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Associations between technological scaffolding and micro-level processes of self-regulated learning

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Measuring the impact of technological scaffolding interventions on micro-level processes of self-regulated workplace learning

Abstract. This paper reports on the findings of an exploratory study in which the effects of technological scaffolding interventions on micro-level processes of self-regulated learning in the workplace were investigated. Empirical research in the workplace has been much less represented than in formal education. Even less research is available that aimed to identify which technological scaffolding interventions, out of those available in a learning environment, had the highest influence on specific micro-level process of self-regulated learning. This paper reports on the findings of a case study conducted in the naturalistic settings of two organizations in Europe (N=53) for the period of two months. Trace data about the events of engagement with the technological scaffolding interventions and micro-level processes of self-regulated learning were collected. Both a transition graph based analysis of the temporal dependencies of the collected events and multiple linear regression analyses showed that an intervention that promoted social awareness had consistently the highest effect on all the micro-level processes used in the study. This intervention was followed by the intervention that offered system-generated recommendations about learning paths, learning activities and knowledge assets to stimulate engagement into the micro-level processes within the forethought or preparatory phase of self-regulated learning. These findings suggest that both the social and organizational contexts should be taken into account when developing interventions aimed at supporting the forethought and engagement phases. Further discussion about research, methodological, and learning technology design implications is provided.

1 Introduction

Turbulent changes in contemporary workplace pose numerous demands for knowledge workers to continuously learn and adapt to the changing environment surrounding their daily activities (Cairns & Malloch, 2011; Littlejohn, Milligan, & Margaryan, 2012). The existing literature posits that learning in the workplace is informal and autonomous (Ellinger, 2005; Eraut, 2004; Kyndt, Dochy, & Nijs, 2009; Lee et al., 2004; Tynjälä, 2008) highlighting a high degree of knowledge workers' control over their learning activities and general high-level of self-directed and self-regulated learning skills. However, this ideal of self-directed learner is highly confounded by two critical research accounts. First, workplace learning research indicates that knowledge workers are generally not proactive to start their learning or they do not have skills how to learn effectively (Margaryan et al., 2009). Rather, demands for structured learning is required in a similar manner as common in educational settings. Second, self-regulated learning research indicates that learners under-appreciate effective learning strategies, are hardly ever taught how to effectively study during their formal education, and are influenced by different types of biases (Bjork, Dunlosky, & Kornell, 2013; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; V. X. Yan, Thai, &

Bjork, 2014). However, to satisfy the needs for the modern and future socio-economic context, knowledge learners need to enhance self-regulation of own learning that happens informal situations of their workplace (Authors, 2012b; Littlejohn, Margaryan, & Milligan, 2009a).

Research on self-regulated learning is primarily conducted in formal educational settings (Azevedo et al., 2010; Chen, 2002; Dabbagh & Kitsantas, 2005; Kumar et al., 2005; Winne et al., 2006; Winne, 2010a), while there is much less research available in workplace settings in spite of the recognition of the importance of self-regulated learning in the workplace (Carneiro et al., 2007; Littlejohn et al., 2009). According to Littlejohn, Milligan, and Margaryan (2012), there are generally two critical issues related to the study of self-regulated learning in the workplace. First, goals and nature of learning are different between formal educational and workplace settings. In educational settings, learning is an objective by itself (Margaryan et al., 2009) and accompanied with the well-structured instructional support. On the other hand, workplace learning is often a "by-product of work" (Margaryan et al., 2009; p.2). In such cases, the objective of a knowledge worker is to complete a work task and learning is to help complete the task (Illeris, 2011; Ley et al., 2010; Margaryan et al., 2009). Second, most of the existing research has been focused on the study of self-regulated learning from the individualized perspective. Although social-cognitive theories of self-regulated learning heavily emphasize contextual and social factors (Zimmerman & Schunk, 1989) – e.g., as reflected in recent work on co- or socially-shared regulation (Hadwin et al., 2011; Hadwin et al., 2010; Inoue, 2007), the sheer amount of existing research (mainly from formal education) has studied the individualized perspective in social situations (Jackson et al., 2000). While suitable for studying some processes of self-regulated learning, this approach is not suitable for workplace learning where work and learning activities are very social and intertwined (Margaryan, Milligan, & Littlejohn, 2009; Marsick, Watkins, & O'Connor, 2011).

Technology has been recognized as a promising approach to addressing ever-growing demands for learning. Present research indicates that technology can provide effective scaffolding for self-regulated learning (Azevedo, 2010; Dabbagh & Kitsantas, 2005; Winne et al., 2006; Winters et al., 2008). However, what is less understood is the extent to which effects of technological scaffolding interventions, available in a software environment supporting self-regulated learning in the workplace, can be assesses. Rather, most of existing studies investigated whether there is an association between a software functionality (i.e., a technological scaffolding intervention) and a certain process of self-regulated learning. The study reported in this paper aimed to investigate which technological scaffolding intervention had the strongest effect on different processes of self-regulated learning in the workplace. To perform the study, we deployed [ANONYMIZED_TOOL] (Authors, 2012b) – a learning software environment designed to support self-regulated learning in the workplace – to two different organizations and collected trace about the software use and self-reported data about the self-regulated learning experience with the software use.

2   Supporting Self-Regulated Learning Processes in the Workplace

In this section, we discuss the SRL model underpinning the theoretical framework and the technological scaffolding interventions designed to support SRL in the workplace. The section also outlines research goals pursued in the study.

2.1 Technological scaffolding for self-regulated learning

Abundance of information, proliferation in the development and use of communication technologies, and widespread social media are just some of the features that shape contemporary work. In this environment, knowledge workers need to solve problems that have not seen before and for which no existing solutions exist (Littlejohn et al., 2012). Therefore, adapting to the rapidly changing environment and continuously learning are the foremost demands. These demands give a clear need for self-regulated learning (SRL) as one of the most critical skills in workplaces (Carneiro et al., 2007; Littlejohn et al., 2012). Although workplace learning happens in a different context than formal education, existing models and general frameworks of SRL (Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, 2001) offer a sound foundation about cognitive, metacognitive, motivational and social processes on which research of SRL in workplace can build. These models have already been accepted as a theoretical foundation for the study of SRL in different learning technologies (Winne, 2006; Winters et al., 2008).

A great majority of the current literature on SRL is centered around formal education (Winne, 2013; Zimmerman & Schunk, 2011). Significantly less attention has been dedicated to the study of SRL in workplaces (Littlejohn et al., 2012; Milligan, Fontana, Littlejohn, & Margaryan, 2015). In principle, some general conceptions of SRL may apply between the two types of learning contexts (workplace vs. formal education). However, workplace and formal education environments and opportunities for delivery and support of learning are considerably different as reported by different authors (Littlejohn et al., 2012; Margaryan, Milligan, Littlejohn, Hendrix, & Graeb-Koenneker, 2009b). This is particularly relevant with respect to the need to unveil the types of scaffolds required to be provided by learning technologies in order to promote effective SRL. Even more significant is to determine particular technological scaffolds that are critical in facilitating different phases of SRL. Similar to the general study of SRL, there is also a significant amount of the literature that looks at the technological support of self-regulated learning of SRL in formal education (Winne, 2006). However, there is much less empirical research that measures the effects of the use of technological scaffolds on the engagement into specific processes of SRL in workplace settings. Scaffolds enabled by technologies such as recommender systems and social media are of high importance due to their growing availability in learning and workplace collaborative technologies (Dabbagh & Kitsantas, 2012; Lytras & de Pablos, 2011; Manouselis, Drachsler, Riina, Hummel, & Koper, 2011; McAfee, 2009; Vargas-Vera, Nagy, & De Pablos, 2013; Verbert et al., 2012a). Specifically, this study aims to fill this gap in research by measuring the impact of the use of different technological scaffolds on individual micro-level processes of SRL in workplace learning.

In a broader sense, research of technological support for workplace learning and links between formal and informal learning has recently received considerable attention in the literature. Social media and virtual worlds as spaces for collaboration and learning have especially been explored in the existing literature. The effects different incentive factors and mechanisms – such as culture, information technologies, department characteristics, and individual roles – on sharing information in online environments are among the most commonly studied topics in relation to workplace and social learning (Zhang, de Pablos, & Zhou, 2013; Zhang, de Pablos, & Xu, 2014; Zhang, de Pablos, & Zhang, 2012; Zhang, Vogel, & Zhou, 2012). Adoption of virtual worlds offered through technologies such as Second Life and their effects on team learning outcomes have also been studied (Zhang, de Pablos, & Zhu, 2012; Zhang, Ordóñez de Pablos, et al., 2014). Social media has particularly attracted researchers to look into the ways for empowering e-learning opportunities in informal learning setting and across different

disciplines (Zhang, Wang, de Pablos, Tang, & Yan, 2015; Zhang, Gao, et al., 2015). However, there is the dearth in the literature that looked at the connections of these emerging technologies with self-regulated learning in workplace and informal learning setting. This study precisely intends to address this gap and aims to measure and mutually compare the effects of different technological scaffolds on SRL in workplace learning.

2.2   Model of Self-regulated Learning

In order to study SRL in the workplace, Authors (2012a) proposed the [ANONYMIZED_MODEL] model that distinguishes between macro- and micro-level processes of SRL, a distinction recently accepted by Artino, Cleary, Dong, Hemmer, & Durning (2014), Cleary, Callan, & Zimmerman (2012), and Greene & Azevedo (2009) among others. Macro-level processes include phases of self-regulated learning as posited by a particular theory. The [ANONYMIZED_MODEL] model proposes – by building on existing theoretical work in SRL (Dettori & Persico, 2008; Puustinen & Pulkkinen, 2001; Winters et al., 2008) – that self-regulated learning goes through the following three macro-level processes: *forethought or preparatory phase*, *task performance or enactment phase*, and *evaluation and reflection phase*. These macro-level phases reflect the needs for SRL in the workplace. Namely, the phases indicate that knowledge workers need to identify and set their learning goals, decided on which learning strategies select and follow towards achieving the goals set, and evaluate how effective choices are in relation to the learning goals set and use that evaluation to inform future learning decisions. Each of the three macro-level processes consists of micro-level processes whereby micro-level processes refer to specific activities such as goal setting in the planning phase. Table 1 provides a summary of the micro-level processes along with their brief description and association with the micro-level processes within which micro-level processes happen.

Table 1. Macro- and micro-level SRL processes and examples of indicator SRL events from the [ANONYMIZED_TOOL] 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
Enactment	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	To revise learning strategies, or	Adding a new activity to an

	appropriate Strategy Changes	apply change in tactics	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

The [ANONYMIZED_MODEL] framework builds on the existing research of SRL (Winne & Hadwin, 1998; Winne, 2006), which deems learners construct knowledge by using tools (cognitive, digital or physical) to operate on raw information in order to create products (e.g., a report reflecting on lessons learned in a project) of their learning. As agents, learners make decisions about their learning through the metacognitive monitoring and control operations. Central to these two metacognitive operations is the evaluation of learning products and the choice of learning operations followed against standards set in the learning goals (e.g., number of sources used to product the report). These standards are shaped by the conditions – external (i.e., learning task such as team-based work) and internal (e.g., prior knowledge, motivation, and affective state). As part of external conditions, [ANONYMIZED_MODEL] recognizes the importance of knowledge artifacts, created collectively in the workplace, on self-regulated learning (Littlejohn et al., 2012; Paavola, Lipponen, & Hakkarainen, 2004). As such, elements of social embeddedness (Uzzi, 1996, 1997) are identified as critical to provide support a) for social processes that are central for workplace learning and b) for harmonization between individual and organizational objectives by recognizing the value of individual contributions and creativity, but at the same time, recognizing the relevance of objectives set by the organizational structures.

Scaffolding interventions are necessary to guide knowledge workers in planning their learning goals by continuously reminding them of organizational needs and how they can construct knowledge that will be valuable for the collective. At the same time, scaffolding based on social embeddedness should enhance group awareness by being able to understand and share learning goals, resources, activities, and experience of others in the organization (Janssen, Erkens, Kanselaar, & Jaspers, 2007; Naaman, Boase, & Lai, 2010; Tollmar, Sandor, & Schömer, 1996). Not only can embeddedness advance planning of personal learning goals, but it can also be a key factor that can also inspire participation in social knowledge creation activities (Bennett, Bishop, Dalgarno, Waycott, & Kennedy, 2012), and thus affect the enactment phase of SRL. Moreover, according to Authors (2010), understanding the value of shared knowledge is a critical factor that can have a positive effect on motivation to share knowledge within an organization. Finally, technological scaffolds for the evaluation and reflection phase (i.e., macro-process) of self-regulated learning should support metacognitive monitoring of the learning progression compared to the own learning goals, organizational expectations, and social updates. Scaffolds for metacognitive monitoring are found to have positive effects for skill acquisition, motivation, and self-efficacy (Monique Boekaerts & Cascallar, 2006; Zimmerman & Schunk, 1989), while Azevedo, Moos, Greene, Winters, & Cromley (2008) reported that an increase in metacognitive monitoring was associated with an increase of feeling of knowing, judgment of learning, and monitoring of progress toward goal. Greene and Azevedo

(2009) also found that metacognitive monitoring is a "key SRL process when developing an understanding of a complex science topic using hypermedia" (p. 18).

2.3 Study Goals

A few studies in the existing literature examine how different affordances of technological scaffolds can be used to support SRL processes in different educational settings. For instance, the study reported by Dabbagh & Kitsantas (2005) examined how different categories of technological affordances (or "web-based pedagogical tools" as called in the Dabbagh & Kitsantas paper) supported different SRL processes. The Dabbagh & Kitsantas (2005) study showed that according to learners' 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 people 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, Nesbit, Jamieson-Noel, Code, & Winne, 2007; Krosnick, 2000; Winne & Jamieson-Noel, 2002), no trace data was used in the Dabbagh & Kitsantas (2005) study to examine the actual evidence of learners' usage of the tools, and to compare it with what they reported in the related questionnaires. Winters et al. (2008) review studies that instigate the effects of computer based environments on self-regulated learning. Besides this limited number of studies, which are explicitly conducted in formal educational settings at present there is no research, to our knowledge, investigating how technology-enabled scaffolding interventions available in a learning environment support self-regulatory learning processes in workplace settings, where learning is contextual and greatly informal.

In this paper, we report on the findings of an exploratory analysis that aimed to investigate which technological scaffolding interventions 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 technological affordances are usually in the form of a set of tools available in an existing learning environment, (e.g., Dabbagh & Kitsantas (2005) studied 12 of the features available in the WebCT learning management system), this study used a learning environment [ANONYMIZED_TOOL] that implemented a set of specifically designed scaffolding interventions to support self-regulated workplace learning (Authors, 2012a) (in the electronic supplement, see Appendix A for the outline of the scaffolding interventions of the [ANONYMIZED_TOOL] software environment). Our related analysis (Authors, 2015a) confirmed a set of hypotheses about the associations between micro-analytic processes of SRL and the use (derived from trace data) and perceived value (measured by self-reports) of the technological scaffolding interventions of [ANONYMIZED_TOOL]. Specifically, the related analysis confirmed the association between micro-analytic processes (see Table 1) and the technological scaffolding interventions available in [ANONYMIZED_TOOL] as follows:

- *task analysis* – providing usage information (Intervention I), user-recommended learning goals (Intervention IV), system-recommended learning paths, learning activities, and knowledge assets (Intervention VI);
- *goal setting* – providing usage information (Intervention I), social wave (Intervention II), system-recommended competences (Intervention V), user-recommended learning goals (Intervention IV);

- *making plans* – providing usage information (Intervention I), social wave (Intervention II), and system-recommended competences (Intervention V);
- *working on task* – social wave (Intervention I) and progress-o-meter (Intervention III);
- *applying appropriate learning strategy* – social wave (Intervention I) and progress-o-meter (Intervention III);
- *evaluation of the learning process* – progress-o-meter (Intervention III); and
- *reflection on the learning process* – knowledge sharing profile (Intervention VII).

Although the results of this related analysis (Authors, 2015a) showed a promise of technological interventions to shape the micro-level processes of SRL in the workplace, that analysis found support only for the associations that could be hypothesized based on the existing research. However, given the lack of existing research on the topic, we could not draw any hypotheses that could indicate which specific intervention had the highest influence on the engagement of specific micro-level processes of SRL. As such, we performed an exploratory analysis that aimed to precisely address this issue and determine which interventions had the highest influence on the micro-level processes of SRL when a) temporal characteristics of SRL are used (Bannert, Reimann, & Sonnenberg, 2014; Greene & Azevedo, 2007; Molenaar & Järvelä, 2014; Winne, 2014), b) the association between the frequency of the use of all interventions and the frequency of the use of micro-level processes is analyzed; and c) when computer skills of knowledge workers and their level of work experience is controlled.

3 Method

We conducted a case-study with the goal to investigate the effects of the technological interventions in an authentic context of daily activities in two different organizations (Eisenhardt, 1989). The study was correlational in nature and aimed to identify the most influential technological interventions on the micro-level process in SRL (Field & Hole, 2003).

3.1 Participants

The impact of individual technological scaffolding interventions, implemented in [ANONYMIZED_TOOL], was investigated during a period of two months. Within the EU-funded [ANONYMIZED_PROJECT] project[1], fifty three (53) knowledge workers participated in the study; of those, 33 from one business case (a leading car manufacturer) and 20 users from another business case (a teacher professional association). The participants used [ANONYMIZED_TOOL] during the study and their use of [ANONYMIZED_TOOL] was recorded as trace data. A subset of the participants (13 from the first and 10 from the second business case) provided their socio-demographic data. Of those who provided socio-demographic data, almost all (i.e. 95%) had university degrees. Majority of the respondents (58%) reported their computer skills as almost excellent (levels 8 and 9, on a 0-10 scale with 0 as very low and 10 as excellent skills). The remaining participants self-assessed their computer skills as higher than average (i.e. levels 5, 6 and 7). An exactly quarter of the participants had between 7 and 19 years of working experience in their current position, 30% between 3 and 5 years of experience and the rest (45%) had up to two years of experience in their respective organization.

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[1] ANONYMIZED PROJECT URL

3.2   Materials and Measures

The study used several materials, including i) study scenarios for the two business cases of the [ANONYMIZED_PROJECT] project (described in Section 3.3), ii) the [ANONYMIZED_TOOL] learning software environment pre-loaded with data relevant for each of the two business cases (see Appendix B for an outline of [ANONYMIZED_TOOL] in in the electronic supplement); iii) questionnaire to collect socio-demographic data; and iv) trace data recorded by [ANONYMIZED_TOOL] about the activities of the study participants during the two months study period.

Different approaches have been used in and suggested by the contemporary research to measure features and elements of self-regulated learning with the most prominent ones being self-reports, think aloud protocols, and trace data (Winne, Zhou, & Egan, 2011; Winne, 2013). The choice of the measurement instruments is influenced by the theoretical model of SRL selected in a study, as suggested in Section **Error! Reference source not found.**). Therefore, to assure validity of the measurement findings and generalizability of the interpretations of the results, the design of the measurement method needs to be synchronized with the adopted SRL model (Greene & Azevedo, 2010; Klug, Ogrin, & Keller, 2011; Winne & Perry, 2000; Winne, 2010b). In this study, we adopted the positon that self-regulated learning in the workplace is a dynamic and contextual process. This process can be characterized as a series of *event*s and this series happens during learning episodes (Molenaar & Järvelä, 2014; Winne, 2014). Consistent with this position, we designed a trace-based methodology to gauge the effect of the technological scaffolding interventions on SRL process. The SRL processes are operationalized at the micro-level through traces of their actual study tactics followed in the [ANONYMIZED_TOOL] environment (Authors, 2015b).

We identified *intervention events* for each of the seven technological scaffolding interventions. These events represented occurrences of the use of a specific intervention, exhibited through its software features available in the [ANONYMIZED_TOOL] environment. All the events were identified, time-stamped and logged by the log-tracking tool of [ANONYMIZED_TOOL]. This allowed us to keep track and measure the occurrence of the use of each intervention and the context of its use. For example, for the scaffolding intervention *providing usage information*, the *intervention events* were recorded when the study participants used the three features of the intervention (see Appendix A in the electronic supplement): i) *Analytics* by clicking on the visualizations about achievement for the analytics section of learning resources available in [ANONYMIZED_TOOL]: competences, learning paths, learning activities, and knowledge assets; alternatively, this intervention event was recorded when users inspected duties in their organizations along with associated competences as shown in [ANONYMIZED_TOOL]; ii) *Social Stream* by clicking on the Social Wave tab of learning resources available in [ANONYMIZED_TOOL] to inspect what operations other users performed with those resources (e.g., started studying towards a competence or updated their progress); iii) *Social Stand* by clicking on the comments or the data tab of an given learning resource.

A similar approach to the measurement of the micro-level processes of SRL based on trace data is applied. Specifically, we define *non-intervention events* that the study participants could trigger when using the [ANONYMIZED_TOOL] environment where each *non-intervention event* was an indicator of the enactment of a particular micro-level process of SRL defined in Table 1. For instance, non-intervention events which were reflective of the *Task Analysis* micro-level process of SRL included trace data recording occurrences of: clicks on the features of [ANONYMIZED_TOOL] with the folders that

contain information about duties, roles, tasks or projects of the organizations in which the study was performed; clicks on a specific duty, project, tasks or roles; clicks on competences available under the specific duty, project, task or role; clicks on the learning goals or competences defined by the colleagues of the user; or searches for a given keyword.

Appendix C of the electronic supplement of this paper provides a complete list of both intervention and (non-intervention) SRL events and the mappings of the specific trace data logged by [ANONYMIZED_TOOL] onto both types of the events used in the study. A detailed description of the entire trace-based protocol applied in this study, including how the interventions were defined, operationalized, technologically extracted from trace data, and measured is discussed in the report by Authors (2015b).

3.3 Procedure

The study was performed in late 2011 and lasted for two months in the scope of the [ANONYMIZED_PROJECT] project. To evaluate the effects of the technological scaffolding interventions in real-world workplace settings, each business case in the [ANONYMIZED_PROJECT] project defined specific test scenarios authentic to its organizational context. These scenarios aimed to provide a naturalistic framework for the study specific for the learning needs of each organization involved. Note that although the [ANONYMIZED_PROJECT] project had three business cases, the [ANONYMIZED_TOOL] environment was not used in one of the business case which was dedicated to a small-medium size organization providing software solutions for the metallurgy domain. Thus, the study was conducted in the context of two of the three business cases of the project.

The first business case (with a large car manufacturing enterprise in Germany) had three scenarios defined in the study. The first scenario was related to provide introduction and support of newcomers in an organizational department. In this scenario, newcomers were supported by the technological interventions of the [ANONYMIZED_TOOL] environment which were designed to help them familiarize with the organizational working practices, norms and expectations. The second scenario in this business case aimed to help knowledge workers advance their expert knowledge. The learning resources available in [ANONYMIZED_TOOL] for these two scenarios were initially generated by more experienced employees of the organization. New resources were contributed to the system by the collective throughout the study and the use of [ANONYMIZED_TOOL]. This was done through creation of different resources such as user-defined competences, learning paths and uploaded/added knowledge assets (e.g., documents). The third and final scenario in this business case aimed to support knowledge workers in situations in which they were confronted with unfamiliar new topics or topics that are frequently changed or extended. In this scenario, the participants used the [ANONYMIZED_TOOL] environment to define the most significant issues of a difficult topic collaboratively; contribute their existing knowledge to provide solutions to those issues; and to create the structure to their solutions to facilitate their use by others.

The second business case of [ANONYMIZED_PROJECT] had a single scenario in a national professional association of teachers from a Baltic country in Europe. The scenario tackled one of the most significant learning needs of teachers who were learning towards their accreditation by using e-portfolios. In-service teachers, the participants in this business case, had several years of experience and aimed to satisfy the requirements for promotion through the accreditation process. The participants were asked to i) work towards acquiring competences for the pedagogical use of educational technology; ii)

collaboratively prepare accreditation learning paths, based on the learning paths recommended by [ANONYMIZED_TOOL] (created by the experts) and the learning paths defined and shared by other users; iii) collaboratively interrogate the accreditation requirements (shown as competences in [ANONYMIZED_TOOL]); and iv) reflect on learning resources provided by the system or shared by other participants through online discussions.

Initially, all the participants had a training session, in which [ANONYMIZED_TOOL] was introduced. During the study period, the participants could contact the [ANONYMIZED_TOOL] development team if they had any questions about the tool. All actions about the use of the [ANONYMIZED_TOOL] environment – of the relevance for the intervention and SRL events investigated in the study– during the two-month study period were recorded into log files and the log files were used for data analysis. In the end of the study, the participants were asked to complete the socio-demographic questionnaire.

3.4   Data Analysis

Given the trace-based methodology, we first calculated the counts of the use of the intervention and non-intervention (i.e., SRL) events. This was done by summarizing the counts of *events* occurring for the given technological scaffolding interventions and SRL micro-level process as recorded by trace data for all the study participants. Following the trace-based protocol proposed by Authors (2015b), we built transition graphs based on the temporal appearance of the both types of events. To investigate which interventions had the highest influence on the micro-level processes of SRL when temporal characteristics of SRL are used, we calculated the centrality measures for each of the scaffolding interventions within the transition graph generated from all users' trace data. We used the Gephi software (v. 0.8.1 beta) to build the transition graph and calculate 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, Mehra, Brass, & Labianca, 2009; Freeman, 1979; Hadwin et al., 2007; Landherr, Friedl, & Heidemann, 2010; Winne & Hadwin, 2013; Winne, 2014; E. Yan & Ding, 2009a). In this study, we considered the centrality value of a node (i.e., an intervention/SRL event hereafter) to represent the importance of an Intervention or SRL event within the network of user's learning actions in the [ANONYMIZED_TOOL] environment. Specifically, we operationalized these four centrality measures as follows.

- ***Degree centrality of a node*** equals to the counts of the links the node has with the other nodes in the transition graph. In other words, it shows the number of the events that occurred before or followed a given event.

- ***Closeness centrality*** 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 is the closer the node is to the other nodes. In a transition graph of intervention and SRL events extracted from the [ANONYMIZED_TOOL] environment, intervention nodes with higher closeness values indicated those interventions via which users could easily perform their SRL processes or use other interventions.

- **Betweenness centrality** of a node is based on the number of the shortest paths from all the nodes to all others, passing through that node (E. Yan & Ding, 2009b). A node with the high betweenness value acts as a "broker" or a bridge, which connects other nodes together. Within the [ANONYMIZED_TOOL] environment and considering the collected trace data, intervention nodes with high betweenness values specified those technological scaffolding interventions that users used as a bridge to perform their SRL processes or engage into other technological scaffolding interventions.

- **Eigenvector centrality** of a node is based on the concept that the 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.

We calculated Pearson's correlation coefficients to explore for possible associations between the usage frequencies of the intervention events and the SRL events. Having identified the associations, we looked for those intervention events whose usage frequencies not only were associated with the engagement in micro-level processes SRL, but also could also be *determinants* of that engagement with the micro-level processes. Accordingly, we performed multiple linear regression analyses per SRL micro-level process in order to explore whether the occurrence frequencies of the scaffolding interventions could significantly contribute to the enactment of that SRL (micro-level) process. We ran multiple linear regression analyses over log-transformed occurrence frequencies of interventions and SRL processes in cases when non-normal distribution was observed. To test the regression assumptions, we built scatterplots and normal probability plots of standardised residuals and calculated the Mahalanobis and Cook's distance values, following the guidelines described by Pallant (2011) and Tabachnick & Fidell (2007). Finally, we compared the effect of users' different levels of usage of the interventions identified in the previous step as the *determinants* on their engagement in SRL processes, considering also the effect of potential confounding variables in the study. To do so, we applied the ANCOVA analysis with the socio-demographic variables as covariates.

4   Results

To gauge which interventions had the highest influence on the micro-level processes of SRL when temporal characteristics of SRL are used, we examined the transition graph of learning actions of all the participants, collected and parsed in terms of their log files. Figure 1 shows the transition graph that was created by aggregating the intervention and SRL events from all the participants. The figure shows only the edges from intervention nodes to SRL nodes, given that we looked at the impact of the interventions on the SRL processes. The sizes of the nodes in the figure are proportionate to their degree centrality values.
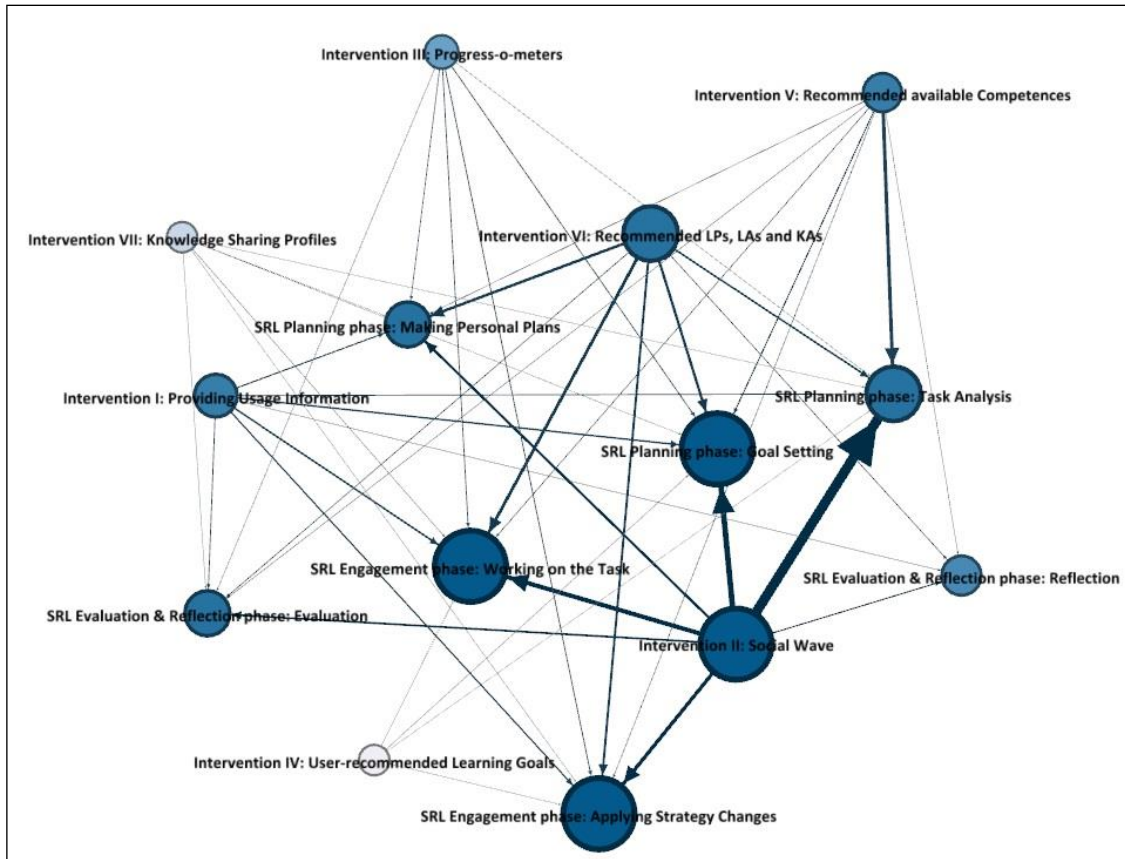
Figure 1. The transition graph generated from the trace data of all users'. Size of a node indicates its degree centrality (i.e., influence) in the graph; thickness of a link represents its frequency of occurrence.

Figure 2 shows the distribution of the degree centrality values within the trace data of all users combined across the scaffolding interventions. As could be seen, Intervention II: Social Wave (denoted with the blue color in Figure 2) had the highest degree centrality when the values of all the participants were combined (M=13.37, SD=8.06[2]), followed by Interventions I (M=9.82, SD=6.82), III (M=7.32, SD=6.24), V (M=9.07, SD=6.99) and VI (M=11.42, SD=6.81) having approximately the same degrees (indicated with the green color), whilst the lowest degrees belong to interventions IV (M=6.45, SD=5.03) and VII (M=5.92, SD=6.50), shown in the red color in Figure 2. The high degree value for an event means that many nodes are connected with that event, making it central to the network of users' learning actions within the [ANONYMIZED_TOOL] 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.

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[2] We also report the mean and standard deviation values of degree centrality based on the transition graphs created for each participants involved in the study.
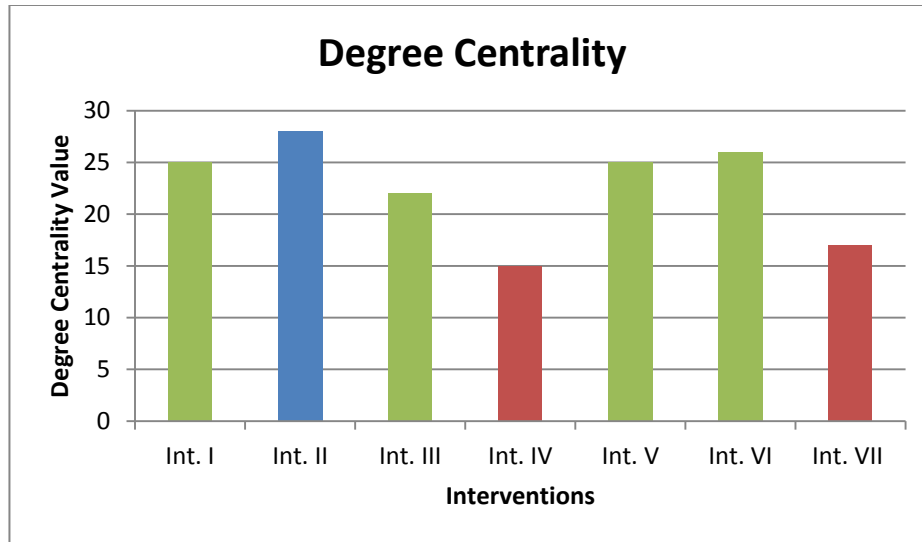
Figure 2. Frequency distribution of degree centrality across the technological scaffolding interventions based on the transition graph created by combining intervention and SRL events of all the participants of the study

Analysis of interventions' centrality measures, namely their degree, closeness, betweenness and eigenvector values, showed that the Social Wave (I) intervention was the most central within the trace data collected from users' actions performed in the [ANONYMIZED_TOOL] environment during the two-month study period. This intervention had the highest degree centrality amongst all the scaffolding interventions, suggesting that the study participants 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 the study participants used this intervention in short intervals from their other learning actions, as well as preceded and/or followed it by other well-performed interventions such as Interventions I, V and VI, or SRL processes planning and engagement. Interventions I, V and VI were the second most focal ones that emerged within the graph of users' trace data, having similar high degree, closeness and betweenness centrality values (see Figure 2 and Figure 3).
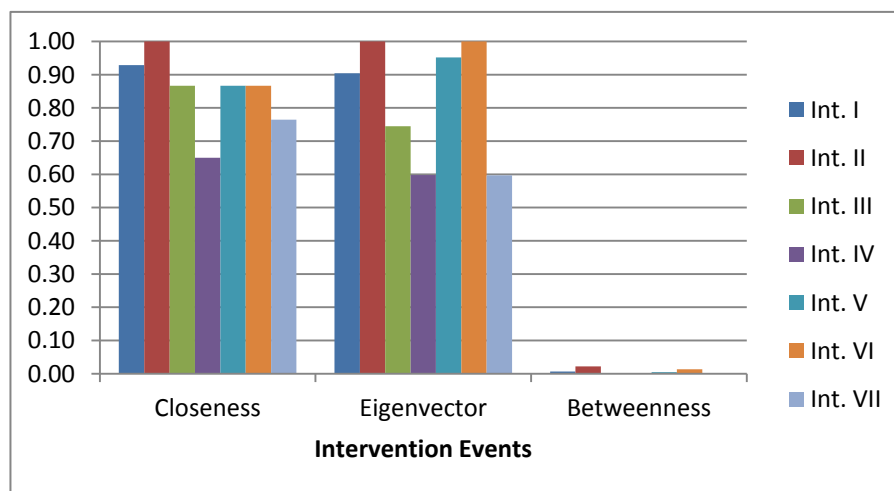

Figure 3. Comparison of closeness, eigenvector and betweenness centrality measures across the technological scaffolding interventions. The values are based on the transition graph created by combining intervention and SRL events of all the participants of the study

Results of Pearson's correlation analyses revealed that the usage frequencies of Interventions I (providing usage information), II (social wave), III (progress-o-meter) and VI (system recommended learning paths, learning activities, and knowledge assets) were positively correlated with that of the theorized SRL process that the participants could potentially perform using the [ANONYMIZED_TOOL] environment during the two-month study period. Interestingly, although Intervention V (system-recommended competences) 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 the Task Analysis micro-level process, and no further significant associations were observed. Contrary to Intervention V, Intervention IV (user-recommended learning goals) did not appear as a focal node in users' graph of learning actions; yet, Pearson's correlation analyses revealed 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 2), 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 (*knowledge sharing profiles*) 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 2), engagement (CR19.d and CR19.e) and Evaluation (CR19.f).

To investigate which technological scaffolding interventions (i.e., their usage) was determinant of users' enacting SRL processes in their workplace learning, we performed multiple linear regression analyses per micro-level SRL process (as the independent variable). The set of independent variables contained those technological scaffolding interventions which were closely correlated with users' SRL processes, i.e. had moderate to high correlation values, according to (Cohen, 1988) as shown in Table 2. To ensure the assumption of no multicollinearity, however the frequency count of Intervention III (progress-o-meter) was removed from the 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 (providing usage information) and II (social wave), r(45)=0.801, p=0.000; r(45)=0.811, p=0.000, respectively; moreover, only 42% of the users had used it during their two-month period of this study. In the following we present and discuss the results of multiple regression analyses, organized across the SRL micro-level processes.

Table 2. High Associations between occurrence frequencies of the technological scaffolding 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		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	SRL Process Planning: Goal Setting	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		r(45) =0.740, p=0.000
CR16.c	Intervention III: Progress-o-meters	SRL Process Planning: Making Personal Plans	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		r(45) =0.781, p=0.000
CR9.a	Intervention III: Progress-o-meters	SRL Process Engagement: Working on the Task	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		r(45) =0.745, p=0.000
CR9.b	Intervention III: Progress-o-meters	SRL Process Engagement: Applying Strategy Changes	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: the SRL micro-level process Task Analysis was highly correlated with Interventions I, II, III (though Intervention III was removed from the predictor model to satisfy the assumption of no multicollinearity), V and VI (Table 2). Results of the respective 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). 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.

Planning – Goal Setting: the occurrence frequencies of all of the scaffolding interventions except for Intervention V (i.e., system-recommended competences) were closely correlated with that of the SRL process planning – Goal Setting (Table 2). 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 (II) having a higher beta value (*beta*=0.551, p=0.000) than Intervention VI (*beta*=0.304, p=0.010).

Planning – Making Personal Plans: similar to the Goal Setting process, Table 2 shows that the occurrence frequency of the *Making Personal Plans* micro-level SRL process was also closely correlated

with that of all of the scaffolding interventions except for Intervention V. Accordingly, the predictor model included Interventions I, II, IV, VI and VII – Intervention III was excluded from the model to satisfy the no-multicollinearity assumption. The multiple linear 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 micro-level process of SRL ($F(5,39)=15.21$, 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 (II) 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.

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 scaffolding interventions except Intervention V (i.e., system-recommended competences) as shown in in Table 2. The multiple linear regression 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, interventions II and VI were the only statistically significant determinants of users' engagement in Working on the Task micro-level process of SRL, with Intervention II having a stronger impact (*beta*=0.553, p=0.000) than Intervention VI (*beta*=0.236, p=0.045).

Engagement – Applying Strategy Changes: Table 2 shows that again except Intervention V, the frequency of occurrence of the Applying Strategy Changes micro-level process of SRL was highly correlated with all of the proposed interventions in terms of their occurrence frequencies. Results of the multiple linear regression analysis indicated that the predictor model, including Interventions I, II, IV, VI and VII, was significant and explained 61.3% of the variance in the occurrence frequency of this SRL micro-level process, $F(5,39)=7.69$, p=0.000. As it was the case in the previously discussed SRL processes, 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).

Evaluation & Reflection – Evaluation: similar to the previous planning and engagement processes, the occurrence frequencies of all of the scaffolding interventions except for Intervention V (system-recommended available competences) were also closely correlated with that of the Evaluation micro-level process of SRL (Table 2). A significant predictor model including Interventions I, II, IV, VI and VII resulted from the multiple linear regression analysis, accounting for 49.1% of the variance in the occurrence frequency of this process ($F(5,39)=9.49$, p=0.000). However, contrary to the previous SRL processes, this time the Social Wave intervention (II) emerged as the only 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.

Evaluation & Reflection – Reflection: finally, Table 2 shows that the occurrence frequency of the Reflection SRL micro-level process of SRL was closely correlated with that of all of the scaffolding interventions except for Interventions V and VII. The performed multiple linear 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 of SRL, again the Social Wave

intervention (II) 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.

As the above results indicate, 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 (system-recommended learning paths, learning activities and knowledge assets) emerged as the second most important factor in the case of the planning (except for the Task Analysis micro-level process) and engagement processes. Not only did the Social Wave intervention play a focal role in the transition graphs of learning actions, but also its usage frequency was the strongest predictor of the frequency with which users performed their SRL processes. It should be noted that the users participating in the study 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.

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, our assumption regarding this demographic factor was 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. Our 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 [ANONYMIZED_TOOL] 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, we performed a one-way between-subjects analysis of covariance (ANCOVA) on users' total frequency of SRL events. 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 (see Figure 3). The participants 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. Having to include users' demographic data led to a reduction in the sample size, from 53 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.

Table 43. Adjusted and unadjusted mean value of the frequency of the total SRL processes for the 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

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 η^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. The adjusted marginal means, shown in Table 43, 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). We 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 Discussion

The transition graph built from the participants' trace data helped to locate the most effective interventions. In contrast to the results of our related analysis (Authors, 2015a), in which we found that the participants did not perceive Intervention II (Social Wave) as useful for the theorized planning and engagement SRL processes, this technological scaffold appeared as the most focal one compared to the other interventions. It also appeared to be the strongest determinant of the engagement in different SRL processes (Figure 4.b). The next most central interventions were Intervention I (Figure 4.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 4.c and Figure 4.d).

Users' actual learning actions showed that being informed of the relevant learning activities of their colleagues (the social context) played a relatively more important role in their SRL processes than the organizational context. This finding may be an indicator that users preferred 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 were 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, Milligan, Littlejohn, et al. (2009), 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. To our 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.

The differences observed in the perceived measures and the actual use of technological scaffolding interventions have direct implications on the use and interpretation of measurement approaches to self-regulated learning in the workplace. Although recent studies indicate that measures of perceived usefulness of technological features, as proxies of metacognitive awareness skills (Clarebout, Elen, Collazo, Lust, & Jiang, 2013), are associated with the actual use of learning technology, the findings of this study did not find support for this association. In addition to the results of the Winne & Jamieson-Noel (2002) study that revealed the weaknesses in calibration between self-reported and actual use of study tools in learning, this study showed that learners in their workplace can underestimate and overestimate the perceived value of certain features for their learning compared to their actual use and the effect on the micro-level processes of SRL. Could a reason for this be that certain features are not perceived as part of learning due to their informal nature such as Social Wave? Existing research found that students in formal educational settings (Dunlosky et al., 2013; Kornell & Bjork, 2007) and life-long learners (V. X. Yan et al., 2014) underappreciated the value of highly potent study strategies or do not recognize them as study strategies in the first place. For example, self-testing – as a way to exercise memory retrieval – is proven to be an effective study strategy. Yet, learners report to rarely use it and when they use it they mainly used to identify gaps in their knowledge rather than as a way to learn. Possibly, the use of Social Wave could be perceived by learners as a way to share knowledge, enhance group awareness, and improve communication with their peers, but such processes may not be recognized by learners to affect their learning processes in spite of the findings of this study. Reasons for that could be organizational cultures in which formal training formats are typically associated with acts of learning, while informal learning experiences through social interactions and work are not seen as learning per se. Therefore, future research needs to collect data about perceptions that learners have with respect to the utility of certain technological features in order to understand why features found with a high effect on the micro-level processes of SRL are not perceived as useful as some other features. Understanding such factors can have implications on the ways how to communicate the significance of technological scaffolding interventions with workplace learners and thus, increase their metacognitive awareness, knowledge and skills (Clarebout et al., 2013; McCabe, 2011; Winne, 2006).
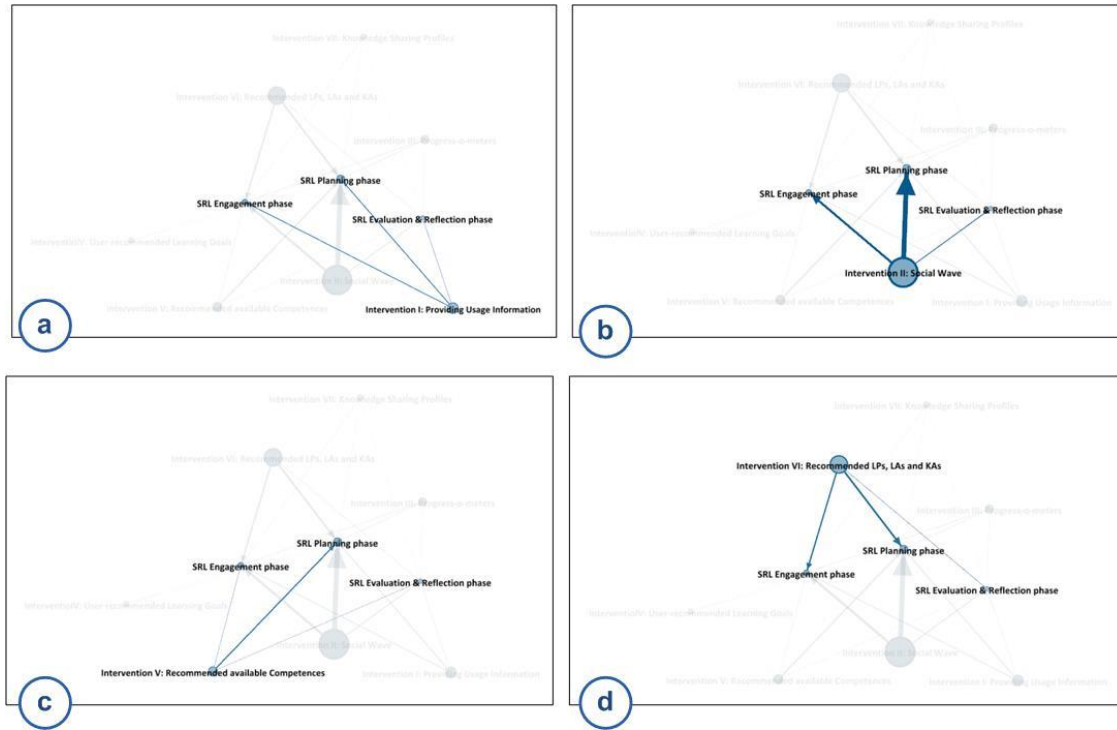
Figure 4. The most central technological scaffolding interventions in the graph of users' learning actions, followed by macro-level SRL processes: a) Intervention I – providing usage information, b) Intervention II – Social Wave, c) Intervention V – system-recommended competences, and d) Intervention VI – system-recommended learning paths, learning activities, and knowledge assets.

SRL in formal, educational settings has been studied quite 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's (2001) social-cognitive model, Winne & Hadwin's (1998) information processing model of SRL or Pintrich's (2000) 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 our 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 can guide researchers to generate their 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 this research in this regard is that when developing targeted scaffolding 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 study, 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.

Findings of the study suggest that Intervention II (Social Wave) was a determinant of users' engagement in all three SRL macro-level processes; whilst Intervention VI (*System-recommended learning paths, learning activities and knowledge assets*) was a determinant for the Goal Setting and Making Personal Plans micro-level processes within 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. Generalizations would particularly be difficult given the high influence of contextual factors – social and organizational – that need to be explored in future research in different organizational settings and across different sectors. However, given that the results of this analysis are consistent with the findings of our related analysis (Authors, 2015a) that validated a set of hypotheses, which were grounded in the existing research on self-regulated learning, the findings reported in this paper can provide a useful guidance for the future studies into the nature of self-regulated learning in the workplace scaffold with the use of technology. One possible suggestion here could be that both the social and organizational contexts should 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. Furthermore, since trace data represent users' actual behavior as they enact it, the micro-analytical, trace-based measurement protocol we applied in the study (Authors, 2015b) allows researchers to measure and analyse the effect of intended scaffolding interventions on knowledge workers' SRL processes in their very own context. Accordingly, such a protocol can assist researchers to design and develop scaffolding interventions with regard to the specific attributes of a learning environment such as workplace learning.

Although this study was grounded in a theoretical model of SRL to allow for the understanding of the effects of technological scaffolding interventions on micro-level processes of SRL, additional factors are shown to play a significant role in self-regulatory processes of learning. Different facets of motivation (e.g. self-efficacy or achievement goal orientation) are one of the most critical factors associated with internal conditions based on which learners make decisions about their learning (Winne & Hadwin, 1998). Motivational factors can shape learning goals set for future, points in time when to stop learning, and the choice of study tactics to use (Inoue, 2007; Schraw, 2010; Winne et al., 2011). This paper adopted a trace-based method for the measurement of self-regulated learning and the definition suggested by Winne "observable representations of cognitive and meta-cognitive events" (Winne, 2010b). However, the use of trace data is not limited to the measurement of the engagement with technological scaffolding interventions and micro-level processes of SRL, but trace data can be used to measure motivation facets such as achievement goal orientation (Zhou & Winne, 2012; Zhou, 2008). Given the significance of motivation for SRL, it would be important to examine to what extent and how technological interventions can affect motivation in the workplace. This type of research can deepen understanding into the ways how learners practice SRL in the workplace and potential barriers that can hamper steady learning.

Given the field nature of the study, there are a number of factors that can be left unaccounted for and that could influence the study results. For example, the study did not collect data about who the

participants typically communicate with (e.g., through informal conversations in shared social spaces in their organizations such as lunch or coffee rooms) in relation to the technology they use for learning and work (Mirriahi, Dawson, & Hoven, 2012). Likewise, the use of other technologies the participants use regularly for their learning and work in addition to [ANONYMIZED_TOOL] could have an effect on the extent to which certain scaffolding interventions played the role on their learning. While we had information about the organizational technologies used in the two organizations involved in the study – Wiki in the business case one and Elgg social networking software in the second business case – we had no information if the participants used other types of technologies and when and how their use was potentially associated with the use of certain features of [ANONYMIZED_TOOL]. To understand this, additional data are needed that can be collected through observational studies and/or sensors such as webcams and traces about the use of Web browsers or entire computers. To do so in naturalistic workplace settings of an organization, special care should be paid to the privacy and ethics policies guiding the ways and extent to which such data can be collected in different organizations and regions of the world.

Self-regulated learning can be considered both process and outcome. As a *process*, SRL can be seen as self-directed actions which learners engage into in order to plan their learning goals, choose and apply learning strategies, and evaluate and reflect on the effectiveness of those actions. As a *product*, SRL can be seen as learners' "disposition to direct their own learning" (Brookfield, 1986; cited in Littlejohn et al., 2012, p. 228). In this research, we looked at the effects of technological scaffolding interventions on micro-level process of SRL, i.e., we studied these effects from the *process* perspective. Future research is needed to understand the effects of technological scaffolding interventions on learning products (i.e., outcomes of learning) in addition to the findings reported in the paper shown the effects on micro-level processes of SRL. Unlike formal educational settings in which predefined and learning outcomes are excepted and measured (Marsick & Volpe, 1999), this is not the case in workplace settings due to its informal nature. Completing a task effectively and efficiently is the most common goal for knowledge workers to engage into learning in the workplace. As such, learning is a by-product of work done towards completing a task (Illeris, 2011; Ley et al., 2010; Margaryan et al., 2009). Therefore, products of informal learning are usually more implicit and not defined upfront such as the mastery of skills specific for a task, adoption of the cultural norms of the organization, and preparedness to adapt to emerging technological and societal transformations (Ellinger, 2005; Marsick et al., 2011; Tynjälä, 2012) . Future research should collect different indicators of learning outcomes, which can be used along with trace and self-report data in order to study the effects of technological scaffolding intervention on learning outcomes in the workplace. As well, such research can help understand the effects of associations between technological interventions and micro-level processes of SRL on the quality of learning products.

Acknowledgement

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Appendix A: Technological Scaffolding Interventions

The appendix describes the seven technological scaffolding interventions that are implemented in the Learn-B learning environment and investigated in the study reported in the paper.

Intervention I: Providing Usage Information

This intervention provides users with usage information about available resources allowing users to be aware of the social context of their organization around a particular learning resource. We have categorized the different functionalities of this intervention into three major features:

- *Analytics* provides users with statistics such as achievement information of the users who have worked with a specific learning resource, 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.

- *Social Streams* show the *popularity* of a certain resource and whether it has been "lively" used by other users or not.

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

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. We implemented this Intervention in three levels:

- *General Social Wave* provided users with all the latest updates from those colleagues the user followed plus the updates on their own learning goals;
- *Social Waves of user's Learning Resources* updated users specifically on a given learning resource, e.g. a competence
- *Bubble Social Waves* 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.

Intervention III: Progress-o-meters

Progress-o-meter designed 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).

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 who 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 the recommendation if they believe it does not match their learning needs.

Intervention V: System-Recommended 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. We have categorized 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* 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* 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.

Intervention VI: System-Recommended 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.

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.

Appendix B: The Learn-B Environment in Use

To illustrate how the scaffolding interventions were developed as part of the Learn-B environment and how they could be typically used in workplace environments, we 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 with 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 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 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 System-recommended Learning Paths, Learning Activities and Knowledge Assets for that competence; provided by Intervention VI (Figure 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 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 1.G).
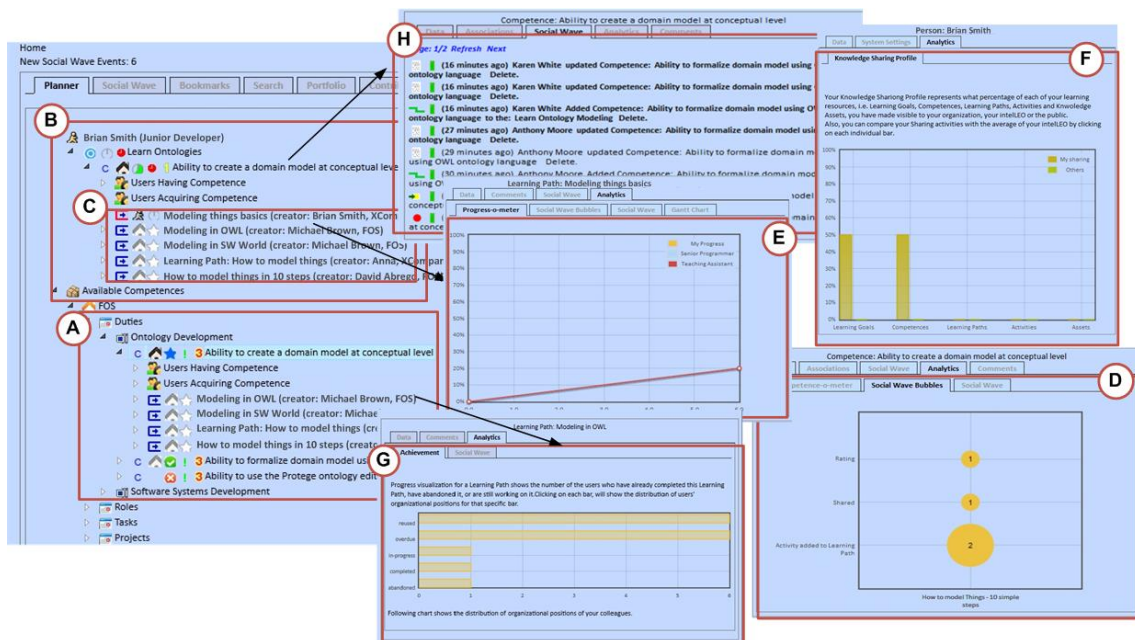

Figure 1. A snapshot of the scaffolding Interventions within the Learn-B environment.

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 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 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 1.F).

Appendix C: SRL and Intervention Events in the Learn-B Environment

SRL Events	
Macro-Level SRL Process: Planning	
Micro-Level SRL Process	**SRL Events in Learn-B**
Task/Analysis	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
	Exploring competences included in other colleagues' learning goals
	Searching for a keyword
Goal Setting	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	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**
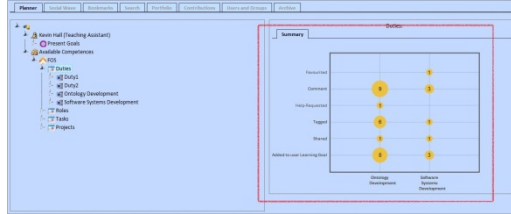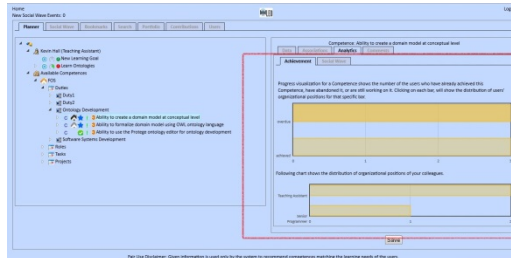
Working on the Task	Assigning a recommended Learning Path as the chosen path for a competence
	Requesting collaboration for a Competence, Learning Activity or a Knowledge Asset
	Marking a Competence as "favourite"
	Following a Competence
	Sharing a Learning Goal with a recommended colleague
	Recommending 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	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	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	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	
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	
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	
	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	
	Clicking on a single Learning Goal under the Recommended Learning Goals folder
Intervention V: Recommended available Competences	
	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	
	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	
	Clicking on one's Analytics tab (the Knowledge Sharing Profiles tab Is the only tab under this tab, so will open automatically)

Appendix D: Items for the Intervention – SRL Constructs used in the Study.

| Constructs	Construct Dimension	Item Identifier	Item Description[1]
Providing Usage Information (QD I, as depicted in Error! Reference source not found.**)**	**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]*
		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).

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[1] 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.*

[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.]

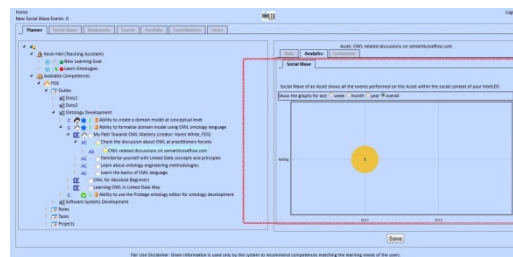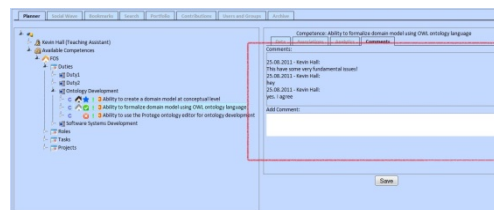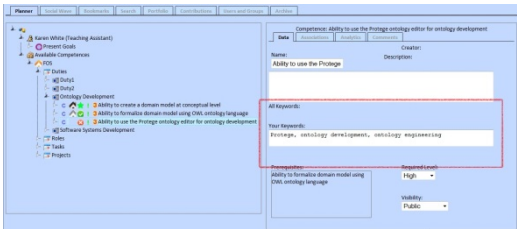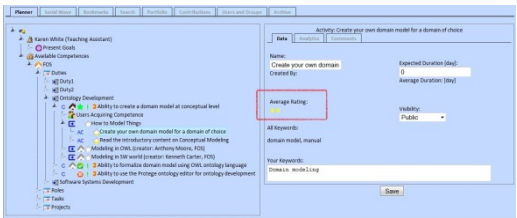|	Q5	The Achievement information about available Activities helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).
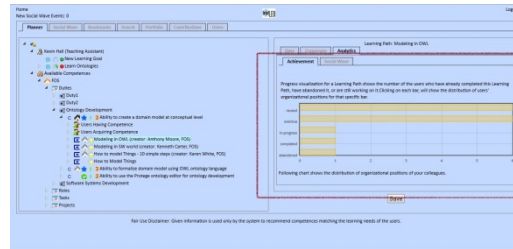
[The bars in the image above show the number and roles of the users who have already completed a certain Learning Path, have it overdue, are still working on it, or are using a modified version of it.]

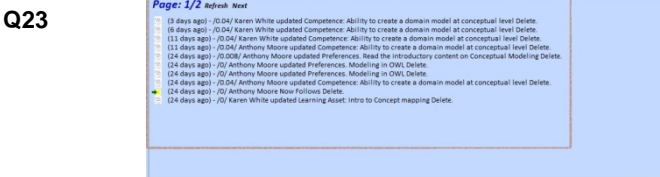|	Q7	The Achievement information about available Activities helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).
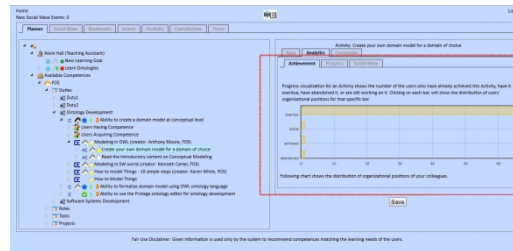
[The bars in the image above show the number and roles of the users who have already completed a certain Activity, have it overdue, are still working on it, or have abandoned it]

	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
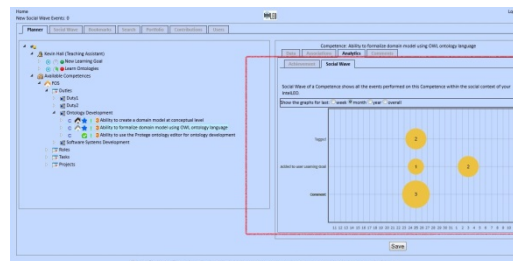
|	**Q6**	The Social Stream of available Learning Paths helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).
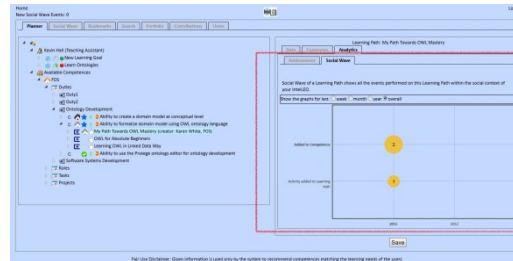
	Q8	The Social Stream of available Activities helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).
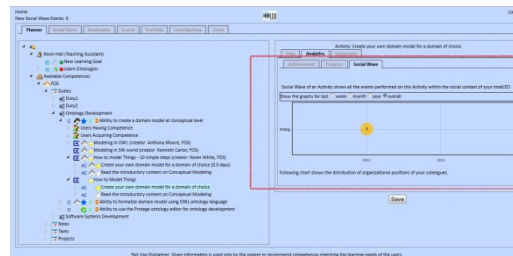
	Q9	The Social Stream of available Assets helped me to plan my personal learning goals (e.g. to decide which competences to include in my personal learning goals).

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.

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.

My general Social Wave gave me insight to apply changes in my learning goals or adopt (new) learning resources.

Q23

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).

Q24

Social Wave
(QD II, as depicted in Error! Reference source not found.)

General Social Wave
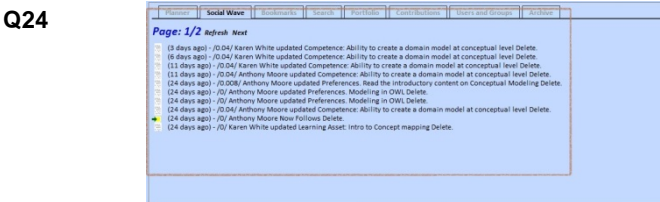
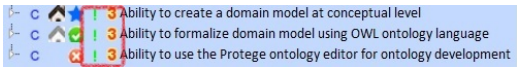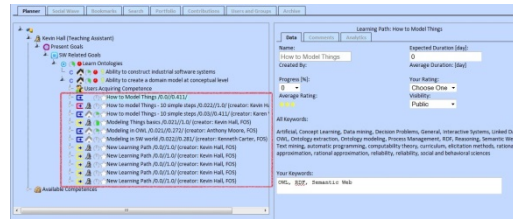|			
Social Waves of Learning Resources	Q25	The Social Waves of my learning resources (i.e. Learning Goals, Competences, Activities, LPs, or Asset) gave me insight to apply changes in my learning goals or adopt a (new) learning resource.	
Bubble Social Waves	Q26	The Social Wave bubbles of my learning 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 Error! Reference source not found.)	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.	
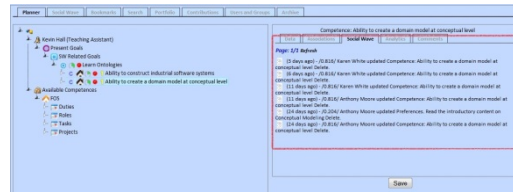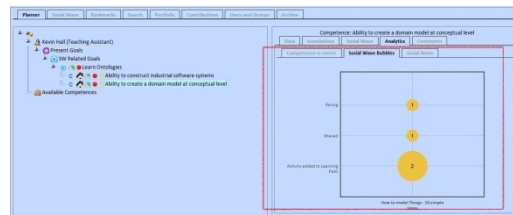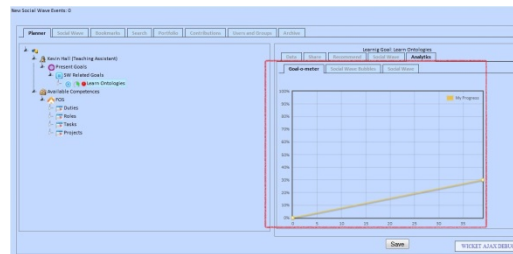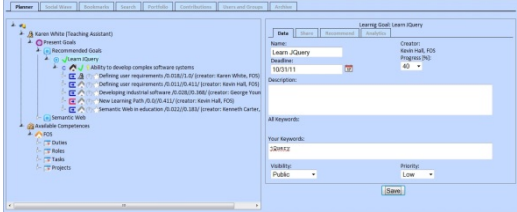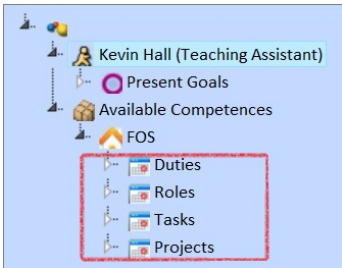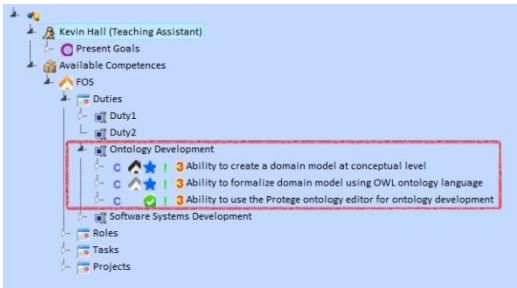
|			
User-recommended Learning Goals (QD IV, as depicted in Error! Reference source not found.)		**Q35**	The Recommended Learning Goals by my peers helped me to start my learning process (e.g., choosing additional competences to include in my learning goal, choosing the learning paths and accompanying assets, and updating their properties).
Recommended available Competences (QD V, as depicted in Error! Reference source not found.)		**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).
Recommended available LPs	**LAs and KAs (QD VI, as**	**Q3a**	I selected a specific competence, because it had many available Learning Paths.

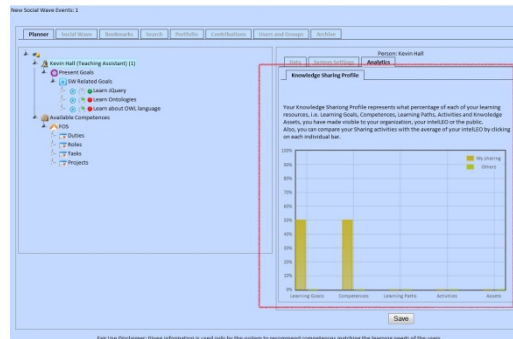The Learning Path on top of the list matched my learning needs.

Q43

Seeing who the creator of a recommended Learning Path is, helped me to pick the Learning Path that suits my learning needs.

Q44
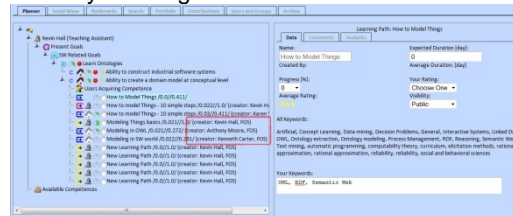
Q48

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.

Knowledge Sharing Profiles
(QD VII, as depicted in Error! Reference source not found.)