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# Responsive and Open Learning Environments (ROLE): Requirements, Evaluation and Reflection

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**Abstract.** Coordinating requirements engineering (RE) and evaluation studies across heterogeneous technology-enhanced learning (TEL) environments is deemed challenging, because each of them is situated in a specific organizational, technical and socio-cultural context. We have dealt with such challenges in the project of ROLE (http://www.role-project.eu/) in which five test-beds are involved in deploying and evaluating Personal Learning Environments (PLEs). They include Higher Education Institutions (HEIs) and global enterprises in and beyond Europe, representing a range of values and assumptions. While the diversity provides fertile grounds for validating our research ideas, it poses many challenges for conducting comparison studies. In the paper, we first provide an overview of the ROLE project, focusing on its missions and aims. Next we present a Web2.0-inspired RE approach called Social Requirements Engineering (SRE). Then we depict our initial attempts to evaluate the ROLE framework and report some preliminary findings. One major outcome is that the technology adoption process must work on the basis of existing LMS, extending them with the ROLE functionality rather than embracing LMS functionality in ROLE.

**Keywords:** Responsive and open learning environment, Social requirements engineering, Web 2.0, Technology acceptance model, Usability, Evaluation

## 1 Introduction

A well recognized phenomenon in the field of Human-Computer Interaction (HCI) is that technological artefacts, users and social contexts they constitute co-evolve at a rapid and somewhat unpredictable manner ([5], [12]). An alternative approach to capturing user requirements on an ongoing basis has been called for and led to the emergence of Social Requirements Engineering (SRE) approach. Grounded in Actor Network Theory [14] and Community of Practice (CoP; [26]), a distinct feature of SRE is to engage all potential stakeholders from the very early phase of a system development lifecycle.

This approach is specifically relevant in quickly changing domains whose success significantly relies on the tight integration of all stakeholders in the development lifecycle. With the emergence of the Web2.0 paradigm of the "Perpetual Beta", more and more web-based systems rely on an ongoing requirements engineering process that incorporate all relevant stakeholders continuously. This is especially relevant for the development of responsive open learning environments (ROLE) where stakeholders are inhomogeneous: learners, teachers, software producers, learning service providers, education organization (e.g. schools, universities, etc.), and accreditation organizations are continuously posing new demands, developing new services and identifying new ways of using and compiling such learning environments. This is also the case in the ROLE project that aims to enable learners to create their individual digital learning environments. The technology of ROLE is based on a widget-approach where widgets capture certain learning services. The widgets are compiled by each user, thereby creating individual learning environments. The learner is supported in this compilation process through recommendation services that take into account her individual goals, preferences, pedagogical needs, but also the requirements imposed on her through the respective organization certifying or accrediting the learning activity. Recommendations are provided within the widget-environment, thereby enabling widgets to be developed once but run anywhere. The environment itself is open in the sense that it relies on open and popular standards, e.g. ROLE widgets base on OpenSocial technology and run in environments like iGoogle and learning management systems like Clix and Moodle.

The widget-based approach leads to a continuous development of new learning services. While the development of widgets itself is loosely supervised only, a continuous requirements engineering approach is required that captures the needs of all stakeholders and makes them explicit, thereby providing a base for new developments. Consequently, the ROLE approach embraces SRE to combine the analysis of CoP-generated contents and system usage on the one hand, and to provide CoP members with a variety of services for the expression of explicit requirements on the other hand.

We outline in this paper how the SRE approach is being facilitated in the ROLE project. In Section 2, we first introduce the goals of the ROLE project. Then we outline how the ROLE project will change the learning world by introducing the ability to use personalized learning environments during the life-long learning processes. In Section 3, we delineate how the ROLE approach ensures that new requirements are being captured and addressed. While many stakeholders are involved in the process, the need arises to capture all requirements and make the explicit as well as provide means to fulfil them. Section 4 describes our first steps to prove the applicability of the ROLE approach as well as details on early evaluation results. Finally, in Section 5 we conclude the paper by summarizing and generalizing the outcomes of the proof of concepts and how they are generalized within the ROLE project.

## 2. ROLE: Advancing State of the Art of Learning Environments

Lifelong learning plays an ever-increasingly important role in our society. New challenges from workplaces entail employees to cope flexibly with rapidly changing business and job requirements. Similarly, employers need to consider hugely diversified backgrounds of their employees in addressing the issue of further education. A significant implication of these challenges for academic institutions is to prepare learners to be self-regulated [29], who are able to learn autonomously and sustain such effort. Traditional learning management systems (LMS) are deemed not flexible enough to address changing needs of lifelong learners [23], who normally migrate back and forth from one learning context to another (e.g., from university campuses through online learning communities to corporate training centres) to acquire formal qualifications and informal credentials.

Indeed, with the advent of Web 2.0 technologies, learners are exposed to, if not overwhelmed by, a plethora of social software tools and services. These emerging technological opportunities enable learners to emancipate from the bounds of traditional brick-and-mortar learning environments and to generate contents as well as consume other-created ones. This has led to a shift from a centralised institutional teaching approach to a more learner-centred decentralised learning approach [27]. Propelled by this shift engendered by lifelong learning, new generation learning environments are required to be more responsive and open, allowing breakthrough levels of personalization. It is considered a huge challenge to develop innovative technologies, concepts and approaches that can support lifelong learners to transfer smoothly through different stages of their personal and professional development, figuratively speaking, from cradle to grave.

The project ROLE (Responsive Open Learning Environments; http://www.role-project.eu/) aims to tackle this complex challenge through, paradoxically, a simple, effective paradigm of relieving learners from the burden of a one-size-fits-all learning environment. Specifically, ROLE develops an infrastructure that enables learners to construct their own learning environment according to their personal as well as contextual needs such as accreditation and corporate goals. The major goal of ROLE is to create an individual world for learning with personalization intelligence on the user's side, thereby enabling users to easily construct and maintain their own Personal Learning Environment (PLE). In brevity, a PLE consists of a mix of preferred learning tools, learning services, learning resources and other related technologies. Indeed, a consensual definition of PLE is yet to be specified – an effort being undertaken in the field of technology-enhanced learning.

Technologically, the ROLE approach is based on two foundations: an architecture enabling the composition and federation of different learning services into a single PLE as well as an integrative approach for services, tools, and data relevant for the learning context of the learner. These foundations require a sophisticated interoperability framework that enables exchanges between data and content, communication protocols, mash-up frameworks and tracking and evaluation services. The major challenge of this interoperability framework is to support the development of customizable and flexible learning environments, where components can be easily amended and new (sub-)systems can be composed out of available services in a responsive way.

In order to address the pedagogical needs within the individual creation and composition of ROLE-based PLEs, we adopt a Psycho-Pedagogical Integration

Model based (PPIM) on a self-regulated learning (SRL) approach. From the components of self-regulated learning (cognition, meta-cognition, motivation, affects, and volition) [9] and from the objectives of the ROLE project, five key aspects for the SRL process model have been derived. These key aspects are guidance and freedom, motivation, meta-cognition and awareness, collaboration and good practice sharing and personalisation. These derived psycho-pedagogical aspects integrated with the technical infrastructure presumably enable learners to assemble and use their learning environments effectively.

The long-term objective of ROLE is to provide the requisite infrastructure for any learner across the world to assemble their own PLE. The ROLE test-beds do exemplify distinctive scenarios of transitions a learner may encounter during their lifetime, as described in chapter 4. At this point of time while ROLE has not yet entered its externalization phase, developments are primarily carried out by a core group of consortium members and evaluation will currently be conducted manually and mostly internally.

The evaluation of the proposed infrastructure, which will constantly change and will be used by diverse user groups, is ongoing with the constant uptake of the results by the widget-developing communities is one of the major success factors for ROLE. The evaluation requires the development of a new evaluation methodology that bases on the SRE approach and is applicable to the so-called *organic* PLE context where usage scenarios can vary substantially with the individual design of PLEs.

## 3. Requirements for ROLE

### 3.1 Requirement Engineering Approaches in ROLE

ROLE embraces the user-centred design (UCD) approach (ISO 9241-210: 2010) and Web2.0 methodologies, with both sharing the philosophy of (r)evolving design and development work around users. The key notions of Web2.0 – user participation, collective intelligence, dynamic content - have instigated the growth of social software. This emerging genre of community-centred applications has been deployed by researchers and practitioners in a range of areas with requirement engineering (RE) being one of the recent attempts [16]. Whilst today's requirement engineering adheres to the UCD, existing tools primarily designed for supporting experts to capture and manage requirements are deemed inappropriate for dealing with a number of highly heterogeneous end-users (or stakeholders), who are not tech-savvy. The problem is aggravated when end-users are geographically and temporally widely distributed. These situations constitute challenges facing ROLE. Without active involvement of potentially large and diverse user and developer communities in the RE, development and exploitation processes, new educational technologies so created may only have limited impact. ROLE intends to address this problem already in early project stages with new Web2.0 inspired means of interaction for the elicitation and distillation of requirements from a multitude of voices from different nationalities, cultures and professions.

In ROLE, we embrace as well as realize the principle of "listening to our users". Accordingly, it is crucial to understand the goals that users want to achieve and the tasks that they intend to perform with the responsive and open learning environment infrastructure. The process of understanding users involves abstraction of why different stakeholders perform certain activities, what their constraints and preferences are, and how trade-offs of their competing needs can best be balanced. Generally speaking, user requirements for an interactive system can never be exhaustive.

In adopting the SRE, the ROLE approach is to combine analysis of Community of Practice [26] (CoP)-generated contents and system usage on the one hand, and provide CoP members with a variety of services for the expression of explicit requirements on the other hand. Furthermore, ROLE aims to refine the SRE approach by introducing, in a staged manner, the provision of several services, including communications, monitoring, requirement elicitation, requirement analysis, and requirement decision support. Specifically, the community-driven requirements process implicated by the SRE approach can result in an extremely large pool of diverse requirements. Hence, the system should first analyse the requirements and then render the results accessible to community members, who should then be enabled to prioritize them. To automate this rather complicated procedure, an appropriately configurable and customizable requirements prioritization model (RPM) is deemed imperative. This model can inform the development of ROLE Requirements Store, which is a system powered by a set of services to elicit requirements from stakeholders and to render the prioritization process transparent.

An important prerequisite for establishing an RPM is the availability of sufficient raw data to be fed into the model, and such data should be acquired unobtrusively. Three complementary techniques, namely social network analysis (SNA), usage monitoring analysis (UMA) and user requirements analysis (URA), are identified as relevant means for a CoP-based RPM. As a baseline, two monitoring data models, namely CAM [28] and MobSOS (Renzel, Klamma & Spaniol, 2008), are investigated; each of them has different objectives. While the CAM model is mainly focused on raising community awareness among end-users, the MobSOS monitoring model is part of an Information System success model [8] intending to measure the quality of individual services or complete information systems such as PLEs. Current efforts working towards a ROLE interoperability framework go in the direction of applying the XMPP protocol [21] and its extension protocols [18] as a distributed scalable approach that inherently provides improved means of monitoring data acquisition even on the remote communication beyond browser instance borders. A current merge of both CAM and MobSOS would provide access to information such as context-aware usage statistics, including frequency, density, patterns, context information on which users and communities use which artefacts at which spatiotemporal coordinates, and which technologies are used. It also provides information on tool quality in different dimensions such as performance, stability, error frequency, and sources, thereby indicating tendencies for or against functional requirements and suggestions for necessary improvements on non-functional requirements. Furthermore, monitoring data should provide sufficient input to the SNA techniques for identifying the relative position of a person within her or his communities (centrality measures) [25], inter- and intra-community communication

behaviour (boundary spanners, brokers, high betweeness centrality) [4], who and what effects a user (influence networks) [15], and what communities a user belongs to (community mining) [6].

Whilst the aforementioned RE modelling work is ongoing, a series of requirements capturing activities have been undertaken with the use of different RE methods and tools. Thematic workshops, be they f2f or virtual, internal or open, have prevalently been used, because workshops can effectively engage members of the wider TEL community in scientific discourses to evaluate the existing work already delivered by the project and to explore the uncharted waters (e.g. fitness and evolvability of PLEs, [30]). Interviews, focus groups and questionnaires - the other commonly used requirements capture instruments - have also been deployed. Besides, the specific CoP tool used in ROLE is the ROLE LinkedIn Group where specific questions or topics are posed to stimulate discussions. Despite the success of acquiring requirements, lessons learnt from the empirical experiences of deploying these RE instruments are:

- Face-to-face workshops, even though costly, proved to be useful in creating a common understanding and identifying CoP common requirements in addition to raising community cohesion. A more cost-effective way is to adopt a blended approach by launching a bootstrapping f2f workshop that will be reinforced by subsequent virtual video-conferences. This approach proved effective in the context of CSCW and is deemed relevant to the SRE.

- The social-network based virtual focus groups worked well for requirements verification and with limited success for elicitation purpose. The performance of the focus groups could improve when group discussions were spearheaded by reputable and visible members of their respective communities. The implication is to engage experts at the very phase of an online community formation, who can weigh in the significance of the community with their views and attract potential participants. However, after scaffolding initial discussions, these experts should fade out (cf. the cognitive apprentice process; [3]) to eschew any predominant effect that may undermine the open participation process.

Whilst open user participation is the celebrative feature of social software, it poses as a great challenge to RE workers how to cost- effectively filter noises from a massive body of data being contributed by the diversity of users. Filtering should be followed by the processes of abstraction and prioritization to categorize and rank requirements in a structured manner that facilitates the subsequent design and development work. While these requirements management tasks are not unique to the SRE approach, its open participation process renders them more time-consuming and resource-demanding than otherwise. The proposed requirements prioritization model (RPM) and the conceptualisation of the ROLE Requirements Store are working towards the resolution of these critical issues in the SRE approaches.

### 3.2 Overview of ROLE Evaluation Scheme

Continuous requirements-driven support is essential for a sustainable success of a highly dynamic network or community that ROLE can well exemplify. User requirements analysis is an error prone part of the development process. It is important to manage changing requirements as the system develops. User requirements should be verified as soon as design solutions and prototypes are available. Software prototypes of low and high fidelity need to be user tested to identify any gap. Outcomes of these tests will be fed back to refine the requirements. Besides, a range of system designs should be generated and discussed with user groups before committing to a solution as a basis for the implemented system. These ideas manifest the tenet of the participatory design (PD) approach [1] in the field of HCI.

Furthermore, the long-term objective of ROLE is to provide the requisite infrastructure for any learner across the world to assemble their own PLE. Evaluation of the proposed infrastructure, which will constantly change and will be used by diverse user groups, is another challenge for ROLE. It requires the development of a new evaluation methodology applicable in the so-called organic PLE context where usage scenarios can vary substantially with individual design of PLE. For instance, the popular Information System Success Model (ISSM) [8] approach cannot be applied in its entirety as there is no "system" to be evaluated, but a cloud of personal and personalised systems. Instead, we comprise our evaluation framework with constructs identified from several evaluation frameworks like ISSM, Davis's original Technology Acceptance Model (TAM) [7] and its extensions by Venkatesh and Bala [24] included information quality, system quality and service quality, which contribute to intention to use, loyalty, user satisfaction and net benefits. Each construct subsumes a set of user-oriented attributes of which values can be moderated by the user's motivations and needs with one of them being the desire for community building.

The key evaluation areas of ROLE include: (i) validating the technical performance; (ii) evaluating the usability of the system/tools/services provided for self-regulated learning (SRL) within ROLE; (iii) evaluating the learning effectiveness and learner satisfaction with the SRL approaches being enabled by ROLE. Traditional evaluation techniques such as interviews, workshops, and paper questionnaires are considered efficient in earlier phases before a large roll-out, where the target populations are clearly known (i.e. ROLE test-beds, ROLE developer team, etc.) which will later be replaced by scalable, automated and unobtrusive techniques [22]. As we deal with a cloud of personal and personalised systems, an iterative case-study-based action research approach is adopted using multi-method data collection for triangulation. Towards the end of the project a cross-case analysis ([10], [17]) will be performed to obtain a holistic view on the outcomes of the project.

# 4. Lessons Learnt from Evaluation

In this session, we first describe the ROLE testbeds which are heterogeneous user groups which are so selected as to validate the multifaceted concepts of ROLE from different perspectives. Then we present the challenges experienced in designing and implementing evaluative activities within as well as beyond these testbeds; primarily quantitative data through a questionnaire and qualitative data through open discussion have been collected. Next we discuss the implications of the results found.

## 4.1 Introducing the ROLE Testbeds

Applying the ROLE evaluation framework proves a somewhat difficult task. ROLE aims to provide the necessary tools, components, and services for empowering learners and teachers to assemble and control their learning environment as per their requirements. Only the successful uptake of requirements and the evaluation of fulfilment will guarantee the sustainable success of ROLE. Hence, it is essential to understand the context of the end users who will be using the ROLE infrastructure, now and in the future – as an ongoing process. In the beginning, the requirements engineering and uptake process starts with those end users organized within the ROLE test-beds, with each test-bed focusing on a specific combination of actors and activities in TEL. The test-beds target a large sample of individuals with significant potential for extending to other learners and learning communities:

- The *RWTH* Aachen test-bed targets academic service providers and consumers with a main focus on supporting the transition from universities to companies (U2C).
- The *FESTO* Lernzentrum test-bed targets inner and outer commercial providers and consumers with a main focus on providing internal job opportunity in a company (Job to jobs: J2J).
- The *SJTU* (Shanghai Jiao Tong University) test-bed targets skilled and motivated student communities who failed the university entrance exams, with a special focus on continuing education for transition between two Jobs in different companies (Company to company: C2C)
- The *BILD* (British Institute for Learning & Development) test-bed targets professional organizations with a special focus on continuing education relying on communities where transition from individual to shared competences can occur (One to many: O2M).
- The *OLrn* (OpenLearn) test-bed targets worldwide public providers (such as the Open University UK) with a special focus on the transition between formal and informal learning and conversely (F2I).

The end-users across the testbeds are highly heterogeneous and greatly vary due to the nature of their organisation, culture, motivations etc. Owing to these and other peculiarities we assume that it might never be possible to accurately establish a generic profile for an end user. Furthermore, looking at the composition of these

testbeds and based on inputs from workshops and focus groups we can certainly establish the fact that users will hugely vary on their needs, motivations, technology competence and acceptance.

In addition to the ROLE evaluation framework, towards the end of the project, a one-time cross-case analysis ([2], [13]) will be performed to obtain a holistic view on the outcomes of the project based on the individual case-study based test-bed evaluations. This is necessary as the evaluation framework does not identify similarities in a diverse set of cases, which is what *most different design* (MDD) [19] offers. Additionally, clustering of cases might also be relevant to ROLE to identify and compare patterns and process pathways to seek typological regularity [11]. Hence, the typologies technique will also be used for ROLE that may lead to the identification of social phenomenon. We will use the cross-case analysis to test if the aforementioned key notion of *fitness* can explain the survival patterns of technological and pedagogical artefacts that are of interest to ROLE.

### 4.2 REFLECT: Evaluative Activities, Results and Discussion

An internal sub-project entitled RELECT has been launched to coordinate the evaluation activities in ROLE. Specific focus is set on evaluating ROLE technologies with representative end-users from different testbeds, which are highly heterogeneous. For instance, some testbed partners cannot integrate prototypical software in their production systems, thus reducing the numbers of early testers and the scale of evaluations. Others were able to apply ROLE technology rather extensively, and to collect data about their users' views.

**Table 1**. Questionnaire on user acceptance of widget-based PLE

| | |
|---|---|
| S1. | I would find a PLE useful for my work. |
| S2. | I would accomplish my work more effectively with a PLE than with the learning technology I am currently using. |
| S3. | It would be easy for me to use a PLE. |
| S4. | It would be clear to me how to assemble a PLE using widgets. |
| S5. | I would find using a PLE frustrating. |
| S6. | I would find interacting with a PLE requires a lot of my mental effort. |
| S7. | Using a PLE would improve my motivation for learning. |
| S8. | Using a PLE would enable me to learn in an independent manner. |
| S9. | I predict that I would frequently use a PLE if I had access to it. |

To enable some basic comparisons across testbeds with regard to the acceptance of widget-based PLE, a core questionnaire with key constructs "Perceived Usefulness (PU)" and "Perceived Ease of Use (PEOU)" has been developed with reference to the Technology Acceptance Model (TAM [7]). The questionnaire contained 4 items (or statements 'S') each for the PU (S1, S2, S7, S8) and PEOU (S3, S4, S5, S6) and one item for Behavioural Intention (BI) (S9) (see Table 1). Respondents are asked to

indicate their agreement with each of the nine statements with respect to a "widget-based Personal Learning Environment" using a five-point Likert-type scale from "Strongly disagree" (rating: 1) to "Strongly agree" (rating: 5).

To enhance the response rate, the questionnaire was intentionally designed as concise as possible. However, some testbed leaders found it necessary to adapt the questionnaire to the particularities of their testbeds to meet certain organizational constraints (e.g., evaluating the learners' performance along multiple dimensions). Consequently, it made the planned cross-testbed comparisons particularly challenging. Eventually, the core questionnaire was administered beyond the ROLE testbeds to the wider audience. As of December 2011 (the survey is still ongoing), 41 responses were collected under three different contexts, namely a university course, a workshop and a summer school in the realm of technology-enhanced learning. The number of participants varied with the context, ranging from a handful to tens. The corresponding numbers of response were obtained, ranging from five to 19. A standard procedure was carried out in each of the events: Participants were first demonstrated the concept of "widget-based personal learning environment" with the use of a video-clip and a set of power point slides. The demonstration was then followed by some discussion. Finally, the participants were asked to complete the core questionnaire without any time limit. The participation was entirely voluntary.

**Table 2**. Results of perceived usefulness (PU) of widget-based PLE

| | **Strongly disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly Agree** |
|---|---|---|---|---|---|
| S1 | 12% | 10% | 22% | 44% | 12% |
| S2 | 12% | 15% | 37% | 29% | 7% |
| S7 | 17% | 5% | 54% | 24% | 0% |
| S8 | 10% | 12% | 32% | 37% | 10% |

**Table 3**. Results of perceived ease of use (PEOU) of widget-based PLE

| | **Strongly disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly Agree** |
|---|---|---|---|---|---|
| S3 | 12% | 10% | 24% | 37% | 17% |
| S4 | 10% | 24% | 17% | 29% | 20% |
| *S5* | *29%* | *27%* | *27%* | *12%* | *5%* |
| *S6* | *17%* | *37%* | *24%* | *20%* | *2%* |

As shown in Table 2, the perceived usefulness (PU) of a widget-based PLE was generally perceived to be high (cf. 44% of the respondents rated '4' for S1). However, it seemed that the participants were less convinced that this new learning environment could enhance their motivation, considering that only 24% of the

respondents agreed on S7 (i.e. "Using a PLE would improve my motivation for learning") and nobody strongly agreed on this statement. A similar trend was observed for the perceived effectiveness of this emergent learning environment as compared with the traditional one. The picture would be different if the participants could have interacted with an interactive prototype.

Concerning the perceived ease of use (PEOU), as shown in Table 3, 54% of the participants tended to agree or strongly agree that the widget-based PLE was easy to use (S3) and to assemble (S4). As S5 and S6 are phrased in the negative manner, corresponding results need to be interpreted accordingly. 56% and 54% of the participants did not think that using the PLE would be frustrating (S5). Nor would it be cognitive demanding. Generally speaking, these findings are encouraging.

**Table 4**. Results of behavioural intention (BI)

| | **Strongly disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly Agree** |
|---|---|---|---|---|---|
| Q9 | 15% | 15% | 29% | 24% | 17% |

With regard to the intention to use the widget-based PLE in the future, about 40% of the participants expressed their willingness to do so (Table 4). About 1/3 of them remained non-committal, and about 1/3 had no intention to deploy it, which might be attributed to the observation that they could not yet appreciate the usefulness of such an environment (cf. the findings in Table 2) without interacting with it.

In addition to the large-scale survey approach, the REFLECT project aims to conduct relatively smaller scale quasi-experimental studies (Figure 1). Classic psychological lab-based experimental approaches are deemed impractical for the authentic learning situations of the ROLE testbeds. The basic idea is that there would be two groups of participants attending the same course offered by an institution: one group would *not* use ROLE (control group) and the other would use ROLE in the learning phase. This information could be captured at the end of the course (i.e. the evaluation phase). In this phase, students would be asked if they have used ROLE during the learning phase (a threshold value is to be set, indicating that participants should have used ROLE at least, say, 50% of the learning time to be classified as the 'experimental group'). Additionally, some objective assessment of learning outcomes would be collected as references. Since the participants differed only in the learning phase (with vs. without using ROLE), the differences in the learning outcomes could be attributed to the influence of using ROLE.

Nonetheless, the quasi-experimental approach was found to be difficult to implement (let alone the traditional experimental one), given certain organizational constraints, for instance, teachers' resistance to expose their students to different treatments. New attempts are being undertaken to realise this kind of study.

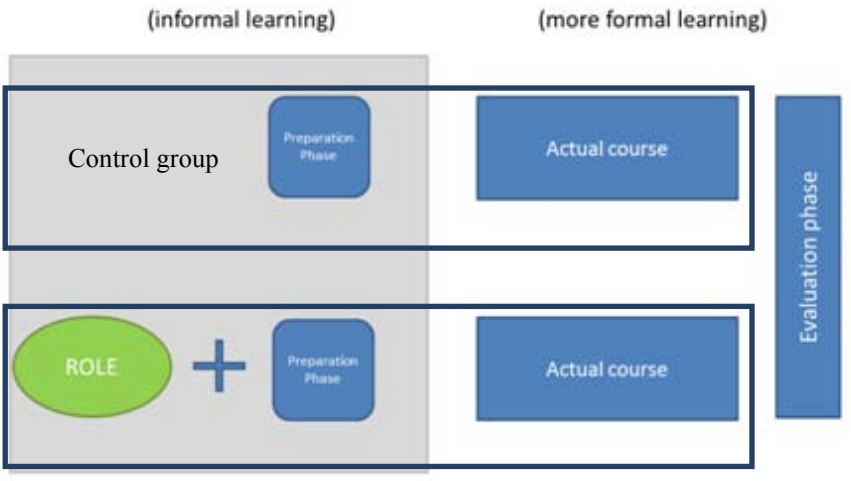


**Figure 1:** Quasi-experimental user-based studies for evaluating widget-based PLE

### 4.3 Reflection on the Transition from LMS to PLE

As mentioned earlier, organisational issues have affected the ROLE testbeds (Section 4.1) to different degrees. RWTH needs to ensure privacy and anonymity by implementing several technical mechanisms. For FESTO, protecting intellectual property is highly relevant and needs to be taken into account when developing widgets. In the SJTU test-bed, users had favourable views on data collection and analysis as long as it serves to improve the overall learning process. The OU testbed employs Moodle and that brings up some difficulties, such as having to host and control widgets that make use of the Moodle database. The BILD has not yet faced privacy issues, but is in a particularly interesting position that each of its members needs to decide about what aspects of their systems they are able to make available. Hence, the BILD testbed includes endusers rather from the group of implementers and vendors in contrast to the other testbeds, where end-users are mostly teachers and students of various types.

The above results tend to indicate that the introduction of PLE concept, even with sufficient provision of relevant information on the nature and use of PLEs, is very difficult and time-demanding. Often, students reported that they would rather use the learning environment that they have been used to. Apart from other possible conclusions, we understand that the most important lesson learned is that in the current state of development, learning management systems (LMS) are inevitable for hosting PLE solutions. While the infrastructure and the widgets available are both progressing very well, it would be extremely helpful for the technology adoption process to work on the basis of existing LMS in the test-beds. A critical success factor for enabling users to adopt PLE as a learning solution is that the new PLE is embedded in a familiar environment to allow them to make a smooth transition from

their established learning experiences to the new freedom given by the assembly of PLE widgets. Hence, in ROLE we do not favour a disruptive innovation approach but an evolutionary process leading from traditional LMS to the PLE of the future.

## Conclusion

This paper outlines the evaluation approaches and preliminary results of the ROLE project. ROLE strives to create a framework that enables life-long learners to assemble and re-assemble their own learning environments according to their requirements as well as to those imposed by the teacher, the certifying organisation (e.g. university) and possibly their employer. As the ROLE approach addresses a multitude of different stakeholders in many, yet unknown types of learning situations, e.g. transition phases from university to job, between jobs, etc., the ROLE evaluation approach is deemed the most successful way of satisfying the requirements posed by various stakeholders.

Therefore, the ROLE evaluation framework was devised that combines a number of already highly successful evaluation methods. Furthermore, it complements these with web 2.0 like features and thus creates a notion of a social requirements engineering process. As a result, the ROLE Requirements Store instantiates the ROLE evaluation framework to be used by all stakeholders of the ROLE framework.

Obviously, while the ROLE Requirements Store has not been implemented fully, manual evaluation with the help of all stakeholder groups from the ROLE test-beds has already been performed and led to a number of significant insights into success criteria for ROLE-based PLE usage. One of the most prominent outcomes is that, no matter which stakeholder group is concerned, all of them require a transition phase from regular LMS-based learning environments via ROLE-enabled LMS to PLEs that incorporate LMS-functionality as one aspect.

Further work in ROLE targets, apart from the development of the ROLE framework the fine-tuning of the ROLE evaluation methodology. For example, the notion of Darwinism [30] still needs to be worked out in more detail. It proves quite difficult to parameterize the respective fitness function that is necessary to predict successful and unsuccessful PLE creations, services and functionality.

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