefulness of seeing the priority of available competences for user's organizational position when setting learning goals. (Recommended available Competences)		r(24)=0.568, p=0.004
CR2.f	Q2f: perceived usefulness of seeing the pre-requisites for an available competence when setting learning goals. (Recommended available Competences)		r(24)=0.579, p=0.003
CR2.g	Q3c: perceived usefulness of seeing the available learning paths for a competence when setting learning goals. (Recommended available LPs)		r(24)=0.583 p=0.003

| CR2.h | Q11: perceived Usefulness of Working on the Task for Personal Learning | r(24)=0.664, p=0.000 |

The first variables in correlations CR2.e, CR2.f and CR2.g (Table 5.5) emphasize the role and importance of the organizational context in workplace learning in that not only do organizations represent their learning direction in terms of the available competences and learning paths for various organizational positions, but also individuals get to know what is expected from them and adjust their learning goals accordingly. Similar to the correlations discussed in the previous subsection, (i.e. section 5.1.3.1.1), these correlations indicate that the extent to which users find it useful for their personal learning in the workplace to create/choose personal plans is strongly correlated to the extent they draw on their organizational context when setting their goals.

As described in the previous sub-section, there existed a very strong positive correlation between the perceived usefulness of the two indicators of the Planning phase, i.e. Task Analysis/Goal Setting and Making Personal Plans (CR1.f). Confirming the reciprocal character of self-regulatory processes once again, Table 5.5 shows that a positive correlation also existed between the perceived usefulness of the Engagement (micro-level) process for personal learning and that of Making Personal Plans (CR2.h).

Similar to the results obtained for the Task Analysis/Goal Setting process in the previous sub-section, positive associations also existed here between the usefulness perception of Making Personal Plans for personal learning and the perceived ease-of-use of the three respective SRL processes using Learn-B (CR4.g, CR5.c and CR6.c, respectively).

5.1.3.1.3. Engagement: Working on the Task

Similar to the results related to the perceived usefulness of the Making Personal Plans process for personal learning, there existed a positive correlation between usefulness perception of seeing available learning paths for a competence (Intervention VI) when planning one's personal learning goals, and the perceived usefulness of Working on Learning Tasks for personal learning (CR3.a in Table 5.6). This correlation indicates that those users who draw on the organizational context (e.g. available

learning paths for a given competence), when setting their learning goals, also find it useful to apply their own appropriate strategy changes (e.g. in terms of adding new knowledge assets) once a learning path is chosen.

Moreover, there existed a noticeable number of significant positive associations between users' perceived usefulness of Working on the Task for their personal learning, and their usefulness perceptions of the various pieces of information provided by Intervention I in performing Task 2, representative of the planning micro-level process: Making Personal Plans (CR3.b, CR3.c and CR3.d).

Table 5.6. Observed correlations between the perceived usefulness of Task3: Working on the Task and the perceived usefulness of the Proposed Interventions

Correlation	First Variable	Second Variable	Correlation Coefficient
CR3.a	Q3c: perceived usefulness of seeing the available learning paths for a competence when setting learning goals. (Recommended available LPs)		r(23)=0.531, p=0.009
CR3.b	Q4b: perceived usefulness of seeing the keywords of a learning activity or document when choosing a learning path. (Providing Usage Information)		r(24)=0.538, p=0.007
CR3.c	Q4c: perceived usefulness of seeing the comments of colleagues on a learning activity or document when choosing a learning path (Providing Usage Information)	Q11: Perceived Usefulness of Working on the Learning Task	r(24)=0.440, p=0.031
CR3.d	Q4d: perceived usefulness of seeing achievement information on a learning activity when choosing a learning path. (Providing Usage Information)		r(24)=0.415, p=0.044
CR3.g	Q2d: perceived usefulness of seeing the priority of available competences for user's organizational position when setting learning goals. (Recommended available Competences)		r(23)=0.520, p=0.011
CR3.h	Q2a: selecting a specific competence, because it was the competence the user needed most urgently to increase his/her job performance. (Recommended available Competences)		r(23)=0.607, p=0.002

The importance of the organizational context is once again emphasized in the first variables of correlations CR3.g and CR3.h representing two functionalities of

Recommended available Competences (Int. V), which provide users with information reflecting the organizational needs and requirements: one concerning the priority of achieving a competence given a user's organizational position (CR3.g) and the other one indicating the urgency according to which the user needs to increase his/her job performance (CR3.h). In line with the previous findings, this correlation clearly shows that users' perceived usefulness of Intervention V for their planning purposes is strongly related to their perceived usefulness of the engagement phase for their personal learning.

5.1.3.2.   Usage Belief: the perceived ease of performing SRL processes (ease-of-use)

The majority of the participants, 76%, agreed that it was easy to perform Task 1, i.e. Task Analysis/Goal Setting, using the Learn-B environment (N=29, M=3.93, SD=1.033). A smaller and almost equal percentage of users found it easy to perform Task 2 (i.e., planning: Making Personal Plans) and Task 3 (Working on the Task) in Learn-B (N=25, M=3.56, SD=1.158; N=24, M=3.67, SD=1.129).

5.1.3.2.1. Planning: Task Analysis and Goal Setting

Table 5.7 shows that there were positive correlations between users' perceived ease* of performing the Goal Setting/Task Analysis SRL process and their usefulness perceptions of the different ways that *Providing Usage Information* supports performing this process: i) *Analytics*, e.g. the achievement information when planning for personal goals (CR4a), and ii) *Social* Stand, e.g. the available keywords for the learning activities/assets included in a learning path when choosing a learning path (CR4.b).

Table 5.7 further indicates that positive correlations existed between the perceived ease of performing the other two SRL processes and this process: CR4.d and CR4.e. Moreover, correlations CR4.f, CR4.g and CR4.h demonstrate the moderate-strong associations between the perceived usefulness of the three SRL tasks and the perceived ease-of-use of the Task Analysis/Goal Setting process, using Learn-B. These findings are in line with the results related to the mutual correlations between the perceived usefulness of all three SRL phases for personal learning (see the discussion in section 5.1.3.1.1).

Table 5.7. Observed correlations between the perceived ease-of-use of Task1:
Task Analysis/Goal Setting and the perceived usefulness of the
proposed Interventions

Correlation	First Variable	Second Variable	Correlation Coefficient
CR4.a	Q1d: perceived usefulness of seeing achievement information on a given competence when planning for personal goals (Providing Usage Information)	Q12: Perceived ease of performing Task Analysis/ Goal Setting	r(29)=0.402, p=0.031
CR4.b	Q4b: perceived usefulness of seeing the keywords for a LA/KA when choosing a learning path (Providing Usage Information)		r(24)=0.612, p=0.001
CR4.d	Q13: perceived ease of performing SRL Making Personal Plans process		r(25)=0.588, p=0.003
CR4.e	Q14: perceived ease of performing SRL Engagement process		r(23)=0.462, p =0.026
CR4.f	Q9: perceived usefulness of Task Analysis/Goal Setting for personal learning		r(29)=0.485, p=0.008
CR4.g	Q10: perceived usefulness of Making Personal Plans for personal learning		r(24)=0.654, p=0.001
CR4.h	Q11: perceived Usefulness of Working on the Task for Personal Learning		r(23)=0.487, p=0.019

5.1.3.2.2. Planning: Making Personal Plans

Positive correlations were observed between users' perceived ease-of-use of Learn-B to perform Task 2: Making Personal Plans and the perceived usefulness of the *Providing Usage Information* intervention. In particular, with its *Analytics* feature, it provides users with: i) the achievement information (CR5.a) and ii) the organizational positions (CR5.b) of other employees when choosing a learning path.

Table 5.8. Observed correlations between the perceived ease-of-use of Task2:
Making Personal Plans and the perceived usefulness of the
proposed Interventions

Correlation	First Variable	Second Variable	Correlation Coefficient
CR5.a	Q4d: perceived usefulness of seeing the achievement info on a learning path when choosing a learning path (Providing Usage Information)		r(23)=0.481, p=0.02

CR5.b	Q4f: perceived usefulness of seeing the roles of the colleagues who finished a learning activity when choosing a learning path (Providing Usage Information)	Q13: Perceived ease of Making Personal Plans	r(25)=0.588, p=0.003
CR5.c	Q10: perceived Usefulness of Making Personal Plans for Personal Learning		r(25)=0.404, p=0.045
CR5.d	Q9: perceived usefulness of Task Analysis/Goal Setting for personal learning		r(24)=0.438, p=0.032

Similar to the Task Analysis/Goal Setting process, the obtained association results (Table 5.8) show that a moderate correlation existed between the perceived usefulness of Making Personal Plans and its perceived ease-of-use in Learn-B (CR5.c). Moreover, as noted in the previous sub-sections, there existed a positive correlation between the perceived ease-of-use of this SRL process with that of the Task Analysis/Goal Setting process (CR4.d) as well as its perceived usefulness (CR5.d).

5.1.3.2.3. Engagement: Working on the Task

Table 5.9 indicates a strong positive correlation between the perceived ease of performing Task3: Applying Strategy Changes using Learn-B, and the perceived usefulness of *Recommendation of Available Learning Paths* when users aim to make personal plans (CR6.a). Interestingly, this time the perceived ease-of-use for this SRL process was not associated with its own perceived usefulness for personal learning; however, it was strongly correlated with that of the Task Analysis/Goal Setting (CR6.d) and Making Personal Plans SRL processes (CR6.c). In addition, correlation CR4.e, described in subsection 5.1.3.2.1, shows the moderate association between the ease of performing the Planning and Engagement SRL processes, using Learn-B.

Table 5.9. Observed correlations between the perceived ease-of-use of Task3: Applying Strategy Changes and the perceived usefulness of the proposed Interventions

Correlation	First Variable	Second Variable	Correlation Coefficient
CR6.a	Q3c: perceived usefulness of seeing the available learning paths for a competence when setting learning goals. (Recommended available LPs, LAs and KAs)	Q14: Perceived ease of Working on the Task	r(23)=0.522, p=0.011
CR6.c	Q10: perceived Usefulness of Making Personal		r(24)=0.457, p=0.025

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CR6.d	Q9: perceived usefulness of Task Analysis/Goal Setting for personal learning	r(23)=0.516, p=0.012

5.1.4. Summary of the Results for RQ2

In my second research question in experiment 1, I explored whether and to what extent users' usage beliefs about the SRL processes they performed within this experiment were associated with their usefulness perceptions of the proposed interventions in performing these processes. As noted previously, the SRL processes that users performed in this experiment included the Planning processes: Task analysis/Goal Setting and Making Personal Plans, and Working on the Task within the Engagement process; these SRL processes were manifested through the three tasks demanded in the respective learning scenario. Interventions I (Providing Usage Information), III (Progress-o-meters), V (Recommended available Competences) and VI (Recommended available LPs, LAs and KAs) were the proposed interventions implemented in an early prototype of the Learn-B environment that the participants used in this experiment.

More than half of the participants (59%) found performing Task Analysis/Goal setting useful for their personal learning, whilst a larger 76% agreed it was easy to perform this micro-level process using the Learn-B environment. Results from the Pearson's correlation analysis showed that users' perceived usefulness of Task Analysis/Goal Setting process for their personal learning in the workplace was positively correlated with their perceived usefulness of the support provided to them by Interventions I and V; in particular, the *Personalized Cues* feature of Intervention I, which allows users to harmonize their learning goals with those of their organization, and the *Social Stand* feature of Intervention V, which provides users with information on the outlook of their colleagues, for instance, on a specific learning path (CR1.a to CR1.d in Table 5.4). Users' perceived ease of performing the Task Analysis/Goal Setting process was positively associated with their usefulness perceptions of both *Analytics* (i.e. the achievement information of their colleagues) and *Social Stand* features (i.e. the available keywords for a learning resource) of Intervention I (CR4.a and CR4.b in Table 5.7).

Making Personal Plans micro-level process was perceived useful by 65% of the participants, and a slightly smaller 60% found it easy to perform this process using the Learn-B environment. Users' perceived usefulness of this process for their personal learning was positively correlated with their perceived usefulness of the support provided to them by Interventions I, V and VI; while Intervention I informs users of the social context of their organization, via its *Analytics*, e.g. colleagues' achievement information on a specific competence, and *Social Stand* features, e.g. colleagues' ratings and keywords for a learning path (CR2.a, CR2.b and CR2.c in Table 5.5), the two latter interventions stress the importance of the organizational context in workplace learning by informing individuals of what is expected from them and enabling them to adjust their learning goals accordingly (CR2.e, Cr2.f and CR2.g in Table 5.5). Positive correlations were also observed between participants' perceived ease of performing Making Personal Plans process, using the Learn-B environment, and their perceived usefulness of the *Analytics* feature of Intervention I (CR5.a and CR5.b, Table 5.8).

70% of the participants found it useful for their personal learning to perform Task 3, manifesting the engagement process: Working on the Task; a smaller 62% agreed that it was easy to perform this task using the Learn-B environment. Similar to the above SRL micro-level process, i.e. Making Personal Plans, users' usefulness perception of the support provided by Interventions I, V and VI was also positively correlated with their perceived usefulness of Working on the Task for their personal learning (correlations CR3.b, CR3.d and CR3.d in Table 5.6). On the other hand, strong positive correlations existed between the functionalities of Interventions V and VII, which aim to inform users of their organizational context, and users' usefulness perception of being informed about the organizational contexts of their workplace (correlations CR3.a, CR3.g and CR3.h, Table 5.6). Positive correlations were observed between participants' perceived ease of performing this SRL process using the Learn-B environment, and only their perceived usefulness of Intervention VI (CR6.a, Table 5.9).

In addition to the above associations between the perceived usefulness of performing the SRL processes for personal learning and the perceived usefulness of the support provided by the proposed interventions, further positive correlations existed between the perceived usefulness of performing Task Analysis/Goal Setting for personal learning, and that of the other two SRL processes, i.e. Making Personal Plans and

Working on the Task (CR1.f and CR1.g in Table 5.4). By the same token, the perceived ease of performing Task Analysis/Goal Setting using the Learn-B environment was correlated with that of the other two SRL tasks that users accomplished in this experiment (CR4.d and CR4.e in Table 5.7). These associations point out the cyclic nature of the underlying SRL model in my research, in that the SRL processes and their subsequent perceived usefulness for personal learning or ease of performing are closely associated with one another.

5.2. Experiment 2

In this section, I present and discuss the results of analysing the data from experiment 2. These data include users' responses to the post-questionnaire as well as the trace data collected from users' actions in the Learn-B environment during the evaluation period. In the following, I have organized the results of this experiment around my research questions (see the section on Research Question and Hypotheses).

5.2.1. RQ1: The Support provided by different SW-enabled interventions for SRL processes in workplace learning environments

To examine the above research question, first I looked into the descriptive statistics of users' responses to the post-questionnaire items. The descriptive statistics are shown in Table 5.10, Table 5.12, Table 5.14, Table 5.16, Table 5.18, Table 5.20 and Table 5.22. The particular features of each intervention (if an intervention contained two or more features in it) are provided in the first column, the second column includes the indicator question item as it was presented to users in the post-questionnaire, the third column shows the number of users who *agreed* (i.e. Likert-scale answers 'agree' and 'fully agree') with a given questionnaire item, and the last column presents the descriptive statistics. For each questionnaire item, I report the central tendency measure i.e., Mean (M), Standard Deviation (SD) and the number of valid responses (N).

In addition to the questionnaire data, I studied different descriptive dimensions of users' trace data, collected from their actions in the Learn-B environment, in order to investigate my first research question. In particular, first I calculated the frequencies of

Intervention and SRL actions that users performed in the Learn-B environment. These frequency counts (occurrences) provide important information about the learning processes users engaged in during the two-month evaluation period. Details on the event indicators, i.e. how they were designed, implemented and measured using the trace data, are discussed in section 4.2.

Second, I generated transition matrices of users' learning events, and used them to examine the contingencies between intervention and SRL actions. In the generated transition graphs, nodes represent SRL/Intervention events, and a transition between two events is represented via a directed link, i.e. an edge. Weights of these edges indicated the frequency of contingencies supporting my a-priori hypotheses related to RQ1. Finally, I performed Pearson's correlation analysis to examine whether and to what extent the occurrence frequencies of Intervention events are associated with that of SRL events which users performed within the Learn-B environment.

In the following, I have organized the presentation and discussion of the above descriptive analysis in accordance to the full prototype interventions evaluated in this evaluation iteration.

5.2.1.1.   Providing Usage Information

This intervention existed during experiment 1 and was fully implemented in the full prototype of the Learn-B environment, including the following features: Analytics, Social Streams and Social Stand. *Analytics* included visualizations and charts showing the usage of and achievement information about various resources in a respective organization. *Social Streams* of various learning resources were introduced in the full prototype. They demonstrated how popular and alive a learning resource was, i.e. how often it was used by other members of the organization and what actions/events were performed on it in a certain period. *Social Stands* reflected the opinion of the collective about a given learning resource through annotations, comments, ratings and keywords.

Results from the Questionnaire Data:

H2.a, H2.b and *H2.c* (Figure 4.10): Results from the participants' responses to the post-questionnaire (Table 5.10) show that amongst the provided *Analytics, Achievement Information* about available Competences (Q3; M=3.39, SD=0.786) and

Learning Paths (Q5; M=3.39, SD=0.916) were the ones perceived most helpful, by more than half of the users (57%) for planning learning goals. *Usage Summary* on each available Duty, that illustrated how widely the competences within a given Duty were used by the collective, was the other *Analytics* functionality perceived useful by a noticeable 52% of the users (Q2; M=3.39, SD=0.956). Interestingly, similar analytics information presented on the level of *all* the Duties, rather than for each particular Duty, was perceived helpful for planning purposes by fewer users (Q1; M=3.29, SD=0.937, 12 out of 28 users). *Achievement Information* about available learning activities was the other *Analytics* functionality which less than half of the users, i.e. 39%, acknowledged as beneficial to their planning process (Q7; M=3.21, SD=0.995).

The majority of the users had a rather positive outlook on the usefulness of the provided *Social Stand.* 68% of the users agreed that the provided *Keywords* helped them to plan their personal learning goals (Q11; M=3.75, SD=0.585); *Comments about* (Q10; M=3.43, SD=0.836) and *Average Ratings* of (Q12; M=3.29, SD=0.897) different available learning resources were also perceived as helpful by nearly half of the users (50% and 46% of the users, respectively). However, contrary to this positive perception of the helpfulness of *Social Stand* information in planning personal learning goals, *Social Streams* of the available learning resources were mostly not considered as useful, i.e. on average 61.5% of the participants did not agree with the related questionnaire items (Q4, Q6, Q8 and Q9).

Table 5.10. Descriptive statistics related to RQ1 – Intervention I: Providing Usage Information.

Feature	Question Description in the post-questionnaire	# of users in agreement	N, Mean, Std Dev
Analytics	Q1: The summary for all the Duties helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	12	28, 3.29, 0.937
	Q2: The summary for each specific Duty helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	15	28, 3.39, 0.956
	Q3: The Achievement information about available Competences helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	16	28, 3.39, 0.786
	Q5: The Achievement information about available Learning Paths helped me to plan my personal learning	16	28, 3.39. 0.916

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	goals (e.g. to decide which competences to include in my personal learning goals).		
	Q7: The Achievement information about available Activities helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	11	28, 3.21, 0.995
Social Stream	Q4: The Social Stream of available Competences helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	11	28, 3.14, 0.932
	Q6: The Social Stream of available Learning Paths helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	12	28, 3.11, 0.956
	Q8: The Social Stream of available Activities helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	10	28, 3.14, 1.008
	Q9: The Social Stream of available Assets helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	10	28, 3.07, 0.900
Social Stand	Q10: Available Comments for an available Competence, Learning Path, Activity or Asset helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	14	28, 3.43, 0.836
	Q11: Keywords for an available Competence, Learning Path, Activity or Asset helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	19	28, 3.75, 0.585
	Q12: Average Ratings of available Learning Paths, Activities or Assets helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).	13	28, 3.29, 0.897

In addition to the above questions asking users about their perceived usefulness of the various features of Intervention I, users were asked to rank these functionalities on "how each of them, relative to the others, helped them to plan their personal learning goals" (Q14 – Q20).
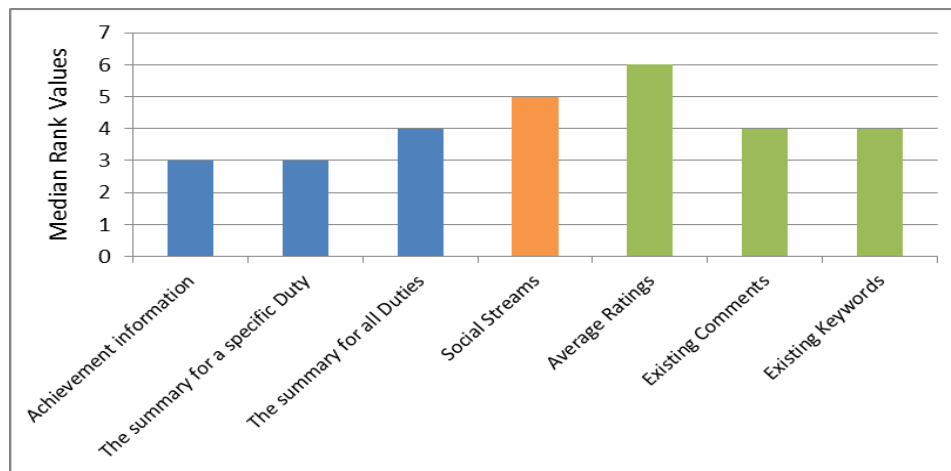
Figure 5.1. Users' rankings of the helpfulness of the functionalities of Intervention I for planning personal learning goals (1: the least helpful, 7: the most helpful).

Figure 5.1 illustrates the median values of users' relative ranks for each of the functionalities; in that rank 1 indicates the least helpful and rank 7 shows the most helpful functionality. In this figure, the functionalities related to the *Analytics* dimension (i.e. achievement information, the summary for a specific Duty and the summary for all Duties) are shown with the blue color; the orange color represents the *Social Stream* dimension, and the bars in green represent the three functionalities related to the *Social Stand* dimension (i.e. average Ratings, existing Comments and existing Keywords). As could be seen in Figure 5.1, the *Social Stand* feature: average ratings was the functionality perceived most helpful for planning processes compared with the other functionalities provided within this intervention, where 61% of the users considered this functionality to have a high rank (ranks 5, 6 or 7). Interestingly, although the majority of the users, i.e. 61.5% on average, did not agree with the respective questionnaire items on the helpfulness of the various *Social Streams* for planning purposes (discussed above), it stood second to the Average Ratings functionality when ranked relative to the other functionalities, with a median rank of 5. Existing comments and keywords (*Social Stand* features), and the summary for all duties (*Analytics* feature) were the functionalities with equal median ranks of 4, indicating they were perceived moderately helpful relative to the other functionalities provided by this intervention. Finally, even though 57% of the users found the achievement information about available competences and learning paths helpful for planning their learning goals, and 52% agreed that the summaries for single duties helped them to plan their learning goals,

these two *Analytics* functionalities were the ones having the lowest median ranks of 3, compared to the other features present in Intervention I.

Results from the Trace Data:

Looking into the frequencies of occurrence of each of my proposed interventions using the intervention event indicators (see section 4.3.4.5) shows that more than half of the participants (56%) used Intervention I at least once (M=3.27, SD=4.653), among which 90% used it less than 10 times, 7% used it between 10 to 15 times, and only one user tried this intervention more than 15 times during the two-month evaluation period.

In the second step of my evaluation approach using the trace data, I examined the contingencies representing the *edges supporting* my a-priori hypotheses (the data analysis approach is discussed in greater details in section 4.3.2.5). In the case of Intervention I: Providing Usage Information, the a-priori hypotheses included *H2.a*, *H2.b* and *H2.c*; see section 4.3.4.1.1 for a detailed discussion on these hypotheses.

H2.a: analyzing the contingencies shows that the majority (62%) of the users who used Intervention I at least one time did not proceed with a planning -Task Analysis action right after; 17% continued with Task Analysis in 5 to 15 percent of the instances that they followed this Intervention with another action (denoted with the red color in Figure 5.2.a); a lower 14% followed with a Task Analysis action in 25 to 50% of the times (denoted with the blue bars) and finally, a minority of 7% went on with a planning event each time that they used Intervention I, shown via the green bars (*H2*.a; Figure 5.2.a; M=14.7, SD=28).

H2.a

Proportion of the pattern "Int.I - Task Analysis" to the total weight of Int.I

Participants who used Int.I at least once

a

H2.b

Proportion of the pattern "Int.I - Goal Setting" to the total weight of Int.I

Participants who used Int.I at least once

b
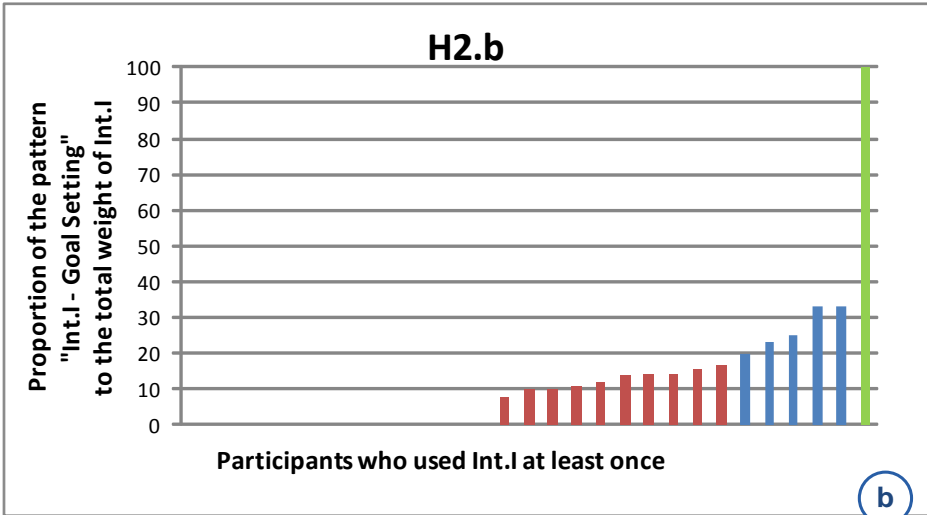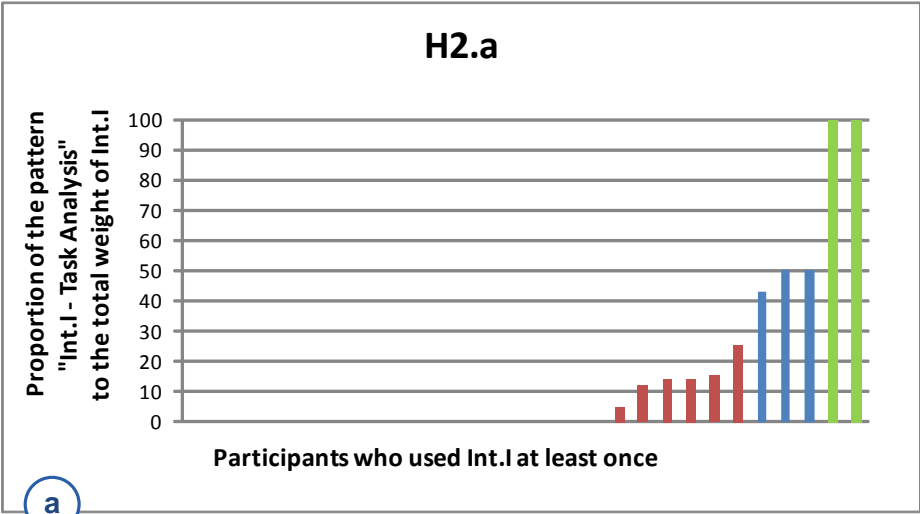
Figure 5.2. Int. I: Providing Usage Information - Analysis of theorized contingencies using trace data, addressing the hypotheses: a) H2.a, b) H2.b and c) H2.c.

H2.b: Users' trace data show that only one user, out of 29 who used Intervention I at least once, engaged in a Goal Setting action after all the instances he/she triggered Intervention I (the green bar in Figure 5.2.b); 17% performed a Goal Setting action right after using Intervention I in 20 to 34 percent of the times they used this intervention (blue bars); for 34% Goal Setting was the performed action in 7 to 17% of the times that they followed Intervention I with another action (red bars) and, less than half of the users, 45%, did not proceed with a Goal Setting action at all after using this intervention (*H2.b*; Figure 5.2.b; M=12.42, SD=19.78).

The results regarding hypothesis *H2.c* indicate that 66% of the users did not follow Intervention I with an indicator of Making Personal Plans; 24% continued with the creation of a personal plan in 5 to 16 percent of the times (denoted with the red color in Figure 5.2.c) and only 10% followed this contingency in 23 to 33% of the times they performed another event right after Intervention I – the blue bars (Figure 5.2.c; M=5.51, SD=9.20).

Additionally, I performed Pearson's correlation analysis on the frequency counts of users' trace data to examine the associations between users' engagement in SRL processes and their use of the proposed interventions. To be consistent with my analysis approach in experiment 1 (see section 4.3.2.1.2), I report only strong and moderate

significant correlations in the following. Following (Cohen, 1988)'s rule of thumb, I considered significant correlations with r values higher than 0.5 as *strong*, and those with r values between 0.3 and 0.5 as *moderate*.

Table 5.11. Observed correlations between the occurrence frequencies of Intervention I and that of SRL Planning processes

Correlation	First Variable	Second Variable	Correlation Coefficient
CR7.a	Planning – Task Analysis occurrence frequency	Int. I: Providing Usage Information usage frequency	r(45) = 0.458, p=0.002
CR7.b	Planning – Goal Setting occurrence frequency		r(45) = 0.673, p=0.000
CR7.c	Planning – Making Personal Plans occurrence frequency		r(45) = 0.682, p=0.000

Results of Pearson's correlation analysis (Table 5.11) show that there were moderate to strong significant, positive correlations between the frequency of using Intervention I and the frequency of engaging in SRL planning processes: i) Task Analysis (CR7.a), ii) Goal Setting (CR7.b), and iii) Making Personal Plans (CR7.c). These correlations show that increases in using Intervention I were correlated with increases in performing planning processes within the Learn-B environment.

5.2.1.2.   Social Wave

The Social Wave intervention was introduced in the full prototype of the Learn-B environment. The objective of this intervention was to inform users of the latest updates about their favourite colleagues (who they follow), as well as to bring them updates about their own learning goals and the learning resources included in them from the social context of their organization. For instance updates such as 'some other colleagues chose a different learning path for the same competence the user has in one of his/her learning goals', or 'they added new activities to a given learning path that the user is also working on', or 'additional knowledge assets were uploaded for a specific learning activity initially created by the users and now being used by other knowledge workers'. This intervention was implemented at three levels in the full prototype: the *General Social Wave* which provided users with all the latest updates from those colleagues the user followed plus the updates on their own learning goals; the *Social*

Waves of User's Learning Resources that updated users specifically on a given learning resource, e.g. a competence and, the *Bubble Social Waves* which illustrated a summarized view on how all the (sub-)resources included in one of user's learning resources were used/updated within the organization, e.g. the social wave bubble of a learning goal showed how all the competences included in that goal were being used by the collective.

Results from the Questionnaire Data:

Table 5.12. Descriptive statistics related to RQ1 – Intervention II: Social Wave.

Feature	Question Description in the post-questionnaire	# of users in agreement	N, Mean, Std Dev
-	Q22: The information provided in Social Waves was clear to me.	15	28, 3.29, 1.013
General Social Wave	Q23: My general Social Wave gave me insight to apply changes in my learning goals or adopt (new) learning resources.	9	28, 2.23, 1.016
	Q24: My general Social Wave helped me to plan my personal learning goals (e.g. to decide which competences to include in my goals, or which Learning Path to choose for a specific competence, or to add a new activity to one of my learning paths).	10	28, 2.93, 1.052
Social Waves of Learning Resources	Q25: The Social Waves of my learning resources (i.e. Learning Goals, Competences, Activities, LPs, or Asset) gave me insight to apply changes in my learning goals or adopt a (new) learning resource.	11	28, 2.96, 1.071
Bubble Social Waves	Q26: The Social Wave bubbles of my learning resources (i.e. Learning Goals, Competences, Activities, LPs, or Asset) gave me insight to apply changes in my learning goals or adopt a (new) learning resource.	9	28, 3.00. 1.054

Users' responses to the questionnaire items on Social Wave (Table 5.12) show that more than half of the users (54%) found this intervention clear in terms of the information it aimed to convey (Q22; M=3.29, SD=1.013). However, 66% of the respondents on average did not agree that their *General Social Wave* helped them with planning (Q24; M=2.93, SD=1.052) or engagement processes (Q23; M=2.23, SD=1.016) – *H2.d* and *H2.e;* and *H2.f* and *H2.g,* respectively. Likewise, the other two features, i.e. the *Social Waves of each particular Learning Resource* as well as the *Bubble Social*

Waves were not considered useful for planning and/or engagement processes by a similar number of users, i.e. 65% on average (Q25 and Q26).

Results from the Trace Data:

In the next step, I examined the collected trace data: the usage frequencies of *Social Wave* during the two-month testing period showed that a noticeable 79% of the participants used this intervention at least one time (M=18.34, SD=25.11), among them 63% used it less than 15 times, 22% used it between 16 to 32 times, and 15% triggered it between 42 to 125 times.

Then, I looked into the theorized contingencies related to this intervention. My a-priori hypothesis with regard to this intervention is that it helps users with the planning (*H2.d* and *H2.e*) and engagement phases (*H2.f* and *H2.g*) of their SRL processes. Hence, I considered the weights of the *supporting edges* that began at indicator events for Social Wave and ended at any of the following four SRL events: Goal Setting (*H2.d*), Making Personal Plans (*H2.e*), Applying Strategy Changes (*H2.f*), and Working on the Task (*H2.g*).

H2.d: the trace data, Figure 5.3.a; M=11.21, SD=16.25, show that about one third (32%) of the users who used Intervention II at least one time, did not follow it with a planning: Goal Setting action. Close to half of them, 44%, engaged in a Goal Setting action right after in 3 to 14% of the times they used this intervention (the red bars in Figure 5.3.a); a smaller 22% continued with a Goal Setting event in 17 to 29% of the times (denoted with blue bars), and only one user (2%) performed a Goal Setting action each time he/she used the Social Wave intervention (the green bar).

H2.d

Proportion of the pattern "Int. II - Goal Setting" to the total weight of Int. II

Participants who used Int. II at least once

a

H2.e

Proportion of the pattern "Int. II - Making Personal Plans" to the total weight of Int. II
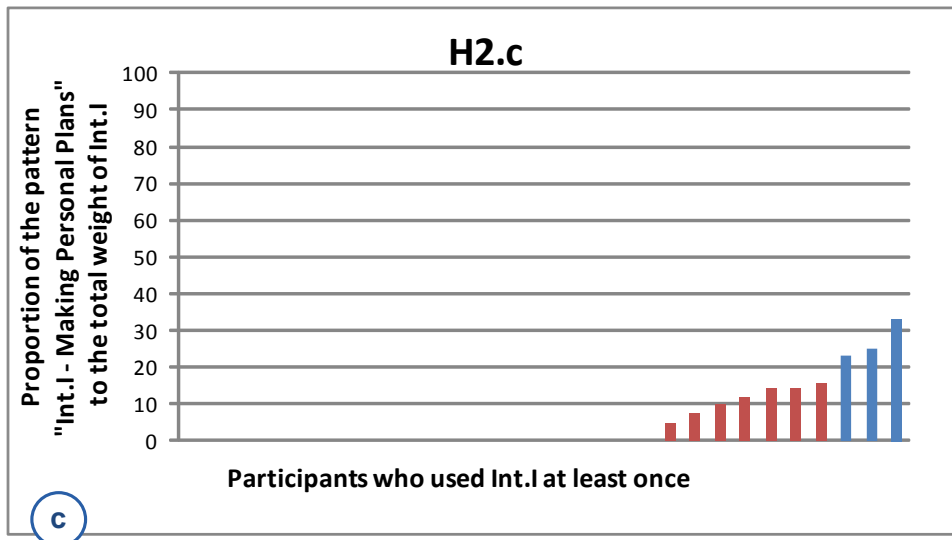
Participants who used Int. II at least once

b

H2.f

H2.g
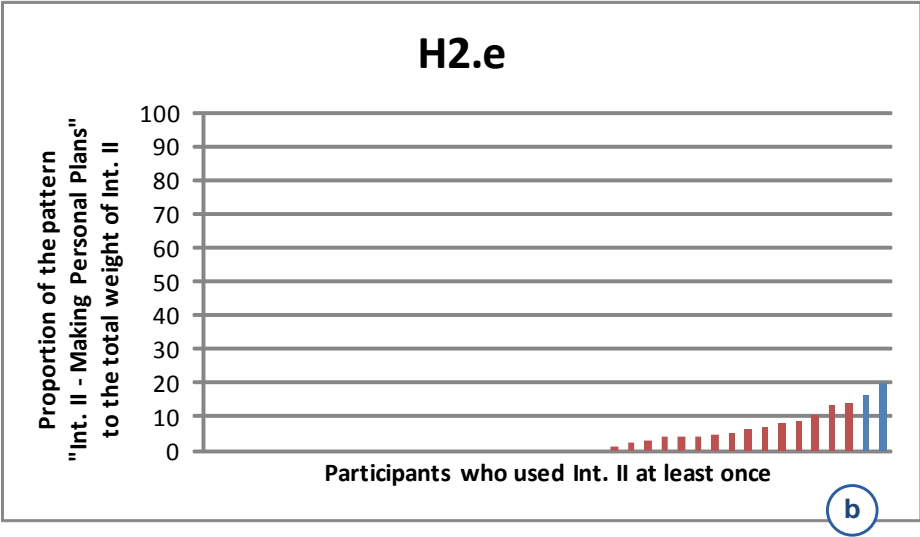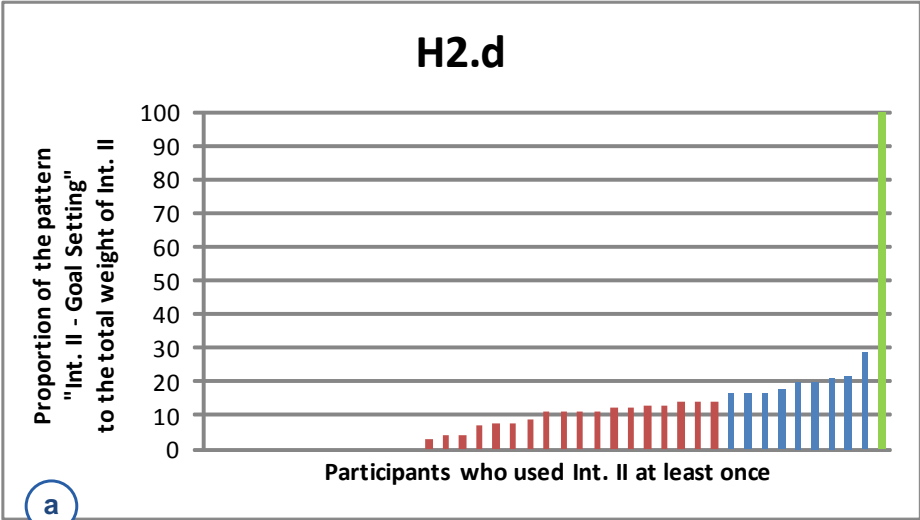
*Figure 5.3. Int. II: Social Wave - Analysis of theorized contingencies using trace
data, addressing the hypotheses: a) H2.d, b) H2.e, c) H2.f and d)
H2.g*

The contingencies regarding *H2.e* indicate that more than half of those who used
Intervention II, i.e. 58%, did not continue their learning actions with Making a Personal
Plan for their learning goals; 37% Made a Personal Plan right after in 1 to 14% of the
time* (red bars); and a small number (5%) followed this pattern in 17 to 20% of the times
they used this intervention – the blue bars (Figure 5.3.b; M=3.29, SD=5.21).

Examining the contingencies supporting hypotheses *H2.f* and *H2.g*, users' trace
data show that an equal 44% of the users, who used the Social Wave intervention at

least once, did not follow this intervention with either of the engagement micro-level processes. 10% of the users performed events indicating Working on their Learning Paths in 20 to 50% of the times right after using Social Wave (the blue bars in Figure 5.3.c), whilst 15% Applied Strategy Changes to their personal plans 16 – 21% of the time (the blue bars in Figure 5.3.d). 43%, on average, continued with actions representing the engagement process in nearly 3 to 14% of the times they used this intervention – the red bars in Figure 5.3.c-d (M=7.41, SD=10.36, and M=5.63, SD=6.61, respectively).

Table 5.13. Observed correlations between the occurrence frequencies of Intervention II and that of SRL processes: Planning and Engagement

Correlation	First Variable	Second Variable	Correlation Coefficient
CR8.a	Planning – Goal Setting occurrence frequency		r(45)=0.778, p=0.000
CR8.b	Planning – Making Personal Plans occurrence frequency	Int. II: Social Wave usage frequency	r(45) =0.740, p=0.000
CR8.c	Engagement – Working on the Task occurrence frequency		r(45)=0.781, p=0.000
CR8.d	Engagement – Applying Strategy Changes occurrence frequency		r(45)=0.745, p=0.000

In the next step of my data analysis approach using the trace data, I focused on exploring the associations between occurrence frequencies of intervention and SRL events. Table 5.13 shows that there were strong, positive correlations between the occurrence frequency of Intervention II, and the frequency of enacting Planning processes: i) Goal Setting (CR8.a), and ii) Making Personal Plans (CR8.b), as well as Engagement processes: i) Working on the Task (CR8.c) and ii) Applying Strategy Changes (CR8.d). As discussed above, the theorized contingencies representing the *supporting edges* did not reveal noticeable occurrences of planning and/or engagement processes right after using the Social Wave intervention. The Pearson correlations, however, clearly show that increases in performing the theorized SRL processes in the Learn-B environment are strongly correlated with increases of using this intervention.

5.2.1.3.   Progress-o-meters

Besides the *Individual Learning Progress* feature which was present in the early prototype, the full prototype implementation of the Progress-o-meters benefited also from the *Comparison* feature. This added functionality allowed users to compare their progress in completing a learning goal, competence, learning path or learning activity with that of their colleagues.

Results from the Questionnaire Data:

During the evaluation of the early prototypes in experiment 1, 72% of the users found the Individual Learning Progress feature useful for their engagement processes (see section 5.1.1.2). Participants' responses from the full prototype evaluation (Table 5.14), however, indicate that this time the majority of the users (78% on average) did not find this intervention useful for the engagement phase of their SRL processes (*H2.j*, *H2.k*: Q29 and Q30).

Table 5.14. Descriptive statistics related to RQ1 – Intervention III: Progress-o-meters.

Feature	Question Description in the post-questionnaire	# of users in agreement	N, Mean, Std Dev
-	Q29: The progress-o-meter of my Learning Resources (i.e. Learning Goals, Competences, Learning Paths and Activities) helped me to monitor my progress in achieving my goals.	7	28, 2.82, 1.123
-	Q30: Observing the progress-o-meter of my Learning Resources (i.e. Learning Goals, Competences, Learning Paths and Activities) helped me to apply necessary changes in my goals and their components.	5	28, 2.64, 1.062

Results from the Trace Data:

Looking into the usage frequencies of Progress-o-meters extracted from users' trace data shows that 42% of the participants used this intervention at least one time (M=5.91, SD=7.62), where 68% used it up to four times, 23% used it between 6 to 16 times, and only two users (9%) tried this intervention between 22 to 30 times during their two-month testing period.
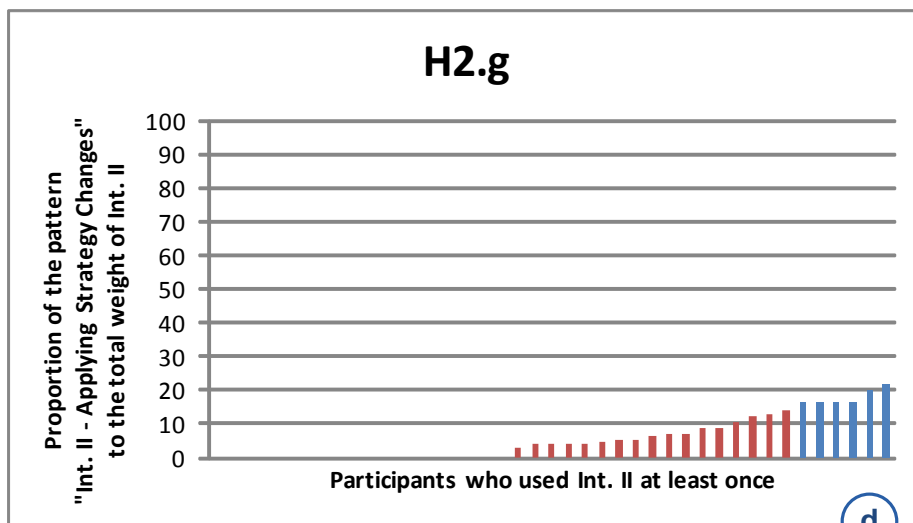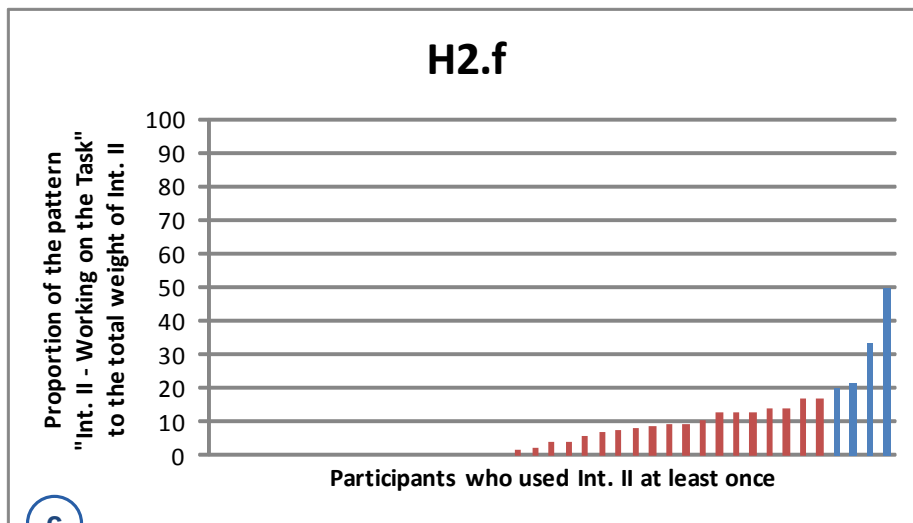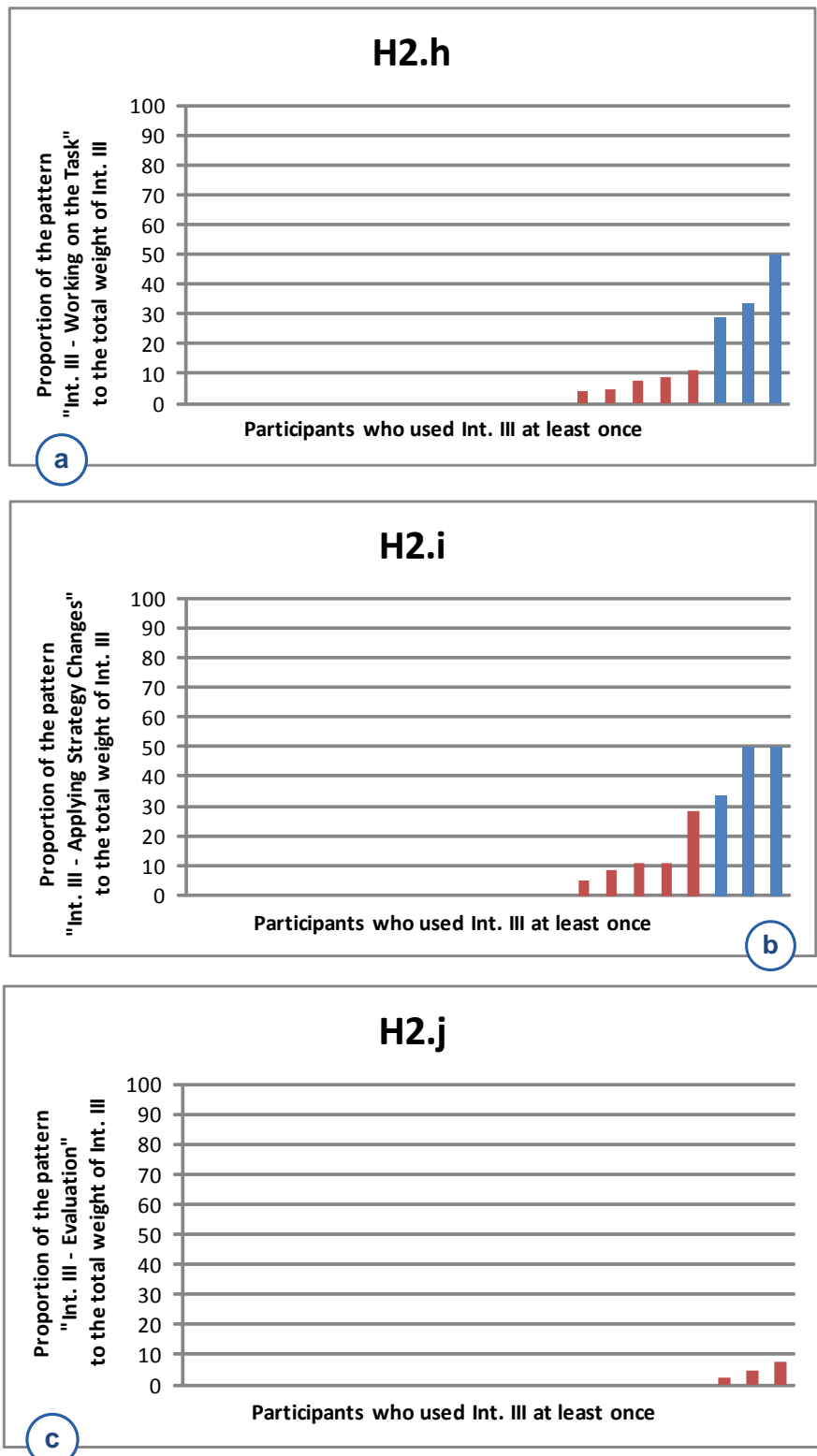
Figure 5.4. Int. III: Progress-o-meters - Analysis of theorized contingencies using trace data, addressing the hypotheses: a) H2.h, b) H2.i and c) H2.j.

In the hypotheses addressing the functionality of this intervention in experiment 2, I theorized that it assists users with their evaluation & reflection, and engagement processes (section 4.3.4.1). To examine the related contingencies, I considered the supporting edges that originated at a Progress-o-meter event and ended at an SRL event representing any of the above SRL processes.

H2.h and *H2.i*: the results from the trace data show that 64% of the users who used Progress-o-meters at least once, did not follow it with either of the engagement micro-level processes (Figure 5.4.a, M=6.753, SD=13.317; Figure 5.4.b, M=8.964, SD=16.176); 23% of the users Worked on their Tasks right after in 4 to 11% of the time (red bars in Figure 5.4.a) and a lower 18% (denoted via the red bars in Figure 5.4.b) Applied Changes to their Learning Tasks in 5 to 11% of the times that they used this intervention. 14% of the users engaged in their learning tasks right after in 29 to 50% of the time (blue bars in Figure 5.4.a), and a slightly higher 18% Applied some Changes in their learning tasks in, similarly, 28 to 50% of the times that they triggered this intervention – shown via the blue bars in Figure 5.4.b.

The theorized contingencies related to *H2.j* show that the majority of the participants, 86%, did not follow their usage of progress-o-meters with an evaluation (micro-level) process; and only a small 14%, the red bars in Figure 5.4.c, performed an evaluation event right after in 2 to 8% of the times that they triggered their Progress-o-meters (Figure 5.4.c; M=0.675, SD=1.93). Remarkably, none of the users engaged in a reflection process after their use of this intervention – *H2.k*.

Table 5.15. Observed correlations between the occurrence frequencies of Intervention III and that of SRL processes Engagement, Evaluation & Reflection

Correlation	First Variable	Second Variable	Correlation Coefficient
CR9.a	Engagement – Working on the Task occurrence frequency	Int. III: Progress-o-meters usage frequency	r(45)=0.696, p=0.000
CR9.b	Engagement – Applying Strategy Changes occurrence frequency		r(45)=0.668, p=0.000
CR9.c	Evaluation & Reflection –Evaluation of the Learning Process occurrence frequency		r(45)=0.550, p=0.000
CR9.d	Evaluation & Reflection –Reflection on the Learning		r(45)=0.544, p=0.000

Table 5.15 shows that strong positive correlations existed between the usage frequency of Intervention III, and the frequencies of performing the hypothesized SRL processes. Although the majority of the users did not perform an evaluation event right after using the progress-o-meter intervention (as discussed above), correlation CR9.c indicates that increases in the usage frequency of this intervention were strongly correlated with the increases in performing evaluation processes. By the same token, correlation CR9.d points to positive correlations between the occurrence frequency of reflection events and the usage frequency of Intervention III in the Learn-B environment, although there were no supporting edges amongst the respective contingency patterns. In other words, none of the users followed their usage of Progress-o-meters with a reflection act, yet the increases in their enactment of reflection events were strongly correlated with increases in using the Progress-o-meters.

5.2.1.4. User-recommended Learning Goals

This intervention was introduced in the full prototype considering the suggestions and feedback received from the evaluation of the early prototypes in experiment 1 – see section 4.3.3 for more details. Its aim was to enable users to collaboratively work on shared learning goals. To this end, users first recommend the intended learning goal(s) to their colleagues, and once the recipient(s) accepts the recommendation the learning goal would appear as a shared goal (via a "sharing" icon next to it) in the Learn-B environment. From this point on, the recipient(s) and the recommender can treat this goal as their other regular goals, with the difference that any changes applied to it would be visible to all the involved parties.

Results from the Questionnaire:

Table 5.16. Descriptive statistics related to RQ1 – Intervention IV: User-recommended Learning Goals.

Feature	Question Description in the post-questionnaire	# of users in agreement	N, Mean, Std Dev
-	Q35: The Recommended Learning Goals by my peers helped me to start my learning process (e.g., choosing additional competences to include in my learning goal,		28, 3.86, 0.651

choosing the learning paths and accompanying assets, and updating their properties).	20

Results from the participants' responses to the respective questionnaire item (Table 5.16, Q35) indicate that a noticeable 71% of the users acknowledged that Intervention IV helped them with their planning processes (*H2.l, H2.*m; M=3.86, SD=0.651).

Results from the Trace Data:

Studying the usage frequencies obtained from the trace data showed that only 15% of the participants (all from the first business case) used this intervention at least once, and to be exact, between 1 to 6 times during the second evaluation period (M=2.87, SD=1.83).

H2.l

H2.m

***Figure 5.5. Int. IV: User Recommended Learning Goals - Analysis of theorized contingencies using trace data, addressing the hypotheses:* a) H2.l, b) H2.m.**

My a-priori hypothesis regarding this intervention is that it assists users with their Task Analysis and Goal Setting processes. To extract the probable contingencies, I examined the supporting edges that started at an event representing Int. IV and ended at an SRL event representing either Goal Setting or Task Analysis processes. The results from the trace data show that among the 15% who used this intervention, the majority (87%) did not follow it with a Task Analysis, or Goal Setting (75%) event. Only one user (12%) performed Task Analysis right after in 20% of the times he/she used this intervention (the red bar in Figure 5.5.a; M=2.50, SD=7.071); and 25% of the users

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engaged in Goal Setting actions in 25 – 100% of the times they triggered this intervention (the red bars in Figure 5.5.b; M=15.625, SD=35.197).

Table 5.17. Observed correlations between the occurrence frequencies of Intervention IV and that of SRL Engagement, Evaluation & Reflection processes

Correlation	First Variable	Second Variable	Correlation Coefficient
CR10.a	Planning – Goal Setting occurrence frequency	Int. IV: User-recommended Learning Goals usage frequency	r(45)=0.452, p=0.002

Results from the Pearson correlation analysis between the usage frequencies of this intervention and that of the hypothesized SRL processes (i.e. task analysis and goal setting) indicate that there existed a moderate positive correlation between this intervention and only the usage frequency of the goal setting process (CR10.a). The occurrence frequency of the Task Analysis process was not significantly correlated with that of this intervention.

5.2.1.5.   Recommended available Competences

The functionality of this intervention remained the same across the two evaluation experiments. The purpose of this intervention is to inform users of the learning objectives and requirements of their organization through recommendation of those competences within the organization that are related to each user's responsibilities and thus of higher importance to that specific user. Such recommendations could assist users to better know the learning requirements of their organization, and plan for their personal learning processes accordingly. Thus, my a-priori hypothesis here was that this intervention supports users in their planning phase, including Task Analysis, Goal Setting and Making Personal Plans micro-level processes.

Results from the Questionnaire:

Results from experiment 1 showed that 72% of the users acknowledged it was useful to know which competences fit their immediate learning needs, so that they could boost their professional performance (see section 5.1.1.1). Remarkably consistent with this finding, users' responses from experiment 2 (Table 5.18) indicate that 75% of the

participants evaluating the full prototype agreed with a similar statement in the context of the second experiment (Q40; M=3.82, SD=0.983). On the other hand, only 38% of the users participating in experiment 1 considered the *visual icons* beside available competences useful for their planning process (see section 5.1.1.1). With a slight increase in the number of the users in agreement, 43% of the users in experiment 2 perceived the visual icons helpful when planning their personal learning goals (Q39; M=2.89, SD=1.315).

Categorization of available competences based on the different dimensions of users' responsibilities and associations in the organization, e.g. the duties they have, the roles they hold or the tasks they are responsible for, was another functionality of this intervention which more than half of the users found helpful in Task Analysis, e.g. finding their required competences (Q38; M=3.57, SD=0.920).

Table 5.18. Descriptive statistics related to RQ1 – Intervention V: Recommended available Competences.

Feature	Question Description in the post-questionnaire	# of users in agreement	N, Mean, Std Dev
Organizational context	Q38: Categorization of competences (to roles, duties, colleagues and the like) helped me to find the competences that I needed.	17	28, 3.57, 0.920
	Q40: Knowing what Competences are required by my organization for each Duty/Task/Role helped me to pick those competences that fit my immediate learning needs.	21	28, 3.82, 0.983
Personalized Cues	Q39: Visual icons beside each available competence helped me to pick those competences that fit my immediate learning needs. (i.e. the priority, required level and prerequisite).	12	28, 2.89, 1.315

Results from the Trace Data:

Analysing users' trace data, the usage frequencies of Intervention V indicated that around half of the participants, i.e. 52%, used this intervention at least once during their two-month testing period (M=6.48, SD=7.45). Among them, the majority used this intervention up to 10 times (81%), and the rest used it between 13 to 29 times.

My a-priori hypothesis regarding the functionalities provided by this intervention, states that it helps users with their planning processes, in particular Task Analysis, Goal Setting and Making Personal Plans micro-level processes (section 4.3.4.1). Exploring the theorized contingencies, I examined the *supporting edges* which started at an event indicative of this intervention and ended at an event representing any of the above three micro-level SRL processes.

H2.n: the proportional weights of the respective edges show that among the users who used this intervention at least one time, 33% did not follow it with a planning - Task Analysis event; 26% engaged in a Task Analysis action in 11 to 25% of the times they used this intervention (red bars in Figure 5.6.a), and 41% continued this intervention with a Task Analysis event in 27 to 67% of the time – denoted with blue bars (Figure 5.6.a; M=22.911, SD=20.139).
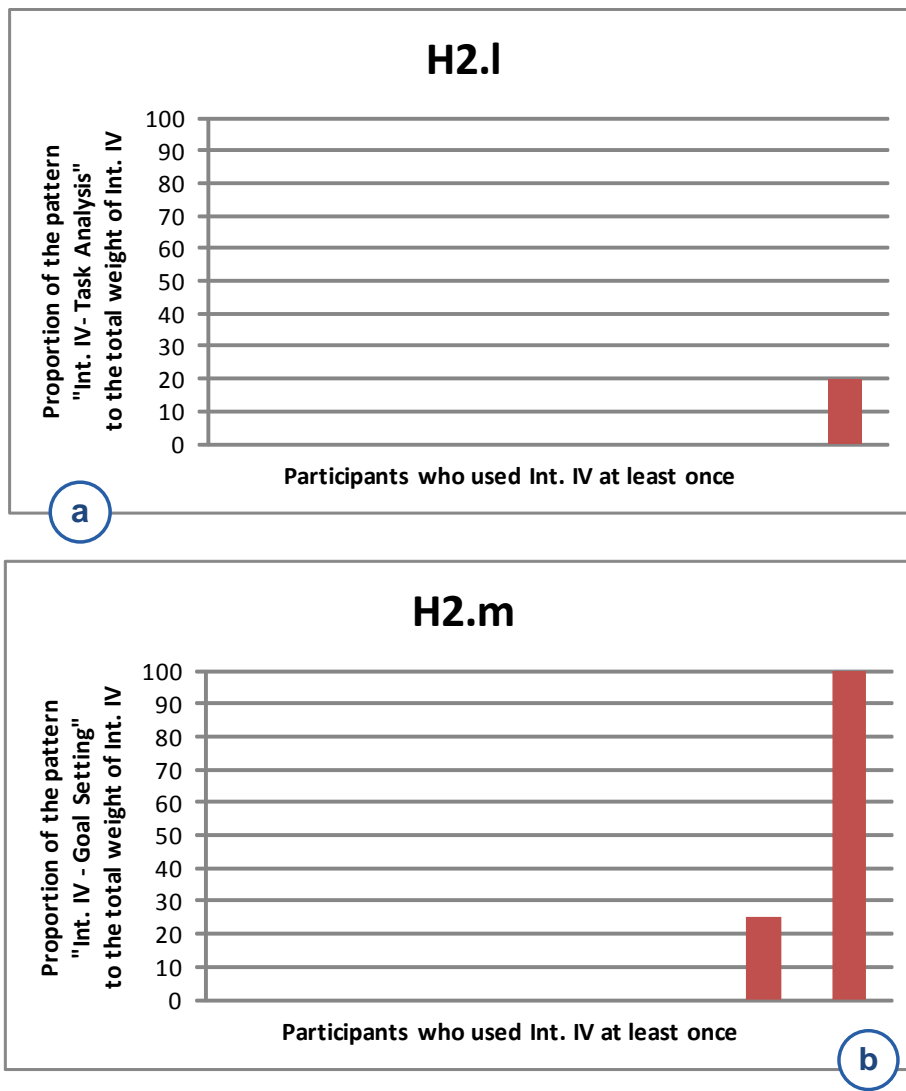
Figure 5.6. Int. V: Recommended Available Competences - Analysis of theorized contingencies using trace data, addressing the hypotheses: a) H2.n, b) H2.o and c) H2.p

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The contingencies related to *H2.o* indicate that nearly half of the users, 52%, did not perform a Goal Setting action after using this intervention; 30% did engage in Setting their learning Goals right after in 2 to 17% of the times they triggered this intervention (represented via the red color in Figure 5.6.b); a lower 11% performed Goal Setting in 25 to 50% of the time (the blue bars in Figure 5.6.b); and only 7% (two out of 27 users) went on with Making their Personal Plans each time that they used Intervention V – the green bars (Figure 5.6.b; M=14.003, SD=27.539).

H2.p: A majority, 85%, of the users who used this intervention did not perform any of the indicators for creating a learning path right after using this intervention, and the remaining 15% followed this intervention with Creating their Learning Plans in 3 to 33% of the time – denoted with the blue bars (Figure 5.6.c; M=2.672, SD=8.024).

Table 5.19. Observed correlations between the occurrence frequencies of Intervention VI and that of SRL Engagement, Evaluation & Reflection processes

Correlation	First Variable	Second Variable	Correlation Coefficient
CR11.a	Planning – Task Analysis occurrence frequency	Int. V: Recommended available Competences usage frequency	r(45)=0.637, p=0.000

The above theorized contingencies showed that users did perform all of the hypothesized planning processes right after using Intervention V, though mostly with frequencies lower than 50% of the time. Table 5.19, however, shows that there existed a strong positive correlation between the usage frequency of this intervention and that of only the Task Analysis micro-level process (CR11.a). The usage frequencies of the other two planning micro-level processes were not significantly correlated with the usage frequency of Intervention V.

5.2.1.6. Recommended available LPs, LAs and KAs

The aim of this intervention is to inform users about the learning needs and expectations of their organization by providing them with information about the available learning paths and the knowledge assets included in those paths, which could be taken to achieve the preferred competences. Its functionalities available in experiment 2 were

the same as in the early prototype, with the addition of a sorted list of the recommended learning paths, where the most matching path came atop the list.

Table 5.20. Descriptive statistics related to RQ1 – Intervention VI: Recommended available LPs, LAs and KAs.

Feature	Question Description in the post-questionnaire	# of users in agreement	N, Mean, Std Dev
-	Q43: The Learning Path on top of the list matched my learning needs.	15	28, 3.36, 0.951
-	Q44: Seeing who the creator of a recommended Learning Path is, helped me to pick the Learning Path that suits my learning needs.	18	28, 3.71, 0.854

Results from the Questionnaire:

H2.q, *H2.r* and *H2.s*: in experiment 1, a good majority of the users (86%) asserted that seeing the available learning paths for a competence was useful to their planning processes (see section 5.1.1.1). In experiment 2, a lower but still notable 64% of the users agreed that knowing about the creator of a learning path helped them with their planning phase (Table 5.20; Q44). Yet, suitability of the recommended learning path atop the sorted list of the recommendations was approved by a much lower percent of the users (Q43; M=3.36, SD=0.951).

Results from the Trace Data:

The usage frequencies of Intervention VI, extracted from users' trace data in experiment 2, indicated that 65% of the users used this intervention at least once during their two-month testing period (M=12.06, SD=11.77), among them 56% used this intervention between 1 to 10 times, 32% used it between 12 to 25 times, and a lower 12% used it between 31 to 47 times.
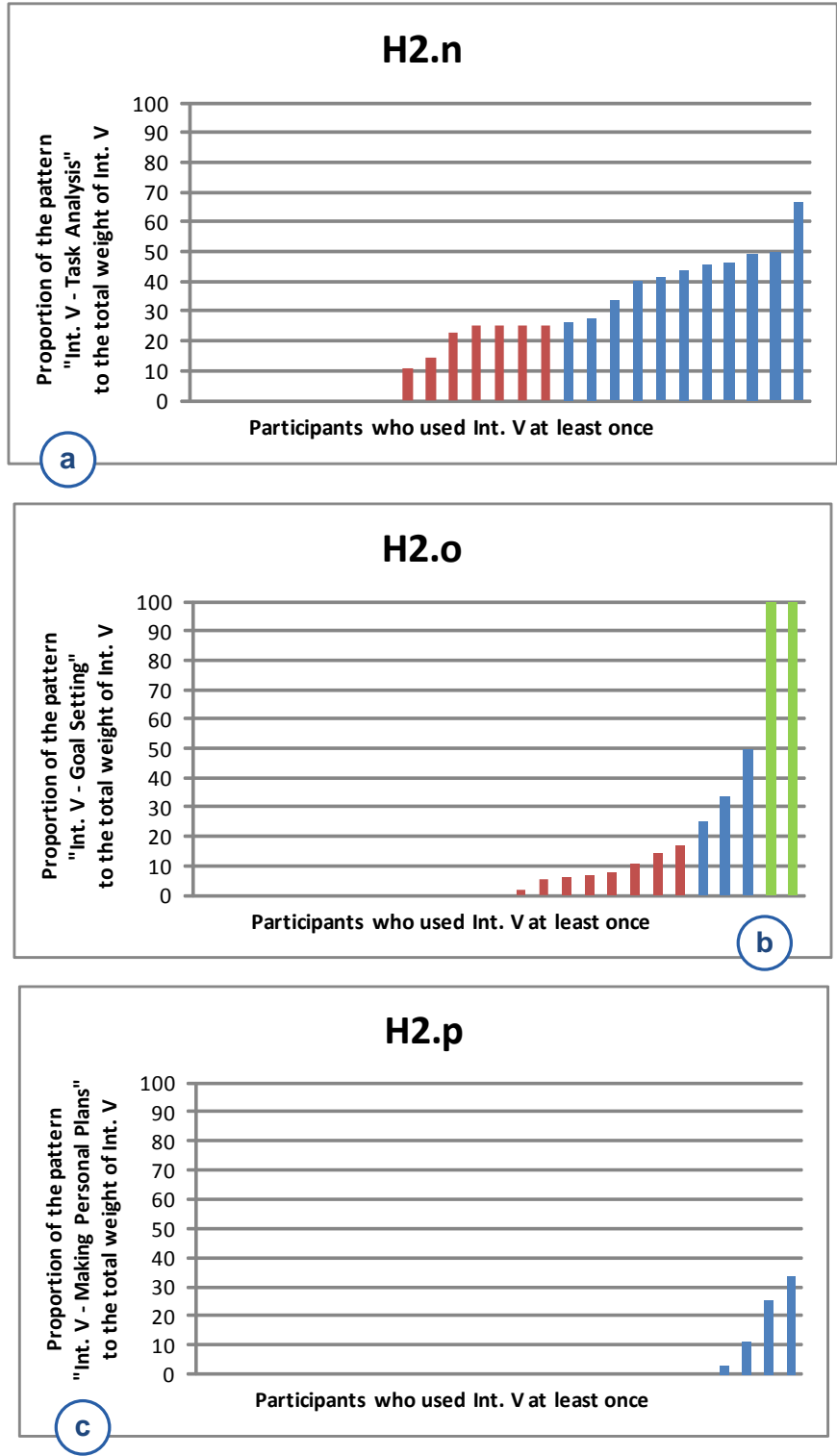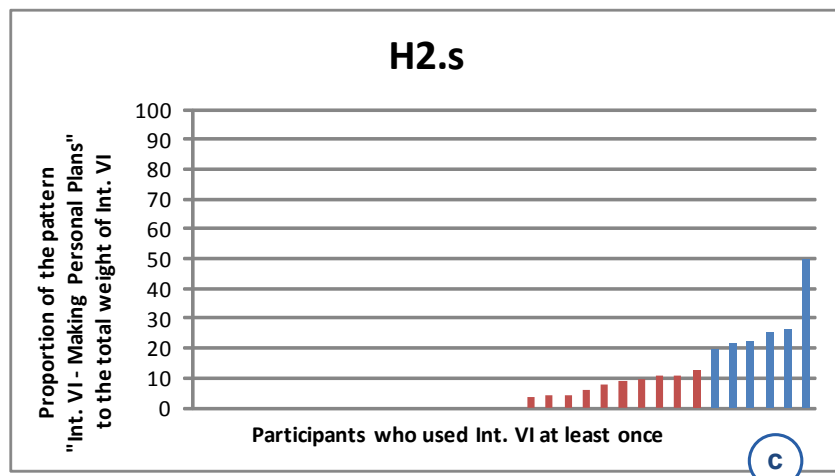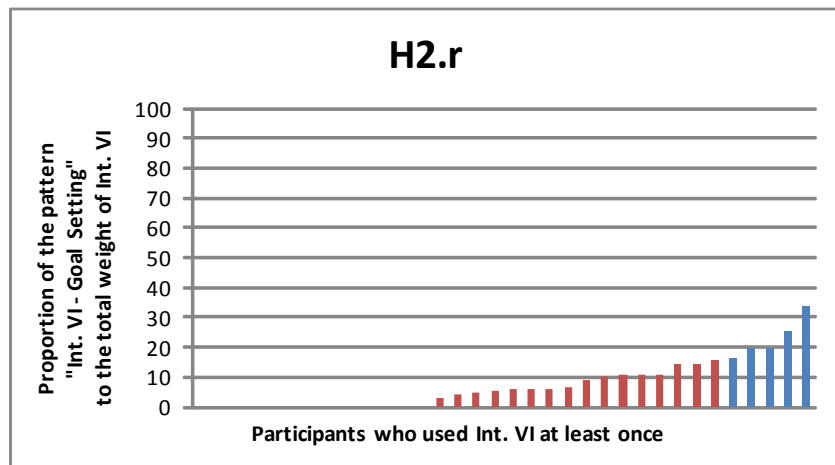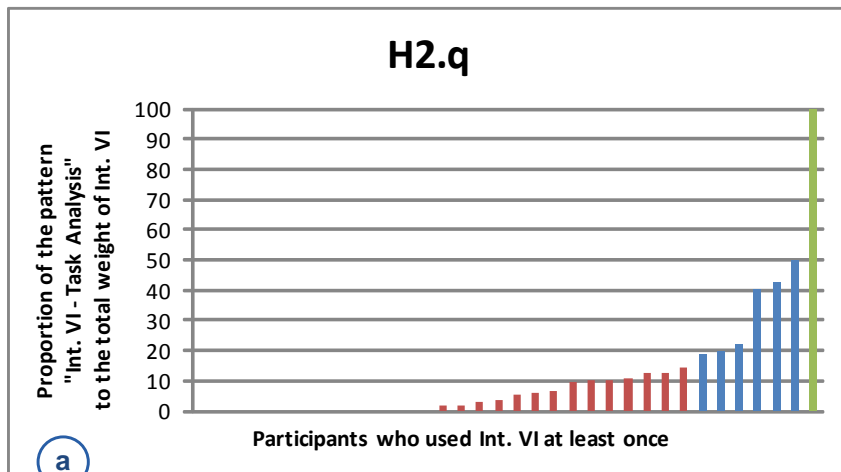
Figure 5.7. Int. VI: Recommended Available Learning Paths - Analysis of theorized contingencies using trace data, addressing the hypotheses: **a) H2.q, b) H2.r and c) H2.s.**

Considering the functionality of this intervention, I hypothesized that, along with Intervention V: Recommended available Competences, it helps users with their planning processes. Accordingly, when exploring the theorized contingencies I looked into the weights of the edges which started at an event manifesting this intervention and ended at an SRL event indicator of the planning process. The resulting supporting edges showed that 38% of the users who used this intervention at least once, did not follow it with Task Analysis or Goal Setting actions (Figure 5.7.a, M=11.83, SD=20.22; Figure 5.7.b, M=7.443, SD=8.406); 41% followed with Task Analysis action in 2 to 14% of the time (the red bars in Figure 5.7.a) and close to half of the users, 48%, engaged in Goal Setting in 3 to 15% of the times that they used this intervention (shown via the red color in Figure 5.7.b). A much lower 18% performed Task Analysis right after in 19 to 50% of the time (the blue bars in Figure 5.7.a); 15% Set their learning Goals in 17 to 33% percent of times they triggered this intervention (the blue bars in Figure 5.7.b); and only one user (3%) engaged in Task Analysis after their every usage of this intervention – the green bar in Figure 5.7.a. More than half of these users, 53%, did not follow their usage of this intervention with Creation of their Personal Plans; 29% performed an event indicator of Making Personal Plans right after in 3 to 12% of the time (the red bars in Figure 5.7.c); and a lower 18% Created their Personal Plans in 20 to 50% of the time; denoted with the blue color in Figure 5.7.c (Figure 5.7.c, M=7.172, SD=11.205).

Table 5.21. Observed correlations between the occurrence frequencies of Intervention VI and that of SRL Planning processes

Correlation	First Variable	Second Variable	Correlation Coefficient
CR12.a	Planning – Task Analysis occurrence frequency	Int. VI: Recommended available LPs, LAs and KAs usage frequency	$r(45)=0.429, p=0.000$
CR12.b	Planning – Goal Setting occurrence frequency		$r(45)=0.670, p=0.000$
CR12.c	Planning – Making Personal Plans occurrence frequency		$r(45)=0.648, p=0.000$

Performing the Pearson correlation analysis, moderate to strong positive correlations were found between the usage frequency of this intervention and that of the hypothesized SRL planning processes (Table 5.21). These correlations indicate that the

extent to which users engaged in SRL Planning processes is positively associated with the frequency with which they used this intervention.

5.2.1.7.   Knowledge Sharing Profiles

Knowledge Sharing Profile was another demanded intervention introduced in the full prototype to: i) allow users to become aware of the extent of their knowledge sharing activities within the organization, as well as ii) enable them to compare such activities with that of their colleagues.

Results from the Questionnaire Data:

When asked about their perception on this intervention in experiment 2 (Table 5.22), 61% of the users stated such a profile, and in particular its comparison feature, affected their knowledge sharing behaviour (Q48; M=3.50, SD=1.106). A fewer number of the users, i.e. an exact 50% of them, agreed that the comparison feature actually motivated them to further share their learning reflections within the organization (Q49) – *H2.t.*

Table 5.22. Descriptive statistics related to RQ1 – Intervention VII: Knowledge Sharing Profiles.

Feature	Question Description in the post-questionnaire	# of users in agreement	N, Mean, Std Dev
-	Q48: Seeing how much other people shared their learning resources compared to my sharing activities, influenced my knowledge sharing behaviour.	17	28, 3.50, 1.106
-	Q49: Seeing how much other people shared their learning resources compared to my sharing activities, motivated me to provide some reflections and feedback on my learning experience.	14	28, 3.32, 1.156

Results from the Trace Data:

The usage frequencies related to this intervention show that only 17% of the users, all from the first business case, used this intervention at least once (M=2.23, SD=3.279), the majority (89%) of which used the intervention up to two times (89%), and only one user triggered it 11 times during their two-month testing period.

Looking for potential theorized contingencies, however, revealed that none of the users, who actually used this intervention, continued with a Reflection action right after (i.e. no supporting edges – *H2.t*); neither was there a significant correlation between the usage frequency of this intervention and that of the Reflection (micro-level) process included in the respective hypothesis, *H2.t*.

5.2.2.   Summary of the Results for RQ1

In my first research question in experiment 2, I aimed to explore whether and to what extent the different features provided via my proposed interventions support users in performing their SRL processes. In this experiment, all of the proposed interventions were implemented as fully working prototypes within the Learn-B environment, including Intervention I (Providing Usage Information), II (Social Wave), III (Progress-o-meters), IV (User-recommended Learning Goals), V (Recommended available Competences), VI (Recommended available LPs, LAs and KAs) and VII (Knowledge Sharing Profiles), and the users could potentially enact all the three SRL phases included in the theoretical framework (see section 3.1), using the Learn-B environment. To answer this research question, I analyzed users' responses to the post-questionnaires which they filled out after the two-month testing period along with their trace data of using the Learn-B environment in this period, collected during the testing period. When analysing the trace data, I looked in particular for theorized contingencies supporting my respective a-priori hypotheses raised in this research question, as well as associations between users' engagement in (micro-level) SRL processes and their use of the proposed interventions, again as hypothesized with regard to each of the proposed interventions (see section 4.3.4.5 for more details on my analysis approach).

In experiment 2, a new feature was added to intervention I. This feature, called *Social Streams*, aimed to inform users about how often different learning resources in their organization have been used by their colleagues or what actions were performed on them in a certain period. Users' responses to the post-questionnaire items show that 50% of the users on average agreed that the different aspects of the *Analytics* feature of Intervention I assisted them with their SRL planning processes. A slightly larger 55% of the users, on average, had a positive perception of the usefulness of different aspects of the *Social Stand* feature, and the *Social Stream,* a new feature implemented in the full

prototype of the Learn-B environment, was the feature that the least number of users, 38%, found useful for their planning actions. Examining the theorized contingencies from users' trace data shows that a noticeable 62% of the ones who used Intervention I, did not proceed with the Task Analysis process (as theorized in *H2.a,* Figure 4.10), and the rest enacted this contingency, on average, only in 39% of the times that they followed Intervention I with another action in the Learn-B environment. A smaller 45% of the participants did not proceed with a Goal Setting action at all after using Intervention I (*H2.b*), and those who did, followed this contingency on average 22% of the time. Finally, the largest number of users, 65%, did not perform an event indicative of the Making Personal Plans process right after using Intervention I (*H2.c*), and the remaining 35% followed this contingency only in 16% of the time, on average. Results of the conducted Pearson's correlation analysis show that users' frequencies of utilising this intervention were positively correlated with their frequency of engaging in the theorized SRL planning processes (CR7.a, CR7.b and CR7.c in Table 5.11).

The Social Wave intervention was implemented in the full prototype of the Learn-B environment, aiming to bring users updates from the social context of their organization about their colleagues (whom they follow), and about their own learning goals and the learning resources included in them. The post-questionnaire data show that although 54% of the users found the information provided via the Social Wave intervention clear, on average only 39% agreed that its different functionalities, i.e. the *general* Social Wave, *individual* Social Waves for *learning resources* and *Bubble* Social Waves, supported them in performing their Planning and/or Engagement processes. Furthermore, users' trace data indicate that a small number (32%) of the users who used Intervention II, did not follow it with a Goal Setting micro-level process (as theorized in *H2.d* - see Figure 4.10 and section 4.3.4.1.1 for more details on my a-priori hypotheses in experiment 2), and the rest who did, followed this theorized contingency on average in 16% of the times. A much larger number (58%) of the participants did not continue their usage of Social Wave with an action indicative of Making their Personal Plans (*H2.e*), and the 42% who did follow this contingency, performed it only 8% of the time. Finally, 44% of the users did not proceed with this intervention using either of the engagement micro-level processes: Working on the Task and Applying Strategy Changes (*H2.f* and *H2.g*); and those who did, performed the theorized contingencies in only 13 and 10

percent of the times, respectively. As could be seen, the trace data did not reveal noticeable occurrences of the theorized contingencies; however, the correlation analyses show there were strong positive associations between users' usage frequency of this intervention and their frequency of performing the theorized SRL processes (CR8.a to CR8.d in Table 5.13).

The *Comparison* feature was added to the Progress-o-meters intervention in experiment 2, which enabled users to also compare their progress in completing their learning goals with that of their colleagues. Users' responses to the post-questionnaire show that despite users' positive outlook on the usefulness of this intervention in experiment 1 (see section 5.1.1.2), a noticeable 78% did not agree that it helped them with their engagement processes. Results from the trace data show that more than half of the users (64%), who used Progress-o-meters at least once, did not follow it with either of the engagement processes (as hypothesized in *H2.h* and *H2.i*, Figure 4.10); and those who did follow these theorized contingencies, performed it in only 18 % (Working On The Task micro-level process) and 25% (Applying Strategy Changes micro-level process) of the time. Moreover, a noticeable majority of 86% did not follow the contingency supporting *H2.j*, i.e. following the use of Progress-o-meters with an action indicative of Evaluating their learning processes, and the rest who did, complied with this contingency very rarely, i.e. 5% of the time on average. Interestingly, no edge from Intervention III to an SRL Reflection micro-level process was observed in users' trace data, supporting *H2.k*. Similar to the previous interventions, Pearson's correlation analyses show that even though there were not many edges in users' trace data supporting the theorized contingencies, users' frequencies of utilising this intervention were positively correlated with their frequency of engaging in the theorized SRL planning processes (CR9.a to CR9.d in Table 5.15).

User-recommended Learning Goals was another intervention implemented newly in the full prototype of Learn-B, with the objective to allow users to share their learning goals with their colleagues and collaboratively work on them. The post-questionnaire data shows that 71% of the users found this intervention useful for their planning processes. Users' trace data show that the majority of the users, who used this intervention, did not follow it at all with either of the theorized planning contingencies (*H2.l* and *H2.m*): 87% in the case of Task Analysis and 75% in the case of Goal Setting

processes; and those who did, followed the theorized contingencies in 20% of the time with regard to the former, and 65% of the time for the latter process, on average. The results of the correlation analysis indicate that a positive correlation existed between users' usage frequency of this intervention and only their engagement in Goal Setting events (CR10.a in Table 5.17).

Users' responses to the post-questionnaire show that 68% of the participants in experiment 2 agreed that different aspects of the *Organizational context* feature of Intervention V assisted them with their planning processes. The *Personalized Cues* feature, however, was found useful for the same purpose by less than half of the participants (43%). Results from users' trace data show that of the users who used this intervention for at least one time, 33%, did not follow it with a Task Analysis event (*H2.n*), the 66% who did follow this contingency (*H2.o*), complied with it on average in 34% of the time; 52% did not perform a Goal Setting action right after, and those who did, performed the theorized contingency in 29% of the time; and finally, a majority of 85% did not follow the contingency supporting *H2.p*, i.e. following their usage of this intervention with an event indicative of Making Personal Plans, whilst the remaining 15% performed this contingency in only 33% of the time. Users' usage frequencies of this intervention were significantly correlated only with their frequency of performing task analysis micro-level process (CR11.a in Table 5.19).

Similar to the previous intervention, the functionality of Intervention VI remained the same across the two experiments. The post-questionnaire data show that around half of the users found the recommendations provided by this intervention matching their learning needs, and a larger 64% agreed that knowing about the creator of a learning path helped them with picking their learning plans. Results from users' trace data indicate that 38% of the users, who used this intervention at least once, did not follow it with either Task Analysis or Goal Setting micro-level processes (*H2.q* and *H2.r*); the remaining 62% engaged in the theorized contingencies in 19 and 12 percent of the times, respectively. More than half of these users, 53%, did not proceed with Making their Personal Plans, and those who did, complied with this contingency in only 15% of the time. Pearson's correlation analyses show that the extent to which users engaged in their respective theorized SRL processes was positively correlated with their usage frequencies of this intervention (CR12.a, CR12.b and CR12.c in Table 5.21).

Knowledge Sharing Profile was the last intervention introduced in the full prototype, aiming to inform users of the extent of their knowledge sharing activities within their organization as well as allowing them to compare their sharing activities with that of their colleagues. Users' responses to the post-questionnaire indicate that half of them found this intervention helpful for their Reflection process. The trace data, however, revealed that none of the users who used this intervention followed it with an event indicative of the reflection process, nor was there any significant correlation between users' usage frequency of this intervention and their engagement in the respective hypothesized SRL micro-level process (*H2.t*).

5.2.3. RQ2. The most effective SW-enabled interventions supporting users' SRL processes in workplace settings

In my second research question, RQ2 (see section 4.3.4.1.2), I aimed to identify the interventions that were the most effective in supporting users' (self-regulatory) learning processes at their workplace. To investigate RQ2, I started with examining the transition graph of learning actions of all the participants, collected and parsed in terms of their log files, in order to find the most influential intervention(s) – see Figure 5.8 (only the edges from an Intervention node to an SRL node are shown in this figure).
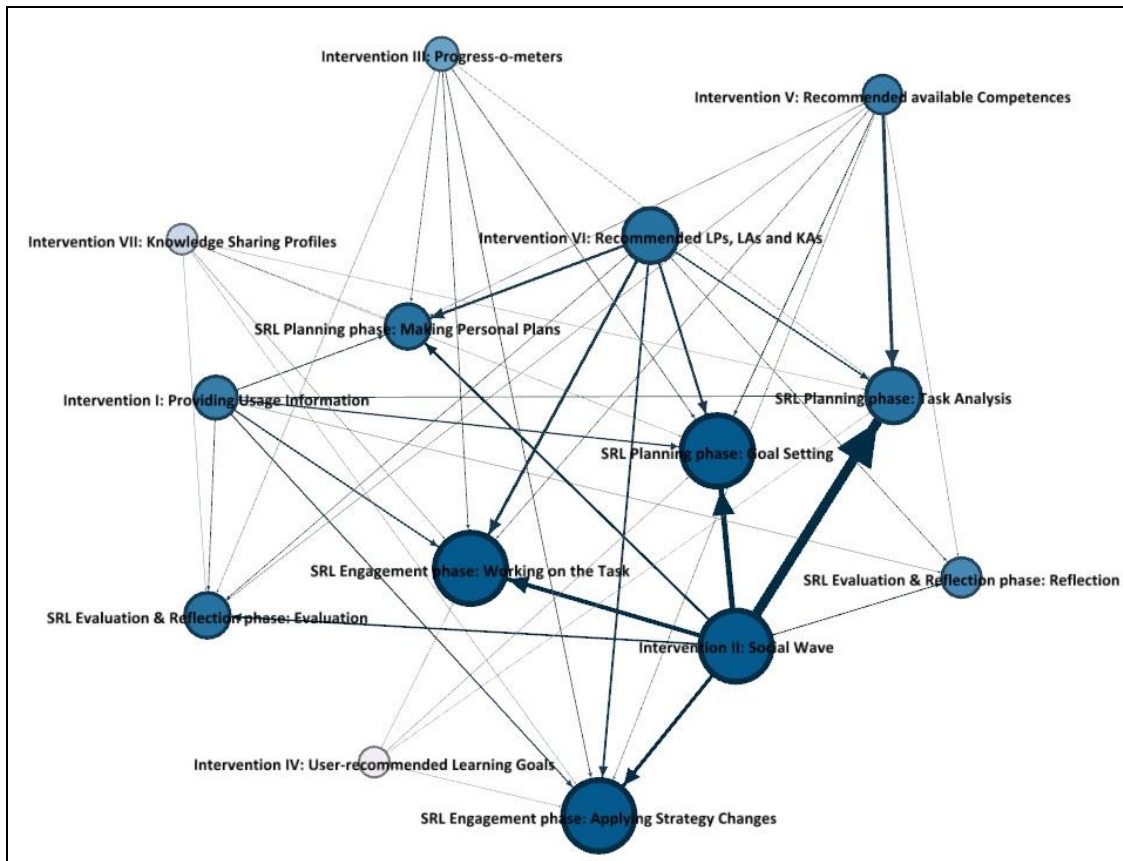
Figure 5.8. The transition graph generated from the trace data of all users'. Size of a node indicates its influence in the graph; thickness of a link represents its frequency of occurrence.

To this end, I calculated and compared the graph theoretic centrality measures of my proposed interventions including their *degree*, *betweenness*, *closeness*, and *eigenvector* values within the graph of users' learning action in the Learn-B environment during the two-month evaluation period. In addition, I was interested to find out whether (and to what extent) users' usage of my proposed interventions was associated with and could account for their engagement in SRL processes. That is, the SRL processes besides those included in my a-priori hypotheses (discussed in RQ1), taking into account the effect of cofounding variables such as users' computer skills and familiarity with both their personal and organizational learning needs. In the following, I present and discuss the findings from the above steps in accordance with my proposed interventions.

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5.2.3.1. Graph Theoretic Centrality Measures

Degree equals to the counts of the links a node (i.e. an intervention/SRL event here) has with the other events in the network. In other words, it shows the number of the events that occurred before or followed a *central* event.
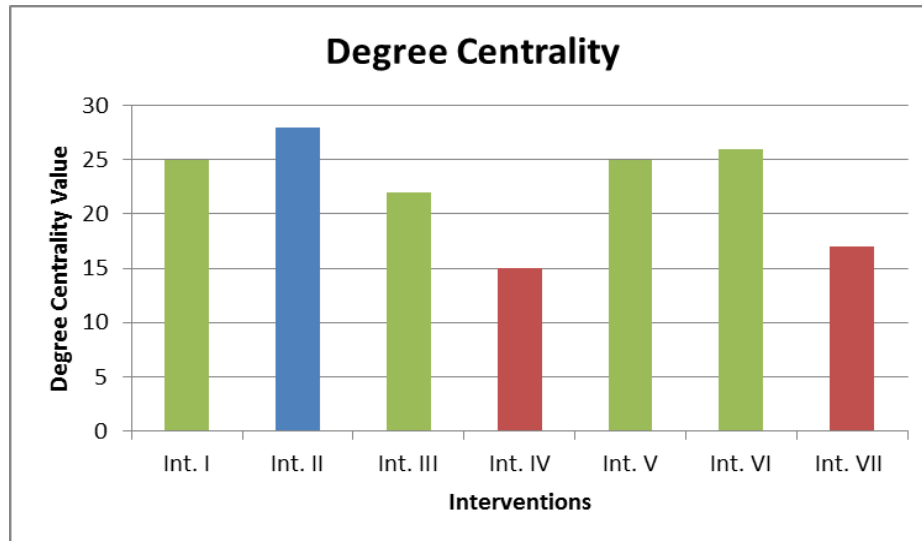
Figure 5.9. Frequency distribution of Degree Centrality across the proposed Interventions.

Figure 5.9 shows the distribution of the degree centrality within the trace data of all users, across the proposed interventions. As could be seen, Intervention II: Social Wave (denoted with the blue color in Figure 5.9) has the highest degree (M=13.37, SD=8.062), followed by Interventions I (M=9.82, SD=6.817), III (M=7.32, SD=6.243), V (M=9.07, SD=6.992) and VI (M=11.42, SD=6.805) having around the same degrees (indicated with the green color), whilst the lowest degrees belong to interventions IV (M=6.45, SD=5.027) and VII (M=5.92, SD=6.501), shown via the red color. A high degree for an event means that many nodes are connected with that event, making it central to the network of users' learning actions within the Learn-B environment. The intervention events with higher degrees could be indicators of those interventions that users used in a variety of ways in their learning processes.

Closeness of a node is defined as the inverse of the sum of its distance (i.e. the shortest path) to all other nodes in the network. The higher the closeness of a node, thus, the closer it is to the other nodes. In a network of users' learning actions within the

Learn-B environment, intervention nodes with higher closeness values indicate those interventions via which users could easily perform their SRL processes or use the other interventions. Figure 5.10 shows that using users' trace data, Intervention II: Social Wave has the highest normalized closeness centrality (indicated via the blue color in Figure 5.10), 1 (M=0.730, SD=0.317). Similar to their degree frequencies, Interventions I (M=0.605, SD=0.217), III (M=0.562, SD=0.169), V (M=0.521, SD=0.210) and VI (M=0.637, SD=0.184) come second to Intervention II, and have around the same closeness values. The green bars in Figure 5.10 denote these interventions. Interventions IV (M=0.463, SD=0.189) and VII (M=0.637, SD=0.184) have the lowest closeness values – the red bars in Figure 5.10.
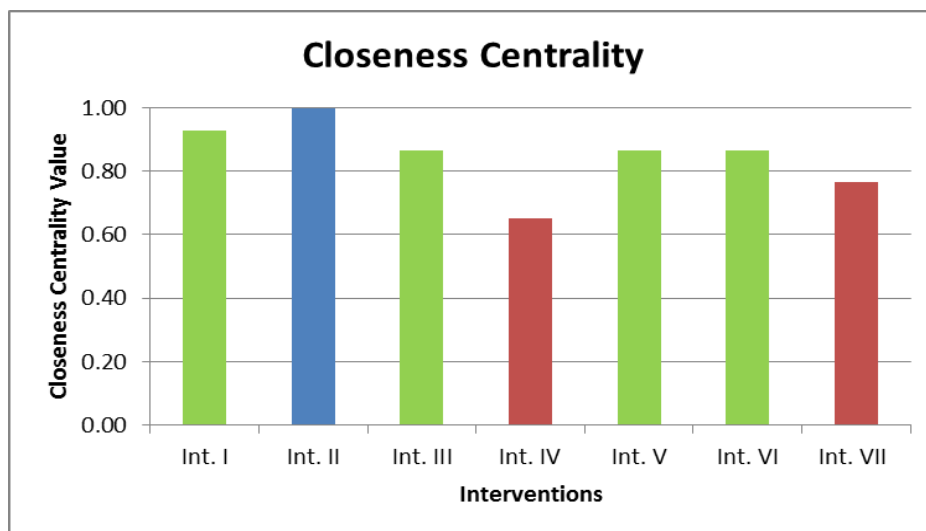
Figure 5.10. Frequency distribution of Closeness Centrality across the proposed Interventions.

Betweenness of a node is based on the number of the shortest paths from all the nodes to all others, passing through that node (Yan & Ding, 2009). A node with high betweenness acts as a "broker" or a bridge, which connects other nodes together. Within the Learn-B environment and considering the collected learning actions of users in this environment, intervention nodes with high betweenness values specify those interventions that users used as a bridge to perform their SRL processes or use other interventions. Distribution of the betweenness centrality of the proposed interventions within the collected trace data is depicted in Figure 5.11.
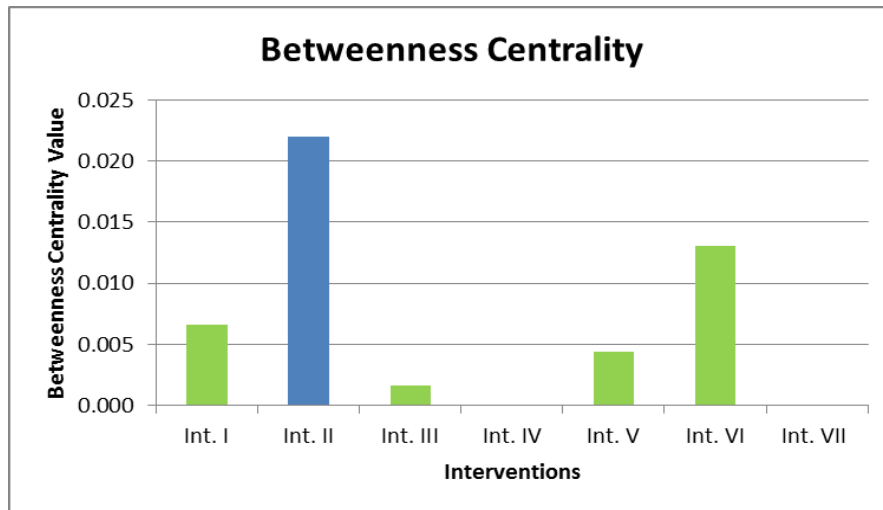
Figure 5.11. Frequency distribution of Betweenness Centrality across the proposed Interventions.

As could be seen, the proposed interventions have rather very low values of betweenness, amongst which the Social Wave intervention has the highest measure (M=0.156, SD=0.161) – shown via the blue color. Second to Social Wave, comes Intervention VI (M=0.074, SD=0.122) and then are Interventions I (M=0.022, SD=0.030), III (M=0.016, SD=0.030) and V (M=0.048, SD=0.098) – all with very low betweenness values, and denoted with the green color in Figure 5.11. Based on all users' trace data, Interventions IV and VII both had a betweenness of zero.

Eigenvector centrality is based on the concept that a node is more central if it is connected to nodes which are central themselves. Accordingly, this conceptualization signifies that centrality of a node does not depend only on the *count* of its neighbouring nodes (i.e. its degree), but on the centrality value of its neighbours as well.
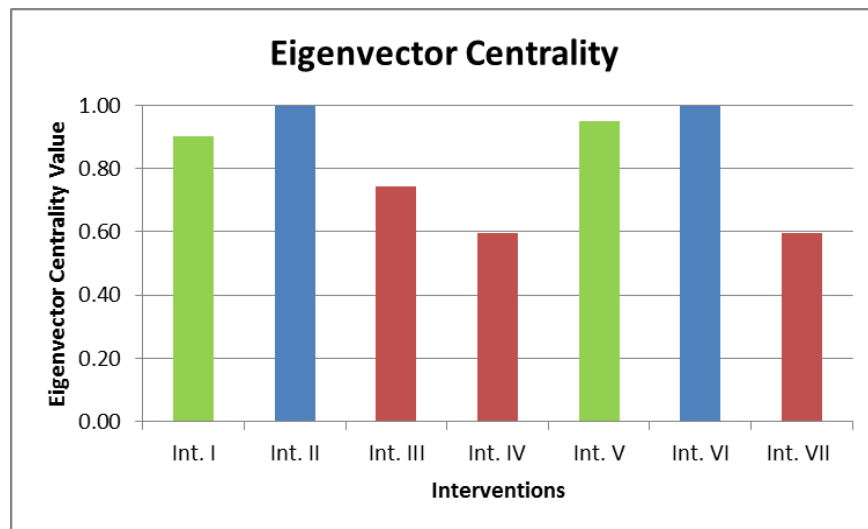
Figure 5.12. Frequency distribution of Eigenvector Centrality across the proposed Interventions.

Figure 5.12 indicates that Interventions II: Social Wave and VI: Recommended available Competences, have the highest eigenvector values, normalized into [0, 1] (M=0.651, SD=0.331; M=0.463, SD=0.334, respectively – the blue bars). With an eigenvector of 0.74 (M=0.304, SD=0.248) Intervention III comes next, whilst Interventions I (M=0.457, SD=0.332), and VI (M=0.370, SD=0.325) have slightly lower eigenvector values (indicated via the red color in Figure 5.12). Interventions IV (M=0.252, SD=0.226) and VII (M=0.225, SD=0.251) have the lowest eigenvector values (shown by the green color). Depending on the model that a network of nodes and edges represents, the eigenvector centrality of a node shows its "well-connectedness" in that model. For instance, a node's eigenvector centrality in a social network (of people) indicates how well that node, i.e. person, is connected with other socially well-connected people. In the network of users' actions in the Learn-B environment, intervention events with higher eigenvalue centralities denote those interventions which were used before/after other well-performed events (either an SRL or Intervention event).

Overall, the above centrality measures show that Intervention II: Social Wave was the most central intervention event within the collected trace data. Having the highest degree centrality, it was the intervention which users employed in many various ways during their learning processes. On the other hand, its high values of closeness and eigenvector centrality indicate that not only was it used in a short distance from performing SRL processes or accessing other interventions, but also users preceded

and/or followed it by other well-performed interventions, such as Interventions I, V and VI, or SRL processes, such as planning and engagement.
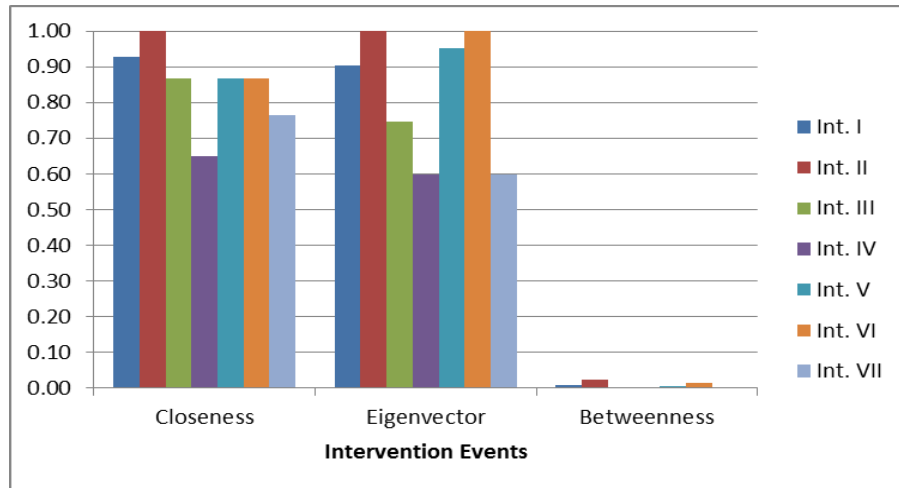
Figure 5.13. Comparison of Closeness, Eigenvector and Betweenness centrality measures across the proposed interventions.

Figure 5.13 shows that second to the Social Wave intervention, Interventions I (Providing usage information), V (Recommended available Competences) and VI (Recommended available LPs, LAs and KAs) were the other focal interventions revealed from the trace data. These interventions, too, had relatively high values for their degree (see Figure 5.9), closeness and eigenvector centrality measures, indicating that users regularly applied these interventions within their employed learning strategies, triggered them in short intervals from their other (learning) actions, and used them right before/after their other well-performed SRL/Intervention actions.

The above discussed centrality measures revealed the relative importance of the proposed interventions within the network of participants' learning actions. Next, using the trace data, I examined whether and to what extent there were *more* associations between the usage frequencies of the Intervention events and the SRL processes. These newly explored associations were not specifically addressed in my a-priori hypotheses, and thus not analyzed within my first research question, RQ1, in experiment 2 - see section 4.3.4.1.1. I discuss these associations in the following subsection.

5.2.3.2. Associations between the Occurrence Frequencies of the Proposed Interventions and SRL Processes

As explained previously, when analysing the log data I used indicators for both the Intervention and SRL events, in that each event was manifested via one or more indicator actions that users could possibly perform in the Learn-B environment. A detailed discussion on these indicators and how they represent each proposed intervention or SRL process is given in section 4.2. To explore all the potential associations, I performed Pearson's correlation analysis over log-transformed occurrence frequencies of intervention and SRL events. To be consistent in all my correlation analyses, I again followed (Cohen, 1988)'s rule of thumb and in the following, present the significant correlations that were *strong* (r>=0.5) or *moderate* (0.3<=r<0.5).

Results of the Pearson* correlation analysis (Table 5.23) show that the occurrence frequency of Intervention I was positively correlated with not only the usage frequencies of SRL processes addressed in my respective a-priori hypothesize (i.e. *h2.a, h2.b* and *h2.c* – see section 5.2.1.1) but also strongly with the Engagement and, Evaluation & Reflection processes. Correlations CR14.a – d indicate that increases in the usage of this intervention were correlated with the increases in users' enacting the above SRL processes.

In the case of the Social Wave intervention, there existed positive, strong correlations between its frequency of occurrence and that of all of those SRL processes which were not addressed in the respective hypotheses related to RQ1 (see section5.2.1.2), i.e. the Planning – Task Analysis (CR15.a) and Evaluation & Reflection processes (CR15.b and CR15.c). These strong correlations show that not only was users' usage of the Social Wave intervention positively correlated with their engagement in planning and engagement actions (as hypothesized a-priori), but with their Evaluation and Reflection processes as well.

Table 5.23. Exploratory correlations emerged (i.e. those not addressed in RQ1) between the occurrence frequencies of the proposed Intervention and that of the SRL processes

Correlation	First Variable	Second Variable	Correlation Coefficient

CR14.a	Engagement – Working on the Task	Int. I: Providing Usage Information	r(45)=0.681, p=0.000
CR14.b	Engagement – Applying Strategy Changes		r(45) =0.636, p=0.000
CR14.c	Evaluation & Reflection – Evaluation		r(45)=0.602, p=0.000
CR14.d	Evaluation & Reflection – Reflection		r(45)=0.603, p=0.000
CR15.a	Planning – Task Analysis	Int. II: Social Wave	r(45) =0.667, p=0.000
CR15.b	Evaluation & Reflection – Evaluation		r(45)=0.685, p=0.000
CR15.c	Evaluation & Reflection – Reflection		r(45)=0.682, p=0.000
CR16.a	Planning – Task Analysis	Int. III: Progress-o-meter	r(45) =0.439, p=0.003
CR16.b	Planning – Goal Setting		r(45)=0.714, p=0.000
CR16.c	Planning – Making Personal Plans		r(45)=0.721, p=0.000
CR17.a	Planning – Making Personal Plans	Int. IV: User Recommended Learning Goals	r(45) =0.431, p=0.003
CR17.b	Engagement – Working on the Task		r(45)=0.479, p=0.001
CR17.c	Engagement – Applying Strategy Changes		r(45)=0.432, p=0.003
CR17.d	Evaluation & Reflection – Evaluation		r(45)=0.465, p=0.001
CR17.e	Evaluation & Reflection – Reflection		r(45)=0.373, p=0.012*
CR18.a	Engagement – Working on the Task	Int. VI: Recommended available LPs, LAs and KAs	r(45) =0.636, p=0.000
CR18.b	Engagement – Applying Strategy Changes		r(45)=0.646, p=0.000
CR18.c	Evaluation & Reflection – Evaluation		r(45)=0.493, p=0.001
CR18.d	Evaluation & Reflection – Reflection		r(45)=0.548, p=0.000
CR19.a	Planning – Task Analysis		r(45)=0.368, p=0.013
CR19.b	Planning – Goal Setting		r(45)=0.421, p=0.004
CR19.c	Planning – Making Personal Plans		r(45) =0.431, p=0.003

CR19.d	Engagement – Working on the Task	Int. VII: Knowledge Sharing Profiles	r(45)=0.430, p=0.003
CR19.e	Engagement – Applying Strategy Changes		r(45)=0.400, p=0.006
CR19.f	Evaluation & Reflection – Evaluation		r(45) =0.356, p=0.016*

* All the correlations are significant at the 0.01 level, except for the ones denoted by an asterisk which are significant at the 0.05 level.

Similar findings were obtained for the Progress-o-meters intervention: considering its functionality, in the respective a-priori hypotheses (*H2.h*, *H2.i*, *H2.j* and *H2.k*), I theorized that this intervention supports users in their Engagement and Evaluation & Reflection processes and the resulting correlations in RQ1 showed significant positive correlations in this regard (see Table 5.15). Table 5.23 shows that the usage frequency of this intervention was also strongly correlated with that of Goal Setting and Making Personal Plans (CR16.b and CR16.c), and moderately with the Task Analysis micro-level processes (CR16.a). CR16.c is in particular consistent with the findings from experiment 1, in that 72% of the users found it useful to see their personal progress in completing a learning activity, when Making their Learning Plans.

Although the graph centrality measures did not present Intervention IV as a central node in the network of users' learning actions (see the previous section: 5.2.3.1) and its occurrence frequency was positively associated only with one of the SRL processes hypothesized a-priori (section 5.2.1.4), Table 5.23 shows that there were positive correlations between the usage frequency of this intervention and that of Engagement (CR17.b and CR17.c), Making Personal Plans (CR17.a) and Evaluation & Reflection SRL events (CR17.d, and CR17.e).

Intervention V, Recommended available Competences, was revealed to be a rather focal node in the graph of users' learning actions during their two-month testing period, having in particular a relatively high value of closeness centrality. However, there existed a positive correlation between its occurrence frequency and users' engagement in Task Analysis actions only (see section 5.2.1.5), whilst no further moderate or strong associations with the rest of the SRL processes were found.

Similar to Intervention V, Intervention VI emerged as a relatively important event in the network of users' learning actions (section 5.2.3.1) with a high closeness centrality value, equal to that of Intervention V. However, contrary to Intervention V it was positively correlated with not only the planning processes hypothesized a-priori (i.e. *H2.q*, *H2.r*, and *H2.s*), but also with Engagement and, Evaluation & Reflection processes (CR18.a – CR18.d).

The Knowledge Sharing Profiles intervention did not appear as a relatively focal event in the graph of users' learning actions (section 5.2.3.1). Plus, the correlation between its usage frequency and that of the only respective hypothesized SRL process (i.e. Reflection), *H2.t*, was not significant. However, Table 5.23 surprisingly shows that there were non-hypothesized-a-priori positive, moderate associations between the usage frequency of this intervention and that of SRL processes: planning (CR19.a, CR19.b and CR19.c), engagement (CR19.d and CR19.e) and evaluation (CR19.f) events.

The above correlation results demonstrate that the occurrence frequencies of the majority of the proposed interventions were not only positively correlated with that of the respective SRL events hypothesized a-priori within RQ1, but also with most of the SRL processes users engaged in during their two-month testing period, using the Learn-B environment. Accordingly, to find the most effective interventions in supporting users' SRL processes, in the next step I used Multiple Regression analysis to examine whether and to what extent users' usage of the proposed interventions can *explain* and predict the frequency of their engagement in SRL processes. In the following, I present the results of the multiple regression analysis in accordance to the performed SRL micro-level processes.

5.2.3.3. Occurrence Frequencies of the proposed Interventions as Determinants of Users' Engagement in SRL processes

To find the proposed interventions whose frequency counts (i.e. representing their usage) was determinant of users' enacting SRL processes at their workplace, I performed multiple regression analyses per micro-level SRL process (as the independent variable). The set of independent variables contained those proposed

interventions which were closely correlated with users' SRL processes, i.e. had
moderate to high correlation values, according to (Cohen, 1988).

To ensure the assumption of no multicollinearity, however, I removed
Intervention III's frequency count from my set of independent variables in these
analyses. Although the respective tolerance levels, and the variance inflation factors
(VIF) did not signal any warnings, this intervention was closely correlated with the usage
frequencies of both Interventions I and II (r(45)=0.801, p=0.000; r(45)=0.811, p=0.000,
respectively); plus only 42% of the users had used it during their two-month testing
period in experiment 2. I performed the multiple regression analyses using the *standard*
method over log-transformed occurrence frequencies of interventions and SRL
processes. To test the regression assumptions, I built scatterplots and normal probability
plots of standardised residuals and calculated the Mahalanobis and Cook's
distance values, following the guidelines described in (Pallant, 2011; Tabachnick &
Fidell, 2007). In the following I present and discuss the results of multiple regression
analyses, organized across the SRL micro-level processes. Table 5.24 summarizes the
existing strong associations between each of the SRL micro-level processes and the
proposed interventions.

Table 5.24. High Associations between occurrence frequencies of the proposed Interventions and Users' engagement in the SRL processes

Correlation	First Variable	Second Variable	Correlation Coefficient
CR7.a	Intervention I: Providing Usage Information	SRL Process Planning: Task Analysis	r(45)=0.458, p=0.002
CR15.a	Intervention II: Social Wave		r(45) =0.667, p=0.000
CR16.a	Intervention III: Progress-o-meters		r(45)=0.439, p=0.003
CR11.a	Intervention V: Recommended available Competence		r(45)=0.637, p=0.000
CR12.a	Intervention VI: Recommended available LPs, LAs and KAs		r(45) =0.429, p=0.003
CR7.b	Intervention I: Providing Usage Information	SRL Process Planning: Goal Setting	r(45)=0.673, p=0.000
CR8.a	Intervention II: Social Wave		r(45) =0.778, p=0.000
CR16.b	Intervention III: Progress-o-meters		r(45)=0.714, p=0.000
CR10.a	Intervention IV: User-recommended Learning Goals		r(45)=0.452, p=0.002

CR12.b	Intervention VI: Recommended available LPs, LAs and KAs		r(45)=0.670, p=0.000
CR19.b	Intervention VII: Knowledge Sharing Profiles		r(45) =0.421, p=0.004
CR7.c	Intervention I: Providing Usage Information		r(45)=0.682, p=0.000
CR8.b	Intervention II: Social Wave	SRL Process Planning: Making Personal Plans	r(45) =0.740, p=0.000
CR16.c	Intervention III: Progress-o-meters		r(45)=0.721, p=0.000
CR17.a	Intervention IV: User-recommended Learning Goals		r(45)=0.431, p=0.003
CR12.c	Intervention VI: Recommended available LPs, LAs and KAs		r(45)=0.648, p=0.000
CR19.c	Intervention VII: Knowledge Sharing Profiles		r(45) =0.431, p=0.003
CR14.a	Intervention I: Providing Usage Information		r(45)=0.681, p=0.000
CR8.c	Intervention II: Social Wave	SRL Process Engagement: Working on the Task	r(45) =0.781, p=0.000
CR9.a	Intervention III: Progress-o-meters		r(45)=0.696, p=0.000
CR17.b	Intervention IV: User-recommended Learning Goals		r(45)=0.479, p=0.001
CR18.a	Intervention VI: Recommended available LPs, LAs and KAs		r(45)=0.636, p=0.000
CR19.d	Intervention VII: Knowledge Sharing Profiles		r(45)=0.430, p=0.003
CR14.b	Intervention I: Providing Usage Information		r(45)=0.636, p=0.000
CR8.d	Intervention II: Social Wave	SRL Process Engagement: Applying Strategy Changes	r(45) =0.745, p=0.000
CR9.b	Intervention III: Progress-o-meters		r(45)=0.668, p=0.000
CR17.c	Intervention IV: User-recommended Learning Goals		r(45)=0.432, p=0.003
CR18.b	Intervention VI: Recommended available LPs, LAs and KAs		r(45)=0.646, p=0.000
CR19.e	Intervention VII: Knowledge Sharing Profiles		r(45) =0.400, p=0.006
CR14.c	Intervention I: Providing Usage Information		r(45)=0.602, p=0.000
CR15.b	Intervention II: Social Wave	SRL Process Evaluation & Reflection: Evaluation	r(45) =0.685, p=0.000
CR9.c	Intervention III: Progress-o-meters		r(45)=0.550, p=0.000
CR17.d	Intervention IV: User-recommended Learning Goals		r(45)=0.465, p=0.001
CR18.c	Intervention VI: Recommended available LPs, LAs and KAs		r(45)=0.493, p=0.001

CR19.f	Intervention VII: Knowledge Sharing Profiles		r(45)=0.356, p=0.016*
CR14.d	Intervention I: Providing Usage Information		r(45)=0.603, p=0.000
CR15.c	Intervention II: Social Wave	SRL Process Evaluation & Reflection: Reflection	r(45) =0.682, p=0.000
CR9.d	Intervention III: Progress-o-meters		r(45)=0.544, p=0.000
CR17.e	Intervention IV: User-recommended Learning Goals		r(45)=0.373, p=0.012*
CR18.d	Intervention VI: Recommended available LPs, LAs and KAs		r(45)=0.548, p=0.000

* All the correlations are significant at the 0.01 level, except for the ones denoted by an asterisk which are significant at the 0.05 level.

Planning – Task **Analysis:** as previously discussed, the SRL micro-level process Task Analysis was highly correlated with Interventions I, II, III (removed from the predictor model to satisfy the assumption of no multicollinearity), V and VI (Table 5.24). Results of the respective *standard* regression analysis indicated that a significant model emerged for the Task Analysis process, in that the usage frequencies of the predictor Interventions I, II, V and VI accounted for 66.3% of the variance in the occurrence frequency of this micro-level SRL process (F(4,40)=22.67, p=0.000). Table 5.25 shows that among the interventions included in the model, only Interventions II and V were statistically significant predictors at the 0.05 level, having very close beta values (*beta* = 0.592, p=0.000; *beta*=0.512, *p* =0.01, respectively). Interventions I and VI were not significant predictors in this model.

Table 5.25. Predictor Interventions for SRL process: Planning – Task Analysis

Predictor Variable	B	Std. Error	Beta
(Constant)	0.137	0.251	
Int. I	-0.110	0.191	-0.076
Int. II	0.565	0.117	0.592*
Int. V	0.656	0.118	0.512*
Int. VI	0.18	0.116	0.018

*. Significant at the 0.05 level.

Planning – Goal **Setting:** the occurrence frequencies of all of the proposed interventions except for Intervention V, Recommended available Competences, were closely correlated with that of the SRL process planning – Goal Setting (Table 5.24). The total variance explained by the resulting significant predictor model as a whole, including Interventions I, II, IV, VI and VII, was 68.8%, $F_{(5,39)}=19.52$, p=0.000. Only two of the predictor interventions, i.e. Interventions II and VI were statistically significant, with the Social Wave intervention having a higher beta value (*beta*=0.551, p=0.000) than Intervention VI (*beta*=0.304, p=0.010) - Table 5.26.

Table 5.26. Predictor Interventions for SRL process: Planning – Goal Setting

Predictor Variable	B	Std. Error	Beta
(Constant)	0.797	0.304	
Int. I	0.191	0.212	0.119
Int. II	0.583	0.141	0.551*
Int. IV	0.322	0.336	0.101
Int. VI	0.343	0.126	0.304*
Int. VII	-0.355	0.408	-0.103

* Significant at the 0.05 level.

Planning – Making Personal Plans: similar to the Goal Setting process, Table 5.24 shows that the occurrence frequency of the *Making Personal Plans* micro-level SRL process was also closely correlated with that of all of the proposed interventions except for Intervention V. Accordingly, the predictor model included Interventions I, II, IV, VI and VII - Intervention III excluded from the model to satisfy the no-multicollinearity assumption. The *standard* regression analysis showed that this model, as a whole, was significant and explained 61.8% of the variance in the occurrence frequency of the Making Personal Plans process ($F_{(5,39)}=15.21$, p=0.000). Again, *Interventions II and VI were the only two statistically significant predictors at the 0.05 level, and the Social Wave intervention had a higher beta value (*beta* = 0.456, p=0.003; *beta*=0.282, *p* =0.026, respectively). Interventions I, IV and VII did not emerge as significant predictors in this model.

Table 5.27. Predictor Interventions for SRL process: Planning – Making Personal Plans

Predictor Variable	B	Std. Error	Beta
(Constant)	-0.371	0.399	
Int. I	0.371	0.278	0.192
Int. II	0.581	0.185	0.456*
Int. IV	0.291	0.440	0.076
Int. VI	0.382	0.165	0.282*
Int. VII	-0.224	0.534	-0.054

* Significant at the 0.05 level.

***Engagement – Working on the* Task:** the engagement process – Working on the Task was highly associated, in terms of its occurrence frequency, with that of all of the proposed interventions except Intervention V (Recommended available Competences), Table 5.24. Table 5.28 shows that the resulting predictor model, which included Interventions I, II, IV, VI and VII, was significant as a whole and accounted for the 66.9% of the variance in the occurrence frequency of this SRL micro-level process (F(5,39)=18.77, p=0.000). Among the variables included in the model, Table 5.28 indicates that interventions II and VI were the only statistically significant determinants of users' engagement in Working on the Task process, with Intervention II having a stronger impact (*beta*=0.553, p=0.000) than Intervention VI (*beta*=0., p=0.045).

Table 5.28. Predictor Interventions for SRL process: Engagement – Working on the Task

Predictor Variable	B	Std. Error	Beta
(Constant)	0.286	0.327	
Int. I	0.272	0.229	0.160
Int. II	0.621	0.152	0.553*
Int. IV	0.476	0.362	0.141
Int. VI	0.282	0.136	0.236*
Int. VII	-0.439	0.439	-0.120

* Significant at the 0.05 level.

Engagement – Applying Strategy Changes: Table 5.24 shows that again except Intervention V, the Applying Strategy Changes process was highly correlated with all of the proposed interventions in terms of their occurrence frequencies. Results of the performed *standard* regression analysis indicated that the predictor model, including Interventions I, II, IV, VI and VII, was significant and could explain 61.3% of the variance in the occurrence frequency of this SRL micro-level process, $F(5,39)=7.69$, p=0.000. As was the case in the previously discussed SRL processes, Table 5.29 shows the Interventions II and VI were the only statistically significant predictors at the 0.05 level, with the Social Wave intervention recording a higher beta value (*beta*=0.536, p=0.001) than Intervention VI (*beta*=0.304, p=0.018).

Table 5.29. Predictor Interventions for SRL process: Engagement – Applying Strategy Changes

Predictor Variable	B	Std. Error	Beta
(Constant)	0.779	0.339	
Int. I	0.152	0.237	0.093
Int. II	0.578	0.157	0.536*
Int. IV	0.314	0.375	0.097
Int. VI	0.348	0.141	0.304*
Int. VII	-0.352	0.455	-0.100

* Significant at the 0.05 level.

Evaluation & Reflection – Evaluation: similar to the previous planning and engagement processes, the occurrence frequencies of all of the proposed interventions except for Intervention V (Recommended available Competences) were also closely correlated with that of the Evaluation micro-level process (Table 5.24). A significant predictor model including Interventions I, II, IV, VI and VII resulted from the *standard* multiple regression analysis, accounting for 49.1% of the variance in the occurrence frequency of this process ($F(5,39)=9.49$, p=0.000). Table 5.30, however, shows that contrary to the previous SRL processes, this time only the Social Wave intervention emerged as a statistically significant predictor, *beta*=0.514, p=0.004. The rest of the interventions, i.e. Interventions I, IV, VI and VII, did not appear as significant predictors in this model.

Table 5.30. Predictor Interventions for SRL process: Evaluation & Reflection –
Evaluation

Predictor Variable	B	Std. Error	Beta
(Constant)	0.236	0.348	
Int. I	0.315	0.243	0.215
Int. II	0.495	0.162	0.514*
Int. IV	0.626	0.385	0.216
Int. VI	0.077	0.144	0.076
Int. VII	-0.624	0.466	-0.198

* Significant at the 0.05 level.

Evaluation & Reflection – Reflection: finally, Table 5.24 shows that the occurrence frequency of the Reflection SRL micro-level process was closely correlated with that of all of the proposed interventions except for Interventions V and VII. The performed *standard* regression analysis indicated that the predictor model, including Interventions I, II, IV and VI, was significant ($F(4,40)=11.12$, p=0.000), and as a whole explained 47.9% of the variance in the occurrence frequency of the Reflection process. Similar to the Evaluation micro-level process, again the Social Wave intervention emerged as the only statistically significant predictor with *beta*=0.456, p=0.007. Interventions I, IV and VI were not significant predictors in this model - Table 5.31.

Table 5.31. Predictor Interventions for SRL process: Evaluation & Reflection –
Reflection

Predictor Variable	B	Std. Error	Beta
(Constant)	0.334	0.319	
Int. I	0.214	0.233	0.152
Int. II	0.425	0.148	0.456*
Int. IV	0.078	0.351	0.028
Int. VI	0.206	0.139	0.208

* Significant at the 0.05 level.

The above *standard* multiple regression analyses revealed that the Social Wave intervention (Intervention II) was the strongest determinant of users' engagement in all of the SRL processes discussed within the theoretical framework, whilst the Recommended available LPs, LAs and KAs intervention (Intervention VI) emerged as the second most important factor in the case of planning and engagement processes. The usage of these two interventions, however, varied noticeably among the participants. In the case of the Social Wave intervention, in particular, users used it to a maximum of 125 times (and a minimum of zero times) during their two month testing period (N=45, M=16.71, SD=24.52). Considering that the Social Wave intervention was revealed to be the most central event in users' network of learning actions (see section 5.2.3.1), plus the strongest predictor of users' engagement in SRL actions, I conducted a one-way between-groups analysis of covariance to compare the effectiveness of users' varied levels of using this intervention (i.e. low, medium and high levels) on the overall frequency of their performed SRL processes. I discuss this analysis in the following.

5.2.3.4. Comparing Users' Usage Level of the Social Wave intervention on the Frequency of their Engagement in SRL processes

Results from the previous subsections showed that, using the trace data collected from the two-month testing period, the Social Wave intervention not only played a focal role in the network of users' learning actions, but also its usage frequency was the strongest predictor of the frequency with which users performed their SRL processes. However, the users participating in the second evaluation experiment consisted of knowledge workers from the two business cases who held different positions in their respective organizations, having different levels of familiarity with the learning needs and requirements of their organizations. Moreover, although these users made use of different software solutions in their day to day work practices, they had diverse levels of computer skills, as well as individual experiences in and familiarity with their current organizational responsibilities. Thus, I aimed to examine whether the following two demographic factors could represent serious confounds, affecting the interpretation of the above findings:

Users' experience in their organizations: previous research has shown that novices (e.g. those with less than three years of experience) and experts (e.g. users with more than eleven years of experience) vary in terms of the patterns they employ to self-regulate

their learning processes in the workplace. For instance, it has been found that they both noticeably rely on the collective in their learning processes, however, novice users do not engage in organized self-reflection processes (Margaryan et al., 2009). Accordingly, my assumption regarding this demographic factor is that it could potentially affect the frequency of a user's engagement in SRL actions: the more experience users have in and the more familiar they are with the context of their organization along with their own responsibilities, the more they are aware of their learning needs as well as the learning requirements of their organization, and the better they know which resources and what strategies to employ in order to address these needs.

Computer Skills: my assumption regarding this potential confounding factor was that it would be easier and more acceptable for users who have stronger computer skills in general to perform the various SRL processes in the Learn-B environment compared to those who are less experienced with computers and modern software solutions.

To account for and control the effect of these potential confounding variables, I performed a one-way between-subjects analysis of covariance (ANCOVA) on users' total frequency of SRL actions. The independent variable included the usage frequency of the Social Wave intervention grouped into three levels, nearly of equal sizes, low, medium and high frequencies. Users' computer skills (measured on a scale of 0: very low to 10: excellent), and their experience in the organization (measured in terms of the years a user has been in his/her current position), factorially combined, were used as the covariates in this analysis. I conducted preliminary checks to ensure that the respective assumptions are not violated. Results of the evaluation of the assumptions of homogeneity of variance, linearity and homogeneity of regression slopes were satisfactory. The sample used in the analysis included the trace data, i.e. the usage frequencies of Intervention II and users' total frequency of SRL actions, along with users' demographic data. Having to include users' demographic data led to a reduction in the sample size, from 52 cases when performing the analyses using only the trace data (which was the case in the previous steps of the evaluation) to 19 cases which was the number of users for whom we had access to both their demographics and trace data. Log transforms were made of users' total frequency of SRL actions to satisfy the normality of sampling distributions.

After adjusting for the covariates, the occurrence frequencies of SRL processes varied significantly with users' usage level of the Social Wave intervention, with $F_{(2,15)}=15.74$, p=0.000. The strength of the relationship between the usage frequencies of Intervention II and users' engagement in SRL processes was very strong, as assessed by partial $\eta 2$, with the Social Wave factor accounting for 68% of the variance in users' total frequency of SRL processes, holding constant the two demographic factors. There was no significant relationship between the covariates and the dependent variable while controlling for the usage of the Social Wave intervention, i.e. the independent variable.

Table 5.32. Adjusted and Unadjusted Mean total SRL Processes for three Usage Levels of the Social Wave Intervention

Social Wave Usage Level, N	Adjusted Mean, Std. Error	Unadjusted Mean, SD
Low Usage (<=6 times), 5	3.152, 0.374	3.149, 0.502
Medium Usage (7- 21 times), 7	4.807, 0.315	4.807, 0.956
High Usage (> 21 times), 7	5.907, 0.316	5.909, 0.809

The adjusted marginal means, shown in Table 5.32, were ordered as expected across the three usage levels of the Social Wave intervention. The high-usage group had the largest adjusted mean (M=5.91), the medium-usage level had a lower adjusted mean (M=4.81) and the low-usage group had the smallest adjusted mean (M=3.15). I used the Bonferroni post-hoc to evaluate pairwise differences among the adjusted means. There were significant differences in the adjusted means between both the medium- and high-usage groups and the low-usage group (p=0.012 and p=0.000, respectively), but no significant difference was found between the medium- and high-usage groups (p=0.079), at the 0.05 level.

5.2.4.   Summary of the Results for RQ2

My second research question in experiment 2 was to explore those interventions which were the most effective in supporting users in conducting SRL processes in their workplace. As described in the previous research question, in this experiment all of my proposed interventions were implemented in the full prototype of the Learn-B

environment. In experiment 1, users were asked to perform three tasks within a learning scenario, manifesting three SRL micro-level processes: Task Analysis/Goal Setting, Making Personal Plans and Applying Strategy Changes. In experiment 2, however, users could potentially perform all the three SRL phases (i.e. planning, engagement and evaluation & reflection processes) using the Learn-B environment. To address my second research question, I started with analysing the centrality measures of each of my proposed interventions, calculated over the transition graph of all users' trace data. In the next step, I examined whether in addition to the correlations examined in my first research question (see section 5.2.1), there existed potential associations between users' usage frequencies of the intervention events and their frequency of performing SRL processes; and if so, to what extent. In the third step I looked for the interventions *determinant* of users' engagement in SRL processes and finally, I examined the effect of potential confounding variables in experiment 2, as well as users' different levels of using the *determinant* interventions on their frequency of performing SRL processes.

Analysis of interventions' centrality measures, namely their degree, closeness, betweenness and eigenvector values, show that the Social Wave intervention was the most central within the trace data collected from users' actions performed in the Learn-B environment during the two-month evaluation period. This intervention had the highest degree centrality amongst all the proposed interventions, suggesting that users triggered it in many different ways within their learning processes. Also, it had the highest values of closeness and eigenvector centrality compared to the other interventions, emphasizing that users used this intervention in short intervals from their other learning actions, as well as preceded and/or followed it by other well-performed interventions e.g. Interventions I, V and VI, or SRL processes planning and engagement. Interventions I, V and VI were the second most focal interventions emerged within the graph of users' trace data, having similarly high degree, closeness and betweenness centrality values (see Figure 5.9 and Figure 5.13).

Results of the Pearson's correlation analyses revealed that users' usage frequencies of Interventions I, II, III and VI were not only positively correlated with that of the theorized SRL processes addressed within RQ1, but with the rest of the SRL processes that users could potentially perform using the Learn-B environment during the two-month evaluation period (Table 5.33). Interestingly, although Intervention V

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appeared as a central node in the graph of users' learning actions, a positive correlation existed only between its usage frequency and users' engagement in Task Analysis micro-level process (see section 5.2.1.5), and no further significant associations were observed. Contrary to Intervention V, Intervention IV did not appear as a focal node in users' graph of learning actions; yet, Pearson's correlation analyses show that in addition to the hypothesized Goal Setting micro-level process, there were positive correlations between users' usage frequency of this intervention and their enactment of the micro-level processes within the engagement phase (CR17.b and CR17.c in Table 5.24), as well as Making Personal Plans (CR17.a) and Evaluation & Reflection micro-level processes (CR17.d, and CR17.e). By the same token, Intervention VII did not appear as a relatively central event in the users' graph of learning actions and no significant correlation existed between its usage frequency and that of the hypothesized Reflection micro-level process; however, results of the correlation analysis pointed out significant positive associations between users' usage frequency of this intervention and their engagement in SRL processes: planning (CR19.a, CR19.b and CR19.c in Table 5.24), engagement (CR19.d and CR19.e) and Evaluation (CR19.f).

Table 5.33. The support provided by the proposed Interventions for various SRL processes. The normal checkmarks represent the support hypothesized a-priori (addressed in RQ1), while the underlined checkmarks indicate the exploratory findings.

Proposed Intervention	Support for SRL processes		
	Planning	**Engagement**	**Evaluation & Reflection**
Int. I: Providing Usage Information	✓ (H2.a, H2.b, H2.c)	<u>✓</u>	<u>✓</u>
Int. II: Social Wave	✓ (H2.d, H2.e)	✓ (H2.f, H2.g)	✓
Int. III: Progress-o-meters	<u>✓</u>	✓ (H2.h, H2.i)	✓ (H2.j, H2.k)
Int. IV: User-recommended Learning Goals	✓ (only H2.m)	<u>✓</u>	<u>✓</u>
Int. V: Recommended available Competences	✓ (only H2.n)	✖	<u>✓</u>
Int. VI: Recommended available LPs, LAs and KAs	✓ (H2.r, H2.q, H2.s)	<u>✓</u>	<u>✓</u>

Int. VII: Knowledge Sharing Profiles	✓ (except Task Analysis micro-level process)	✓	✓ (only Evaluation micro-level process)

Results of the standard multiple regression analyses indicated that the Social Wave intervention was the strongest determinant of users' engagement in all of the SRL processes included in the theoretical framework; and Intervention VI (Recommended available LPs, LAs and KAs) emerged as the second most important factor in the case of planning (except for the Task Analysis micro-level process) and engagement processes.

Results of the ANCOVA test with the usage level of the Social Wave intervention as the between-subjects factor and users' computer skills and experience in their respective organizations as the covariates demonstrated that the Social Wave factor accounts for 68% of the variance in users' total frequency of performing SRL processes, whilst the influence of the covariates (i.e. users' computer skills and experience in their positions) was insignificant.

6. General Discussions and Implications

6.1. Discussion

In my research, I aimed to investigate the effect of a set of Semantic Web-enabled interventions in supporting users' SRL processes in workplace settings. Underpinned by my theoretical framework, I enhanced the design and implementation of these interventions with social embeddedness elements and harmonization features to bring out the social and contextual dimensions of workplace learning to knowledge workers' (cyclic) phases of SRL. I evaluated these interventions via two iterations of non-experimental studies. In the first experiment I used users' responses to a set of related questionnaire items, in order to gauge their perceived usefulness of the interventions for performing SRL processes. In the second experiment, I used a trace-based methodology that I developed for my research to track users' learning actions on the fly and in their authentic context.

Results from users' perceived usefulness of the proposed interventions from the first experiment showed that when in the planning phase of their SRL processes, users found the functionalities provided by Interventions V and VI useful. These interventions informed users about the context of their organization in terms of its learning objectives, the importance of those objectives in view of the users' individual position, as well as the availability of resources (such as learning paths and knowledge assets) for those objectives. The results also suggested that users were relatively positive about the usefulness of the usage information provided by Intervention I, when planning their learning goals. Such information was meant to illustrate the social context of the organization in terms of comments, ratings and achievement information of other users. Users, however, emphasized that such information did not act as the primary basis of the choices which they made in this phase.

Consistent with the results from the first experiment, users' responses to the post-questionnaire in the second experiment indicated that they did consider Interventions I and IV beneficial to their planning process, but rather as complementary to the functionalities of Interventions V and VI. The first two interventions provided users with the social context of their organization in the form of usage information of and goal-recommendations by other users, respectively; whilst the latter two conveyed information about the organizational context of users' workplace.

These findings in the first place agree with the existing research on the importance of organizational context in informal workplace learning (Ashton, 2004; Ellinger, 2005; Fuller & Unwin, 2004; Marsick, 2009; Tynjälä, 2008) and show that when directly asked about their own perspectives, users tend to primarily rely on their organizational context in their planning phase. That is, they prefer to clearly know what competences they are expected to achieve and what options their organization is offering in that regard. Secondly, the findings suggest that knowledge workers do consider the social context of their organization when planning their learning goals; yet, it does not serve as the most influential factor for them. This might be indicative of a lack of trust to the accuracy and credibility of the provided usage information. Trust has been recognized as an essential element of organizational culture in previous studies, acting as a precondition for knowledge sharing and influences both individual and organizational learning (Casey, 2005; Siadaty et al., 2010). Users' lack of trust to information emerging from the social context can also be due to a poor organizational culture which does not nurture collaboration and social interactions among employees. Still, these speculations deserve further empirical investigation.

Analysis of users' actual learning actions in the second experiment revealed a moderate balance between their reliance on both social and organizational contexts in performing their SRL processes. Firstly, frequency counts of SRL and Intervention events showed that occurrence of users' activities related to i) Planning phase was highly correlated with their usage of Interventions I, II, V and VI; ii) Engagement phase was correlated with users' usage of Interventions II and VI and; iii) Evaluation & Reflection phase was correlated only with their usage of Intervention II. (A quick reminder: Interventions I and II provided users with information from the social context of their organization such as usage data and updates; Interventions V and VI provided

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them with information from the organizational context such as recommendations on available competences and learning paths).

Secondly, the transition graph built from users' trace data helped to locate the most effective interventions. Although in the post-questionnaire users did not perceive Intervention II (the Social Wave) as useful for the theorized planning and engagement SRL processes, it appeared as the most focal one compared to the other interventions. Also, it appeared to be the strongest determinant of users' engagement in different SRL processes (Figure 6.1; Figure 6.1.b). The next most central interventions were Intervention I (Figure 6.1.a), informing users about how various learning resources were used by their colleagues, along with Interventions V and VI, which provided users with the organizational context of their workplace (Figure 6.1.c and Figure 6.1.d).

These findings illustrate a different image than what users reported on in the questionnaires. That is, users' actual learning actions show that being informed of the relevant learning activities of their colleagues (the social context) plays a relatively more important role in their SRL processes than the organizational context. This finding may be an indicator that users prefer to rely on the learning activities of the collective to stay on the learning track. As well, it could be suggestive of the point that users are more willing to learn from the learning experiences of those colleagues whom they personally choose to follow, or prefer to receive updates on the learning resources which are of interest to them versus knowing about the usage information of the entire community on various, available learning resources. This corroborates the findings from the study by Margaryan et al., in which the participants, mostly experts in their field, asserted that they draw heavily upon their personal networks of *trusted* colleagues in the process of diagnosing and attaining their learning goals (Margaryan et al., 2009). To my knowledge, this study is the only existing research which, besides its' findings pertinent to knowledge sharing factors, reports on how experts self-regulate their learning and draw upon (and contribute to) the collective within their organizational community.
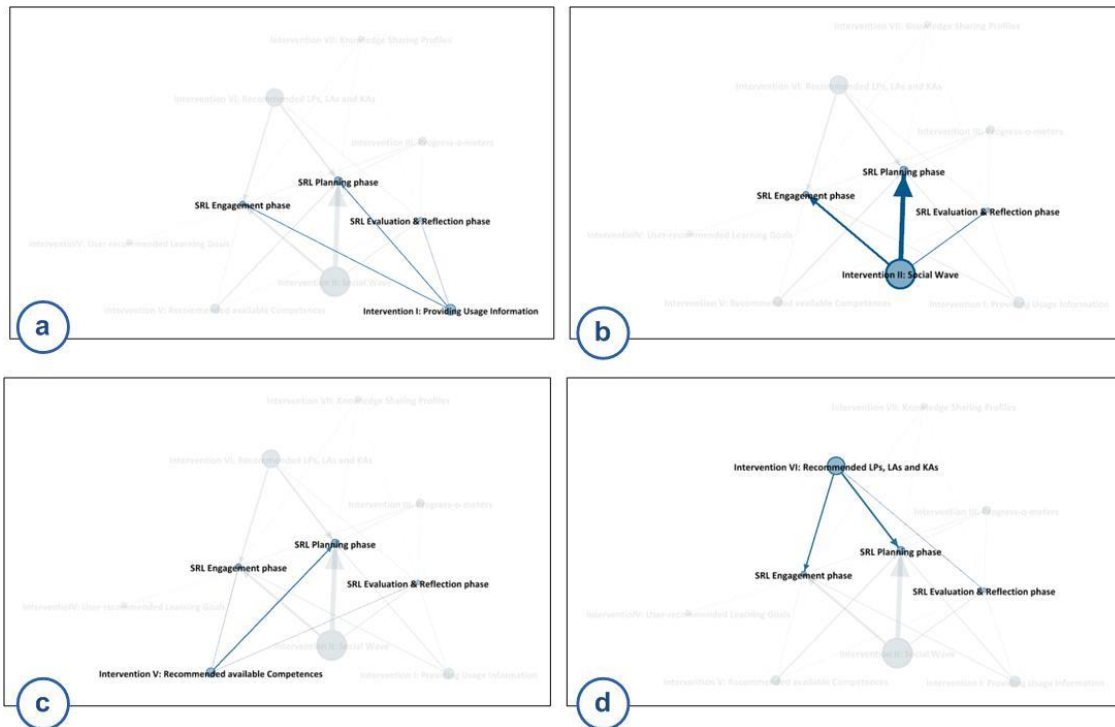
***Figure 6.1. The most central Interventions in the graph of users' learning actions,
followed by macro-level SRL processes: a) Int. I, b) Int. II, c) Int. V,
and d) Int. VI.***

In addition, analysis of the theorized contingencies via users' trace data showed that users' responses to the post-questionnaire items, asking them about their usefulness perceptions of the proposed interventions for their SRL processes, poorly matched with their actual, traced learning actions. For instance, 68% of the users stated that Intervention II was not beneficial to their engagement activities, whilst only less than half of the users (44%) never conformed to the corresponding contingency in their logged trace data. The theorized contingency here was that upon triggering this intervention (condition), users will proceed with performing an event related to the engagement phase (action).

This poor matching can be due to the fact that post-questionnaire responses reflected participants' static state, and rather generic perspective on how the implemented prototypes of the interventions supported them in their self-regulatory learning processes. Whereas the trace data built an image of their gradual and specific use of the system during the evaluation scenarios, I should point out here that there were a limited number of users (i.e. 23 participants) for whom I had access to both their

trace data and questionnaire responses. Another factor for this incongruity might be that the participants completed the post-questionnaire with an, often noticeable, delay after their usage of the system, which could have led to a discrepancy between what users recalled and what they actually did on the fly during their use of the system. Nonetheless, these findings resonate with the past research, which also indicated that users' self-reports on different aspects of learning (e.g. SRL processes, achievement and use of study tactics, and goal-orientation) do not necessarily align with their actual learning activities (Dinsmore et al., 2008; Hadwin et al., 2007; Winne & Jamieson-Noel, 2002; Zhou & Winne, 2012). These results pertain to academic settings with university students; still, together with my findings, they highlight the importance of integrating self-reports with trace-based methodologies in order to build a fuller account of i) users' (self-regulatory) learning processes in their authentic context of occurrence, plus ii) users' interpretations and memories of the if-then-else productions that underlie these processes – as suggested in the existing literature (Cleary et al., 2012; Greene & Azevedo, 2010; Winne, 2010).

As with any empirical evaluation, the two experiments in this research faced some specific limitations and threats which could have affected the validity of the findings. In the following, I examine these limitations, discuss how they might have influenced the internal, external and construct validity of my experiments, and what steps were taken to address them.

6.2. Study Limitations

Internal validity refers to the degree to which the results of a study can be attributed to the applied interventions rather than extraneous or confounding variables (Campbell & Stanley, 1963). The possible confounding factors within my two experiments included: i) *Instrumentation*: the main instruments in the first experiment were the early prototypes of Interventions I, III, V and VI, and the questionnaires in the form of self-reports. As with any piece of new technology, the prototypes of the functionalities could have faced some inevitable usability issues. To address this, first the implemented functionalities were tested in a pilot study prior to making them available to the participants. Second, users were asked to perform the requested tasks

within a structured learning scenario authentic to the context of their workplaces. The advantage of this scenario was that it offered detailed navigation instructions on how to perform the tasks using the Learn-B environment. The objective was to keep users away from getting lost in the Learn-B environment, or facing some unpredicted technical issues. The instruments in the second experiment included the fully implemented versions of all the proposed interventions, post-questionnaires in form of self-reports and the collected trace data. Again, the full prototypes were run through several testing iterations prior to starting the experiment to eliminate, as much as possible, the potential technical difficulties and software bugs. Additionally, the post-questionnaire items related to my research questions, together with the other questions related to the generic objectives of the IntelLEO project, were pre-tested using *cognitive interviews* (Beatty & Willis, 2007) with a sample of three users. ii) *Selection*: one potential issue with data collection in the two experiments was that the participants were selected from different workplace environments. Although this allowed me to evaluate my research questions across various organizational contexts, participants' possible organizational bias against available affordances of the interventions was not controlled. For instance, in the first business case users were generally very privacy-cautious and in some cases even reluctant to share their contributions and learning related data within the organization. This could have affected their use of, and accordingly perspective on the interventions built upon the social context, such as Interventions I and II. Moreover, the language and terminology barrier were the other major issues concerning data collection. For instance a "learning goal" might have been perceived differently across the first and third business cases (the leading car manufacturer and the professional teacher association, respectively). The introductory presentations of the interventions and structured scenarios authentic to participants' organizational context were aimed to tackle these issues and ensure that users did not acquire a misleading understanding of the provided functionalities or perceived them risky to their organizational position.

To overcome the threat of limited population, the participants in the two experiments were selected from a sufficiently diverse sample of organizational contexts, in that each business case represented a different workplace setting. Another possible threat to the external validity of the experiments was that the end-users knew they were participating in a research study. To minimize the effects of this threat, the study

arrangement was as close to the users' real working environment as possible; the learning scenarios were phrased in accordance to the users' organizational context and data from the users' very own work environment was used to load the interventions. One might consider these scenarios limiting, as they could have put some restrictions on how freely users' regulated their learning processes. However, it should be noted that the scenarios were representatives of the most common situations in each of the business cases; thus, they actually were aimed to help the participants in their day-to-day working tasks in accordance to their very own organizational settings.

Construct validity explores whether the constructs used in a study provide accurate measurements of what they are intended to measure (Bagheri et al., 2012). I defined and measured three sets of constructs (namely, SRL, Interventions and usage belief constructs) in the first experiment. To minimize the *operationalism* threat, the SRL processes were operationalized via the three tasks that users performed in the study. This was a straightforward and direct mapping between the processes and the tasks as each of the macro and micro-level SRL processes had a clear description in my underlying theoretical framework, and the measurement methodology. Thus, each study task in the scenario was designed in a way to explicitly manifest one micro-level SRL process. Usage belief constructs were measured via plain questionnaire items. Each of the available interventions in this experiment was also (multi-)operationalized via a set of items in the respective questionnaires, where each question item was associated with some available functionality of an Intervention.

The second experiment included the SRL and Intervention constructs. Both of these constructs were measured via post-questionnaire items and trace data. There are some unavoidable challenges in how users answer items in a questionnaire. According to (Krosnick, 2000), to respond to questions (of a survey) with high-quality answers respondents usually go through a four-step cognitive process. First, respondents interpret the meaning of each question; next, they search their memories trying to recall relevant information; then, they integrate the information they found into summary judgments and finally, they map this final judgment into one of the available options. To be more realistic, however, respondents are usually prone to reduce the burden of this cognitive effort and make the task of question-answering as easy as they can. This is often referred to as *satisficing* (Tourangeau et al., 2000). To minimize the threat of

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satisficing, I used Likert scales, in that I formulated the available options in a balanced order and avoided agree/disagree, true/false and yes/no questions (Krosnick, 2000). Also, a valid challenge with regard to Likert scales is that it provides a limited number of ordinal options. This might prevent participants from precisely articulating their opinion. Empirical studies have shown that the best number of options for a Likert scale is between 4 and 7(Lozano et al., 2008). Accordingly, I chose the five-point scale to minimize threats to the validity of this measurement mechanism.

Inferences based on traces can face limitations similar to users' self-reports (Winne et al., 2010). For instance, the trace data collected in the second experiment likely constitute only a sample of all the possible users' SRL processes, which i) happened within the Learn-B environment and ii) the log tracking module was programmed to capture (that is, they were included in the underlying *pattern library*). Moreover, such inferences are rather event-specific and may not scale beyond the contexts wherein the original traces were generated. These issues were overcome to a certain extent, as I tried to be as inclusive as possible in associating users' actions with micro-level SRL processes. Still, this association could be subject to researcher's bias, because it did not include users' explicit view of how their performed actions were linked to their SRL processes. Such a bias could be diminished by asking for users' explicit acknowledgement before storing a specific event as the indicator of a certain SRL micro-level process. However, an implication of asking for users' direct acknowledgement is that it may in turn interrupt their flow of cognition.

This dissertation highlights several conceptual, methodological and analytical implications pertinent to the research on supporting SRL processes in workplaces. In the following I discuss these implications.

6.3. Conceptual, Methodological and Research Implications

SRL in formal, educational settings has been studied rather extensively for three decades now. In the educational context, research investigating use of technologies to support SRL might be based on any of the three principal SRL models, namely (Zimmerman, 2001)'s social-cognitive model, (Winne & Hadwin, 1998)'s information

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processing model or (Pintrich, 2000)'s general framework for SRL, or a conceptual merging of several models; see (Carneiro et al., 2007; Winters et al., 2008) for a review on the existing empirical studies. Conversely, very little is known about how SRL is employed by knowledge workers in informal learning contexts of workplaces and how it can be supported and enhanced via technological advancements. As in the case of educational settings (Azevedo, 2009; Winters et al., 2008), it is imperative that researchers plainly formulate the theoretical model used in their studies and make it clear how it contributes to their assumptions about specific mechanisms, processes and constructs. Considering the lack of research in this area, this would allow building a consistent body of theoretical and conceptual definitions as well as evidence on support for SRL processes in workplace contexts. In my view, one of the advantages of this research is that it investigated the effect of the provided support, grounded in an explicit theoretical framework, considering challenges specific to the nature of workplace learning. This framework guided me to generate my a-priori hypotheses regarding the role of each intervention in supporting users' SRL processes in the workplace, and analyse the results accordingly. An implication of the findings of my research in this regard is that when developing targeted interventions aimed at supporting users' SRL processes in the workplace, researchers and practitioners should incorporate both the social and organizational contexts in those interventions. One challenge here is that organizational context might be interpreted differently in different domains (Ashton, 2004; Ellinger, 2005; Marsick, 2009). Considering what participants in the two experiments, who came from very different workplaces, commonly emphasized especially when planning their learning goals, one suggestion here could be that organizational context in general may be in the form of learning objectives and norms of a workplace with regard to an individual's position and responsibilities.

Although the elements of my research strategy are not totally new, in my view, together they suggest a unique, forward-looking approach, which was not done previously, for designing interventions and investigating their support for SRL processes in workplace settings. First, because workplace learning is highly informal and contextual, I employed design-based research to design, revise and evaluate my proposed interventions in the very context for which they were aimed. This allows

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aligning the integrity and effectiveness of the proposed interventions with the nature of workplace learning and avoiding developing interventions isolated from real practice.

Second, I aimed to examine the provided support for SRL processes in their entirety, including the processes related to all of the three phases in my SRL model. Reviewing the existing literature, e.g. (Dettori & Persico, 2008; Greene & Azevedo, 2009; Puustinen & Pulkkinen, 2001; Sitzmann & Ely, 2011), I articulated a set of more generic processes within the three phases of my underlying SRL model as *macro-level* processes, and defined the specific activities within each of these phases as *micro-level* SRL processes. I examined the effect of the provided support at the level of these micro-processes. This enabled me to provide a more accurate picture of the role of the interventions within the larger construct of SRL.

Third, because SRL processes are dynamic and contextual, I pursued an event-based conceptualization of them, and aimed to measure them as a sequence of events (traces) in the real context where they happen. Pioneered by Winne and associates, tracing methodology has started to find its way as another method for examining self-regulated learning processes in formal, educational settings (Hadwin et al., 2007; Winne & Jamieson-Noel, 2002; Zhou & Winne, 2012). Compared to questionnaires, trace data are not bound to a certain point in time, and operationalize "what users do as they do it" (Winne, 2010). In my view, the trace-based methodology that I employed in my research together with the micro-analytical measurement method provide a distinctive lens through which I could accurately measure and analyse how knowledge workers' SRL processes were supported by the proposed interventions. Comparable with the potential objective of micro-analytical protocols in formal education (Cleary et al., 2012), this combination of trace-based methodology and micro-analytical measurement can guide researchers in intervention planning and development for workplace settings.

Findings of the second experiment suggested that Intervention II was a determinant of users' engagement in all three SRL macro-level processes; whilst Intervention VI was a determinant for Goal Setting and Making Personal Plans, micro-level processes plus the engagement macro-level process. These findings are not intended to be generalized to a population, but rather to inform theory and analysis regarding support for SRL processes. One possible suggestion here could be that both

the social and organizational contexts be taken into account when developing interventions aimed at supporting the engagement phase; whilst to support users' evaluation and reflection processes in the workplace, incorporation of only the social context might be helpful.

7.   Conclusions and Future Directions

7.1. Conclusions

In this dissertation, I have investigated how a set of Semantic Web-enabled interventions, designed in view of the challenges specific to the nature of workplace learning, support users' SRL processes in the workplace. I followed a design-based research approach to design, refine and evaluate the proposed interventions in the real, dynamic context of practitioners' every-day work practices, and developed a trace-based methodology to investigate users' deployment of SRL processes as they occurred in their authentic context. Through two evaluation experiments, I drew out the interventions that evidently supported knowledge workers' SRL processes at different macro and micro levels. This research makes two important contributions to the field. First, the findings deliver a theoretical understanding of the linkage between the social and organizational dimensions of workplace, and individuals' deployment of self-regulatory learning processes in these environments. This understanding can guide researchers in intervention planning and development for workplace settings. Second, in light of the significant limitations of self-reports, this work is a first take on developing and applying a micro-analytical, trace-based methodology for measuring SRL processes in the workplace. This methodology takes promising steps toward adopting new methodological approaches in investigating SRL (Schraw, 2010; Winne et al., 2002; Winne, 2010) and offers new ways to achieve insight into factors that promote knowledge workers' use of the self-regulatory processes.

In the first stage of my design-based research approach, I explored the existing literature on challenges of workplace learning. Supporting workplace learning faces many challenges, some of which are in particular due to the informal, contextual and social nature of learning in the workplace: i) the informal nature of workplace learning coupled with dynamics of highly competitive business climates demand individuals in contemporary workplaces to be able to self-regulate their learning processes; ii) the

contextual nature of workplace learning implies the imperative role of organizational context in how learning in the workplace is conducted and desired goals are defined and attained; and iii) its social nature emphasizes that individuals' work and learning activities are socially mediated and collective-centred. In addition to these challenges, through my participation in the IntelLEO project I observed and analysed knowledge workers' practical learning issues within the authentic context of their organizations.

I used these insights in the second stage of my research approach to do the initial design of my proposed interventions and formulate my a-priori hypotheses. Intervention I provided users with information on how a given learning resource was employed by other users in the organization. I hypothesized that this assisted users in the *planning* phase of their SRL process. Intervention II provided users with the latest updates related to i) their learning goals and ii) learning activities of their colleagues. My hypothesis was that it supported users in their *planning* and *engagement* SRL processes. Intervention III provided users with information on their individual progress in achieving their defined learning goals, plus a comparison of their progress with their colleagues'. I hypothesized that this supported users in their performing *engagement* and, *evaluation & reflection* SRL processes. Intervention IV allowed users to receive recommendations on learning goals from their colleagues. My hypothesis was that this aided users with task analysis and goal setting activities during the *planning* phase. The organization's learning objectives and requirements in terms of available competences and their required prerequisites were provided to users via Intervention V which, I hypothesized, supported users in their *planning* phase. Intervention VI provided users with recommendations on different options (in terms of learning paths) available for achieving a given competence. I hypothesized that this supported users in performing *planning* activities. Finally, Intervention VII informed users of the extent to which they had shared their learning resources with others, and a comparison of this extent with that of their colleagues. My hypothesis was that it helped users with their *reflection*-related activities.

In the third stage, I refined the interventions through three iterations: a preliminary exploration using paper prototypes, plus two non-experimental evaluation studies using the early and full prototypes of the interventions, respectively. Users were introduced to the paper prototypes via focus groups in the preliminary exploration, and

their feedback was collected through a discussion after this demonstration. The results from this iteration were used to address users' explicit usability concerns related to the design of the proposed interventions. Also, users' feedback on paper prototypes' overall functionality was used to improve and revise the conceptualization and design of the interventions in the subsequent iterations. In the first evaluation study, users were asked to perform a set of tasks, in the form of a learning scenario, using the early prototypes and fill in a questionnaire after completing each task. With an emphasis on users' perceived usefulness and usage belief constructs, I investigated two research questions in this iteration: (RQ1) how useful users perceived the proposed interventions in performing SRL processes at their workplace, and (RQ2) whether and to what extent users' usage beliefs about the performed SRL processes were associated with their perceived usefulness of the proposed interventions. To examine my research questions, I applied descriptive and inferential statistics to users' responses to the questionnaires. In the second evaluation study, users used the full prototypes of the interventions to conduct a set of learning scenarios during a two-month testing period and filled in a related post-questionnaire after this period. My research questions in this final iteration were: (RQ1) how the proposed interventions supported users in conducting their SRL processes in the workplace and (RQ2) which interventions were most effective in providing this support. I developed a micro-analytical, trace-based methodology to capture users' use of the interventions as well as deployment of SRL processes in real time across their authentic contexts. I used two sources of collected data to investigate my first research question: i) participants' responses to the post-questionnaire and ii) trace data, from which I extracted events' frequency counts plus weights of the hypothesized contingencies. I used descriptive statistics to analyse the former, and descriptive and inferential statistics to analyse the latter. To investigate RQ2, first I analyzed users' trace data in terms of graph theoretic measures. Then, I explored whether and to what extent there were potential associations, on top of the ones analysed in RQ1, between users' usage of the interventions and their deployment of SRL processes. Finally, I examined the trace data to find the interventions which were the strongest predictors of users' deployment of SRL processes in light of potential confounding variables.

In the fourth stage of my research approach, I reflected on the results of these two non-experimental evaluation studies to highlight the important issues associated with supporting users' self-regulatory learning processes in the workplace. When asked through self-reports, in the first experiment users perceived Interventions V and VI useful for their planning phase. Intervention I was also perceived relatively useful in this iteration, but not as an influential factor for planning decisions. Consistent with these results, in the second experiment users perceived Interventions I and IV useful for their planning processes, but only when complemented with the functionalities of Interventions V and VI. These findings suggest that what learners have *in mind* (and assert it via self-reports) is that they do consider the social context of their organization when planning their learning goals; yet, it does not serve as the most influencing factor for them. Instead, they tend to primarily rely on their organizational context in this initializing phase. Analysis of users' traces of their actual learning actions, however, revealed a relative balance between their reliance on both social and organizational contexts when conducting different SRL processes. The trace data showed that users' deployment of planning and engagement processes were strongly associated with their use of Interventions II and VI (in the case of both phases), I (in the case of the planning phase) and V (in the case of the engagement phase). Users' evaluation and reflection activities were correlated only with their usage of Intervention II. In addition, Intervention II appeared as the most important node in the users' graph of learning actions followed by Interventions I, V and VI. Intervention II was also the strongest determinant of users' engagement in different SRL processes. Compared to the self-reports, these findings painted a different image, showing that being informed about the relevant learning activities of colleagues (the social context) played a relatively more important role than the organizational context in supporting users' deployment of SRL processes.

Taken together, these findings in this research suggest that elements from both social and organizational aspects of a workplace should be integrated into the design and development of interventions which aim to support users' SRL processes in that environment. Social context can be manifested through different lenses, depending on the SRL processes targeted by an intervention. For instance, it can be in the form of updates on other users' learning actions that are relevant to a specific user, updates/usage information from the collective regarding a certain learning activity, users'

comments, keywords and tags about a knowledge asset, learning goals recommended by other users, a combination of all of these forms, or any other desired manifestation which best suits the learning needs and requirements of a given workplace and its knowledge workers. Likewise, organizational context might be interpreted differently based on the characteristics of the targeted domain. For instance, in the case of the participants in my research it was in the form of personalized recommendations on available competences and learning paths for achieving them, since these users, although coming from very different domains, commonly emphasized that they would like to be aware of the learning objectives and norms of their workplace with regard to their very own individual position and responsibilities.

7.2. Directions for Future Research

This dissertation provides insights into issues that have not been yet addressed in the field. Still, there are many promising avenues of future work in supporting learning, specifically self-regulatory learning in the workplace. I recommend four potential useful directions as follows:

Besides the insights gained from the results of the two evaluation experiments, another contribution of this research is the micro-analytical, trace-based methodology that I developed in this research. This methodology was built upon the *event*-based conceptualization of SRL that I pursued in this dissertation, and was used in order to accurately capture knowledge workers' SRL processes on the fly and in their authentic context of occurrence. It should be borne in mind that any applied SRL measurement methodology should be in accordance with the underlying conceptualizing (Greene & Azevedo, 2010). In future research, first, this methodology needs to be complemented with other forms of data that conceptualize SRL as an *aptitude* (Winne, 2010b; Winne & Perry, 2000). Although traces can provide researches with detailed, valuable information on users' learning activities "in action", they are subject to some limitations and biases, and thus, not inherently the best and only method for gathering data about SRL (Winne et al., 2010). *Aptitudes* are also essential to researching SRL, as they represent what users have "in mind" when they engage in SRL processes. Aptitudes are most commonly measured via self-reports. The self-reports, which I designed in this research,

were rather focused on users' perceived usefulness of the support provided by the interventions, and did not target users' views on what they were doing and how they engaged in SRL processes. Together, traces and self-reports can be used to paint a much fuller and more detailed picture of users' actual engagement in SRL processes.

Second, more exploration is needed regarding the different aspects of the complex phenomenon of SRL, specifically in workplace settings. Motivational constructs (e.g. self-efficacy or achievement goal orientation) are one of these aspects which play an undeniably important role in users' SRL processes. For instance, they can affect why users' adopt a particular learning goal, or how they shape their behaviour in general (Inoue, 2007; Schraw, 2010; Winne et al., 2010). In this dissertation, traces were understood as "observable representations of cognitive and meta-cognitive events" (Winne, 2010). Yet, traces can also be used to operationalize, capture and measure motivational constructs; for instance, see the research conducted by Zhou on tracing goal orientation in academic settings (Zhou, 2008; Zhou & Winne, 2012). An intriguing avenue for future research in this regard could be to examine how technological advancements may influence users' motivation (and other constructs such as affect) for SRL in the workplace. This would enable us to gain deeper insight into common working practices of knowledge workers and the bottlenecks they encounter in their learning processes. This insight in turn can mediate designing interventions that provide a richer support for users' SRL processes in the workplace.

Third, future research might study how innovative interventions supporting SRL processes affect users' learning outcomes, or in other words, products of their learning processes. As opposed to formal educational settings where often a measurable achievement is desired and validated as the outcome of the learning process, the informal nature of workplace learning implies that all learning processes will not necessarily lead to some predefined, explicit outcomes (Marsick & Volpe, 1999). Task performance is most often knowledge workers' main goal in the workplace. This implies that learning typically happens as a by-product of work in workplaces to achieve this goal in the workplace (Illeris, 2011; Ley et al., 2010; Margaryan et al., 2009). Accordingly, outcomes of informal learning are often manifested through rather implicit products such as learning practical skills, learning about the culture of the organization, being prepared for existing jobs as well as being able to adapt to emerging technological

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and societal transformations (Ellinger, 2005; Marsick et al., 2011; Tynjälä, 2012) . On the other hand, SRL can be seen both as a process and as an outcome. As a *process*, it can be perceived as self-initiated actions which users take to plan their learning goals, engage in learning strategies and, evaluate and reflect on these actions. As a *product*, it can be perceived as "users' disposition to direct their own learning" (Brookfield, 1986; cited in Littlejohn et al., 2012, p. 228). In this research, I focused on investigating how the proposed interventions can support users' SRL processes, looking from the *process* perspective. Nevertheless, future research can integrate other data indicator of learning outcomes, such as users' portfolio and performance assessments, with users' trace and self-report data in order to investigate how potential targeted interventions relate to learning outcomes in the workplace.

Finally, I recommend future research to investigate the extent to which different tools, aimed to provide users with social and organizational contexts of their workplace, can support SRL processes. SRL is contextual; in this research I proposed and examined the effect of a set of particular interventions, implemented as prototypes within the IntelLEO project. An important lesson learned in this process was that many users, especially those coming from highly competitive organizational settings, are not comfortable enough or used to working with (research) prototypes. In addition, each software or tool delivers different cognitive affordances, according to which different traces of users' SRL activities could be expected and captured. These issues point to a need to design and evaluate how more mature, different types of tools can support different macro and micro-level SRL processes.

In all, the above future areas of research would enhance and complement current research on supporting SRL in workplaces, and I hope that this dissertation provides the initial steps and will make a valuable contribution toward this goal.

References

Allemang, D., & Hendler, J. (2008). *Semantic Web for the working ontologist: effective modeling in RDF, RDFS and OWL*. Amsterdam: Morgan Kaufmann/Elsevier.

Amiel, T., & Reeves, T. C. (2008). Design-based research and educational technology: Rethinking technology and the research agenda. *Educational Technology & Society*, *11*(4), 29-40.

Anderson, P., Hepworth, M., Kelly, B., & Metcalfe, R. (2007). What is Web 2.0? Ideas , technologies and implications for education. *Technology*, *60*(1), 64.

Anderson, T. (2005). Design-based Research and its Application to a Call Centre Innovation in Distance Education. *Canadian Journal of Learning and Technology*, *31*(2), 69 - 83.

Ang, S., & Joseph, D. (1996). Organizational Learning and Learning Organizations : Trigger Events , Processes , and Structures. *Proceedings of the Academy of Management Meeting* (Vol. 4813). Cincinnati, OH.

Ashton, D. (2004). The impact of organisational structure and practices on learning in the workplace. *International Journal of Training and Development*, *8*(1), 43–53. Wiley Online Library. doi:10.1111/j.1360-3736.2004.00195.x

Azevedo, R. (2009). Theoretical, conceptual, methodological, and instructional issues in research on metacognition and self-regulated learning: A discussion. *Metacognition and Learning*, *4*(1), 87 - 95. doi:10.1007/s11409-009-9035-7

Azevedo, R. (2010). Using Hypermedia as a Metacognitive Tool for Enhancing Student Learning ? The Role of Self- Regulated Learning. *Educational Psychologist*, *40*(4), 199 - 209.

Azevedo, R., Johnson, A. M., Chauncey, A. D., & Burkett, C. (2010). Self-regulated learning with MetaTutor: Advancing the science of learning with MetaCognitive tools. In M. Khine & I. Saleh (Eds.), *New science of learning: Computers, cognition, and collaboration in education* (pp. 225 - 247). Amsterdam: Springer.

Azevedo, R., Moos, D. C., Johnson, A. M., & Chauncey, A. D. (2010). Measuring Cognitive and Metacognitive Regulatory Processes During Hypermedia Learning: Issues and Challenges. *Educational Psychologist*, *45*(4), 210-223. doi:10.1080/00461520.2010.515934

Azouaou, F., & Desmoulins, C. (2006). Using & Modeling Context with Ontology in e-learning: the Case of Teacher's Personal Annotations. *International Workshop on Application of Semantic Web Technologies for E-Learning. June 21-23.* Dublin, Ireland.

Bagheri, E., Ensan, F., & Gašević, D. (2012). Decision support for the software product line domain engineering lifecycle. *Automated Software Engineering*, *19*(3), 335-377. doi:10.1007/s10515-011-0099-7

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, *44*(9), 1175-84. American Psychological Association.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the learning sciences*, *13*(1), 1 - 14.

Bastian, M., Heymann, S., & Jacomy, M. (2009). Gephi: An open source software for exploring and manipulating networks. *International AAAI Conference on Weblogs and Social Media* (pp. 361 - 362).

Beatty, P., & Willis, G. (2007). Research synthesis: The practice of cognitive interviewing. *Public Opinion Quarterly*, *71*(2), 287 - 311.

Benbasat, I., & Barki, H. (2007). Quo vadis TAM? *Association for Information Systems*, *8*(4), 211-218.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Hillsdale, NJ: Lawrence Erlbaum.

Bereiter, C., & Scardamalia, M. (2003). Learning to Work Creatively with Knowledge. *Powerful learning environments: Unravelling basic components and dimensions*, 55 - 68.

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The Semantic Web. *Scientific american*, *284*(5), 28 - 37.

Blaikie, N. (2003). *Analysing Quantitative Data: From Description to Explanation*. London: Sage Publications.

Boekaerts, M. (1997). Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers, and students. *Learning and Instruction*, *7*(2), 161-186. Elsevier.

Boekaerts, M., & Cascallar, E. (2006). How Far Have We Moved Toward the Integration of Theory and Practice in Self-Regulation? *Educational Psychology Review*, *18*(3), 199-210. Springer Netherlands.

Borgatti, S., Mehra, A., Brass, D., & Labianca, G. (2009). Network analysis in the social sciences. *science*, *323*(April), 892-896.

Braun, S., Kunzmann, C., & Schmidt, A. (2010). People Tagging and Ontology Maturing: Toward Collaborative Competence Management. *From CSCW to Web 2.0: European Developments in Collaborative Design* (pp. 133-154).

Braun, S., Schmidt, A., & Hentschel, C. (2007). Semantic Desktop Systems for Context Awareness–Requirements and Architectural Implications. *1st Workshop on Architecture, Design, and Implementation of the Semantic Desktop (SemDesk Design), 4th European Semantic Web Conference (ESWC 2007), Innsbruck, Austria*.

Breslin, J. G., Passant, A., & Decker, S. (2009). *Social Semantic Web.* Springer.

Breslin, J. G., Passant, A., & Vrandec, D. (2011). *Handbook of Semantic Web Technologies.* (J. Domingue, D. Fensel, & J. A. Hendler, Eds.). Berlin, Heidelberg: Springer Berlin Heidelberg.

Cairns, L., & Malloch, M. (2011). Theories of Work, Place and Learning: New Directions. In M. Malloch, L. Cairns, K. Evans, & B. N. O'Connor (Eds.), *The SAGE Handbook of Workplace Learning* (pp. 3 - 16). London: SAGE Publications Ltd.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research.* (N. L. Gage, Ed.)*Information Processing* (Vol. 20, p. 84). Rand McNally. doi:10.1016/0306-4573(84)90053-0

Carifio, J. (1987). Measuring vocational preferences: ranking versus categorical rating procedures. *Career Education Quarterly*, *3*(2), 17-28.

Carifio, J., & Perla, R. (2008). Resolving the 50-year debate around using and misusing Likert scales. *Medical Education*, *42*(12), 1150-1152.

Carmen, M., & Torres, G. (2004). Self-Regulated Learning : Current and Future Directions. *Educational Psychology*, *2*(1), 1-34.

Carneiro, R., Lefrere, P., & Steffens, K. (2007). Self-regulated Learning in Technology Enhanced Learning Environments: A European Review. *Higher Education*, *17*(3). Shaker-Verlag.

Carroll, J. (Ed.). (1995). *Scenario-based design: Envisioning work and technology in system development.* New York: Wiley.

Casey, a. (2005). Enhancing Individual and Organizational Learning: A Sociological Model. *Management Learning*, *36*(2), 131-147. doi:10.1177/1350507605052555

Chen, C. S. (2002). Self - regulated Learning Strategies and Achievement in an Introduction to Information Systems Course. *Spring*, *20*(1), 11-25.

Chuttur, M. (2009). Overview of the Technology Acceptance Model: Origins, Developments and Future Directions. *Sprouts: Working Papers on Information Systems*, *9*(37).

Cleary, T. J., Callan, G. L., & Zimmerman, B. J. (2012). Assessing Self-Regulation as a Cyclical, Context-Specific Phenomenon: Overview and Analysis of SRL Microanalytic Protocols. *Education Research International*, *2012*, 1-19. doi:10.1155/2012/428639

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. (L. Erlbaum, Ed.)*Statistical Power Analysis for the Behavioral Sciences* (Vol. 2nd, p. 567). Lawrence Erlbaum Associates.

Colley, H., Hodkinson, P., & Malcolm, J. (2003). *Informality and formality in learning: a report for the Learning and Skills Research Centre. London Learning and Skills Research Centre.*

Collis, B., Bianco, M., Margaryan, A., & Waring, B. (2005). Putting Blended Learning to Work: a case study from a multinational oil company. *Education Communication Information*, *5*(3), 233-250.

Crossan, M. M., Lane, H. W., & White, R. E. (1999). An organizational learning framework: From intuition to institution. *Academy of management review*, *24*(3), 522–537.

Dabbagh, N., & Kitsantas, A. (2004). Supporting self-regulation in student-centered web-based learning environments. *International Journal on E-learning*, *3*(1), 40-47.

Dabbagh, N., & Kitsantas, A. (2005). Using Web-based Pedagogical Tools as Scaffolds for Self-regulated Learning. *Instructional Science*, *33*(5-6), 513-540. doi:10.1007/s11251-005-1278-3

Dabbagh, N., & Reo, R. (2010). Back to the Future: Tracing the Roots and Learning Affordances of Social Software. In M. J. W. Lee & C. McLoughlin (Eds.), *Web 2.0 Based ELearning Applying Social Informatics for Tertiary Teaching* (pp. 1-20). IGI Global.

Dasgupta, S., Khosrow-Pour, M., Clarke, S., Jennex, M. E., & Becker, A. (Eds.). (2009). *Social Computing: Concepts, Methodologies, Tools and Applications* (Vol. 2009). Hershey, PA: Information Science Reference - Imprint of: IGI Publishing.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319. JSTOR. doi:10.2307/249008

Dehler, J., Bodemer, D., Buder, J., & Hesse, F. W. (2011). Guiding knowledge communication in CSCL via group knowledge awareness. *Computers in Human Behavior*, *27*(3), 1068-1078. Elsevier Ltd. doi:10.1016/j.chb.2010.05.018

Derntl, M., & Hummel, K. A. (2005). Modeling Context-Aware e-Learning Scenarios. *Third IEEE International Conference on Pervasive Computing and Communications Workshops* (pp. 337-342).

Dettori, G., & Persico, D. (2008). Detecting Self-Regulated Learning in Online Communities by Means of Interaction Analysis. *IEEE Transactions on Learning Technologies*, *1*(1), 11-19.

Dey, A. K. (2001). Understanding and Using Context. *Personal and Ubiquitous Computing*, *5*(1), 4-7. Springer-Verlag.

Dinsmore, D., Alexander, P., & Loughlin, S. (2008). Focusing the conceptual lens on metacognition, self-regulation, and self-regulated learning. *Educational Psychology Review*, *20*(4), 391 - 409.

Easterby-Smith, M., & Malina, D. (1999). Cross-Cultural Collaborative Research: Toward Reflexivity. *Academy of Management Journal, 42*(1), 76-86. Academy of Management. doi:10.2307/256875

Ellinger, A. D. (2005). Contextual Factors Influencing Informal Learning in a Workplace Setting : The Case of " Reinventing Itself Company ." *Human Resource Development Quarterly*, *16*(3), 389–415. Wiley Online Library.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of education and work*, *14*(1), 133 - 156.

Eraut, M. (2004a). Informal learning in the workplace. *Studies in continuing education*, *26*(2), 247–273. Taylor & Francis. doi:10.1080/158037042000225245

Eraut, M. (2004b). Transfer of knowledge between education and workplace settings. In H. Rainbird, A. Fuller, & A. Munro (Eds.), *Workplace learning in context* (pp. 201-221). London: Routledge.

Eraut, M. (2011). How researching learning at work can lead to tools for enhancing learning. In M. Malloch, L. Cairns, K. Evans, & B. N. O'Connor (Eds.), *The SAGE Handbook of Workplace Learning* (pp. 181-197). London: SAGE Publications Ltd.

Fenwick, T. (2008a). Workplace learning: Emerging trends and new perspectives. *New Directions for Adult and Continuing Education*, *2008*(119), 17–26. Wiley Online Library. doi:10.1002/ace

Fenwick, T. (2008b). Understanding Relations of Individual--Collective Learning in Work: A Review of Research. *Management Learning, 39*(3), 227-243. doi:10.1177/1350507608090875

Fischer, G. (2000). Lifelong learning-more than training. *Journal of Interactive Learning Research*, *11*(3/4), 265-294.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behaviour: An introduction to theory and research*. Addison-Wesley.

Freeman, L. C. (1979). Centrality in social networks conceptual clarification. *Social networks*.

Fuller, A., & Unwin, L. (2004). Expansive learning environments: integrating personal and organisational development. In H. Rainbird, A. Fuller, & A. Munro (Eds.), *Workplace learning in context* (pp. 126–144). London: Routledge.

Gorelick, C. (2005). Organizational learning vs the learning organization: a conversation with a practitioner. *The Learning Organization*, *12*(4), 383 - 388.

Greene, J. A., & Azevedo, R. (2007). A Theoretical Review of Winne and Hadwin's Model of Self-Regulated Learning: New Perspectives and Directions. *Review of Educational Research*, *77*(3), 334-372. doi:10.3102/003465430303953

Greene, J. A., & Azevedo, R. (2009). A macro-level analysis of SRL processes and their relations to the acquisition of a sophisticated mental model of a complex system. *Contemporary Educational Psychology*, *34*(1), 18-29. Elsevier Inc. doi:10.1016/j.cedpsych.2008.05.006

Greene, J. A., & Azevedo, R. (2010). The Measurement of Learners' Self-Regulated Cognitive and Metacognitive Processes While Using Computer-Based Learning Environments. *Educational Psychologist*, *45*(4), 203-209. doi:10.1080/00461520.2010.515935

Gruber, H., & Harteis, C. (2011). Researching workplace learning in Europe. In M. Malloch, L. Cairns, K. Evans, & B. O'Connor (Eds.), *The SAGE Handbook of Workplace Learning* (pp. 224 - 235). London: SAGE Publications Ltd.

Gruber, T. (2008). Collective knowledge systems: Where the Social Web meets the Semantic Web. *Web Semantics: Science, Services and Agents on the World Wide Web*, *6*(1), 4-13.

HR-XML Competencies. (2004). HR-XML Competencies (Measurable Characteristics) Recommendation. Retrieved May 21, 2010, from http://ns.hr-xml.org/2_3/HR-XML-2_3/CPO/Competencies.html

Habibi, M. (2004). *Java regular expressions: taming the java.util.regex engine*. Berkeley, CA: Apress.

Hadwin, A. F., Järvelä, S., & Miller, M. (2011). Self-regulated, co-regulated, and socially-shared regulation of learning. *Handbook of Self-Regulation of Learning and Performance* (pp. 65 - 84). Taylor & Francis.

Hadwin, A. F., Nesbit, J. C., Jamieson-Noel, D., Code, J., & Winne, P. H. (2007). Examining trace data to explore self-regulated learning. *Metacognition and Learning*, *2*(2-3), 107-124. doi:10.1007/s11409-007-9016-7

Hadwin, A. F., Oshige, M., Gress, C. L. Z., & Winne, P. H. (2010). Innovative ways for using gStudy to orchestrate and research social aspects of self-regulated learning. *Computers in Human Behavior*, *26*(5), 794-805. Elsevier Ltd. doi:10.1016/j.chb.2007.06.007

Hager, P. (2004). The conceptualization and measurement of learning at work. In H. Rainbird, A. Fuller, & A. Munro (Eds.), *Workplace learning in context* (pp. 242 - 258). London: Routledge.

Hager, P. (2005). Current theories of workplace learning: A critical assessment. *International handbook of educational policy*, 829–846. Springer.

Hager, P. (2011). Theories of Workplace Learning. In M. Malloch, L. Cairns, K. Evans, & B. N. O'Connor (Eds.), *The SAGE Handbook of Workplace Learning* (pp. 17-32). London: SAGE Publications Ltd. doi:10.4135/9781446200940

Hager, P., & Halliday, J. (2007). *Recovering informal learning: Wisdom, judgement and community (Vol. 7)*. Springer.

Hager, P., Halliday, J., Aspin, D. N., & Chapman, J. D. (2006). *Lifelong, Informal and Workplace Learning* (Vol. 7, pp. 15-45). Dordrecht: Springer Netherlands. doi:10.1007/1-4020-5346-0

Hart, J. (2010). The State of Learning in the Workplace Today. *Center for Learning and Performance Technologies website*. Retrieved March 15, 2010, from http://c4lpt.co.uk/social-learning-handbook/

Herrington, J., McKenney, S., Reeves, T. C., & Oliver, R. (2007). Design-based research and doctoral students: Guidelines for preparing a dissertation proposal. In C. Montgomerie & J. Seale (Eds.), *World Conference on Educational Multimedia, Hypermedia and Telecommunications* (Vol. 2007, pp. 4089-4097). Chesapeake, VA: Association for the Advancement of Computing in Education.

Hodkinson, P., & Hodkinson, H. (2004). The Complexities of Workplace Learning: problems and dangers in trying to measure attainment. In H. Rainbird, A. Fuller, & A. Munro (Eds.), *Workplace learning in context*. London: Routledge.

Holden, R. J., & Karsh, B.-T. (2010). The technology acceptance model: its past and its future in health care. *Journal of biomedical informatics*, *43*(1), 159-72. Elsevier Inc. doi:10.1016/j.jbi.2009.07.002

Holocher-Ertl, T., Fabian, C., Siadaty, M., Jovanović, J., Pata, K., & Gašević, D. (2011). Self-regulated learners and collaboration: how innovative tools can address the motivation to learn at the workplace? In C. D. Kloos, D. Gillet, R. M. C. García, F.

Wild, & M. Wolpers (Eds.), *Towards Ubiquitous Learning - 6th European Conference onTechnology Enhanced Learning, EC-TEL 2011, Palermo, Italy. (Lecture Notes in Computer Science, Vol. 6964)* (pp. 506-511). Springer.

Houde, S., & Hill, C. (1997). What do prototypes prototype. In M. Helander, T. Landauer, & P. Prabhu (Eds.), *Handbook of human-computer interaction* (2nd ed., pp. 367 - 381). Amsterdam: Elsevier Science.

IEEE 1484.20.1.D8. (2007). IEEE draft Standard for Learning Technology-Data Model for Reusable Competency Definitions. Retrieved May 21, 2010, from http://www.ieeeltsc.org:8080/Plone/working-group/competency-data-standards-working-group-20/IEEE_1484.20.1.D8.pdf

IEEE STD.2002.94128. (2002). *IEEE Standard for Learning Object Metadata (IEEE LOM). IEEE Std 14841212002*. IEEE. doi:10.1109/IEEESTD.2002.94128

IMS RDCEO. (2002). IMS reusable definition of competency or educational objective. Retrieved May 21, 2010, from http://www.imsglobal.org/competencies/

Illeris, K. (2011). Workplaces and learning. In M. Malloch, L. Cairns, K. Evans, & B. N. O'Connor (Eds.), *The SAGE Handbook of Workplace Learning* (pp. 32 - 45). London: SAGE Publications Ltd.

Inoue, Y. (Ed.). (2007). *Online Education for Lifelong Learning*. Hershey, PA: Information Science Pub.

IntelLEO Consortium. (2010a). *Deliverable D1.1: State-of-the-Art Analyses, 7th Framework Programme Theme 3, ICT – Information and Communication Technologies.*

IntelLEO Consortium. (2010b). *Deliverable D2.4: Business Case Full Specification, 7th Framework Programme Theme 3, ICT – Information and Communication Technologies.*

Jackson, T., MacKenzie, J., & Hobfoll, S. E. (2000). Communal aspects of self-regulation. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 275-299). San Diego, CA: Academic Press.

Janssen, J., Berlanga, A., Vogten, H., & Koper, R. (2008). Towards a learning path specification. *International Journal of Continuing Engineering Education and Life Long Learning, 18*(1), 77-97.

Johnson, B., & Christensen, L. (2007). *Educational research: Quantitative, qualitative, and mixed approaches* (3rd ed.). Los Angeles: Sage Publications.

Jovanović, J., Gašević, D., Knight, C., & Richards, G. (2007). Ontologies for effective use of context in e-learning settings. *Educational Technology & Society, 10*(3), 47 - 59.

Jovanović, J., Gašević, D., Torniai, C., Bateman, S., & Hatala, M. (2009). The Social Semantic Web in Intelligent Learning Environments: state of the art and future challenges. *Interactive Learning Environments*, *17*(4), 273-309.

Kane, K., Robinson-Combre, J., & Berge, Z. L. (2010). Tapping into social networking: Collaborating enhances both knowledge management and e-learning. *Vine*, *40*(1), 62–70. Emerald Group Publishing Limited.

Keene, O. N. (1995). The Log-Transformation is Special. *Statistics in Medicine*, *14*(8), 811-819.

Kieslinger, B., & Gillet, D. (2008). How Social Is My Personal Learning Environment (PLE)?, Part 2. In J. Luca & E. Weippl (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications* (Vol. 2008, pp. 4990-4995). Chesapeake, VA: AACE.

Kimmerle, J., & Cress, U. (2007). Group awareness and self-presentation in computer-supported information exchange. *International Journal of Computer-Supported Collaborative Learning*, *3*(1), 85-97. doi:10.1007/s11412-007-9027-z

Klug, J., Ogrin, S., & Keller, S. (2011). A plea for self-regulated learning as a process : Modelling , measuring and intervening. *Psychological Test and Assessment Modeling*, *53*(1), 51-72.

Knight, L. (2002). Network Learning: Exploring Learning by Interorganizational Networks. *Human Relations*, *55*(4), 427-454. Passagen Verlag. doi:10.1177/0018726702554003

Krosnick, J. A. (2000). The threat of satisficing in surveys: the shortcuts respondents take in answering questions. *Survey Methods Centre Newsletter*, *20*(1), 4-8.

Kumar, V., Winne, P. H., Hadwin, A. F., Nesbit, J. C., Jamieson-Noel, D., Calvert, T., & Samin, B. (2005). Effects of self-regulated learning in programming. *Fifth IEEE International Conference on Advanced Learning Technologies (ICALT 2005)* (pp. 383-387). IEEE.

Kyndt, E., Dochy, F., & Nijs, H. (2009). Learning conditions for non-formal and informal workplace learning. *Journal of Workplace Learning*, *21*(5), 369–383. Emerald Group Publishing Limited.

Landherr, A., Friedl, B., & Heidemann, J. (2010). A Critical Review of Centrality Measures in Social Networks. *Business & Information Systems Engineering*, *2*(6), 371-385.

Lee, T., Fuller, A., Ashton, D., Butler, P., Felstead, A., Unwin, L., & Walters, S. (2004). *Workplace Learning: Main Themes & Perspectives. Learning as Work Research Paper* (Vol. 44, p. 41). Centre for Labour Market Studies, University of Leicester.

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management*, *40*(3), 191-204. doi:10.1016/S0378-7206(01)00143-4

Ley, T., Kump, B., & Albert, D. (2010). A methodology for eliciting, modelling, and evaluating expert knowledge for an adaptive work-integrated learning system. *International Journal of Human-Computer Studies*, *68*(4), 185-208. Elsevier. doi:10.1016/j.ijhcs.2009.12.001

Littlejohn, A., Margaryan, A., & Milligan, C. (2009). Charting Collective Knowledge: Supporting Self-Regulated Learning in the Workplace. *2009 Ninth IEEE International Conference on Advanced Learning Technologies*, *24*(3), 208-212. Ieee. doi:10.1109/ICALT.2009.14

Littlejohn, A., Milligan, C., & Margaryan, A. (2012). Charting collective knowledge: supporting self-regulated learning in the workplace. *Journal of Workplace Learning*, *24*(3), 226-238.

Liu, X. (2010). Empirical Testing of a Theoretical Extension of the Technology Acceptance Model: An Exploratory Study of Educational Wikis. *Communication Education*, *59*(1), 52-69. doi:10.1080/03634520903431745

Lozano, L. M., García-Cueto, E., & Muñiz, J. (2008). Effect of the Number of Response Categories on the Reliability and Validity of Rating Scales. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences*, *4*(2), 73-79. Hogrefe & Huber Publishers. doi:10.1027/1614-2241.4.2.73

Maier, R., & Thalmann, S. (2007). Describing learning objects for situation-oriented knowledge management applications. *4th Conference on Professional Konwledge Management Experiences and Visions. Vol. 2* (pp. 343-351).

Margaryan, A., Milligan, C., & Littlejohn, A. (2009). Self-regulated learning and knowledge sharing in the workplace: differences and similarities between experts and novices. *the 2009 Researching Work and Learning (RWL) Conference*. Roskilde, Denmark.

Margaryan, A., Milligan, C., Littlejohn, A., Hendrix, D., & Graeb-Koenneker, S. (2009). Self regulated learning and knowledge sharing in the workplace. *Organisational Learning Knowledge and Capabilities*, 1-15.

Marsick, V. J. (2009). Toward a unifying framework to support informal learning theory, research and practice. *Journal of Workplace Learning*, *21*(4), 265–275. Emerald Group Publishing Limited. doi:10.1108/13665620910954184

Marsick, V. J., & Volpe, M. (1999). The nature and need for informal learning. *Advances in Developing Human Resources*, *1*(3), 1 - 9.

Marsick, V. J., Watkins, K., & O'Connor, B. N. (2011). Researching Workplace Learning in the United States. In M. Malloch, L. Cairns, K. Evans, & B. N. O'Connor (Eds.), *The SAGE Handbook of Workplace Learning* (pp. 198 - 210). London: SAGE Publications Ltd.

McLoughlin, C., & Lee, M. J. W. (2007). Social software and participatory learning: Pedagogical choices with technology affordances in the Web 2.0 era. In R. J. Atkinson, C. McBeath, S. K. A. Soong, & C. Cheers (Eds.), *ICT: Providing choices for learners and learning, ascilite Singapore* (Vol. 2007, pp. 664-675). Ascilite Singapore 2007.

McMillan, J. H., & Schumacher, S. (2001). *Research in education : a conceptual introduction*. New York: Longman.

Mcloughlin, C., & Lee, M. J. W. (2010). Pedagogy 2.0: Critical challenges and responses to Web 2.0 and social software in tertiary teaching. In M.J.W. Lee & C. McLoughlin (Eds.), *Web 2.0-Based E-Learning: Applying Social Informatics for Tertiary Teaching* (pp. 43 - 69). Hershey, PA: Information Science Reference.

Mikroyannidis, A. (2007). Toward a social semantic web. *Computer*, *40*(11), 113- 115.

Nesbit, J. C., Xu, Y., Zhou, M., & Winne, P. H. (2007). Advancing Log Analysis of Student Interactions with Cognitive Tools. *12th Biennial Conference of the European Association for Research on Learning and Instruction* (pp. 1-20). Budapest.

Nonaka, I., & Konno, N. (1998). The concept of "Ba": building a foundation for knowledge creation. *California Management Review*, *40*(3), 40- 54.

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. New York: Oxford University Press.

Paavola, S., & Hakkarainen, K. (2005). The Knowledge Creation Metaphor – An Emergent Epistemological Approach to Learning. *Science & Education*, *14*(6), 535-557.

Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of Innovative Knowledge Communities and Three Metaphors of Learning. *Review of Educational Research*, *74*(4), 557-576. doi:10.3102/00346543074004557

Pallant, J. (2011). *SPSS survival manual: A step by step guide to data analysis using SPSS* (4th ed.). Allen & Unwin.

Papailiou, N., Christidis, C., Apostolou, D., Mentzas, G., & Gudjonsdottir, R. (2008). Personal and group knowledge management with the social semantic desktop. *Collaboration and the Knowledge Economy: Issues, Applications and Case Studiese, e-Challenges* (pp. 1475 - 1482). Stockholm, Sweden.

Pedler, M., Burgoyne, J. G., & Boydell, T. (1991). *The Learning Company*. London: McGraw-Hill.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of Self Regulation* (Vol. 451, pp. 451-502). San Diego, CA: Academic Press.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ). *Ann Arbor Michigan.* University of Michigan.

Puustinen, M., & Pulkkinen, L. (2001). Models of self-regulated learning: A review. *Scandinavian Journal of Educational*, *45*(3), 269-286. doi:10.1080/00313830120074206

Rasmussen, J. L., & Dunlap, W. P. (1991). Dealing with Nonnormal Data: Parametric Analysis of Transformed Data vs Nonparametric Analysis. *Educational and Psychological Measurement*, *51*(4), 809-820. doi:10.1177/001316449105100402

Razmerita, L., Kirchner, K., & Sudzina, F. (2009). Personal knowledge management: The role of Web 2.0 tools for managing knowledge at individual and organisational levels. *Online Information Review*, *33*(6), 1021-1039. doi:10.1108/14684520911010981

Reeves, T. C. (2006). Design research from a technology perspective. In J. van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research* (pp. 52 - 66). London: Routledge.

Sampson, D. G., & Fytros, D. (2008). Competence Models in Technology-enhanced Competence-based Learning. In H. H. Adelsberger, Kinshuk, J. M. Pawlowski, & D. G. Sampson (Eds.), *International Handbook on Information Technologies for Education and Training* (2nd ed.). Berlin: Springer.

Sangin, M., Molinari, G., Nüssli, M. A., & Dillenbourg, P. (2008). Knowing what the peer knows: The differential effect of knowledge awareness on collaborative learning performance of asymmetric pairs. *Times of Convergence. Technologies Across Learning Contexts*, 384 - 394.

Schraw, G. (2010). Measuring Self-Regulation in Computer-Based Learning Environments. *Educational Psychologist*, *45*(4), 258-266. doi:10.1080/00461520.2010.515936

Senge, P. M. (1991). *The Fifth Discipline: The Art and Practice of the Learning Organization*. New York: Doubleday Currency.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational researcher*, *27*(2), 4 - 13.

Siadaty, M., Jovanović, J., Gašević, D., & Jeremić, Z. (2010). Leveraging Semantic Technologies for Harmonization of Individual and Organizational Learning. In M. Wolpers, P. A. Kirschner, M. Scheffel, S. N. Lindstaedt, & V. Dimitrova (Eds.), *Sustaining TEL: From Innovation to Learning and Practice - 5th European Conference on Technology Enhanced Learning, EC-TEL 2010 (Lecture Notes in Computer Science, Vol. 6383)* (pp. 340-356). Barcelona, Spain: Springer.

Siadaty, M., Jovanović, J., Gašević, D., Milikić, N., Jeremić, Z., Ali, L., Giljanović, A., et al. (2012). Semantic Web and Linked Learning to Support Workplace Learning. In S. Dietze, M. D'Aquin, & D. Gašević (Eds.), *The 2nd International Workshop on Learning and Education with the Web of Data (LiLe 2012 at WWW'12)*. Lyon, France.

Siadaty, M., Jovanović, J., Pata, K., Holocher-Ertl, T., Gašević, D., & Milikić, N. (2011). A Semantic Web-enabled Tool for Self-Regulated Learning in the Workplace. *11th IEEE International Conference on Advanced Learning Technologies (ICALT 2011)* (pp. 66-70). IEEE.

Siadaty, M., Torniai, C., Gašević, D., Jovanović, J., Eap, T. M., & Hatala, M. (2008). m-LOCO: An Ontology-based Framework for Context-Aware Mobile Learning. *Proceedings of the 6th International Workshop on Ontologies and Semantic Web for Intelligent Educational Systems. 9th International Conference on Intelligent Tutoring Systems Montreal Canada (ITS'08). June 2008*. Montreal, Canada.

Sitzmann, T., & Ely, K. (2011). A meta-analysis of self-regulated learning in work-related training and educational attainment: what we know and where we need to go. *Psychological bulletin*, *137*(3), 421-42.

Slotte, V., Tynjälä, P., & Hytönen, T. (2004). How do HRD practitioners describe learning at work? *Human Resource Development International*, *7*(4), 481- 499.

Snyder, C. (2003). *Paper prototyping: The fast and easy way to design and refine user interfaces*. San Francisco, CA: Morgan Kaufmann.

Steffens, K. (2006). Self-Regulated Learning in Technology-Enhanced Learning Environments: lessons of a European peer review. *European Journal of Education*, *41*(3-4), 353-379. Wiley Online Library. doi:10.1111/j.1465-3435.2006.00271.x

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston: Pearson Education.

The Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, *32*(1), 5 - 8.

Tiropanis, T., Davis, H., Millard, D., & Weal, M. (2009). Semantic Technologies for Learning and Teaching in the Web 2.0 Era. *IEEE Intelligent Systems, 24*(6), 49 - 53.

Tochtermann, K., & Granitzer, G. (2008). The Long Way towards Workplace-Integrated Learning. *Eighth IEEE International Conference on Advanced Learning Technologies*, 8-13. Ieee. doi:10.1109/ICALT.2008.170

Tourangeau, R., Rips, L. J., & Rasinski, K. (2000). *The Psychology of Survey Response. Response*. Cambridge, England: Cambridge University Press.

Tynjälä, P. (2008). Perspectives into learning at the workplace. *Educational Research Review*, *3*(2), 130-154. doi:10.1016/j.edurev.2007.12.001

Tynjälä, P. (2012). Toward a 3-P Model of Workplace Learning: a Literature Review. *Vocations and Learning*, 1 - 26. doi:10.1007/s12186-012-9091-z

Ulbrich, A., Scheir, P., Görtz, M., & Lindstaedt, S. (2006). A Context-Model for Supporting Work-Integrated Learning. In W. Nejdl & K. Tochtermann (Eds.), *Innovative Approaches for Learning and Knowledge Sharing - 1st European Conference on Technology Enhanced Learning, EC-TEL 2006 (Lecture Notes in Computer Science, Vol. 4227)* (pp. 525-530). Crete, Greece: Springer.

Unwin, L., Felstead, A., Fuller, A., Lee, T., Butler, P., Jewson, N., & Kakavelakis, K. (2007). Worlds within worlds: The relationship between context and pedagogy in the workplace. *The learning potential of the workplace*. Rotterdam: Sense Publishers.

Valle, A., Núñez, J. C., Cabanach, R. G., González-Pienda, J. a, Rodríguez, S., Rosário, P., Muñoz-Cadavid, M. a, et al. (2009). Academic goals and learning quality in higher education students. *The Spanish journal of psychology*, *12*(1), 96-105.

Vassileva, J. (2008). Toward social learning environments. *IEEE Transactions on Learning Technologies*, *1*(4), 199-214.

Venkatesh, V., & Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences*, *39*(2), 273-315. doi:10.1111/j.1540-5915.2008.00192.x

Wang, F., & Hannafin, M. J. (2005). Design-Based Research and Technology-Enhanced Learning Environments. *Educational Technology Research & Development*, *53*(4), 5-23.

Weinstein, C. E., Schulte, A. C., & Palmer, D. R. (1987). *Learning and study strategies inventory (LASSI)*. Clearwater, FL: H & H Publishing.

Whipp, J., & Chiarelli, S. (2004). Self-Regulation in a Web-Based Course: A Case study. *Educational Technology Research and Development*, *52*(4), 5-22.

Winer, D. (2005). RSS 2.0 Specification. *Berkman Center for Internet & Society at Harvard Law School.*

Winne, P. H. (2010a). Bootstrapping learner's self-regulated learning. *Psychological Test and Assessment Modeling*, *52*(4), 472-490.

Winne, P. H. (2010b). Improving Measurements of Self-Regulated Learning. *Educational Psychologist*, *45*(4), 267-276.

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 227-304). Hillsdale, NJ: Lawrence Erlbaum Associates.

Winne, P. H., & Jamieson-Noel, D. (2002). Exploring students' calibration of self reports about study tactics and achievement. *Contemporary Educational Psychology*, *27*, 551 - 572.

Winne, P. H., Jamieson-Noel, D., & Muis, K. (2002). Methodological issues and advances in researching tactics, strategies, and self-regulated learning. *Advances in motivation and achievement: New directions in measures and methods*, *12*, 121-155.

Winne, P. H., Nesbit, J. C., Kumar, V., Hadwin, A. F., Lajoie, S. P., Azevedo, R., & Perry, N. E. (2006). Supporting Self-Regulated Learning with gStudy Software: The Learning Kit Project. *Technology Instruction Cognition And Learning*, *3*(1/2), 105 - 113.

Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of Self Regulation* (pp. 531-566). San Diego, CA: Academic Press. doi:10.1016/B978-012109890-2/50045-7

Winne, P. H., Zhou, M., & Egan, R. (2010). Designing assessments of self-regulated learning. In G. Schraw (Ed.), *Assessment of higher-order thinking skills*. New York: Routledge.

Winters, F. I., Greene, J. A., & Costich, C. M. (2008). Self-Regulation of Learning within Computer-based Learning Environments: A Critical Analysis. *Educational Psychology Review*, *20*(4), 429-444. doi:10.1007/s10648-008-9080-9

Wolters, C. A. (2010). Self-Regulated Learning and the 21 st Century Competencies. *Department of Educational Psychology, University of Houston*. Retrieved from

Yan, E., & Ding, Y. (2009). Applying centrality measures to impact analysis: A coauthorship network analysis. *Journal of the American Society for Information Science and Technology*, *60*(10), 2107-2118. doi:10.1002/asi.21128

Zhou, M. (2008). *Operationalizing and tracing goal orientation and learning strategy*. *Unpublished Doctoral Dissertation*. Simon Fraser University.

Zhou, M., & Winne, P. H. (2012). Modeling academic achievement by self-reported versus traced goal orientation. *Learning and Instruction*, *22*(6), 413-419. Elsevier Ltd. doi:10.1016/j.learninstruc.2012.03.004

Zhou, M., Xu, Y., Nesbit, J. C., & Winne, P. H. (2010). Sequential pattern analysis of learning logs: Methodology and applications. In C. Romero (Ed.), *Handbook of Educational Data Mining* (pp. 107 - 121). Boca Raton, FL: CRC Press.

Zimmerman, B. J. (1990). Self-Regulated Learning and Academic Achievement: An Overview. *Educational Psychologist*, *25*(1), 3-17.

Zimmerman, B. J. (2001). Theories of Self-Regulated Learning and Academic Achievement: An Overview and Analysis. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-Regulated Learning and Academic Achievement: Theoretical Perspectives* (2nd ed., pp. 1-37). Mahwah, NJ: Lawrence Erlbaum Associates.

Zimmerman, B. J. (2008). Goal setting: A key proactive source of academic self-regulation. In D. H. Schunk & B. J. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research and applications* (pp. 267-290). New York: Lawrence Erlbaum.

Zimmerman, B. J., & Schunk, D. H. (Eds.). (1989). *Self-Regulated Learning and Academic Achievement: Theory, Research, and Practice*. New York: Springer Verlag.

van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (2006). Introducing educational design research. In J. van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research* (pp. 3 - 7). London: Routledge.

van der Klink, M., Schlusmans, K., & Boon, J. (2006). Designing and Implementing views on Competencies. In M.-A. Sicilia (Ed.), *Competencies in Organizational E-Learning*. IGI Global. doi:10.4018/978-1-59904-343-2

Appendices

Appendix A.

SRL and Intervention Events in the Learn-B environment (according to each SRL micro-level process or feature of the proposed Interventions, respectively)

SRL Events	
Macro-Level SRL Process: Planning	
Micro-Level SRL Process	**SRL Events in Learn-B**
Task/Context Analysis (TD VIII, as depicted in Figure 4.10)	Clicking on Duties, Roles, Tasks or Projects folders
	Clicking on a single Duty under the Duties folder
	Clicking on a single Role under the Roles folder
	Clicking on single Task under the Tasks folder
	Clicking on single Project under the Projects folder
	Clicking on different Competences related to a Duty, Role, Task or Project
	Selecting Competences from other Colleagues' learning goals
	Searching for a keyword
Goal Setting (TD IX, as depicted in Figure 4.10)	Creating a new goal
	Dragging and dropping an available competence to a new or an existing learning goal
	Adding a new Competence to a new or an existing learning goal
	Adding a new Learning Path to a new or an existing competence
	Adding a new Learning Activity to a new or an existing learning path
	Adding a new Knowledge Asset to a new or an existing learning activity
	Removing a Competence from a learning goal
	Deleting a Learning Path from a competence
	Removing a Learning Activity from a learning path
	Removing a Knowledge Asset from an learning activity
	Setting the properties of a Learning Goal e.g. its name, deadline, visibility, priority, keywords and user's progress
	Setting the properties of a Competence, e.g. its name, deadline, visibility,

	current user's level, desired level, keywords and user's progress
	Setting the properties of a Learning Path, e.g. its name, expected duration, visibility, rating, keywords and user's progress
	Setting the properties of a Learning Activity, e.g. its name, start date, expected duration, visibility, rating, keywords and user's progress
	Setting the properties of a Knowledge Asset, e.g. its name, URL, expected duration, visibility, rating, keywords and user's progress
	Sharing a Learning Goal with a recommended colleague
	Requesting collaboration for a Competence, Learning Activity or a Knowledge Asset
Making Personal Plans (TD X, as depicted in Figure 4.10)	Requesting collaboration for a Competence, Learning Activity or a Knowledge Asset
	Assigning a recommended Learning Path as the chosen path for a competence
	Requesting collaboration for a Competence, Learning Activity or a Knowledge Asset
	Adding a new Learning Path to a new or an existing competence
	Adding a new Learning Activity to a new or an existing learning path
	Adding a new Knowledge Asset to a new or an existing learning activity
	Removing a Competence from a learning goal
	Removing a sub-Competence from an upper competence
	Removing a Learning Path from a competence
	Removing a Learning Activity from a learning path
	Removing a Knowledge Asset from an learning activity
	Setting the properties of a Learning Path, e.g. its name, expected duration, visibility, rating, keywords and user's progress
	Setting the properties of a Learning Activity, e.g. its name, start date, expected duration, visibility, rating, keywords and user's progress
	Setting the properties of a Knowledge Asset, e.g. its name, URL, expected duration, visibility, rating, keywords and user's progress

Macro-Level SRL Process: Engagement

Micro-Level SRL Process	SRL Events in Learn-B
Working on the Task (TD XI, as depicted in Figure 4.10)	Assigning a recommended Learning Path as the chosen path for a competence
	Requesting collaboration for a Competence, Learning Activity or a Knowledge Asset

	Marking a Competence as "favourite"
	Following a Competence
	Sharing a Learning Goal with a recommended colleague
	Recommending a Learning Goal to a colleague
	Searching for a keyword
	Marking a Learning Goal, Competence, or Learning Activity as "completed"
	Leaving a comment for a Competence, Learning Path, Learning Activity or Knowledge Asset
	Updating the properties of a Learning Goal e.g. its name, deadline, visibility, priority, keywords and user's progress
	Updating the properties of a Competence, e.g. its name, deadline, visibility, current user's level, desired level, keywords and user's progress
	Updating the properties of a Learning Path, e.g. its name, expected duration, visibility, rating, keywords and user's progress
	Updating the properties of a Learning Activity, e.g. its name, start date, expected duration, visibility, rating, keywords and user's progress
	Updating the properties of a Knowledge Asset, e.g. its name, URL, expected duration, visibility, rating, keywords and user's progress
	Following a colleague
	Creating a learning group for a Competence
Applying appropriate Strategy Changes (TD XII, as depicted in Figure 4.10)	Adding a new Competence to an existing learning goal
	Adding a new sub-Competence to an existing competence
	Updating the properties of a Learning Goal e.g. its name, deadline, visibility, priority, keywords and user's progress
	Updating the properties of a Competence, e.g. its name, deadline, visibility, current user's level, desired level, keywords and user's progress
	Updating the properties of a Learning Path, e.g. its name, expected duration, visibility, rating, keywords and user's progress
	Updating the properties of a Learning Activity, e.g. its name, start date, expected duration, visibility, rating, keywords and user's progress
	Updating the properties of a Knowledge Asset, e.g. its name, URL, expected duration, visibility, rating, keywords and user's progress
	Removing a Competence from a learning goal
	Removing a sub-Competence from an upper competence
	Following or unfollowing a competence

	Requesting collaboration for a Competence, Learning Activity or a Knowledge Asset
	Adding a new Learning Activity to an existing learning path
	Adding a new Knowledge Asset to an existing learning activity
	Removing a Learning Path from a competence
	Removing a Learning Activity from a learning path
	Removing a Knowledge Asset from an learning activity

Macro-Level SRL Process: Evaluation & Reflection

Micro-Level SRL Process	SRL Events in Learn-B
Evaluation **(TD XIII, as depicted in Figure 4.10)**	Rating a Learning Path, Learning Activity or a Knowledge Asset
	Marking a Learning Goal, Competence, or Learning Activity as "completed"
	Leaving a comment for a Competence, Learning Path, Learning Activity or Knowledge Asset
	Adding new keywords to or updating existing keywords of a Learning Goal, competence, Learning Path, Learning Activity or Knowledge Asset
Reflection **(TD XIV, as depicted in Figure 4.10)**	Leaving a comment for a Competence, Learning Path, Learning Activity or Knowledge Asset
	Adding new keywords to or updating existing keywords of a Learning Goal, competence, Learning Path, Learning Activity or Knowledge Asset
	Updating the visibility property of Learning Goal, competence, Learning Path, Learning Activity or Knowledge Asset
	Sharing a Learning Goal with a recommended colleague
	Recommending a Learning Goal to a colleague

Intervention Events

Intervention I: Providing Usage Information
(TD I, as depicted in Figure 4.10)

Intervention Feature	Intervention Events in Learn-B
Analytics	Clicking on the Achievement tab (under Analytics) of an available Competence, Learning Path or Learning Activity
	Click on Duties node (the summary tab will show in the right panel)
Social Stream	Clicking on the Social Wave tab (under Analytics) of an available Competence, Learning Path, Learning Activity or Knowledge Asset
Social Stand	Clicking on the comments tab of a Competence, Learning Path , Learning Activity or Knowledge Asset

	Clicking on the data tab of a Competence, Learning Path, Learning Activity or Knowledge Asset

Intervention II: Social Wave
(TD II, as depicted in Figure 4.10)

Intervention Feature	Intervention Events in Learn-B
Generic Social Wave	Clicking on one's Social Wave tab
Learning Resources' Social Waves	Clicking on the Social Wave tab of one's Learning Goal, Competence, Learning Path, Learning Activity or Knowledge Asset
Bubble Social Waves	Clicking on the Social Wave Bubbles tab (under Analytics) of an available Competence, Learning Path, Learning Activity or Knowledge Asset
	Clicking on Duties, Roles, Tasks or Projects folder
	Clicking on a single Duty under the Duties folder
	Clicking on a single Role under the Roles folder
	Clicking on single Task under the Tasks folder
	Clicking on single Project under the Projects folder

Intervention III: Progress-o-meters
(TD III, as depicted in Figure 4.10)

	Intervention Events in Learn-B
	Clicking on the Goal-o-meter tab (under Analytics) of one's Learning Goal
	Clicking on the Competence-o-meter tab (under Analytics) of one' Competence
	Clicking on the Progress-o-meter tab (under Analytics) of a Learning Path
	Clicking on the Progress-o-meter tab (under Analytics) of a Learning Activity

Intervention IV: User-recommended Learning Goals
(TD IV, as depicted in Figure 4.10)

	Intervention Events in Learn-B
	Clicking on a single Learning Goal under the Recommended Learning Goals folder

Intervention V: Recommended available Competences
(TD V, as depicted in Figure 4.10)

	Intervention Events in Learn-B
	Clicking on different Competences related to a Duty, Role, Task or Project

	Clicking on Users who are acquiring/have already acquired an available competence

Intervention VI: Recommended available Learning Paths, Learning Activities and Knowledge Assets (TD VI, as depicted in Figure 4.10)

	Intervention Events in Learn-B
	Clicking on a Learning Path(s) for an available competence
	Clicking on a Learning Activity within an available learning path
	Clicking on a Knowledge Asset related to an available learning activity
	Clicking on a recommended Learning Path
	Clicking on an abandoned Learning Path, i.e. a previously chosen recommended learning path
	Clicking on the data tab of an available Learning Path, Learning Activity or Knowledge Asset

Intervention VII: Knowledge sharing Profiles (TD VII, as depicted in Figure 4.10)

	Intervention Events in Learn-B
	Clicking on one's Analytics tab (the Knowledge Sharing Profiles tab Is the only tab under this tab, so will open automatically)

Appendix B.

Items for the Constructs used in Experiment 1

Construct type	Constructs	Construct Dimension	Item Identifier	Item Description[11]
Intervention	Providing Usage Information	Social Stand	Q1a	I selected a specific competence, because it had positive comments from my colleagues.
			Q1c	When I plan my personal learning goals, I think it is useful to see comments from my colleagues concerning the competence.
			Q4a	I perceive the following functions as useful when I have to select my learning path, to see my colleagues' rating of a learning activity or document.
			Q4b	I perceive the following functions as useful when I have to select my learning path, to see the keywords of a learning activity or document.
			Q4c	I perceive the following functions as useful when I have to select my learning path, to see the comments of my colleagues concerning the learning activity or document.
			Q4e	I selected a specific learning path, because the learning activities and documents had positive comments from my colleagues.
			Q4h	I selected a specific learning path, because the learning activities and documents had a good rating from my colleagues.
		Analytics	Q1b	I selected a specific competence, because many colleagues successfully completed it.
			Q1d	When I plan my personal learning goals, I think it is useful to see how many people have already achieved and not yet achieved this competence.
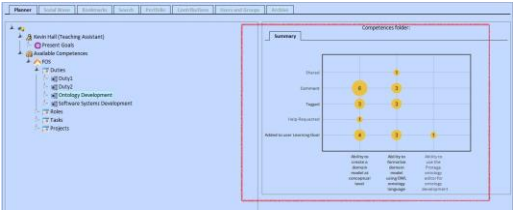
[11] Interventions' usefulness was measured on a 5-point Likert scale, where 1: *strongly disagree*; 2: *disagree*; 3: *neither agree nor disagree*; 4: *agree*; 5: *strongly agree*. Tasks' (i.e. SRL Processes) usefulness was measured on a 5-point Likert scale where 1: *not useful at all* to 5: *very useful*.

|				
			Q1e	When I plan my personal learning goals, I think it is useful to see the role of employees who [have] achieved this competence.
			Q4d	I perceive the following functions as useful when I have to select my learning path, to see how many people completed the activity or are still actively involved in it.
			Q4f	I perceive the following functions as useful when I have to select my learning path, to see the roles of the colleagues who finished this learning activity.
			Q4g	I selected a specific learning path, because many colleagues were and still are involved with the related learning activity.
Progress-o-meters			Q5a	I perceive the following functions as useful when I have to select my learning path, to see my personal progress for a learning activity.
Recommended available Competences	**Personalized Cues**		Q2a	I selected a specific competence, because it was the competence I would need most urgently to increase my job performance.
			Q2b	In general, visual icons beside each available competence help me to pick those competences that fit my immediate learning needs.
			Q2d	When I plan my personal learning goals, I think it is useful to see the priority of the available competences for my position.
			Q2e	When I plan my personal learning goals, I think it is useful to see the expected level of the available competence for my position (low, medium and high level).
			Q2f	When I plan my personal learning goals, I think it is useful to see if I have the pre-requisites for an available competence.
	Organizational Context		Q2c	When I plan my personal learning goals, I think it is useful to see the available competences within my organization.
			Q2g	When I plan my personal learning goals, I think it is useful to see the name, description and keywords of a competence.
			Q6a	I selected a specific learning path, because the related learning activities and documents had a good and clear description.
Recommend available LPs, LAs and KAs	**Availability of Learning**		Q3a	I selected a specific competence, because it had many available Learning Paths.
			Q3b	Seeing all the available and recommended learning paths for each competence help me

		Paths		better make a decision whether to choose a competence or not.
			Q3c	When I plan my personal learning goals, I think it is useful to see the available learning paths for a competence.
		Availability of Learning Activities and Knowledge Assets	Q7a	I perceive the following functions as useful when I have to select my learning path, to see the available learning paths, learning activities and documents within my organization.
Usage Belief	**Perceived Usefulness**	**Task Analysis/Goal Setting**	Q9	How useful do you perceive Task 1 for your personal learning?
		Making Personal Plans	Q10	How useful do you perceive Task 2 for your personal learning?
		Working on the Task	Q11	How useful do you perceive Task 3 for your personal learning?
	Perceived Ease of Use	**Task Analysis/Goal Setting**	Q12	How easy or difficult was the solution of Task 1 in the Learning Planner?
		Making Personal Plans	Q13	How easy or difficult was the solution of Task 2 in the Learning Planner?
		Applying Strategy Changes	Q14	How easy or difficult was the solution of Task 3 in the Learning Planner?
SRL Process	**Planning**	**Task Analysis/Goal Setting**	Task1	Creation of a new Learning Goal…
		Making Personal Plans	Task 2	Selecting and adapting one's learning path
	Engagem ent	**Working on the Task**	Task 3	Add[ing] learning resources to the learning path

Appendix C.

Items for the Intervention – SRL Constructs used in Experiment 2, RQ1.

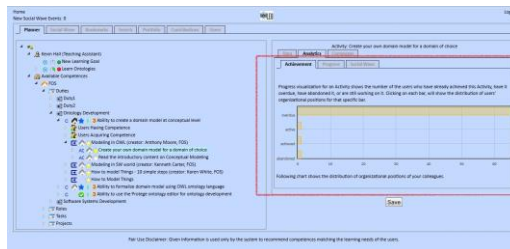| Constructs	Construct Dimension	Item Identifier	Item Description[12]
Providing Usage Information (QD I, as depicted in Figure 4.10)	**Analytics**	**Q1**	The summary for all the Duties helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals). *[The summary in the image above shows the number of the times each of all the available Competences is being commented on, tagged, shared, added to users' learning goals, etc.]*
		Q2	The summary for each specific Duty helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals). *[the summary in the image above shows how many times each of the Competences required for a specific Duty is being commented on, tagged, shared or added to learning goals by other members of the IntelLEO]*

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[12] These Intervention – SRL constructs were measured on a 5-point Likert scale, where 1: *strongly disagree*; 2: *disagree*; 3: *neither agree nor disagree*; 4: *agree*; 5: *strongly agree*.
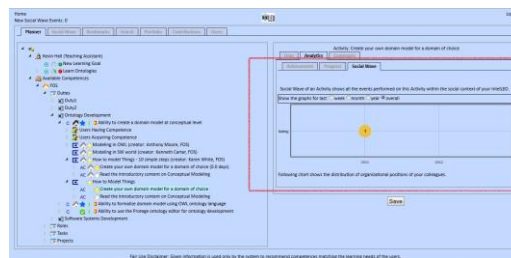
Q3 The Achievement information about available
Competences helped me to plan my personal
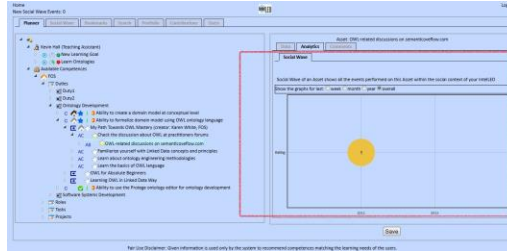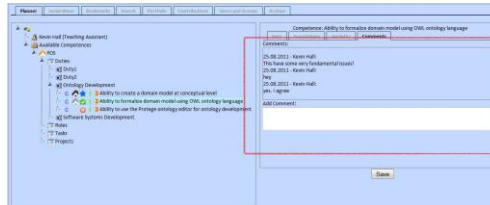learning goals (e.g. to decide which
competences to include in my personal learning
goals).
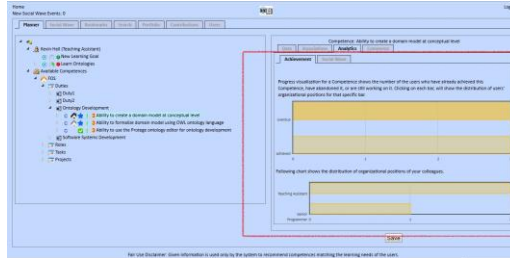
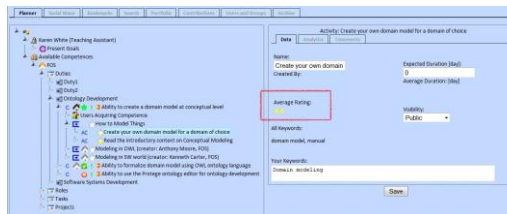*[The bars in the image above show the number and
roles of the users who have already achieved a
certain competence, have it overdue or are still
working on it.]*

Q5 The Achievement information about available
Activities helped me to plan my personal
learning goals (e.g. to decide which
competences to include in my personal learning
goals).
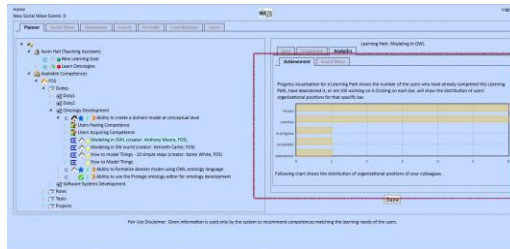
*[The bars in the image above show the number and
roles of the users who have already completed a
certain Learning Path, have it overdue, are still
working on it, or are using a modified version of it.]*

Q7 The Achievement information about available
Activities helped me to plan my personal
learning goals (e.g. to decide which
competences to include in my personal learning
goals).

*[The bars in the image above show the number and
roles of the users who have already completed a*

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certain Activity, have it overdue, are still working on it, or have abandoned it]

Q4   The Social Stream of available Competences helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal.

Social Stream

Q6   The Social Stream of available Learning Paths helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).

Q8   The Social Stream of available Activities helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).

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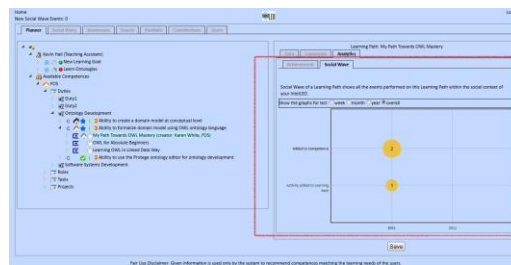
Q9   The Social Stream of available Assets helped
me to plan my personal learning goals (e.g. to
decide which competences to include in my
personal learning goals).

Q10   Available Comments for an available
Competence, Learning Path, Activity or Asset
helped me to plan my personal learning goals
(e.g. to decide which competences to include in
my personal learning goals.

Q11   Keywords for an available Competence,
Learning Path, Activity or Asset helped me to
plan my personal learning goals (e.g. to decide
which competences to include in my personal
learning goals).

Q12   Average Ratings of available Learning Paths,
Activities or Assets helped me to plan my
personal learning goals (e.g. to decide which
competences to include in my personal learning
goals).

	Q22	The information provided in Social Waves was clear to me.
	Q23	My general Social Wave gave me insight to apply changes in my learning goals or adopt (new) learning resources.
	Q24	My general Social Wave helped me to plan my personal learning goals (e.g. to decide which competences to include in my goals, or which Learning Path to choose for a specific competence, or to add a new activity to one of my learning paths).
	Q25	The Social Waves of my learning resources (i.e. Learning Goals, Competences, Activities, LPs, or Asset) gave me insight to apply changes in my learning goals or adopt a (new) learning resource.

Social Wave (QD II, as depicted in Figure 4.10)
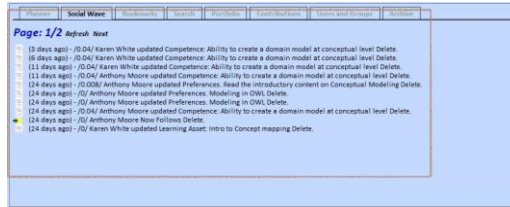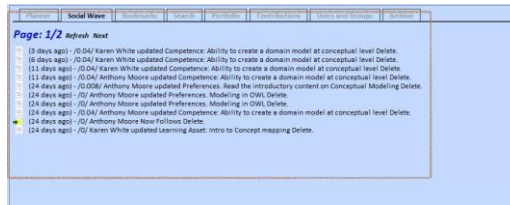
General Social Wave

Social Waves of Learning Resources

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Bubble Social Waves	**Q26**	The Social Wave bubbles of my learning resources (i.e. Learning Goals, Competences, Activities, LPs, or Asset) gave me insight to apply changes in my learning goals or adopt a (new) learning resource.
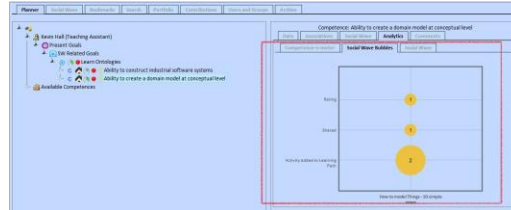
Progress-o-meters (QD III, as depicted in Figure 4.10)	**Q29**	The progress-o-meter of my Learning Resources (i.e. Learning Goals, Competences, Learning Paths and Activities) helped me to monitor my progress in achieving my goals.

	Q30	Observing the progress-o-meter of my Learning Resources (i.e. Learning Goals, Competences, Learning Paths and Activities) helped me to apply necessary changes in my goals and their components.
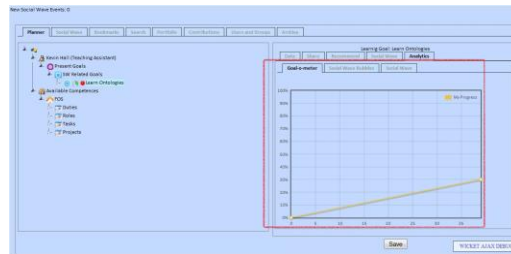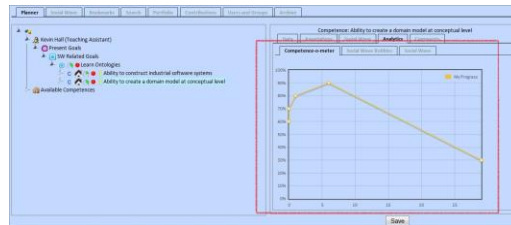
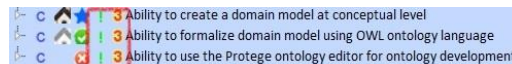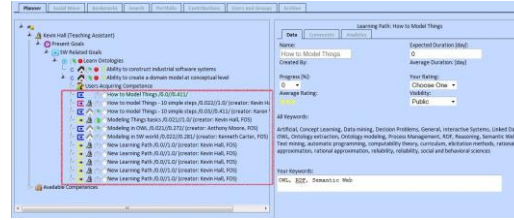|		
User-recommended Learning Goals (QD IV, as depicted in Figure 4.10)	**Q35**	The Recommended Learning Goals by my peers helped me to start my learning process (e.g., choosing additional competences to include in my learning goal, choosing the learning paths and accompanying assets, and updating their properties).
Recommended available Competences (QD V, as depicted in Figure 4.10)		
	Q38	Categorization of competences (to roles, duties, colleagues and the like) helped me to find the competences that I needed.
Organizational Context	**Q40**	Knowing what Competences are required by my organization for each Duty/Task/Role helped me to pick those competences that fit my immediate learning needs.
Personalized Cues	**Q39**	Visual icons beside each available competence helped me to pick those competences that fit my immediate learning needs. (i.e. the priority, required level and prerequisite).
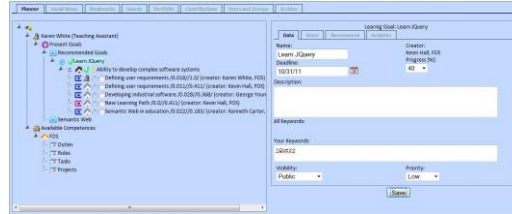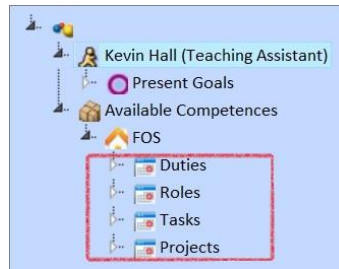
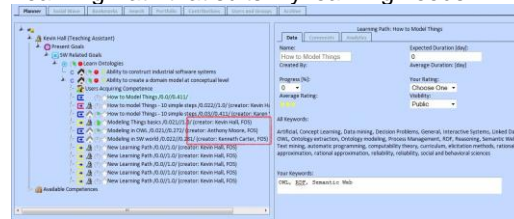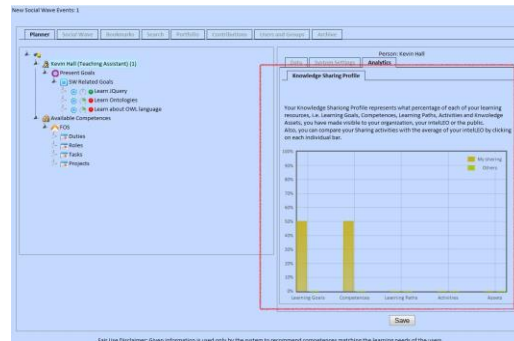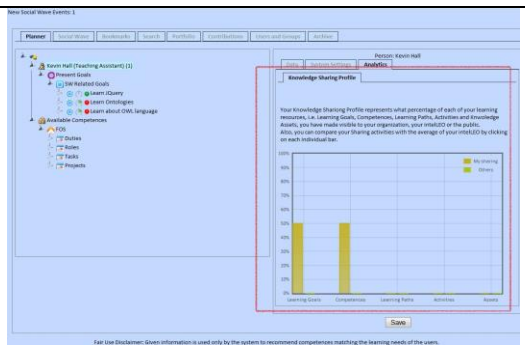| Q3a	I selected a specific competence, because it had many available Learning Paths.
Q43	The Learning Path on top of the list matched my learning needs.
Q44	Seeing who the creator of a recommended Learning Path is, helped me to pick the Learning Path that suits my learning needs.

Q48	Seeing how much other people shared their learning resources compared to my sharing activities, influenced my knowledge sharing behaviour.
Q49	Seeing how much other people shared their learning resources compared to my sharing activities, motivated me to provide some reflections and feedback on my learning experience.

Appendix D.

The Learn-B Environment

The Learn-B environment is designed and developed within the IntelLEO project[13]. The objective of this environment was to support workplace learning and integrate the different tools that employees often interact with during their everyday (working and learning) practices. Examples of these tools include a wiki (MediaWiki[14]), a social networking and collaboration platform (Elgg[15]), and a bookmarking tool (the Tagging tool which was implemented within the IntelLEO project as a bookmarklet).

IntelLEO ontologies

A set of ontologies build the common (linked) data model underpinning the Learn-B environment. These ontologies were developed by following a combined top-down (i.e. review of existing work in the field) and bottom-up (i.e. based on the requirements of the IntelLEO business cases) approach. In developing these ontologies, we tried to rely on and link to the vocabularies and ontologies already available and in use (Allemang & Hendler, 2008). Detailed specifications of all the IntelLEO ontologies are available on IntelLEO's website[16]. Examples showing how these ontologies support the gathering and integration of various users' activities could be found in (Siadaty et al., 2011).

The Learn-B Implementation

The Learn-B environment was implemented as a Java-based web application. The implementation leveraged several open-source solutions for communication with

[13] http://www.intelleo.eu/
[14] http://www.mediawiki.org/wiki/MediaWiki
[15] http://elgg.org/
[16] http://intelleo.eu/index.php?id=183

external services as well as Semantic Web frameworks. To exchange data and communicate with external services used within Learn-B, RESTful services were implemented using the Jersey framework[17]. The RDF repository for storing all instances of users' activities was implemented using Jena SDB[18]. This framework enabled scalable storage and query of RDF data using relational databases. To enable effective manipulation of triples from the RDF repository, the Jenabean framework was used[19]. Details about the architecture of Learn-B are available in (Siadaty et al., 2012).

Learn-B in Use

To illustrate how the proposed interventions were developed as part of the Learn-B environment and how they could be typically used in workplace environments, I present a brief, typical scenario for workplace learning involving a newcomer in a large organization. Let's assume that Brian is a newcomer in a company and plans to start his learning and knowledge building activities in his new workplace. To help Brian start his learning process and plan his learning goals, Intervention V provides him a ranked list of the competences which are valued by his company and required for accomplishing his duties. Brian can also examine the learning goals recommended by his peers, through Intervention IV. Additionally, Brian can benefit from the personalized visual hints that indicate those competences of higher importance for him, considering his current state of expertise as well as the duties for which he is responsible (Figure 7.1. A).

Having analyzed the organizational requirements and his learning needs, Brian can now set a new learning goal in his Learn-B environment (Figure 7.1. B), and add the selected competences to it. Next, he needs to obtain information about the best ways to achieve these competences and make his personal plans. For each recommended competence in his Learn-B, Brian can glance over the Recommended Learning Paths, Learning Activities and Knowledge Assets for that competence; provided by Intervention

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[17] http://jersey.java.net

[18] http://openjena.org/SDB/

[19] http://goo.gl/jfvCW

VI (Figure 7.1. C), and also explore their *usage information* through Intervention I. This information include visual representations showing the number of users, along with their organizational positions, who have been successful in achieving a certain competence by following a recommended learning path; the average time that took other users to complete a recommended learning path; and indicators representing how *"live"* a learning path has been recently, e.g., the number of comments, rankings, tags, and submitted help requests for it (Figure 7.1. D). Also, this recommendation of a learning path is further augmented with the number of users (or organizational roles) who have successfully finished this path or a revision of it, and their average completion times (Figure 7.1. G). The integrated set of ontologies is the main enabler for the induction of all these diverse pieces of information, which are generated and can be captured based on the activities of various users in different working environments.
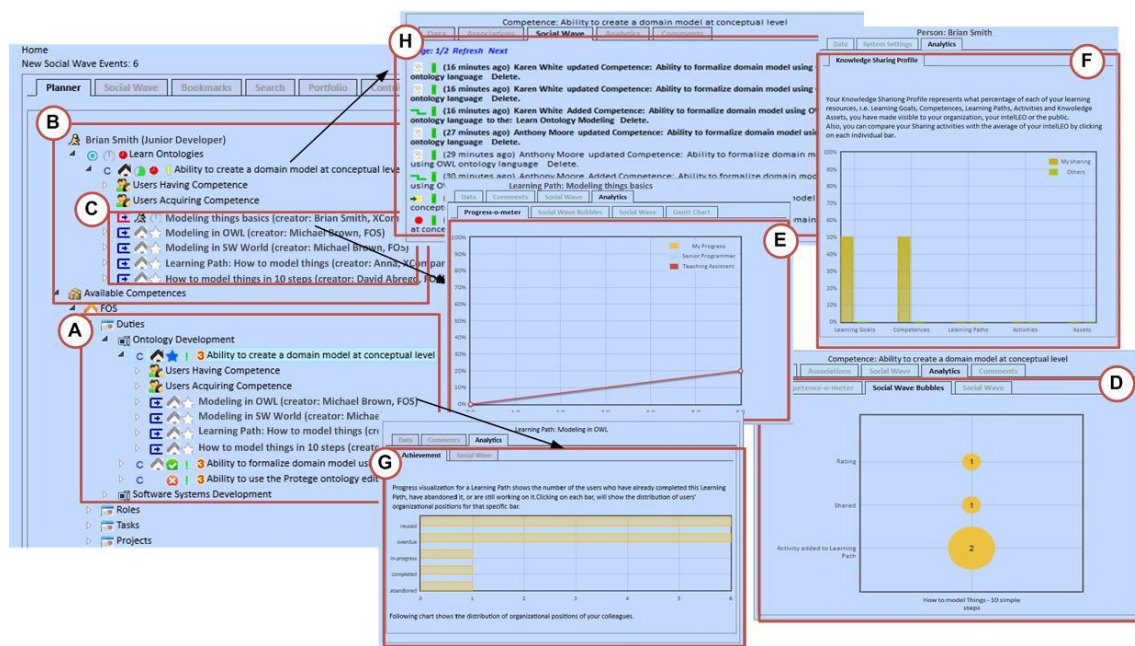

Figure 7.1. A snapshot of the proposed Interventions within the Learn-B environment.

Once Brian has chosen the desired learning paths for the competences included in his new learning goal, he can simply follow the selected learning paths toward achieving each competence. At this level, Intervention III enables him to monitor his learning process (Figure 7.1. E). Further, the updates provided by Intervention II enable Brian to better adapt his learning strategies with regard to the social context of his

organization (Figure 7.1. H). To monitor the extent of sharing his learning experiences within the organization and compare it with that of other users within the same group, project, or the entire organization, Brian can make use of Intervention VII (Figure 7.1. F). Again, having all these activities tracked and gathered in one place is enabled through the underlying ontologies.