Paving the Way for Lifelong Learning

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Facilitating competence development through a learning path specification

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through a learning path specification

José Janssen

Synopsis

Efficient and effective lifelong learning requires that learners can make well informed decisions regarding the selection of a learning path, i.e. a set of learning actions that help attain particular learning goals.

In recent decades a strong emphasis on lifelong learning has led educational provision to expand and to become more varied and flexible. Besides, the role of informal learning has become increasingly acknowledged. In light of these developments this thesis addresses the question: How to support learners in finding their way through all available options and selecting a learning path that best fit their needs?

The thesis describes two different approaches regarding the provision of way finding support, which can be considered complementary. The first, inductive approach proposes to provide recommendations based on indirect social interaction: analysing the paths followed by other learners and feeding this information back as advice to learners facing navigational decisions. The second, prescriptive approach proposes to use a learning path specification to describe both the contents and the structure of any learning path in a formal and uniform way. This facilitates comparison and selection of learning paths across institutions and systems, but also enables automated provision of way finding support for a chosen learning path. Moreover, it facilitates automated personalisation of a learning path, i.e. adapting the learning path to the needs of a particular learner.

Following the first approach a recommender system was developed and tested in an experimental setting. Results showed use of the system significantly enhanced effectiveness of learning.

In line with the second approach a learning path specification was developed and validated in three successive evaluations. Firstly, an investigation of lifelong learners' information needs. Secondly, an evaluation of the specification through a reference (sample) implementation: a tool to describe learning paths according to

the specification. Finally, an evaluation of the use and purpose of this tool involving prospective end-users: study advisors and learning designers. Following the various evaluations the Learning Path Specification underwent some changes over time. Results described in this thesis show that the proposed approach of the Learning Path Specification and the reference implementation were well received by end-users.

Contents

Chapter 1

General introduction

'*The growing belief that education is a key component of economic success and competitiveness is driving demographic changes in student populations and impacting on the curriculum and the provision of studies.*' (Brown, 2002, p. 579)

The transition to a 'knowledge economy' has reinforced the need to enhance effectiveness and efficiency of education and training (Brown, 2002; CAUDIT, EDUCAUSE, JISC, & SURF, 2010; Holmes, 2006; Jarvis, 2002; Kelly, 2002). Against the background of the European ambition to become the most competitive and dynamic knowledge-based economy in the world, facilitation of lifelong learning and transferability of knowledge and competences within the European context became of great importance (Adam, 2001; Bologna-Declaration, 1999; Karran, 2004). The stronger emphasis on lifelong learning has led educational institutions to adapt and make their provision more flexible in a number of ways affecting both organisation and pedagogy:

- Greater variety of delivery modes: part-time education, blended learning, e-learning;
- Greater variety of subjects covered in a modularised form so that programmes can be adapted to individual needs;
- Greater emphasis on bridging the gap between education and occupation, e.g. competence-based learning, authentic tasks, problem-based learning;
- Increased focus on self-directed learning to prepare for lifelong learning;
- Alignment with European agreements and standards, e.g. European Credit Transfer System (CEC, 2004), Bachelor-Master structure;
- More collaboration between educational institutions to achieve cost-efficiency.

The above developments are not without undesired side-effects. For one, increased provision and modularisation have increased the challenge of finding one's way both in education and lifelong learning. This thesis describes research that was carried out to develop a generic solution to support learners in finding their way, enabling informed decisions on available options.

Studies into student progress and retention highlight that even within the relatively structured confines of formal education, learners experience difficulties finding their way through the curriculum and the courses on offer. These way finding problems increase the risk of attrition (Martinez & Munday, 1998; Rovai, 2003; Simpson, 2004; Yorke, 1999). Within the realm of lifelong learning the challenge of finding one's way is only likely to increase as is illustrated by the following example. Currently a search via Google for a course on, for instance, interior design, will result in over 70 million hits, referring to all kinds of interior design courses, at different levels, some accredited, others not, with different price tags attached, varying study load, etcetera. Apart from the fact that this clearly represents a case of information overload, a novice in the field has no idea where to start, even if some course titles might offer a clue using terms like 'introduction' or 'basics'. Especially novices in a field need to be provided with navigational support to reduce disorientation and help them develop a structural representation of the knowledge domain (Chen, Fan, & Macredie, 2006). A study by Lea, Stephenson & Troy (2003) reveals that though students consider student-centred approaches more motivating and effective than conventional didactic models, they also "*expressed anxiety about an approach that lacked structure, guidance and support in the name of being student-centred*" (Lea, Stephenson, & Troy, 2003, p. 331). For learners to be self-directed they need to be in a position in which they can oversee what is available and determine how this matches their needs (Koper & Tattersall, 2004). As lifelong learning opportunities are expanding and learners can choose from a greater variety offered by different institutions, traditional facilities like course catalogues or face-to-face study advice are no longer adequate in supporting learners in choosing those learning opportunities that best meet their needs. Finding one's way in education and lifelong learning is an issue in two respects:

a. in the process of selecting a suitable learning path (i.e. a set of one or more learning activities which help to attain certain learning goals)
b. in the ensuing process of proceeding along a chosen learning path (i.e. how best to combine or sequence the learning activities).

The terms way finding and navigation are used as synonyms to refer to both these processes.

This thesis describes two, seemingly opposing, but complementary approaches in offering navigational support. Initially, a solution was sought in applying principles of self-organisation (Koper, Rusman, & Sloep, 2005b; Theraulaz & Bonabeau, 1999) and collaborative social filtering (Nichols, 1997; Pennock & Horvitz, 1999). Self-organisation refers to a system, organisation, or network that operates and sustains itself based on direct or indirect feedback about its own performance. Collaborative social filtering is a technique that can be used to provide such feedback and is now widely used on the Internet to provide consumer recommendations: information about preferences of a large number of users is used to recommend items to a single, presently active user. Similarly, we developed a solution, described in chapter 2, providing recommendations for a best next learning activity based on information about choices made by other learners (Janssen et al., 2007). This bottom-up solution was tested in an experimental design, in order to establish whether it helped to increase efficiency and effectiveness of learning (ISO, 1998; Koper, 2005b). Though the results were promising, the experimental design was inevitably restricted in a number of respects. The number of learning activities was limited and the activities could be studied in any order, so that there were no dependencies between the activities. Besides, no alternatives were available for any of the learning activities. Nevertheless, meaningful recommendations should take into account, for instance, that some activities are prerequisite to others, or that exchangeable activities represent a choice.

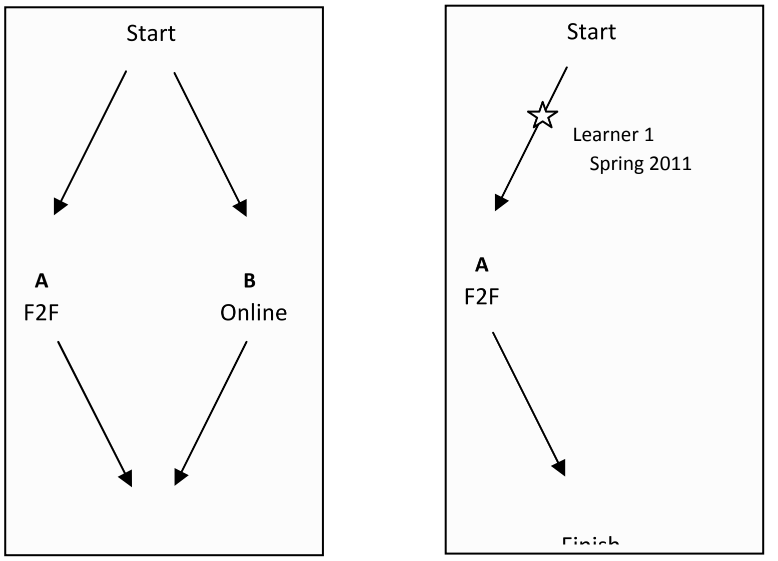
So the question was raised: how can we describe learning paths and their constituent parts[1] in a way that makes them comparable and amenable to computer processing. The remainder of the thesis addresses this question and describes the development, implementation and evaluation of a generic, formal and interoperable description of learning paths, i.e. a learning path specification.

A *specification* is the expression of a set of requirements to be satisfied by a material, product or service. The Learning Path Specification enables to describe learning paths in a formal, uniform way, so that they become amenable to computer processing, enabling (semi-)automated comparison and navigation. Of course the advantages of such a specification increase when it is widely used, enabling users to search and select across institutions and systems. For this purpose the specification should meet the technical requirement of interoperability: it should enable data exchange between systems without additional transformation effort (Pawlowski & Adelsberger, 2002).

In order to clarify the notion of a learning path and the level of abstraction associated with it, we distinguish between a learning path, a planned instance of a learning path and a learning path in execution. This distinction might be best explained using the metaphor of public transport. Consider the railway journey from London to Inverness. One can take this journey several times a day, choosing to travel either along the east coast via Edinburgh or along the west coast via Glasgow. Note that a *learning path* also describes a possible way to arrive at a chosen destination: a learning goal. There may be several ways (paths) to reach that goal. A train passage is scheduled, irrespective of the number of passengers boarding the train. Similarly, learning paths exist (i.e. are on offer) regardless of any learner actually following the path. They simply exist as opportunities: e.g. training A by company X and training B by Y, help to attainment similar learning goals. Training A is delivered in face-to-face mode, while B is an online training. Training A starts twice a year, training B starts anytime. Figure 1.1.a illustrates this abstract notion of a learning path.

[1] Constituent parts of a learning path might be alternately referred to as learning activities or learning actions.

A particular transit from the schedule chosen by a passenger (e.g. the train leaving at 10.30 and travelling via Edinburgh) is a planned instance of the train journey. Similarly, training A starting in the spring of 2011 becomes a *planned instance of the learning path* when a learner has chosen to follow this particular 'run' of the learning path (figure 1.1.b).



a. Learning paths A and B

b. Planned instance of A

Figure 1.1. Learning path and planned instance of a learning path

Much as passengers will board the train somewhere along the route, similarly a learner might 'hop on board' somewhere along the learning path because some of the competences covered by the learning path have already been acquired. This is taken into account in the planned instance of a learning path as well. In figure 1.1.b this is indicated by a star representing the actual starting point for this learner. The moment the learner starts to proceed along the planned instance of the learning path, the planned instance becomes a learning path in execution. Note that a planned instance is not a fixed path, first of all because the path may offer choices concerning the learning activities to perform and the order in which to perform them. Secondly - again much like the train transit - things may not go as planned, e.g. unforeseen circumstances may cause delays, demand detours or even alternative transportation. In terms of the learning path: it is possible that the plan is adapted due to unforeseen circumstances or because attractive alternatives have presented themselves. So throughout the execution the road ahead remains a planned instance that is subject to change as long as the learning path is being executed (i.e. the learner has not achieved the learning objectives yet and has not given up either).

The role of the Learning Path Specification is to enable transparent descriptions of possible ways to attain a particular learning goal, so that:

1. it becomes easier for learners to compare and select learning paths
2. it becomes possible to automate navigation support for a chosen learning path
3. it becomes easier to see which parts of a learning path (i.e. which learning actions) can be substituted by other learning actions (e.g. prior learning).

Whereas studies in the area of Adaptive Hypermedia and Artificial Intelligence (Baylari & Montazer, 2009; Chen, 2009; De Meo, Garro, Terracina, & Ursino, 2007) are directed towards fully automated generation of learning paths, using techniques such as collaborative filtering (community-based) and semantic reasoning (ontology-based), our own experiences with a collaborative filtering approach have led us to conclude that there will always be situations in which a prescriptive rather than an inductive approach is required, for instance, in the case of newly designed learning paths (Wong & Looi, 2009), in formal settings, or in cases where learners do not trust automatically generated learning paths (Chen, 2008). With Wong & Looi (2009) we believe that both approaches are complementary: inductive approaches could be used to validate prescriptive course sequencing, or to discover new prescriptive rules. Likewise, prescriptive learning paths can be used to identify the areas where inductive approaches can offer added value. Having thus identified the need for a uniform way to describe learning paths, subsequent studies presented in this thesis focus on the development and validation of a learning path specification.

Functional and technical requirements for the specification are described in chapter 3 (Janssen, Berlanga, Vogten, & Koper, 2008). These requirements have been derived from a review of literature on curriculum design and lifelong learning as well as current practice that aims to enhance exchangeability of learning actions and programs. The chapter also investigates to what extent existing specifications may fulfil these requirements and consequently may be used as a formal, interoperable way to describe learning paths. The conclusion of this investigation is that the existing IMS Learning Design specification (IMS-LD, 2003) might be used for the purpose and the learning path conceptual model ultimately presented in chapter 3 can be clearly mapped on this specification. It has since become clear, however, that using IMS Learning Design would entail including a number of constructs which the Learning Path Specification itself does not require, but which are needed to ensure compliancy with IMS-LD. Eventually, it was decided not to use a subset of IMS Learning Design to specify learning paths but to develop a new ‘lean’ specification[2].

Related specifications that aim at supporting learners in finding suitable learning opportunities, include eXchanging Course-Related Information (XCRI, 2006), Course Description Metadata (CDM, 2004) and Metadata for Learning Opportunities – Advertising (MLO-AD, 2008). However, these specifications focus on advertising courses provided through formal learning, whereas the Learning Path Specification enables description of formal, non-formal and informal learning. The Learning Path Specification still has clear links with the IMS-LD specification, but distinguishes itself from this specification because it does not provide a detailed description of the actual learning process: the activities, assignments, and materials involved. Instead, the Learning Path Specification is a vehicle to connect units which on their turn describe these learning processes and activities in more detail. These units might in fact be an IMS-LD unit-of-learning, but they might also be a workshop, a manual, a video, a classroom course, a blog, and so forth.

Chapter 4 (Janssen, Berlanga, & Koper, submitted) describes the conceptual (UML) model of the ‘lean’ Learning Path Specification. The implementation of the model in a binding was realised through XML, Extensible Markup Language (W3C, 2008), an international standard which meets the technical requirements of formality and interoperability. The conceptual model states that a learning path has a start (formerly ‘prerequisites’) and a finish (formerly ‘learning objectives’) which are defined in terms of competences at particular levels of proficiency. A learning path further defines one or more learning actions that lead from the start to the finish. Both the learning path and its actions are further described by a set of metadata specifying content, process, and planning information (e.g. title, description, assessment, tutoring, delivery mode, attendance hours). These metadata are assumed to play a role in the process of choosing a learning path. Some of these metadata are compliant with the IEEE Learning Object Metadata (IEEE/LOM, 2002) (e.g. identifier, title, language, description, version, typical learning time) while others are specified in addition (URI, provider, start conditions, recognition, delivery mode, guidance, location, start date, end date, attendance hours, contact times, assessment, further information, completion, type, number to select). The chapter describes in some detail how the specification is meant to be applicable to formal, non-formal and informal learning alike. Besides, it explains a specification as a conceptual model and presents a framework for the evaluation of the specification, drawing on theories of model quality (Krogstie, 1998; Moody, 2005; Nelson, Poels, Genero, & Piattini, 2005).

[2] Note that the learning path conceptual model has evolved over time. This will be reflected in subsequent chapters of this thesis. The learning path information model of the final schema is provided through appendix A of this thesis.

Whereas the initial solution described in chapter 2 was tested regarding the criteria of efficiency and effectiveness, these criteria prove less appropriate for the evaluation of a specification. The solution described in chapter 2 was a tool that provided recommendations, i.e. a concrete system that could be tested in an experimental setting. The Learning Path Specification is not a completed system, but part of a solution within a particular approach. Again a parallel can be drawn with travelling by train, e.g. the introduction of the high speed train: it makes sense to evaluate the benefits of high speed train journeys in terms of efficiency, effectiveness and satisfaction, but do these criteria apply to the rails that carry the trains as well? An evaluation of the railway track is more likely to include the quality of the materials used, the way the materials have been connected as well as the foundation of the track.

The research approach taken in this thesis is design-based[3]. It is directed at a variety of solutions to enhance efficiency, effectiveness, some of them are more manifest, concrete products. However, considerable efforts are directed towards the development of specifications and standards to enable reuse and exchange of particular solutions (Hodgins et al., 2003; McClelland, 2003; Sloep, 2004). This more 'hidden' technology's impact is far less tangible than that of a concrete tool. Moody (2005) makes a similar observation regarding the evaluation of conceptual models, stating that whereas a finished product can be evaluated against initial requirements, evaluation of a conceptual model involves (tacit) needs, desires and expectations as well. Though the Learning Path Specification has been developed to meet certain requirements (e.g. enable to express modularity, nested structures, etc.) evaluating the specification against those requirements would prove a rather superfluous exercise, comparable to packing a suitcase following a checklist and then unpacking it again to ascertain that all the items on the checklist have been packed.

Drawing on theories of model quality we developed a framework for the evaluation of the Learning Path Specification, which distinguishes three aspects of model quality:

1. Syntactic quality: does the model/specification express what it intends to express in a correct way, i.e. in accordance with the syntax rules of the modelling language?
2. Semantic quality: does the model/specification represent essential features?

[3] Design-based research is "*a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories"* (Wang & Hannafin, 2005, p. 6)

3. Pragmatic quality: is the model/specification easily comprehended and used by the stakeholders for its intended purpose?

Following the description of this framework chapter 4 further describes a case study that was carried out to investigate both semantic and pragmatic quality of the Learning Path Specification, more particularly the question whether the metadata included in the specification are clear and whether they reflect the characteristics which play a role in lifelong learners' choice processes. Choice processes were studied retrospectively through semi-structured interviews with learners (*n*=15) who recently decided upon a learning path having compared at least two different options. The interviews focused on identifying characteristics which played a role in the comparison and selection of learning paths, relying first on spontaneous recall, followed by a more structured approach of aided recall.

This first evaluation focused on particular elements of the Learning Path Specification, i.e. those elements relevant to comparing and selecting a learning path. A second study was carried out to evaluate the specification 'as a whole'. Chapter 5 describes this second evaluation, which addresses the question how easily the specification is comprehended and used by stakeholders considering its intended purposes (Janssen et al., submitted). The *immediate* purpose of the Learning Path Specification is to guide system development, with the *eventual* aim to describe learning paths in a formal and uniform way. Following this difference between immediate and future purpose, two different stakeholder groups can be identified: software developers and experienced authors describing learning paths. Chapter 5 distinguishes first-order and second-order pragmatic quality in relation to direct and indirect use of the specification. To return to the metaphor of the high speed train: technical personnel involved in the construction and maintenance of the train and railway tracks are likely to assess the quality of the innovation from a different perspective than the crew operating the trains. Of course this metaphor implies a third order pragmatic quality, relating to those using the infrastructure to travel from A to B, i.e. learners receiving navigational support through tools that draw on the specification. Due to time constraints, however, this third order pragmatic quality is out of scope of this thesis.

First-order pragmatic quality was evaluated during the process of developing a reference or sample implementation: a tool to describe learning paths in line with the specification, called the Learning Path Editor. The software developers involved in developing the Editor had not been involved in the development of the specification, so that to start with, they had to rely on the information contained in the schema and the information model (Janssen, Hermans, Berlanga, & Koper, 2008). Chapter 5 describes minor and major changes suggested by the software developers to enhance pragmatic quality of the specification/schema (Janssen, Berlanga, Heyenrath et al., submitted).

Assessment of second-order pragmatic quality requires a somewhat different approach because end users do not engage with the specification in a direct way. The background and purpose of the specification have to be explained to them before they can understand the way learning paths are described using the Learning Path Editor. Besides, the shift from first-order pragmatic quality to second-order pragmatic quality, implies a slight shift in the interpretation of 'pragmatic quality' as the intended purpose changes from 'developing a tool that enables description of learning paths according to the specification' to 'describing learning paths according to the specification in order to provide way finding support to lifelong learners'. These nuances concerning the interpretation of pragmatic quality have inspired the exploration of related concepts of usability and desirability. Though the concept of usability is very close to pragmatic quality, it misses the aspect of 'intention to use', i.e. desirability. This aspect is not directly relevant in first-order quality assessment as software developers usually are not prospective users of the tool. However, it becomes a crucial factor with end users and so also in the evaluation of second-order pragmatic quality. Eventually, second-order pragmatic quality was assessed through a number of workshop sessions involving 16 prospective end users (study advisors and educational technologists). The workshop sessions entailed a video explaining the purposes of the Learning Path Specification including a demo of the Learning Path Editor (Janssen, 2010). Next, participants gained some hands-on experience with the Editor through three small tasks involving the adaptation of the learning path description they had watched being created in the demo. Finally, they were asked to evaluate their experiences taking a broad perspective: i.e. considering the entire approach of describing learning paths through a learning path specification in the proposed way and its intended effects. The evaluation was carried out using an online adaptation of the Desirability Toolkit (Benedek & Miner, 2002; Storm & Börner, 2009). Drawing on the product reaction cards methodology the toolkit allows respondents to elaborate on issues they consider of interest for the evaluation rather than having them rate particular aspects which the researcher has identified as important. The product reaction cards contain positive, neutral and negative adjectives. Participants are asked to select six cards which best express their experiences and evaluation of the proposed approach. However, as the results of chapter 5 further confirm, the main value of this method does not so much lie in the selection of the adjectives, but in the motivations provided along with them.

Although the desirability of using a learning path specification can be identified and evaluated at the level of a single institution, the benefits of using the specification would increase if the Learning Path Specification became more widely adopted, as this would offer the added value of exchange of learning paths between institutions and systems. This raises the question what the chances are for the Learning Path Specification to gain wide adoption, perhaps even to the extent of developing into a standard. In chapter 6 we reflect on the work presented in this thesis in the light of this question. A standard is a common agreement that enables communications, between people and/or systems (Krechmer, 2006). As Hodgins et al. (2003) point out a specification can become a *standard* either through an open process of review, balloting, and certification (*de jure* standard) or simply by becoming widely used (*de facto* standard). A distinction can be made between standards concerning the outcomes of learning (education standards) and standards relating to the design and delivery of learning (learning technology standards). The distinction is sometimes subtle. For example, a standard competence description is an education standard, enabling comparison and exchange of courses and programmes across the borders of a single institution or nation, so that courses taken in one programme or country can be interpreted and transferred to a programme in another educational system. These standard competence descriptions need to be put in a learning technology standard format such as the IMS Reusable Definition of Competency or Educational Outcome (IMS-RDCEO, 2002), so as to make them amenable to computer processing. Learning technology standards *'deal with the interoperability of components of learning environments, such as authoring systems, learning management systems (LMS), and learning resources and services'* (Ehlers & Pawlowski, 2006, p. 6).

The Learning Path Specification proposes to draw on education standards for competence descriptions, to further enhance exchange (Kickmeier-Rust, Albert, & Steiner, 2006; Van Assche, 2007). This, in fact, is one advantage of the specification that distinguishes it from related specifications in the field. Chapter 6 discusses this and other features of the specification in the light of the specification's prospects of gaining adoption. For this discussion we draw on Rogers' (1995) five perceived characteristics of innovations which affect their chances of adoption: relative advantage, compatibility, complexity, triability, and observability.

Finally, chapter 6 identifies areas for future research, including integration of inductive and prescriptive approaches to way finding support and further validation of the Learning Path Specification in a variety of contexts, e.g. work place learning, and a variety of tools, e.g. learning path presentation tools.

Chapter 2

Self-organising navigational support in lifelong learning: How predecessors can lead the way

Janssen, J., Tattersall, C., Waterink, W., Van den Berg, B., Van Es, R., Bolman, C., & Koper, R. (2007). Self-organising navigational support in lifelong learning: How predecessors can lead the way. *Computers & Education, 49*(3), 781-793.

Abstract

Increased flexibility and modularisation in higher education complicates the process of learners finding their way through the offerings of higher education institutions. In lifelong learning, where learning opportunities are diverse and reach beyond institutional boundaries, it becomes even more complex to decide on a learning path. However, efficient and effective lifelong learning requires that learners can make well informed decisions. Drawing on principles of self-organisation and indirect social interaction, this article suggests solving the problem by analysing the paths followed by learners and feeding this information back as advice to learners facing navigational decisions. This article starts by introducing the principles of self-organisation and indirect social interaction. It describes how we expect the use of indirect social interaction using collaborative filtering to enhance effectiveness (completion rates and amount of progress) and efficiency (time taken to complete) in lifelong learning. The effects were tested in a controlled experiment, with the results showing effects on effectiveness though not on efficiency. The study shows that indirect feedback is a promising line of enquiry for navigational support in lifelong learning.

1. Introduction: the need for navigational support in education and lifelong learning

In general terms, navigation can be defined as ''the process of determining a path to be travelled by any object through any environment'' (e.g. Darken & Silbert, 1993). Several studies into student progress and retention highlight navigational issues in educational institutions. Yorke (1999, p. 105) concludes that ''As the unitization of curricula spreads through higher education, so there is a need for greater guidance for students to navigate their way through the schemes.'' Research at the Open University of the Netherlands reveals that students feel a need for adequate information on further study possibilities in an early stage of their study and that they find it hard to gain an overview of the number of modules and the best sequence of study. Here information overload seems to cause the problem, rather than a lack of information (Joosten & Poelmans, 1998). Martinez and Munday (1998) point to 'presentation of course/programme overviews' and 'sequenced, structured course work of progressive difficulty' as part of the solution to the drop-out problem. Simpson (2004) mentions a more recent (2002) survey of students withdrawing from courses at the British Open University where 21% of the withdrawers identify 'inadequate course choice guidance' as a reason for dissatisfaction.

Although findings from research indicate there is a relationship between navigation/planning problems and drop-out, they also reveal that it is only one factor among many others (Bean & Metzner, 1985; Kember, 1990; Rovai, 2003). Unfortunately, although research in the field identifies factors such as study-advising and program fit as of influence on retention, few clues as to the nature of advice are available (Chyung, 2001; Martinez & Munday, 1998; Rovai, 2003). Simpson (2004) suggests several alternatives to costly one-to-one advice: diagnostic materials, 'taster' materials, and student views - all with their own limitations. This leads the author to conclude that they should probably be used in combination, although this may prove too burdensome for students.

At present, faculties of the Open University of the Netherlands recommend a certain route through the courses available in their programmes. To some extent there is a 'natural order' (i.e. the contents of one course require prior knowledge offered in another), but apart from these kind of interdependencies, the recommendations hold little 'empirical base'. That is to say, they are not guided by knowledge of actual sequences students follow and/or the extent to which they proved to be successful. Useful though these recommendations may be, and responsive to learner's need for consistency and clarity of programs, they run counter to principles of learner centeredness and learner control. The need for alternative solutions to pre-planned routes is even more pressing in lifelong learning where learning opportunities are more diverse and reach beyond institutional boundaries. The concept of Learning Networks (Koper, Rusman, & Sloep, 2005b) provides a framework for addressing this complexity. Learning Networks (LNs) are self organised, distributed eLearning systems designed to facilitate learner controlled lifelong learning in particular knowledge domains. Self-organised, here means that organisational structures evolve from the actions and interactions of individuals, rather than being pre-defined; bottom up rather than top down. An important motive for bringing about self-organisation in Learning Networks lies in increased efficiency of the support structure (Koper, Giesbers, Van Rosmalen, Sloep, Van Bruggen & Tattersall, et al. 2005a).

Figure 2.1 is a simplified representation of a Learning Network in a certain domain D. The Network contains Activity Nodes (ANs, learning events or units-of-learning) which have to be mastered for the attainment of a certain objective or competency level. These activity nodes are the offerings of different educational providers. The learner's goal is the level of competence he or she would like to achieve. A route consists of one or more ANs that lead to the achievement of that level of competence. A 'to-do list' gives the ANs that still need to be completed. The learner in figure 2.1 has to complete six more ANs to reach the goal: the dark ANs in figure 2.1. The white ANs in the figure are out of scope for this learner at this stage: they have not been mastered yet (are not part of the learner's position) nor constitute part of the goal. The grey ANs represent the learner's position: either ANs that have been completed within the current Learning Network, or ANs accredited through prior learning. As the learner proceeds through the Learning Network, working towards his or her goal completing one AN after another, a learning track is built up, consisting of the sequence of ANs the learner has completed.

This is a simplified figure; in reality there may be many more ANs perhaps including alternatives from which to choose. Even this simplified example raises the question of how best to work toward the goal; what path should be followed through the to-do list.

Alternatives to one-to-one advice and pre-planned routes for navigational support can be sought in several directions (Tattersall et al., 2005). Social navigation, like the student views proposed by Simpson (2004), is one of the alternatives. However, as Nichols (1997) points out, social filtering systems using explicit ratings require a large number of ratings to remain viable and users might consider it too much of a burden to rate ANs. A way to avoid placing a burden on learners is to rely on indirect social navigation, a concept closely related to the principle of self-organisation.

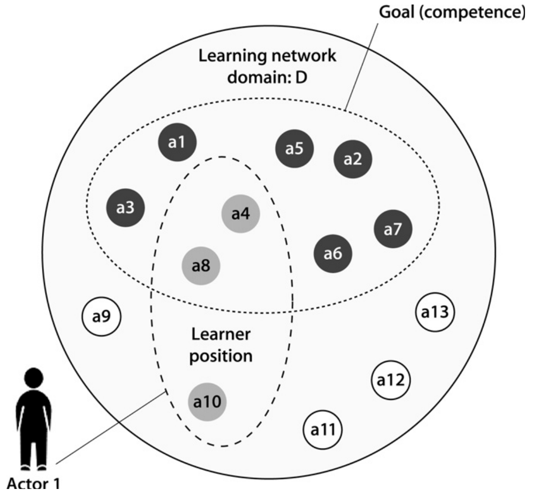


Figure 2.1. Illustration of the concepts learner position and goal in a learning network

2. Self-organised indirect social navigation

An example often used to explain the concept of self-organisation is that of ant colonies, where individual ants leave behind pheromones (chemical traces) that signal to other ants the shortest routes to food (Bonabeau, Dorigo, & Theraulaz, 1999). These trails feed information back on the progress of preceding ants. For self-organisation to occur in a network, actors have to have a high level of interactivity as well as access to feedback concerning the performance of similar others ('neighbours') in the network (Koper, 2005a). This does not necessarily require direct interaction or feedback, but might take place through indirect feedback, also known as stigmergy: traces left and modifications made by individuals in their environment can function as feedback (Theraulaz & Bonabeau, 1999). Where Rovai (2003) states that ''other students, staff, and faculty may not be readily accessible that can provide students with the information that they seek'' our approach to offer indirect feedback might help bridge the gap: other students may be consulted as a source of information, albeit indirectly, by offering information on their navigational choices: the traces they have left behind while working towards their goal within the Learning Network.

Our study explored the use of this principle of stigmergy in offering way finding support, aimed at increasing the effectiveness (i.e. producing the desired effect) and efficiency (i.e. producing the desired effect with a minimum of effort) of Learning Networks. More specifically, we offered learners feedback concerning the choices and results of preceding learners aiming for the same goal. Our approach to offer navigational support in a Learning Network based on choices made by those who went before is quite similar to collaborative filtering used in recommender systems, where knowledge about the preferences of a large number of users is used to recommend items to a single, presently active user (Pennock & Horvitz, 1999). Our approach exploits information on choices/actions of users to derive (calculate) a recommendation. There are various types of information that could be offered as feedback to learners: information on the fastest route, the route with highest success or satisfaction rates, or a combination of several of these leaving it to the student to choose between these options. In order to feedback this information, a collective log of learner interactions within the Learning Network is filtered and processed as described in Tattersall et al. (2005). In our study, learners were offered feedback regarding the best next step, based on the number of times an AN had been successfully completed. In the study, an AN was successfully completed when a learner passed the assessment related to the AN. A similar approach is followed in work carried out for the French e-learning company Paraschool (Semet, Lutton, & Collet, 2003; Valigiani et al., 2005), although the feedback we propose is independent of any predefined or preferred routes. The feedback in this study is calculated as follows: if an activity node AN1 has been completed by 10 learners and 4 of those learners went on to successfully complete AN4, whereas 2 went on to successfully complete AN3, the advice for the next best step to a learner who has just completed AN1 as a first node, will be a random draw from the set {AN4,AN4,AN4, AN4,AN3,AN3}. Taking a random draw ensures that the most frequently completed AN is most likely to be recommended, while leaving room for other successfully completed ANs to be recommended as well, thereby avoiding sub optimal convergence to a single next step. For a more detailed explanation of this feedback calculation and the rationale behind it, see Koper (2005a).

We expect that the navigation tool will enhance effectiveness and efficiency in Learning Networks since navigational support will facilitate planning decisions and reduce the risk of information overload by offering accessible and more learner centred (i.e. related to learner's present position) planning information. Moreover, as the feedback makes use of success rates, we expect learners to make better choices based on ''tried and tested'' sequences.

The nature of distance education and lifelong learning and, more generally, discussions on definitions and calculations of output and dropout in education (Cookson, 1990; Fritsch, 1991; Kember, 1995; Reimann, 2004; Woodley, de Lange, & Tanewski, 2001; Yorke, 1998) suggest that by simply defining effectiveness in terms of goal attainment we would be overlooking the fact that progress may have been made despite non-completion. In our study we will therefore not only look at goal attainment (the number of learners achieving a predefined goal), but also at the amount of progress made (the number of ANs that have been completed). Efficiency on the other hand will be indicated by a single variable: the time it takes to attain the goal.

The following hypotheses were tested in an experiment, using a feedback tool recommending a best next step based on successful choices of other learners:

1. Offering feedback on the best next step, based on past choices of successful learners will result in increased effectiveness as indicated by both the amount of progress made (the number of ANs completed) and goal attainment (the proportion of learners reaching a predefined goal).

2. Offering feedback on the best next step, based on past choices of successful learners, will result in increased efficiency as indicated by the time required to attain the goal.

The method section describes the experimental design in more detail as well as the way the advice regarding the best next step was presented to learners.

3. Method

To test the assumed effects of the navigational feedback a true experiment (Ross & Morrison, 1996) was carried out in which participants were randomly assigned to an experimental group that was offered feedback and a control group that proceeded through an otherwise identical Learning Network without any feedback.

3.1. Participants

Participation in the LN was free, i.e. no fees were charged and a popular topic was chosen for the Learning Network, namely the Internet. The target group was defined as people who have some experience with Internet – surfing the worldwide web and using email – and who face questions such as: How safe is it to buy things on the Web? Are there more efficient ways to search the Web? What do I need to do to ensure that my children are not confronted with 'adult' websites or adverts on the Web?

The recruitment announcement highlighted that the course was designed with the purpose of testing new technology, that it would take approximately 22 hours to study the course, that the course would be available for three months, and that completion of the course would be rewarded with a certificate. Prerequisite knowledge was defined as: ''having some experience with Internet (surfing the web and using email) and a passive understanding of English''. At the start of the course participants were asked to fill in a small questionnaire aimed to gather some basic background information about the learners: age, sex, educational level and computer skills.

A group of 1011 people initially showed an interest in taking the course. They were randomly assigned to either experimental group or control group and given login details accordingly. Twenty percent (n = 203) did not log into their assigned Learning Network site, and this group of non-starters is not included in our study of the effects of navigational support. This leaves a group of 808 learners who did enter the Learning Networks; 398 in the control group and 410 in the experimental group. Response rates on the background variables questionnaire were about 60%, showing that overall there were more women (59%), people over 45 years old (57%) and people with a high educational level (higher professional education or university level; 63%). Finally, 48% said their computer skills were poor or very poor.

3.2. Materials

A Learning Network was designed with the purpose of creating an appropriate experimental context to present and test the effects of navigational feedback. Designing the Learning Network, we took into account that:

- Due to time constraints the experiment should take no more than three months, meaning that learners must be able to reach the goal within three months.
- The Learning Network should contain sufficient ANs, so a navigational ‘‘problem’’ does indeed present itself.
- Completion of an AN must be ‘‘formally’’ established so that learning tracks can be determined and feedback can be derived from them.
- The Learning Network should reflect as closely as possible a realistic lifelong learning context, being both intrinsically and extrinsically motivating (reaching the goal would be rewarded by a certificate).

Eleven ANs were developed with the following titles: ‘‘The many roads to the Internet’’, ‘‘Web searching’’, ‘‘Chatting‘‘, ‘‘Secure payments on the Internet’’, ‘‘Do more with Internet Explorer’’, ‘‘Worms and Horses’’, ‘‘Beating spam & spy ware’’, ‘‘Interesting and pleasant sites’’, ‘‘Watching and listening on the Internet’’, ‘‘Dealing with inappropriate web content’’, ‘‘Making a personal web page’’. The ANs were designed to take an average of two hours to complete. Formal completion of an AN was established through the use of a short test consisting of five equally weighted questions. A score of 60% or more indicated successful completion.

Two Learning Networks consisting of the above ANs were created in the open source learning environment Moodle (Dougiamas, 2004), one for the experimental group, the other for the control group. In Moodle, each AN was modelled as a separate entity, thus ensuring that the learning environment kept adequate log records needed to provide the feedback and to test the hypothesis. The learning environment was modified such that all learners, both in the control and experimental group, received an overview of the ANs in the Learning Network, with a list of completed ANs on the left hand side and a to-do list on the right hand side. For learners in the experimental group the overview also contained the advice: ''Continue with: [the best next step, based on successful choices of other learners]''. Figure 2.2 shows the overview for a learner in the experimental group.

The only difference in the experimental set-up for the control group lies in the absence of the ''Continue with'' area. The order of the ANs in the to-do list was reshuffled each time the page was viewed so that there would be no effect in the sequencing of ANs due to the presentation in a fixed list.

3.3. Procedure

Participants were randomly assigned to an experimental group and a control group. Both groups received login details for their respective websites and a link to further instructions in an on-line user manual, and were informed that certificates would be issued to learners completing all eleven ANs in the experimental time period. Participants could study the ANs in any order, though learners in the experimental group were advised to follow the recommendation ''Continue with:''.

All participants were told the list of ANs to complete would appear in a different order each time, but were not told why this was the case. It was explained that they would be randomly assigned to one of two groups who would work in a slightly different environment but with the same course content. There were separate email helpdesks for both groups offering technical and practical support. We deliberately chose not to offer any support regarding the course contents as this might have affected the experiment. During the three months the course was running, three newsletters were sent to inform students about technical topics that were raised via the helpdesk, and to remind them of the closing date of the course. The newsletters were identical for both groups and were sent simultaneously. The first newsletter was sent within a week as a number of learners had problems logging in to the course websites, and consequently turned to the email helpdesk for assistance. This first newsletter focused on those problems by explaining how to avoid mistakes with username and password and how to adapt cookie and Internet security settings. A second newsletter was sent one month after the first and a final newsletter was sent as a last reminder of the closing date, ten days prior to the end of the experimental period.

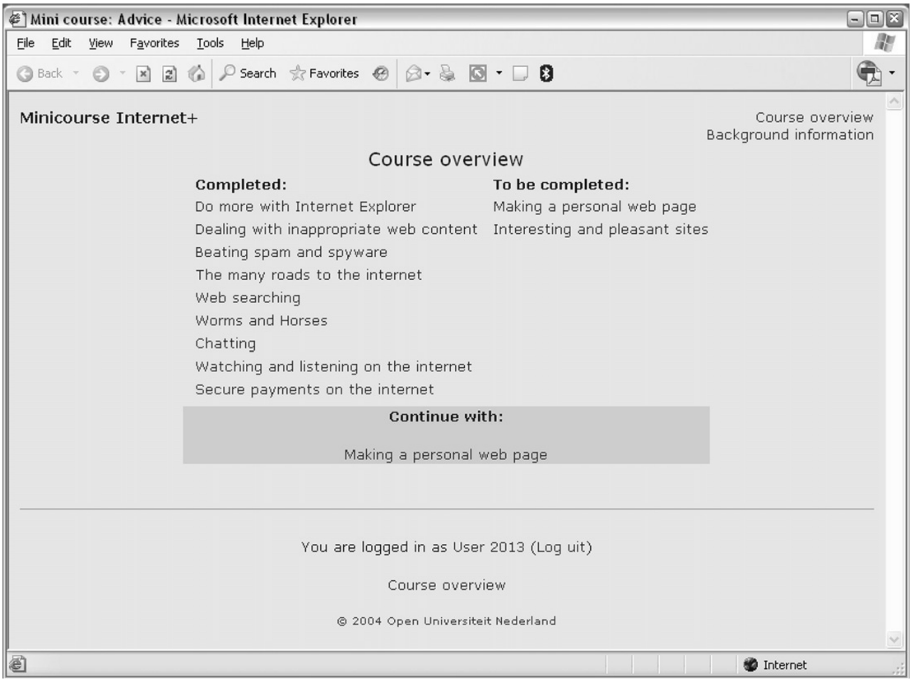


Figure 2.2. Overview for a learner in the experimental group

3.4. Analyses

The first hypothesis stating that the feedback offered will result in more effective lifelong learning was tested for two different variables: amount of progress (the number of ANs completed over time) and goal attainment (the proportion of learners receiving a certificate; i.e. completing all 11 ANs). Goal attainment was measured by a single indicator, namely the proportion of learners having completed all 11 ANs at the end of the experimental period. Progress, in contrast, was measured over time, allowing for a comparison of the way progress developed in both groups using multivariate analysis of variance for repeated measures. In the experimental period of 13 weeks, measures were taken at three weekly intervals, with the exception of the first measurement which was done after four weeks. The average number of ANs completed over these four successive moments in the experiment, was analysed by means of linear and quadratic trend analysis. Average ANs scores were transformed into linear and quadratic trend contrast scores by means of computation of orthogonal polynomials. Multivariate analysis of variance for repeated measures was applied on these contrast variables, which were chosen a priori, with Group (containing two different values: experimental or control) as between-subjects factor and Progress (four values for four successive moments) as within-subjects factor. In case of significant interactions of contrast scores with Group or progress, testing of simple contrast effects were performed. Due to the a priori character of these tests, they were performed with the conventional Type I error of 0.05 (cf. Tabachnick & Fidell, 2001).

In order to compare goal attainment for the experimental and control group a χ^2 test was used.

To test the second hypothesis concerning the effect on efficiency, a t-test was used to compare the average time taken to complete 11 ANs in both groups. The time taken to complete was measured by counting the number of days between initial login and completion of the final AN.

4. Results

4.1. Effectiveness

The results for effectiveness will be described separately for the two variables amount of progress made towards achieving the goal (the number of ANs completed) and goal attainment (the number of learners completing all 11 ANs).

4.1.1. Amount of progress

The amount of progress made by learners as indicated by the number of ANs completed in the course of time in both groups is represented in figure 2.3.

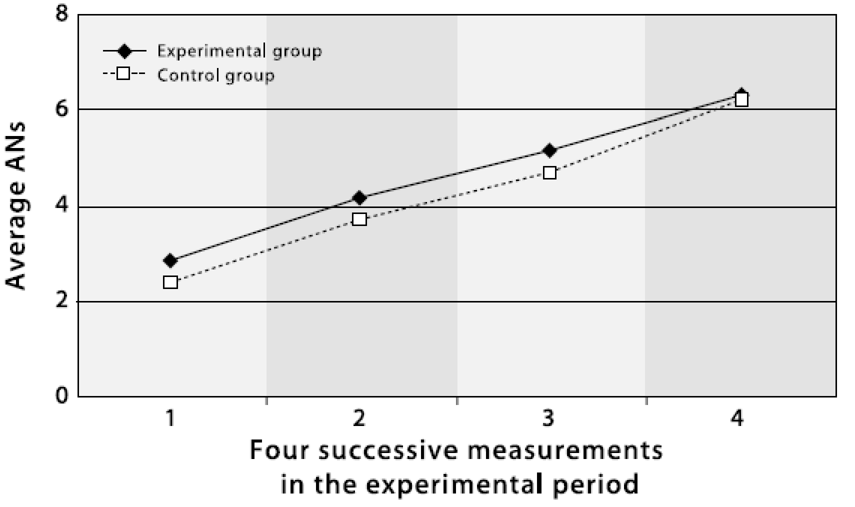


Figure 2.3. Time course of progress (completed ANs) for the experimental and control group

The overall completed ANs over time was denoted by a significant positive linear trend ($F(1,806) = 586.91$, $p < 0.001$) and a significant positive quadratic trend ($F(1,806) = 10.55$, $p < 0.001$). This means that the total group of participants has made significant curvilinear progress over time.

There was, however, no significant overall effect of Group, indicating that on average the two groups did not differ significantly. The interaction between Group and Progress was also not significant. However a significant effect of Group on the quadratic trend was found ($F(1,806) = 4.96$, $p < 0.05$), but not on the linear trend. Simple effects analysis showed only a significant linear increase for the experimental group (positive linear trend: $F(1,806) = 272.90$, $p < 0.001$) and a curvilinear increase for the control group (positive linear trend: $F(1,806) = 314.48$, $p < 0.001$; positive quadratic trend: $F(1,806) = 14.77$, $p < 0.001$). These results indicate that AN completion in the experimental group developed along a straight line, whereas in the control group the amount of progress made accelerated towards the end. Figure 2.3 indicates this: the average number of completed ANs is consistently higher in the experimental group except for the final measurement. In the end, the average number of completed ANs is about the same for both groups. This shift towards the end may have been influenced by an intervention, carried out ten days prior to the end of the experiment, when learners where reminded of the course deadline. To test the possibility that the intervention may have had an unintended and different impact for the control group, a repeated measurement analysis was performed for the last three weeks for learners who completed at least one AN. Figure 2.4 shows study progress over the last three weeks of learners who completed one or more ANs during the experimental period.

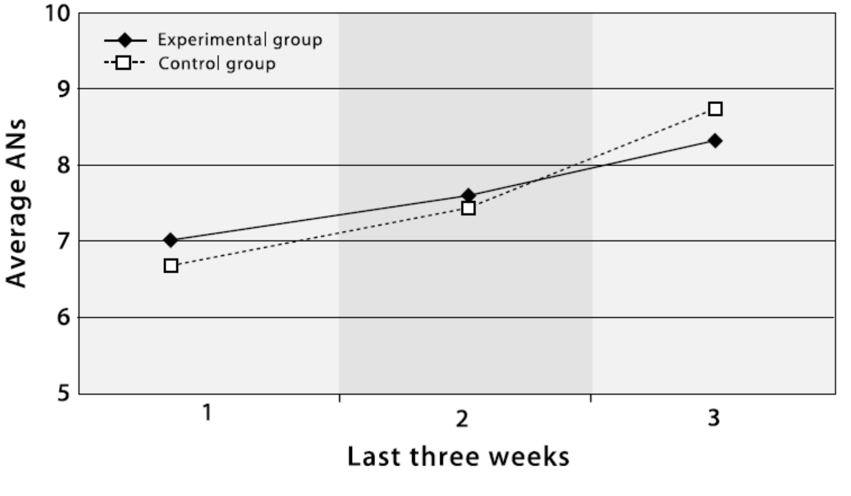


Figure 2.4. Time course of the last three weeks of study progress of the experimental and control group

The overall completed ANs over the last three weeks was denoted by a significant positive linear trend ($F(1,600) = 185.08$, $p < 0.001$) and a significant positive quadratic trend ($F(1,600) = 17.02$, $p < 0.001$). An overall significant effect of Group was not found. But there was a significant interaction between Group and Progress ($F(2,599) = 4.37$, $p < 0.05$) and there was a significant effect of Group on the linear trend ($F(1,600) = 8.67$, $p < 0.005$). Simple effects analysis showed a significant linear increase for the experimental group (positive linear trend: $F(1,600) = 59.79$, $p < 0.001$), and a curvilinear increase for the control group (positive linear trend: $F(1,600) = 130.43$, $p < 0.001$; positive quadratic trend: $F(1,417) = 15.80$, $p < 0.001$). This shows that the intervention indeed only had an effect for the control group. As a result, further analyses focused on the period up to the point where the intervention was made.

Repeating the analysis for four measurements during the period prior to the intervention shows a significant effect for Group ($F(1,806) = 4.32$, $p < 0.05$) on the number of ANs completed, indicating that the amount of progress made by learners in the experimental group was significantly higher over the period up to the intervention.

4.1.2. Goal attainment

Table 2.1 shows completion rates in the control group and experimental group immediately prior to the intervention. The percentage of learners completing all 11 ANs is significantly higher in the experimental group (40.2%) than in the control group (33.4%) ($\chi^2 = 4.04$, df = 2, $p < 0.05$).

Table 2.1. Completion rates (percentages) in control group and experimental group prior to intervention

Completion of 11 ANs	Group	
	Control[a]	Experimental[b]
No	66.6	59.8
Yes	33.4	40.2

[a] *n* = 398; [b] *n* = 410.

4.2. Efficiency

For the group of learners who had completed 11 ANs at the point of intervention, the average number of days elapsed between enrolment for the first AN and completion of the 11th AN was 36.49 in the experimental group, compared to 38.96 in the control group. Although learners in the experimental group reached the goal in fewer days, a t-test comparing these means shows that this difference is not significant.

5. Conclusions and discussion

The results of the experiment lead us to conclude that our approach to navigational support based on feeding back the choices of successful learners enhances effectiveness, though not efficiency, in lifelong learning. Improved effectiveness was not clear from the initial analysis. However, subsequent analyses corrected for the unexpected and unequal effect of the course deadline reminder and showed a significantly higher amount of progress and higher completion rates in the experimental group. The navigational support proposed in this study did not have a significantly positive effect on efficiency, i.e. the time taken to complete 11 ANs.

There are, however, a number of limitations with the experiment. First, although our work addresses lifelong learning, the limited experimental period of three months inevitably excludes some of the navigational and motivational problems faced by lifelong learners; a study of several years would be required to better reflect the intended application of our approach. A second limitation lies in our use of elapsed time rather than actual study time to indicate the time taken to complete 11 ANs. The use of this rather crude measure may mask significant differences in efficiency between the groups; subsequent work would benefit from a more accurate measurement of study time, although this is fraught with difficulties. Third, the experimental set-up did not force learners to take the recommended next step, and we do not know to what extent learners actually followed the advice. This resulted from the dynamic, just-in-time nature of the recommendation which was recalculated each time the overview page was refreshed. As a result the improved effectiveness cannot be unambiguously ascribed to the recommendation itself; the mere presence of an advisory aid may have stimulated the experimental group. An additional experiment involving a control group receiving ‘‘fake’’ advice would help clarify this point. A further clarification of the results could be reached by investigating the extent to which the advice is followed and how this relates to the effects identified in this experiment. Finally, the best next AN was calculated using the most recently completed AN and relating this to the ANs successfully completed next by predecessors (but not yet completed by the learner). Extending the calculations to include a greater proportion of the position of a learner (rather than only the most recently completed AN) or even the full track of a learner and to move beyond ‘next best single step’ to the advising of next best sequences, might lead to stronger effects.

Further research is needed to address these limitations and to reveal whether alternative feedback calculations would have a greater impact on effectiveness and efficiency in lifelong learners. Alternatives to the feedback presently offered (based on frequency of success) include using study time, popularity or final grade. In addition, learner characteristics such as age, sex or competence level could be taken into account to filter the data before calculating the feedback, leading to recommendations which would allow the next best step taken by women, undergraduates, or the over fifties to be presented.

Despite the limitations of the present study, we believe it shows that the use of self-organisation principles offers a promising line of inquiry for efficient and effective navigational support in lifelong learning.

Chapter 3

Towards a learning path specification

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

Abstract

Flexible lifelong learning requires comparability and exchangeability of courses, programmes and other types of learning actions both in a national and international context. In order to achieve comparability and exchangeability, a uniform and meaningful way to describe learning paths towards attainment of learning outcomes is needed. This paper identifies requirements for a Learning Path (LP) specification, drawing on literature in the field of curriculum design and lifelong learning and on recent initiatives to enhance comparability and exchangeability of learning actions. Two existing specifications designed to describe learning programmes, eXchanging Course-Related Information (XCRI) and IMS Learning Design (IMS-LD), are investigated to see whether they can fulfil the identified requirements. The fact that IMS-LD has a generic way to define completion of learning paths as well as an expression language to describe all kinds of conditions makes IMS-LD a more likely candidate. A learning path model is presented identifying the main elements of an LP specification and mapping them on IMS-LD.

1. Introduction

Notions like the 'European area of higher education' (Bologna Declaration, 1999) or 'a European area of lifelong learning' (CEC, 2001) are still merely concepts rather than realities, although quite some progress has been made exploring ways to start realising easy exchange of courses and programmes across national and institutional borders (Pöyry, Pelto-Aho & Puustjärvi, 2002; González & Wagenaar, 2003; CEC, 2004; TENCompetence, 2005; PLOTEUS, 2006). Apart from the aim of improving the mobility of employees across Europe, the idea is to enhance flexible lifelong learning by removing barriers to the exchange of programmes, courses and other educational offerings, which in this paper will all be called *learning actions*. Exchangeability is an attribute of the relation between learning actions, indicating that one action can be substituted or replaced by another, simply because they result in similar learning outcomes or because they result in learning outcomes which are formally recognised (certified) as a valid alternative within a wider programme. To establish whether or not learning actions are exchangeable they have to be described in a way that they can be compared at least on the main variable in this definition: learning outcomes or competences. If two learning actions lead to the same competences at comparable levels, this information might suffice to conclude they are exchangeable. However, other factors might be included in the equation, like the amount of effort the learning action requires, previous studies and formal recognition (Ramos, Kautonen & Keller, 2001; Pöyry et al., 2002). On a more prosaic level, a learner might find a course cannot simply be replaced by another due to all kinds of possible constraints (e.g. time, costs). Information on these and possibly other characteristics have to be provided to enable lifelong learners to compare learning actions and select those that best match their needs.

In formal education the aim to create a European area of higher education has led to calls for an 'over-arching European credit accumulation and transfer framework that can systems have witnessed reforms leading to greater convergence of qualification structures in the wake of the Bologna Declaration. Despite a broad adoption and use of the European Credit Transfer and Accumulation System (ECTS), the desired transparency and convergence of higher education systems still has not been achieved (Adam, 2001; Karran, 2004). Apart from difficulties stemming from different deployment of the system, true transparency would require that credits gained from different types and levels of educational experience are clearly labelled, identified and understood.

An additional challenge lies in the fact that in lifelong learning the learner might perform formal, non-formal and informal learning actions in parallel: take a job related training course at work, retrieve information from the Internet, and study for a master's degree at a university in the evening. Instead of addressing the problem of exchangeability by agreeing on structures and formats for exchange beforehand, we would like to facilitate exchange of learning actions which are not necessarily developed within agreed upon curricular contexts.

Regarding lifelong learning, the concept of Learning Networks (LNs) has been introduced (Koper & Tattersall, 2004; Koper, Rusman & Sloep, 2005b). LNs are envisaged to facilitate a broad variety of learning opportunities in a particular domain, covering both formal and non-formal learning, both emergent and pre-planned learning actions. Given this broad variety of learning actions, a learner in an LN may achieve the same learning outcomes by following different learning paths. Consequently learners will need navigational support in identifying alternatives and finding an optimal way to achieve the learning outcomes. For learners to be self-directed, they need an overview of available learning actions that fit their learning needs, preferences and prior knowledge.

Figure 3.1 illustrates the concept of an LN. The small nodes in the LN represent learning outcomes a learner might want to attain in this particular domain, 'competence A' for instance. The learner in figure 3.1 aims towards the long-term goal of acquiring competence profile X, e.g. a basic level in nursing or an 'advanced level' in playing acoustic guitar that includes competences I, U, M, R, Q, A, G. A competence profile describes the set of competences and proficiency levels needed to perform adequately in a particular job, function or role. The learner profile represents the competences already acquired by the learner. In figure 3.1 the learner has already acquired some competences in the domain (H, D, K and R). These might have been attained within the LN or through acknowledgement of prior learning (APL). At any rate, part of competence profile X, namely competence R, already has been mastered.

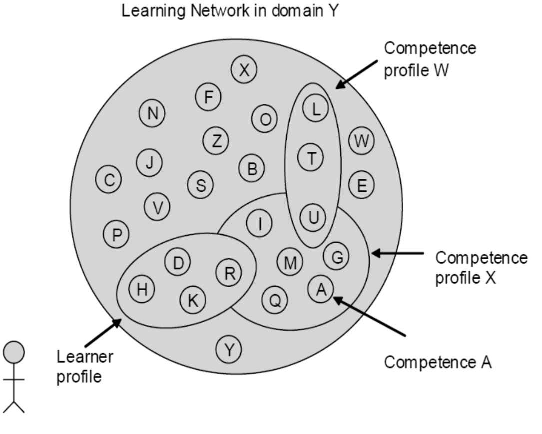


Figure 3.1. Lifelong Learner in a Learning Network

Apart from the overlap between the learner profile and the competence profile, overlap might exist between different competence profiles as figure 3.1 illustrates: competence profiles W and X share competence U. Competences related to life aid for instance will be relevant for both the competence profile of a nurse and a doctor.

To the extent that a competence consists of different proficiency levels this is modelled within the competence node rather than through separate nodes for each level. We assume dependencies exist between competences, but these are not modelled, rather derived from dependencies expressed at the level of learning actions. We will return to this issue later on.

The learning goal of a learner might vary from acquiring a single competence to an entire competence profile. Some support might be needed for the learner to 'translate' learning goals to competences and competence profiles.

Once a competence or competence profile has been selected, the question arises how best to work towards that learning outcome, i.e. which learning path to follow. A learning path that covers more than one competence is called an extended learning path. First of course the learner profile has to be taken into account: checks have to be made for possible overlap between competences in the competence profile and the learner profile. Apart from the learner profile, the 'best' way will depend on various characteristics which will not be equally relevant to all learners. Characteristics most evidently affecting the choice for a learning path are, for instance, costs, delivery mode (distance teaching or face-to-face), and scheduling.

Ideally, information about learning outcomes and learning actions should be amenable to automatic processing, thereby enabling learning brokerages or software agents to intermediate between learners and learning providers to identify the most appropriate steps to be taken at any point in a learning lifetime (TENCompetence, 2005). However, the selection and decision processes regarding appropriate learning paths are unlikely to become fully automated, simply because some human interpretation is likely to remain needed, for instance regarding the descriptions of the contents, learning strategies, etc. Nevertheless some automated filtering could be applied, offering learners the possibility to indicate, for instance, cost ranges, start and end dates, weekly study load, etc. To support such filtering, learning paths must be described in a uniform and meaningful way. This paper will investigate the requirements for an LP specification: what aspects of learning, learning actions and learning paths should be incorporated?

2. General requirements for a learning path specification

The concept of Learning Paths (LPs) has been chosen in order to stress the specific character of lifelong learning as compared to formal, initial education. Initial education is organised in curricula designed for cohorts of learners with comparable entry levels and delivered by formal educational institutions. Lifelong learning, on the other hand, is not 'organised' and pre-planned like that, but develops through actions that enable a learner to attain certain competences he or she likes to or has to acquire. It is influenced by changing interests and needs both on the part of the learner and his or her situation. Lifelong learning evolves as a process of constant adaptation and change. These actions are not restricted to formal learning offered by an educational institution but include training on the job and informal learning. For lifelong learning an LP specification therefore must be able to describe both formal curricula and other actions that result in learning outcomes, varying from reading a book, watching a video, creating a spreadsheet, preparing a recipe to taking a course.

Thus far we can derive the following functional requirements for an LP specification, still in very general terms:

1. An LP specification must enable the description of actions that lead to certain learning outcomes, whether formalised in a curriculum offered by an educational institution or merely suggested by a co-learner as an appropriate way to achieve some desired learning outcomes.

This means that, like a curriculum, a learning path consists of a coherent set of actions as well as rules associated with these actions: optional and mandatory actions, and restrictions regarding the order in which the actions should be performed. Apart from the learning outcomes and actions resulting in these outcomes, the specification should enable the description of rules governing progress through and completion of a programme, e.g. 'for at least three out of four units a minimum grade of X must have been obtained before the learner can proceed with unit Z'. In the case of informal learning, an LN will necessarily rely on learners' willingness to describe their informal learning paths in hindsight.

2. An LP specification must describe these actions taking into account a decision support perspective, i.e. it must contain all information needed to support decisions on relevant actions for a learner who wants to achieve certain learning outcomes, given his or her present know-how in the field.

In image theory two phases of decision-making are distinguished: screening and choice (Beach, 1997; Rundle-Thiele, Shao & Lye, 2005). Screening involves the selection of options taken into consideration, whereas the choice phase involves the actual decision for an option. Figure 3.2 schematically illustrates why a decision support perspective is needed. The figure indicates how a single competence can be acquired through various learning paths. A learning path is represented as a set of actions, subsets of actions to choose from (selections), and/or subsets of actions to be performed in a specific order (sequences). Note that an extended learning path would cover a number of competences and thus would have to combine two or more singular learning paths to one. As stated before we expect dependencies between competences to be expressed in the prerequisites of a learning path leading to a single competence or in dependencies between actions belonging to learning paths that lead to different competences.

In order to support learners in choosing a learning path from all available ones, the LP specification must facilitate identification of learning paths leading to the same learning outcomes. In this sense learning outcomes are the primary base for screening. Facilitation of further screening and final choice for an option requires that the LP specification describes characteristics most relevant to learners' decision-making. This way the specification can be used to apply filters as stated before, for instance regarding language, costs, accreditation, delivery mode, and pacing.

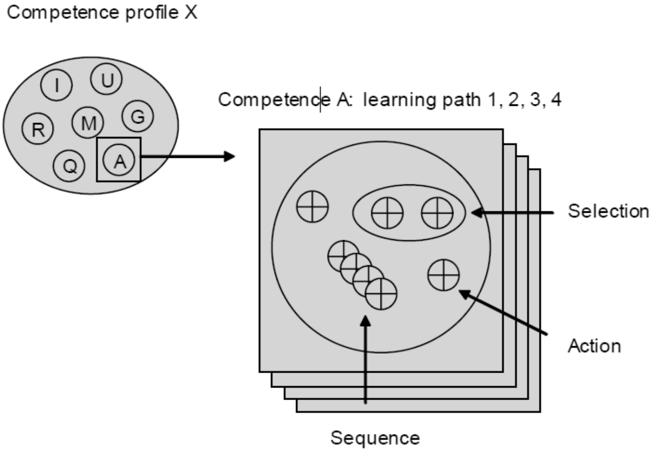


Figure 3.2. Learning path or competence development plan

A complication in facilitating learners in selecting efficient and effective learning paths which is not reflected in figure 3.2 lies in the fact that actions might be part of a number of learning paths. A learner might choose a path containing actions he or she has already performed while following another learning path in the past. This means that checks have to be made for overlap between an optional learning path and the learner's learning track: the chronological description of all actions a learner has completed in the past. And of course then criteria will have to be applied to determine whether the learning outcomes which have been attained in the past can still be considered valid and up-to-date.

In summary this section has described some very general requirements for an LP specification. These general requirements state that an LP specification must be able to describe the structure of a learning path and all possible rules that apply to it on one hand. On the other hand, the LP specification should include those characteristics that learners apply in selecting the most appropriate learning path from the available offers. Related to this second requirement, a further general requirement is that we want the specification to be in line with existing standards in the field of educational technology, most notably the IEEE Learning Object Metadata (IEEE/LOM, 2002). So we will strive to bring the selection of characteristics and their description in line with this metadata standard. The next section describes our approach in further specifying these requirements.

3. Method

In order to derive more precise requirements for an LP specification, we have pursued two lines of investigation. Firstly, a review of literature on curriculum design was carried out to further investigate the structure and rules connected to a learning path. There is no standard yet in the field of curriculum design to test on suitability to describe learning paths, but there are several specifications in the field that will be analysed in this respect: the IMS Learning Design (IMS-LD, 2003) and the eXchanging Course-Related Information (XCRI) curriculum specification (XCRI, 2006). The IMS-LD specification allows defining which roles should carry out which activities, using which supportive materials and services, in order to achieve certain learning objectives. It is this ‘workflow-based’ approach, as opposed to simple sequencing inspired approaches (IMS-SS, 2003; SCORM, 2004), that makes it appear a suitable candidate to model flexible learning pathways (Marjanovic, 2007). Although the XCRI project’s main focus, namely exchanging course-related information, prioritises an interest in fragments of curriculum, the schema enables the description of linkages between curriculum fragments as well. The XCRI project is built on the Norwegian Course Description Metadata project (CDM, 2004) to define a vocabulary to describe course-related information in a way that fits UK needs. Compared to CDM the XCRI specification offers a more generic curriculum specification object and has more options to specify curriculum structure. The vocabulary ‘encompasses course marketing, course quality assurance, enrolment and reporting and personal development requirements’ (Stubbs & Wilson, 2006).

Secondly, a number of recent and current initiatives aiming towards exchangeability of learning actions were analysed to see what characteristics they provide or propose to provide to learners to facilitate their decision-making. Following the recommendation to ‘differentiate luxury from necessity’ (Hodgins et al., 2003, p.40), we will aim to select the most important characteristics rather than strive for completeness, to then proceed to determine whether these can be described using the LOM set of metadata (IEEE/LOM, 2002).

Initiatives directed towards joint development of learning actions with the purpose of exchange have not been included in our analysis because they approach the problem of exchangeability from the other end, i.e. agreeing on formats for exchange beforehand, whereas we would like to facilitate exchange of learning actions which are not developed in joint agreement. Besides numerous exchange programmes exist in higher education institutions, describing opportunities and procedures either for their own students to take courses elsewhere or for foreign students to enrol in their courses. Again these are considered too specific to include them in our study.

The initiatives we studied all aim towards transparency and exchangeability at a more generic level. Different approaches can be identified which are by no means mutually exclusive, but merely represent different scopes and levels of generalisation and formalisation. We briefly describe the different categories as follows (see table 3.1 for examples of each category).

T**able 3.1.** Examples of approaches aiming towards comparability and exchangeability

Approaches	Examples
1. Portals	UCAS [http://www.ucas.com/] (UK)
	PLOTEUS [http://europa.eu.int/ploteus/portal/home.jsp] (EU)
	Curriki [http://www.curriki.com/] (Global)
2. General guidelines	Two cycles in higher education: undergraduate and graduate (EU)
	Quality Assurance Agency Guidelines (UK)
	European Credit Transfer and Accumulation System (EU)
3.Metadata applications	CUBER (EU)
	CDM (Norway)

1. Portals: There are quite a number of websites, which list courses and programmes of various educational institutions within a country or region, across countries or even irrespective of countries. We have selected three examples which are open for anyone to search: UCAS, which covers higher education at a national (UK) level; PLOTEUS, which, at a European level, covers all levels of formal education and Curriki, a fairly recent global initiative which is more a community than merely a portal, which aims to develop and deliver curricula through community contributors. The aim of all these initiatives is to offer learners easy access to courses and programmes. Though some directly enable learners to enrol, others link learners to the provider's website for further information and enrolment. We will compare the options these portals offer for learners to search appropriate learning actions.

2. General guidelines: Several initiatives have been directed towards formulating general guidelines to enable comparison of courses and programmes. Of course adoption of the undergraduate and graduate cycle in universities and higher education institutions serves that purpose on a very general level (Bologna Declaration, 1999). The ECTS guidelines offer more concrete suggestions concerning a number of

characteristics that are likely to be needed in comparing courses and programmes (CEC, 2004). The Quality Assurance Agency (QAA) guidelines for programme specifications describe a template to provide more detailed descriptions of programmes for learners (QAA, 1999). We will compare characteristics mentioned by the ECTS and QAA guidelines to the choice options offered by the portals.
3. Metadata applications: The third category concerns initiatives applying metadata or adapting metadata standards to suit particular needs (application profiles). Application profiles may involve selecting a subset of the metadata or extending them in a prescribed way. The CUBER project is an example of an application profile of the LOM metadata standard (Lamminaho, 2000). The CDM project is a Norwegian initiative that 'specifies the structure and semantics of key concepts used in course descriptions' (CDM, 2004, p.3).

As will become clear in the next sections, metadata are not only relevant to provide information to learners, but also to combine actions to learning paths. Regarding both these aspects, parsimony will be an important criterion in deciding upon the necessary set of characteristics for the LP specification.

4. Analysis

This section describes the requirements derived respectively from the review of curriculum design literature and the analysis of initiatives aiming towards exchangeability.

4.1. Curriculum design literature

Building on the reasoning followed in Sections 1 and 2 and further study of literature in the field of curriculum design and lifelong learning (Bligh, 1999; Livingstone, 1999; Harden, 2000; Marsick & Watkins, 2001; Ramos et al., 2001; Colardyn & Bjornavold, 2004; NOCN, 2004; Tattersall et al., 2006), the LP specification must enable to describe learning paths taking into account the following characteristics:

- *Modular* composition: learning paths must be able to be built from units.
- *Nested composition*: learning paths must be able to be composed of other learning paths.
- *Learning outcomes*: learning paths must be defined in terms of learning outcomes.
- *Entry requirements*: it must be possible to specify entry requirements for a learning path.
- *Selection*: it must be possible to specify which elements of a learning path are mandatory and which are optional.

- *Sequencing*: it must be possible to specify a fixed order in which elements of a curriculum are to be completed.
- *Temporal coordination*: an LP specification must enable to express parallel programming of two or more learning actions.
- *Completion*: the requirements for completion of a learning path must be able to be specified.
- *Conditional composition:* it must be possible to specify conditions under which learning path elements are to be included or excluded.
- *Substitution*: the LP specification must enable description of substitution rules. Substitution rules describe which units in the learning path might be replaced and the criteria that exist regarding the substitute.

Besides, the LP specification must meet the general requirements of:

- *Formality*: the language must describe a route in a formal way, so that automatic processing is possible.
- *Interoperability*: the language must support interoperability of routes, so that different support systems can share and exchange information.

Bearing in mind these requirements, we will now address the question to what extent they are met by two existing more elaborate specifications in the field of learning design (IMS-LD, 2003) and curriculum modelling (XCRI, 2006).
Using IMS-LD, a learning path (*unit-of-learning*) can be described that consists of actions (*activities*), groupings of actions (*activity structure*) or learning paths, thus enabling both modular and nested compositions. Both actions and learning paths can be related to competences/competence profiles using the element *learning objectives*. A grouping of actions can be defined as either a selection or a sequence. A selection indicates that the referenced actions can be done in any order and through specification of a number to select that is smaller than the number of referenced actions, it is possible to define a free choice range. Sequences always contain mandatory actions that have to be performed in the specified order.

Temporal coordination (parallel planning) can be specified in a number of ways. It is possible for instance to set a time-limit on a set of two actions or on each action separately. (Of course true enforcement of temporal coordination would require face-to-face actions that are planned in parallel.) Regarding completion, IMS-LD contains a number of elements to indicate when an action or a learning path is completed (*complete activity/complete play*). This might be simply when the learner considers his or her goals to have been achieved (*user choice*). Besides, IMS-LD contains an expression language that can be used to define more complex rules for completion (e.g. ‘if assignment X has been approved by the tutor’). The same expression language can be used to define conditional compositions (e.g. ‘if learner has preference A then show action X, learning path Y', etc.). Finally, it is possible to express substitution rules like 'action X can be replaced by any other action under the condition that the substitute action either leads to the same competence, and requires a similar amount of input from the learner', by modelling the alternatives as a selection. This entails referencing concrete instances of alternatives. IMS-LD is a declarative language and can only target what is defined. Applying substitution rules in a more generic way, enabling for instance inclusion of newly developed learning actions that are in line with the rule, would require a 'meta-rule language' that can specify learning designs in an abstract way to later generate instances of learning paths using the then available learning actions which comply with that particular specification.

The XCRI specification is a generic curriculum object that can be further typed as a programme, course, module, lesson plan, etc. Besides the curriculum object can consist of a number of these fragment types so that modular compositions can be described. Nested compositions are possible by defining fragment associations. All kinds of requirements (e.g. prerequisites and co-requisites) can be described and for each curriculum fragment learning outcomes can be specified. Fragment associations are by default interpreted as sequences but can also be defined as collections with a certain order, selection range, and selection criteria. Temporal coordination can be expressed through fragment associations, co-requisites, and calendar events. The XCRI specification enables to specify assessments in great detail, but it is not possible to specify other ways a course or programme can be completed (e.g. by user choice). Conditional compositions can be realised by specifying the inclusion and exclusion requirements. Substitution can be specified in the same way as in IMS-LD: by modelling the alternatives as choice options.

Both XCRI and IMS-LD meet the general requirements of formality and interoperability: they are open specifications using the XML schema formalism. Though both specifications provide means to specify learning paths, IMS-LD more broadly meets the requirements because it enables to describe completion of curriculum elements in a more generic way and because it has an expression language to describe all kinds of conditional compositions.

4.2. Initiatives to enhance exchangeability of learning actions

In this section we describe for each category of initiatives identified in table 3.1, which characteristics are used or proposed to facilitate learners' choices of learning actions. Based on these descriptions and the conclusions drawn from them, we will present our own proposal in the conclusion section, describing a learning path model that integrates structure and characteristics of the LP specification.

4.2.1. Portals

The portals selected for our analysis vary considerably in the search options they provide to learners. Table 3.2 lists all information (metadata) the portals provide to learners in a quick search and/or advanced search. The Curriki portal provides the most extensive metadata. This might be due to the fact that it is not just a portal but a community where both learners and teachers not only come to find but also add learning materials; the metadata provided in a search more or less mirror the metadata that are requested upon uploading materials. The UCAS and PLOTEUS portals are clearly organised around courses and institutions, whereas the Curriki portal includes all types of 'instructional components'. In this respect the Curriki portal more closely reflects an LN.

Table 3.2. Information provided to learners by different portals

Metadata	UCAS	PLOTEUS	Curriki
Course code	X		
Course type/level	X	X	X
Region/country	X	X	X
Subject/title	X	X	X
Description			X
Keywords		X	X
Status* (e.g. draft, final)			
(Link to) institution*	X	X	
Attendance type	X		
Language		X	
Resource type* (e.g. URL, image, text)			X
Publish date*			X
Contributor*			X
Instructional component* (e.g. lesson plan/presentation/course)			X
Learning resource type: comprehensiveness (individual asset/course/curriculum)			X
Framework alignment (e.g. Master Framework–Science–Technology)			X
Licence			X
Right holder			X

* The metadata indicated by an asterisk contain information that is subsequently provided, rather than used as basis for a search.

The Curriki portal offers direct access to the resources for free, whereas the UCAS and PLOTEUS portals link to institutional websites where the learner can find more information. This makes it necessary for the Curriki portal to offer more information on the resources. However, information like publish date, contributor, licence, and right holder do not seem that relevant to someone who is searching for learning actions that will help him or her attain certain learning outcomes. In this respect and also in view of initiatives described in the next sections, it is remarkable that all three portals focus on subject as the central search option, rather than learning outcomes.

4.2.2. General guidelines

The QAA guidelines for preparing programme specifications state that 'a good programme specification will improve student understanding of how and when learning occurs, and of what is being learned, and thereby inform reflection upon personal learning, performance and achievement, and subsequent planning for educational and career development' (QAA, 1999, p.3). The information which the QAA guidelines suggest will normally be included in a programme specification is:

- awarding body/institution
- teaching institution (if different)
- details of accreditation
- name of the final award
- programme title
- UCAS code
- aims of the programme
- relevant subject benchmarks statements and other reference points used to inform programme outcomes
- programme outcomes: knowledge and understanding, skills and other attributes
- teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated
- programme structures and requirements, levels, modules, credits and awards
- date at which the programme specification was written or revised.

The guidelines state that in addition institutions might want to include criteria for admission to the programme, information about assessment regulations, indicators of quality, particular support for learning and methods for evaluating and improving the quality and standards of learning.

The ECTS guidelines (CEC, 2004) aim at making study programmes easy to compare. It is based on the (estimated) average student workload required to achieve the objectives of a programme of study and its constituent parts. ECTS can be used for accumulation within an institution and for transfer between institutions. Its basic parameters – *workload* and *learning outcomes* – can also be applied to self-study and work experience, thus making it a suitable instrument in the context of lifelong learning as well. ECTS starts from the principle that the *workload* of a full-time student during one academic year (1500–1800 hours) equals 60 credits. One credit thus equals about 25 to 30 hours of work. Credits are allocated to a study programme and its constituent parts based on a realistic estimation of the average student workload that is required to achieve the learning outcomes. The ECTS Users' Guide describes *learning outcomes* as 'sets of competences, expressing what the student will know, understand or be able to do after completion of a process of learning, whether long or short. (...) Learning outcomes specify the requirements for award of credit.' (CEC, 2004, p. 12)

The ECTS Information Package and Diploma Supplement define items to be described in order to make study programmes easy to understand and compare. These items are very similar to those proposed by the QAA programme specification guidelines Gosling (2001) strongly defends the use of credit and level as descriptors of curricula components to increase flexibility in support of lifelong learning. He goes on to argue that the use of 'qualification level' as an indicator for level is too strongly related to the status quo – existing qualifications and national systems – to increase flexibility. Key concepts of a credit-based curriculum mentioned by Gosling are: credit (a means of quantifying learning), level (an indicator of relative demand, complexity, depth of study, and learner autonomy), level descriptors, learning outcomes, assessment criteria, notional learning time, module or unit and Assessment of Prior Learning (APL).

4.2.3. Metadata applications

The CUBER system is designed to be a search engine or a broker system that enables students to search for courses from a number of higher education institutions (Pöyry et al., 2002). The goals of the system are (amongst others) to enable comparison of courses from different providers and to find the best matches to one's personal educational goals; to provide information on how courses are integrated and to make it possible to generate a complete curriculum plan; and to provide information on degrees and (international) recognition of degrees and certificates. As the project aimed towards interoperability, the metadata specification of CUBER was based on the (then) emerging LOM standard. Interestingly, a questionnaire was used to gather information about courses from each partner country. Extensions were made to the LOM metadata schema to enable descriptions of begin, end, phase, ECTS credits, interests, study load, learning objectives, examination method, teaching method, study guidance, and provider (Lamminaho, 2000). Regarding requirements (part of the technical metadata in the LOM), a distinction was made between technical requirements, skills, and previous studies and certificates.

A separate study was directed towards finding out which parameters and rules appear to guide decisions regarding course acknowledgement (i.e. parameters and rules used in comparing two courses for exchangeability), with the aim to include these parameters into the CUBER metadata model (Ramos et al., 2001). The parameters used in course comparison were: credits, content, extent (detail of content), difficulty, and examination method.

The CDM project intends to facilitate description and exchange of information about course units, standardisation of course unit descriptions, establishment of national and international course catalogues, course portals and other student services. Although the focus is on courses, CDM groups metadata in four types:

1. *Organisation unit type* represents an organisational unit that provides study programmes and courses.
2. *Programme type* contains the description of a study programme, which can have a hierarchical structure with subordinate study programmes.
3. *Course type* where a course is defined as 'a complete unit of instruction which provides the learner with the knowledge or skills required for competence in a subject matter'.
4. *Person type* contains the description of a person with the focus on providing contact information.

The CDM metadata to describe programmes are similar to the items defined by ECTS and QAA, though both the latter go into more detail regarding qualification, accreditation and quality indicators. Unlike other initiatives, the CDM specification includes 'target group' as a programme characteristic and also distinguishes between formal and recommended prerequisites.

4.2.4. Comparing the approaches

Different initiatives clearly place different accents in describing educational offerings, depending on different aims and backgrounds. Whereas PLOTEUS and CUBER for instance seem more strongly driven by a wish to compare and exchange educational offerings, CDM seems more strongly inspired by a 'provider perspective', while QAA and ECTS share a wish to accurately cover prospectus information and information pertaining to awarding and accrediting institutions and quality procedures.

Facilitating lifelong learning, however, requires that the focus of attention is on the learner and his/her learning needs. To enable learners' choices, it will be more important to indicate whether or not a learning path leads to formal recognition, than to describe which institution it is awarded by. We believe that quite a lot of this more detailed information could be suitably offered by linking to a provider's website. Moreover, learners will need to have planning information and information on all kinds of possible prerequisites, in order to decide whether a learning path is suitable to their needs. Some of the initiatives investigated describe quite a number of planning aspects in parallel (for instance, study load in weeks as well as typical learning time). We propose to use a minimum set of start date, end date, and total workload. Together with information on contact hours we believe this to suffice for learners or software agents to decide whether the learning path complies with personal schedules. Total workload is also considered to suffice to quantify the learning involved. Though ECTS seems widely adhered to in European projects, we propose to use the more general term 'workload' or 'typical learning time' (as used in LOM) because the credit system is only known in Europe and EC's and can be easily derived from the workload in hours.

As to level indicators, the first sections of this paper already revealed how we consider levels to be intricately connected to competences (learning outcomes). Competences and proficiency levels are guiding principles in structuring and describing learning paths. All other types of level descriptors might be used ('bachelor', 'graduate') but they necessarily need to be elaborated in terms of learning outcomes in order to make them meaningful. This is why we believe these general level indicators to be superfluous ultimately. Besides proficiency levels related to competences are more suitable as level indicators in the realm of lifelong learning because they exceed these 'school career' level indicators.

5. Conclusions

Figure 3.3 represents a model of the LP specification we propose. The figure maps the LN and LP terminology on IMS-LD elements (between brackets) and describes further characteristics already provided by IMS-LD (in the model these are presented as attributes, whereas in fact they are either elements or attributes). A learning path leads to the acquirement of one or more competences or to a competence profile. The learning path consists of one or more actions, clusters of actions or learning paths. These actions and/or clusters of actions and/or learning paths are presented in a certain structure, describing the overall learning flow.

The learning flow may depend on certain circumstances as expressed in 'if-then' rules, pertaining for instance to learner preferences or the way the learning process evolves. In other words, a learning path basically describes a structure of one or more actions, clusters of actions or learning paths, in a way that explicates restrictions and degrees of freedom for the learner. Restrictions and degrees of freedom are not only defined through structuring principles, describing optional and required elements or through rules, but can also be reflected in metadata describing the learning path or its constituting parts, e.g. delivery mode, teaching place, contact hours, etc. Table 3.3 provides a more detailed description of the classes of the learning path model and their attributes, as well as the additional metadata we propose to facilitate learner choice.

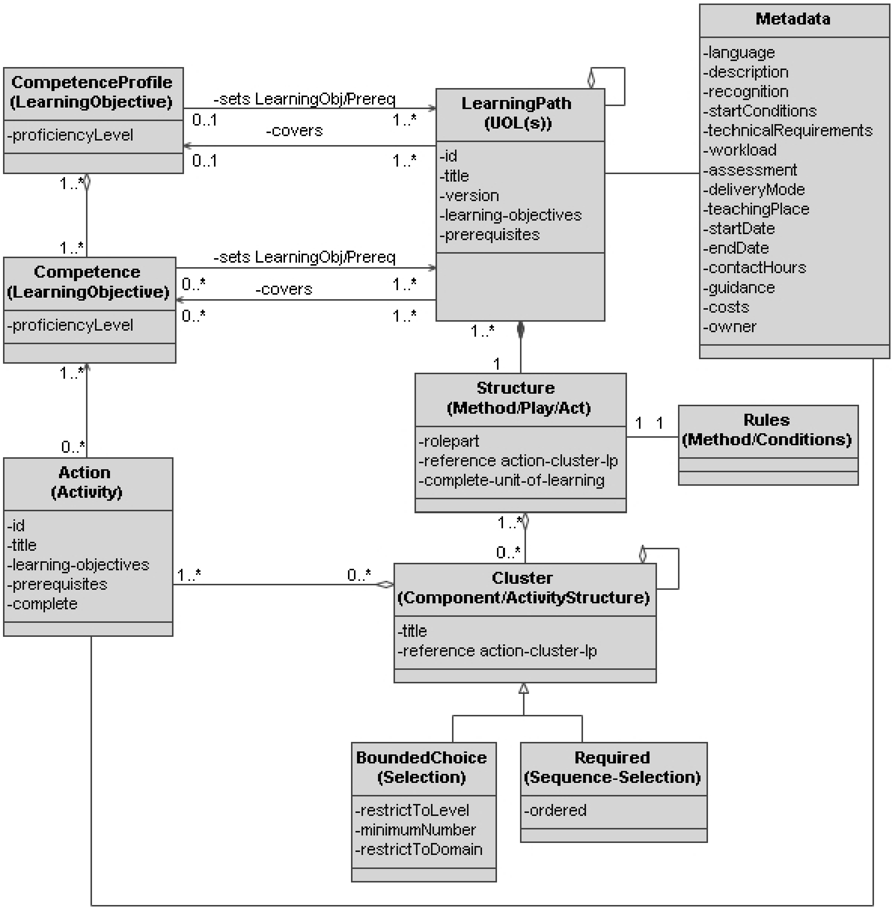


Figure 3.3. Learning path model

Table 3.3. Classes and attributes of the Learning Path model

Class / attribute	Description
LearningPath	A Learning path describes the actions a learner has to perform in order to attain a competence or competence profile.
identifier	An identifier that can be used to refer to the learning.
title	Title of the learning path equals the title of the action when the learning path consists of a single action.
version	Versioning will be necessary to allow for updates of learning paths and enable identification of specific versions.
learning-objectives	Describe the intended outcome for learners.

Class / attribute	Description
prerequisites	Describes the entry-requirements for learners in terms of competences (knowledge, skills, and attitudes). It still remains to be seen whether and how the distinction between formal and recommended prerequisites must be made.
CompetenceProfile/ Competence	A competence profile describes the set of competences a person has to master in order to perform adequately in a particular job or function. Competence is defined as the ability of an actor to act effectively and efficiently in an ecological niche (e.g. occupation, hobby, sport etc).
proficiencyLevel	Competence profiles and competences can have one or more proficiency levels, i.e. levels of mastery (novice, expert, etc.).
Action	Any activity performed with the aim to develop a competence. Actions have the same attributes as learning paths.
identifier, title etc	See under: Learning Path
complete	Contains a choice of elements to specify when an activity is completed, e.g. when certain task has been completed, by user choice.
Structure	The structure defines the 'work/learning flow' of a learning path and its constituent parts.
rolepart	The structure is defined by linking roles (learner, teacher, tutor, assessor) to actions, clusters of actions or learning paths by referring to them.
reference	
Complete-unit-of-learning	Specifies when a learning path can be considered completed, e.g. upon passing examination, by user choice, on a time-limit. Without this element completion is 'unlimited'.
Rules	Rules can be used to specify whether some actions, clusters or learning paths should be included or excluded under certain conditions.
Cluster	A cluster is used to group actions (and/or clusters and/or learning paths) that are somehow related, for instance because they compose a set a learner can choose from, or because they have to be studied in a particular order. See below.
title	A header for the grouping of actions, clusters, and/or learning paths.
BoundedChoice	Bounded choice describes a cluster of actions, clusters and/or learning paths a learner can choose from.
restrictToLevel	Specifies that the cluster should only contain elements that relate to a certain level.
minimumNumber	Specifies the number of elements from the given set that the learner has to minimally complete.
restrictToDomain	Specifies that the cluster should only contain elements that relate to a certain domain.
Required	A cluster of actions, clusters, and/or learning paths a learner has to complete either in a specific order (sequence) or in a free order (selection) to complete the learning path.
ordered	Specifies whether or not the elements of the cluster have to be completed in the given order.
Metadata	Characteristics of the learning path which are relevant to learner's screening and eventual choice of a learning path.

Class / attribute	Description
language	Specifies which language(s) the learner needs to know to follow the learning path.
description	General description of the learning path.
recognition	This attribute only states whether completion of the learning path leads to a formal recognition (diploma/certificate). (N.B.: this is not the same as distinguishing between formal, non-formal, and informal learning. Formal learning not necessarily results in formal recognition).
startConditions	Several entry or start requirements may hold apart from the required competences (prerequisites) e.g. a specific diploma or course certificate, a minimum age or minimum average grade. Other conditions might relate to practical or pedagogical issues: a minimum number of enrolments.
technicalRequirements	Specifies technical equipment and tools a learner needs in order to take this path.
workload	The total workload in hours.
assessment	Describes which formative and/or summative assessments are in place to determine to what extend the learner has attained the competence.
deliveryMode	Describes the modes used for delivery of the learning path, e.g. distance learning using all kinds of media, face-to-face teaching etc. We expect this attribute to be important for initial selection (screening) of relevant learning paths to choose from.
teachingPlace	In case a learning path requires face-to-face meetings the learner needs to know where they take place in order to decide whether this suits him/her.
startDate	In case there are fixed starting dates for a learning path, for instance in a semester schedule, this information is needed to see whether it fits the learner's needs and schedule. This attribute will be empty in case learners are free to start whenever they want.
endDate	See startDate.
contactHours	Contact hours informs on the hours the learner is expected to attend (virtual) meetings. Teaching place, workload, start date and end date together still do not suffice to provide the learner with complete picture of the flexibility of the learning path in terms of time, place and pace.
guidance	Describes what support is available to learners taking the learning path (tutoring, counselling, helpdesk . . .).
costs	Specifies costs for enrolment and additional expenses (books, tools, etc.)
owner	Links to a webpage containing more detailed information on the owner of the learning path (person or institution), enrolment, accreditation regulations, facilities for special needs students, contact information etc.

6. Discussion

The learning path model presented in this paper is a first step towards an LP specification. Several issues are still open. Firstly, the LOM metadata set does not have elements describing planning information, assessment or study guidance for instance. Somehow these characteristics will have to be included in the LP specification. The model will be elaborated into a more detailed information model. In this process it will also be decided more precisely how the characteristics identified in the model can be expressed through IMS-LD elements and attributes or through (extensions to) LOM metadata.

Secondly, competences and competence profiles are dynamic entities. They may change over time due, for instance, to technological developments in a profession. Besides, once acquired, they may require regular updates even if the competences themselves have not changed, simply because competences can grow weaker or decline due to lack of practice. Changes in competences and competence profiles can be expressed through versioning and a period of validity can be defined at a personal level. How changes of competences and competence profiles will affect learning paths and whether the version attribute of learning paths suffice to indicate these changes is not entirely clear.

Finally, there is the issue of adding metadata to actions and learning paths: who will do it and will it be done? While many authors stress the advantages of adding metadata over free text search, they also express concerns regarding the accuracy it requires and the costs involved (Lamminaho, 2000; Hirvasniemi & Öörni, 2001; Pöyry et al., 2002). For extended learning paths some metadata might be automatically derived or calculated from the metadata of the constituting actions: start and end dates for instance, but also workload, delivery mode and costs. However, that still means these metadata will have to be available at the lower level of actions. A solution might be found in automated metadata generation. Possibilities for that are being investigated and some promising results have been achieved (Cardinaels, Meire & Duval, 2005).

The learning path model proposed in this paper is based on a literature study as well as observation of current practices aiming to facilitate learner choice and to enhance comparability of learning actions. These observations have been reflected upon from a lifelong learning perspective, striving for parsimony. Further empirical evidence will have to be gathered to confirm whether the specification is sufficiently elaborate to describe all kinds of learning actions. To that end, the specification will be tested on a variety of actual formal, non-formal and informal learning paths (e.g. can it describe the training programme of company X, can it describe the master's programme of university Y, the learning path of Z). Once that has been established, the specification will be tested in a pilot where it will be used to facilitate navigational support. In this pilot, it will become clear whether the specification is balanced in the sense that it contains sufficient information to enable learners to decide upon a suitable learning path.

Chapter 4

Evaluation of the Learning Path Specification: Lifelong learners' information needs

Janssen, J., Berlanga, A. J., & Koper, R. (submitted). Evaluation of the Learning Path Specification: Lifelong learners' information needs.

Abstract

Flexible lifelong learning requires that learners can compare and select learning paths that best meet individual needs, not just in terms of learning goals, but also in terms of planning, costs etc. To this end a learning path specification was developed, which enables to describe both the contents and the structure of any learning path, be it formal, non-formal, informal, or indeed a combination of these. This paper briefly explains the Learning Path Specification and its purpose to then present a framework for the evaluation of the specification based on theories of model quality. A study of learner choice processes (*n*=15) was carried out to investigate the specification's semantic and pragmatic quality (clarity, completeness, and parsimony) with respect to the selection of a learning path. Results indicate that the specification does not contain any redundant information. Instead, the study has led to improvement of the specification's (feasible) completeness by further refinement of scheduling information.

1. Introduction

Learning paths can be roughly defined as sets of one or more learning activities leading to a particular learning goal. Learning paths can vary from a relatively small activity like reading a book or taking a course to following an entire programme or curriculum. Learning paths may vary also regarding the level of formality. In line with the Commission of the European Communities we distinguish formal, non-formal and informal learning (CEC, 2000). Whereas formal learning is learning that occurs in education and training institutions, which leads to recognised diplomas and qualifications, informal learning is described as "a natural accompaniment to everyday life" which is not necessarily intentional learning (CEC, 2000, p. 8). Non-formal learning, finally, is learning that takes place alongside the mainstream systems of education and training, for instance at the workplace or in arts or sports, which does not necessarily lead to formalised certificates.

In order to support lifelong learners in comparing and selecting suitable learning paths, a uniform way to describe learning activities and learning paths has been developed (Janssen, Berlanga, Vogten, & Koper, 2008). This Learning Path Specification is supposed to enable description of formal, informal and non-formal learning because these all are important ways in which people learn (Colardyn & Bjornavold, 2004; Colley, Hodkinson, & Malcolm, 2003; Livingstone, 1999).

The specification is envisaged to support several processes. Firstly, it is meant to be used by educational providers to describe formal and non-formal educational courses and programmes in order to make them available through specific search engines, thus enabling comparison across providers. We assume that educational providers will want to describe learning paths in a uniform, formalised way, because the benefits of transparency and opportunities for automated learner support outweigh the costs. Costs can be relatively low since educational providers already have to describe their offerings; it will merely be a matter of organising this information in a way that enables storage and update in one place and subsequent use in different contexts: printed catalogues, websites, and search engines.

A second process the Learning Path Specification is meant to support was initially defined as follows: lifelong learners use the specification to describe their informal learning paths to make them available as an example to other learners with similar learning goals. However, a pilot-study revealed that it requires considerable efforts and skills on the part of the learner to identify activities that did or did not after all contribute to achieving those outcomes. To distil a learning path from one's own informal learning experiences and describe it in a way that is useful for others, is not an easy task (cf. Skule, 2004). Though we still maintain that the specification can be used to describe all kinds of learning (a point we later further elaborate), we believe that in the case of informal learning it is not likely going to happen on a large scale by lifelong learners themselves, because it requires learning design skills. It is not unreasonable though to expect employers and employment agencies to be willing to invest in these descriptions of informal learning paths as they can offer tried and tested alternatives to more costly formal and non-formal learning paths. Research indicates that people spend an average of six hours a week on employment related informal learning (Livingstone, 1999) and description of these informal learning paths is likely to enhance efficiency when they can offer guidance to learners rather than have them find things out through trial and error. In any case, the second process the Learning Path Specification is meant to support eventually is defined as: description of informal learning paths in order to make these learning paths available for other learners with similar learning goals.

Finally, a third process the Learning Path Specification is envisaged to support is selection of suitable learning paths. To this end the specification identifies main characteristics to be used in comparing and selecting a learning path (e.g. learning objectives, prerequisites, study load, costs, etcetera). Lifelong learners must be offered means to efficiently choose the learning path that best fits their needs. Taking a decision support perspective, we distinguish two stages in this process: screening and choice (Beach, 1997; Rundle-Thiele, Shao, & Lye, 2005). Screening involves selecting a number of options one wants to take into consideration, i.e. narrowing down the number of choice options to a number that can be 'managed'. Research shows that choice overload may occur due to the number of available options, as well as to the number of attributes related to these options (Fasolo, McClelland, & Todd, 2007; Malhotra, 1982). In other words: having to choose from a large number of learning paths is one thing, having to compare even a limited number of learning paths might lead to choice overload when a large number of attributes are related to these options. But even apart from these considerations regarding choice overload, lifelong learners will rather invest the scarce resources of time and attention in developing competences than in comparing all kinds of ways to do so. What is needed then is some tool for the learner to select a limited set of learning paths to take into account in the choice process.

There are quite a number of criteria that could be relevant to finding the most suitable learning path but not all criteria might be equally relevant to all learning paths or to all learners for that matter. The study of Fasolo, McClelland and Todd (2007, p. 23) shows that "it is possible for consumers to make good choices based on one or two attributes, when attributes are positively related or consumers care unequally about attributes and choose on the basis of the most important ones". To the extent that learners do not equally care about the learning path attributes included in the Learning Path Specification progressive disclosure of functionality could contribute to help the learner focus on those criteria that are most relevant for her (Turbek, 2008). Progressive disclosure is a strategy for managing information complexity in which only necessary or requested information is displayed at any given time (Lidwell, Holden, & Butler, 2003).

Requirements for the specification have been derived from a review of literature on curriculum design and lifelong learning as well as observations of current practices to support learner choice (Janssen et al., 2008). This paper describes a study directed towards evaluation of the conceptual model of the Learning Path Specification. It provides an outline of the specification and explains how the specification supports description and selection of learning paths. Subsequently, a framework for the evaluation of model quality is presented, guiding the specific research questions. Finally, the paper describes method and results of the evaluation.

2. Learning path conceptual model and specification

According to Moody (2005) conceptual modelling is a process of formally documenting a domain (a system or a problem) in order to enhance communication and understanding. He further points out that conceptual modelling may be used to describe requirements at different levels: functional and non-functional requirements at the level of an application, and information requirements at the level of an organisation or even an industry.

A formal specification can be considered a conceptual model as is illustrated by the following definition: "a formal specification is the expression, in some formal language and at some level of abstraction, of a collection of properties some system should satisfy" (Van Lamsweerde, 2000).

The Learning Path Specification identifies information requirements for lifelong learners: generic elements of a learning path which are essential to selecting, planning and executing a learning path, such as learning goals, learning actions, delivery mode, etc. It describes fixed as well as optional elements; both contents and structure. Figure 4.1 describes the learning path conceptual model. The model has evolved from being initially a subset of IMS-LD as described in chapter 3, to a new 'lean' specification, as drawing on the IMS-LD specification would entail including a number of constructs which the Learning Path Specification itself does not require, but which are needed to ensure compliancy with IMS-LD. So a new learning path model was developed, less closely connected to IMS-LD and its terminology.

Like any other path a learning path has a Finish and a Start (i.e. learning goals and prerequisites). In order to get to the finish one or more LearningActions have to be completed. Learning goals and prerequisites can be specified both at the level of the learning path and its constituent actions. They are preferably defined in terms of standardized competences so as to facilitate automated identification of parts of a learning path a learner may skip when these competences have already been attained through prior learning (Kickmeier-Rust, Albert, & Steiner, 2006). The LearningActionsCluster element is used to group learning actions and/or learning paths (LearningPathRef) which are somehow related, for instance because they compose a set a learner can choose from (selection), or because they have to be studied in a particular order (sequence). Most elements from the model have attributes like id, URI and title. Besides, the elements LearningPath as well as LearningAction and LearningActionsCluster have a set of metadata, i.e. information about the learning path and its constituent actions, considered relevant in identifying and selecting suitable learning paths.

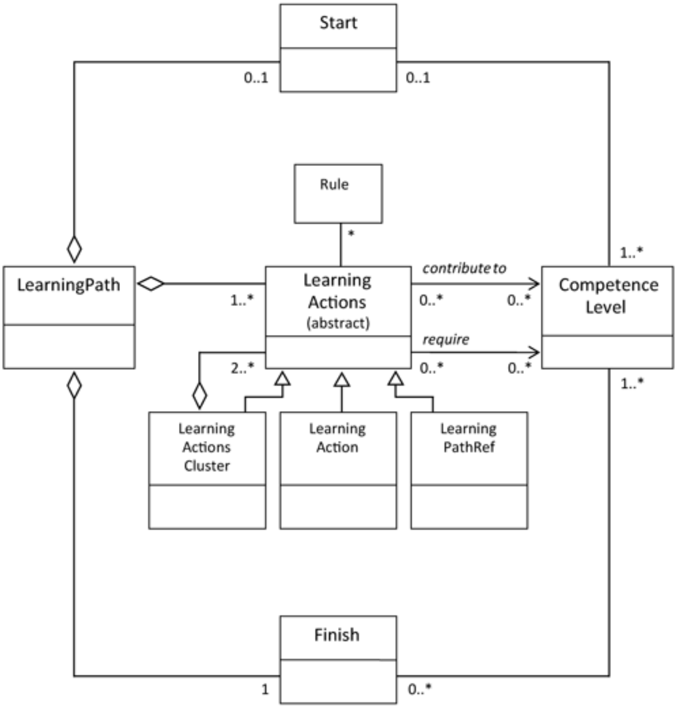


Figure 4.1. Learning path conceptual model

The LearningPath metadata are described in Table 4.1. (For a more detailed account of the attributes and metadata associated with each of the elements see Janssen, Hermans, Berlanga, & Koper (2008)).

Table 4.1. Learning Path metadata

Characteristic	**Explanation**
Title	The name of the program, course, workshop etc.
Description	A brief description of the program, course, workshop, etc.
Prerequisites (prior knowledge)	The knowledge and skills which are expected to have been acquired beforehand
Start conditions	Other conditions that must be met before you can start: e.g. a minimum number of participants, a special diploma, access to a computer, microscope, etc.
Language	Can I study everything in my own language or do I need to know other languages?
Recognition (diploma/certificate)	Will I receive an officially recognized diploma or certificate upon completion?
Workload (time investment)	Total number of hours it takes to complete
Delivery mode	Can I study on my own, are there face-to-face meetings, or does it involve a combination of these? Am I expected to attend (virtual) meetings?
Guidance	What kind of guidance is offered?
Assessment	How is progress/attainment of learning goals assessed?
Start date/end date	How soon can I start/finish?
Costs	What are the total costs for materials, enrolment, etc.
Number of contact hours	How many hours do I spend in meetings with a tutor, collaborating with others, etc.?
Location	Where do meetings take place? How far do I have to travel?
Completion	Is there a deadline for completion? Do I decide myself when I have finished?
Provider	Who is offering the program, course, workshop, etc.
Further information	Link to a website for contact details, information on regulations, teachers, accreditation, etc.

3. Formal, non-formal and informal learning paths

Schugurensky (2000) distinguishes between formal, non-formal and informal learning in a way similar to the aforementioned definitions of the Commission of the European Communities (CEC, 2000). He characterises formal education as highly institutionalized; implementing a prescribed curriculum; propaedeutic (each level prepares for the next one); hierarchically organized; and certified. Non-formal education in his view refers to organized educational programs that take place outside the formal school system, whereas informal learning takes place outside the programs offered by formal and non-formal education. Schugurensky stresses the fact that informal learning can also take place inside formal and non-formal educational institutions: within these institutions some learning occurs independently of the intended goals of the curriculum. Using two categories (intentionality and consciousness) he goes on to identify three forms of informal learning: self-directed learning (intentional + conscious), incidental learning (unintentional + conscious) and socialization (unintentional + unconscious). The Learning Path Specification is merely meant to enable description of informal learning with the aim to suggest informal ways to develop competences, drawing from other learners' personal informal learning experiences. This means the Learning Path Specification is only meant to cover conscious informal learning. As to the intentionality of learning it is often stated that workplace learning and other informal learning have no formal curriculum or prescribed outcomes (Hager, 1998). This is also illustrated by the wide range of terms used as synonyms or examples of learning in studies concerning informal workplace learning: problem solving, feedback, planning, applying, trying things out, etc. (Boud & Middleton, 2003; Hoekstra, Beijaard, Brekelmans, & Korthagen, 2006). Regarding unintentional conscious learning we maintain that this type of learning can be described in hindsight as a learning path, describing the previously unintentional learning outcomes as learning objectives, to present as an option to other learners interested in achieving these learning objectives.

Concerning the distinction between different types of learning a major review of literature suggests there is no clear agreement on the difference between informal and non-formal learning: the terms are used interchangeably (Colley et al., 2003). Moreover, it is impossible to distinguish formal learning from other learning in ways that have broad applicability or agreement. The authors conclude it is more sensible to consider *attributes of informality and formality* present in all learning situations. These attributes concern four aspects of learning:

- *Process*: informality and formality attributes relating to the learning process relate to questions like who's in control of the process (teacher controlled versus student led), whether and what kind of assessment is involved (formative or summative).
- *Location/setting*: where does the learning take place (e.g. in an educational institution, at the workplace, etc.) and does it involve certification?
- *Purposes*: is learning intended or does it happen unintentionally; are learning outcomes determined by the learner or designed to meet needs which are externally determined?
- *Content*: does the learning focus on acquisition of established knowledge or development of knowledge from experience?

Attributes relating to the process aspect of learning included in the specification are the metadata elements 'guidance' and 'assessment'. The location/setting aspect is covered by the metadata 'recognition', 'delivery mode', and 'location'. Regarding the purpose aspect we conclude that the Learning Path Specification only covers intentional learning: a learning path is directed towards learning goals. This does not mean that the Learning Path Specification can not be used to describe unintentional learning as well, but this would always be in hindsight: learning which has occurred unintentionally can be retrospectively described to serve as an example to other learners who can then embark on the same path purposefully. Attributes of formality and informality relating to the content aspect of learning can be described through the metadata element 'description' of the learning path as well as of its constituent actions. Whether the learning goals of a learning path are achieved through 'formal knowledge acquisition' or through 'learning by doing' will be of interest to the learner, but whether it requires a separate metadata element remains to be seen.

4. Model evaluation: a framework

Seeking alignment with the ISO 9000 definition of quality Moody (2005) defines conceptual model quality as "The totality of features and characteristics of a conceptual model that bear on its ability to satisfy stated or implied needs" (p. 252). Based on a review of research in the field of conceptual model quality Moody concludes that there are no generally accepted guidelines for evaluating the quality of conceptual models. Nor do experts agree as to what makes a conceptual model a 'good' model. One of the explanations given for this lack of consensus is that a conceptual model exists as a construction of the mind, and therefore quality of a conceptual model cannot be as easily assessed as the quality of a concrete product: "While the finished product (the software system) can be evaluated against the specification, a conceptual model can only be evaluated against people's (tacit) needs, desires and expectations. Thus the evaluation of conceptual models is by nature a social rather than a technical process, which is inherently subjective and difficult to formalise" (Moody, 2005, p. 245).

The Learning Path Specification is a case in point: rather than a "finished product" it is a model to describe learning paths which can be used to develop tools to support lifelong learners in finding and navigating suitable learning paths. This implies a number of stakeholders:

- lifelong learners
- learning path designers
- providers
- software developers.

Someone interested in finding suitable learning paths is likely to focus on different aspects of the Learning Path Specification than someone interested in designing learning paths or in developing tools to support these processes. Consequently, evaluation of the specification requires input from these different perspectives.
Addressing the lack of consensus in the field Moody (2005) proposes the ISO/IEC9126 software quality model as a template to structure conceptual model quality frameworks. This template identifies the following important features:

- hierarchical structure of quality characteristics (characteristics, sub-characteristics and metrics)
- familiar labels
- concise definitions
- measurement (characteristics are operationally defined)
- evaluation procedures (who should be involved how and when).

The remainder of this section will focus on the framework for the evaluation of the Learning Path Specification we developed using these template features (table 4.2).

Concerning the hierarchical structure of quality characteristics, we will draw on a distinction which, despite the observed overall lack of consensus, several researchers in the field adhere to (albeit not exclusively): syntactic quality, semantic quality and pragmatic quality (Krogstie, 1998; Leung & Bolloju, 2005; Lindland, Sindre, & Solvberg, 1994; Moody, Sindre, Brasethvik, & Sølvberg, 2002; Recker, 2006; Teeuw & Van den Berg, 1997).

Syntactic quality involves the extent to which the conceptual model adheres to the syntax rules of the language it is modelled in. In the case of the learning path conceptual model evaluating the question would be whether UML has been properly used (i.e. in accordance with UML syntax rules) to express what was meant to be expressed.

Semantic quality refers to the extent to which the model accurately represents the essential features of the phenomenon under study. Some of the differences in defining model quality revolve around the interpretation of what constitutes an accurate representation. Interpretations of accuracy vary, depending on whether or not the phenomenon under study is considered an 'objective reality' (ontology), and whether or not it is possible to objectively know this reality (epistemology) (Recker, 2005). Regarding semantic quality several authors mention specific criteria like completeness, validity, clarity, consistency, etc. (Krogstie, 1998; Leung & Bolloju, 2005; Recker, 2005; Teeuw & Van den Berg, 1997).

Table 4.2. Framework for evaluation of the Learning Path Specification

Quality dimensions	Description	Sub-characteristics	Description	Evaluation methods	Metrics
Syntactic quality	Does the model correctly express what is meant to be expressed in accordance with UML syntax rules?	proper notation of association, aggregation, generalization, multiplicity etc.		- submit model to peer/expert review - validity checks through software	- number and type of errors, ambiguities, etc.
Semantic quality	Does the model represent essential features of the phenomenon under study?	adequate [1] orthogonal/independent [3,5] valid [2,4]	The model adequately reflects the domain, i.e., independent aspects are captured by different concepts and relations are adequately represented.	- explain the model to lifelong learners and learning path providers to see whether they find it adequate on points relevant to them - analyse lifelong learners' learning path choice processes to establish learning path characteristics essential in this process - map existing learning paths on model	- number and type of issues open to debate - number of changes made to the model - number and type of frictions in mapping learning paths
		complete [1,3,4,5] nothing missing what is expected [2]	The model describes all essential features.		
		minimal [1] parsimonious [3,5] nothing unexpected presented [2]	The model does not contain irrelevant aspects and relations		
Pragmatic quality Social & Technical	Is the model easy to understand/ interpret correctly?	unambiguous [1,3]	Concepts and relations have a clear single meaning	- establish whether the specification is adequate to develop tools. - establish whether tools developed are considered useful	- perceived ease of use - perceived usefulness - intention to use
		internally consistent [1,3]			
		general	Concepts should be as independent as possible from any specific application(domain)	- map informal and non-formal learning paths from different domains	

[1] van Lamsweerde (2000) [2] Leung & Bolloju (2005) [3] Teeuw & van den Berg (1997) [4] Krogstie (1998) [5] Moody et al. (2002)

However, usage of these criteria is not consistent. Moody et al. (2002) for instance use the term validity to indicate a number of criteria (completeness, parsimony, and independence) which others use to define semantic quality. Interestingly, Krogstie (1998) introduces the notion of feasibility. Whereas completeness means that the model contains all the statements which are correct and relevant to the domain, feasible completeness means that there are no statements in the domain, and not in the model, which would be cost-efficient to include. Besides, this author distinguishes between semantic quality and perceived semantic quality. He argues that the primary goal for semantic quality is for the model to correspond with the domain. However, this correspondence can not be checked directly since:

"To build a model, one has to go through the participant's knowledge regarding the domain, and to check the model, one has to compare with the participant's interpretation of the externalized model. Hence, what we observe at quality control is not the actual semantic quality of the model, but a perceived semantic quality, based on comparisons of the two imperfect interpretations" (Krogstie, 1998, p. 87).

Pragmatic quality, finally, refers to the question whether/how easily the model is comprehended by the stakeholders in view of its purpose. The purposes of conceptual models can vary widely: enhance communication, document the current state of knowledge, guide system development, exploration, prediction, decision support (Beck, 2002; Moody, 2005). Pragmatic quality can be further split into technical pragmatic quality and social pragmatic quality (Nelson, Poels, Genero, & Piattini, 2005), indicating whether the model is easily interpreted by tools and human users, respectively.

5. Research questions

Syntactic quality has been evaluated mainly through peer review and expert consultation. So far the model mainly has been used for communication purposes. Eventually the UML model will be transformed to an XML schema which requires greater refinement and detail, and further evaluation of syntactic quality. This evaluation will be reported about in a separate publication.

Semantic quality has been evaluated through collaboration with software developers and processes of peer review. However the elements and characteristics identified by the model have been derived from a review of literature and current practice, but are these really the elements and characteristics lifelong learners want to be informed about? Are these the elements and characteristics they take into account when considering different options?

Evaluation of *pragmatic quality* will focus on software developers and tools. However, in our view it makes sense only to evaluate pragmatic quality after semantic quality has been sufficiently tested, because poor semantic quality will inevitably result in poor pragmatic quality. Still, some aspects of pragmatic quality will be included in the present study as well, involving the question whether the learning path characteristics included in the specification are clear and easy to understand.

More particularly, the focus of the present study is on the following quality aspects relating to the purpose of enabling comparison and selection of learning paths:

1. Is the information provided by the model clear?
2. Is the specification complete: does the model contain all essential information lifelong learners desire/need to select suitable learning paths?
3. Is the specification minimal: does the model contain information which is not considered relevant by lifelong learners?

6. Method

Above research questions were addressed through a case study examining lifelong learners' decision making processes (Flyvbjerg, 2006; Yin, 2003). Data on decision making processes were gathered through semi-structured interviews with learners (*n*=15) who recently chose a learning path, having considered at least two different options. Participants for the study were recruited asking colleagues and acquaintances to propose candidates from their network of family and friends.

Typically sampling for multiple-case studies is guided by the research questions and conceptual framework. Our main sampling strategy was maximum variation of cases (Flyvbjerg, 2006; Miles & Huberman, 1994), meaning that we sought to include a broad variety of learning paths regarding domains of personal/professional development, and level of formality. Besides we aimed to have a broad variety of respondents regarding age, gender, employment status, and prior education. The number of cases to include was not pre-determined, but including over about 15 cases is acknowledged to make it harder to keep an overview without losing sight of necessary details (Miles & Huberman, 1994). Though essentially each case has unique properties and is therefore interesting in its own, in hindsight it appears that the last four interviews did not provide any new information regarding the characteristics taken into account in the decision making so that in this respect a point of saturation (Miles & Huberman, 1994) seems to have been reached. The risk of retrospective distortion due to inaccurate recall was reduced by requiring that the decision making process had come to a conclusion no longer than three months ago, and by using a technique of aided recall during the interviews (Coughlin, 1990).

6.1. Interview protocol

The interview protocol included four steps. Firstly, participants were asked to tell a bit more about their motives to learn. The second step focused on spontaneous recall: participants were asked to describe their search for ways to achieve these learning goals and how they 'weighed' these different options, i.e. on which characteristics they compared them to arrive at a final choice. Any characteristics mentioned during the interview which were not part of the Learning Path Specification were noted down by the interviewer. The third step involved aided or prompted recall: participants were invited to go through a set of cards, each card containing a label and description of a characteristic included in the specification as shown in table 4.1, complemented with two additional cards for learning outcomes (knowledge and skills to be developed) and learning actions (things you have to do: study, investigate, write, present, etc.). For some characteristics the original labels used were adapted to reflect common language e.g. 'prior knowledge' rather than 'prerequisites'. Table 4.1 gives these adapted labels between brackets.

For each of the cards participants were asked to indicate whether the described characteristic was clear to them and whether it had played a role in the recent choice of a learning path. The fourth step required of participants that they shift from the most recent decision making process to deciding on a learning path more generally, and to consider whether in general they would want to take this information into account.

6.2. Cases

Figure 4.2 presents the learning paths included in the study classifying them along two dimensions: relation to career and 'urgency', i.e. the question whether the learning path is considered a 'must have'. This second dimension emerged as a relevant distinction during the interviews: i.e. to what extent is the learning path conditional, a 'sine qua non', without which the learner is somehow restricted.

Though at face value one might expect conditional learning paths to exist mainly in the realm of professional development, figure 4.2 gives several counter examples, such as learning to cook for dietary requirements. In the case of the career related learning paths the 'must have' learning paths were conditional either to adequate job performance, or to a job or career switch. Other career related learning paths were merely meant to 'look good on the CV', without an immediate urge to find another job. Figure 4.2 further provides information on formality of the learning paths and learner characteristics (gender, age, social status).

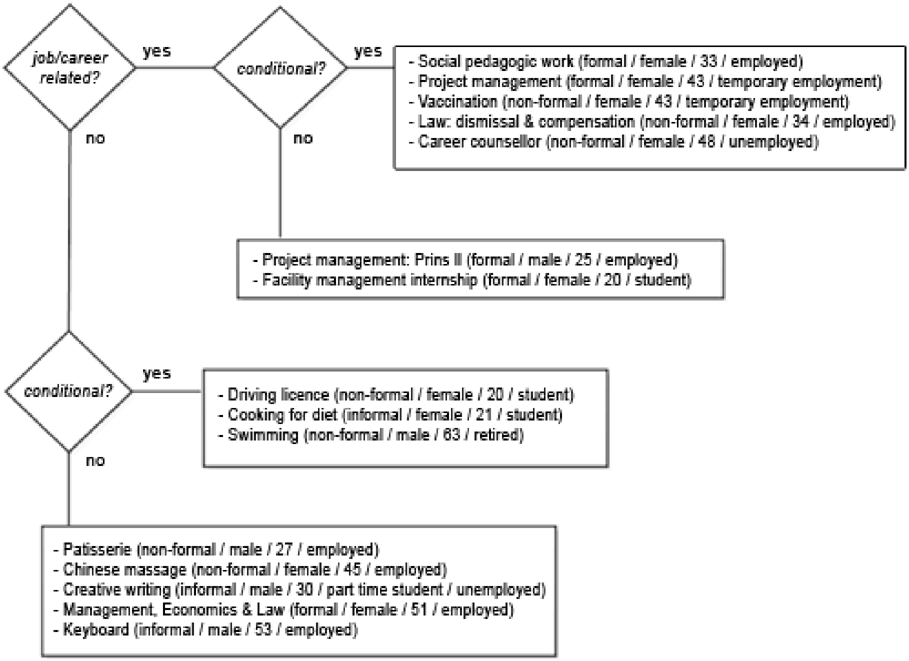


Figure 4.2. Learning paths included in the study

7. Results

The number of learning paths compared in depth in the decision making processes varied between 2 and 8, with an average of 4. In twelve cases Internet was used to search for suitable learning paths. Two cases involved a restricted choice between two options offered by the employer or educational institution.

In a number of cases the process of screening had started about a year before. The distinction between screening and choice is not as clear-cut in practice as in theory: rather there exists a grey area of learning paths which are considered more closely but still get dropped long before the final choice is made. A clear distinction between screening and choice can be made only in those cases where one or two criteria stand out as initial selection criteria as was, for example, the case with the choice of a driving school, where a first selection (screening) took place on the base of reputation (pass/fail rates) and location.

An interesting general observation regarding the in-depth comparison leading up to the final choice is that in the case of the informal learning paths the choice process entailed some probing of different options. Of course this was possible because these options were freely available and did not require any formal subscription or enrolment. However, they were nevertheless considered as clearly distinctive options: though there was a period of 'trial' eventually a choice for a particular option was made, rather than for a mix.

Spontaneous recall

Figure 4.3 shows - in descending order - to what extent learning path characteristics played a role in the decision making process according to the spontaneous recall of participants. The characteristics 'title' and 'description' have been left out, as they are obvious. Characteristics which were mentioned during the interview and which were not included in the Learning Path Specification are marked by (+).

Some caution is required regarding the interpretation of these results. All participants were more or less aware of the learning outcomes of the learning paths under consideration but they did not always play a role in the comparison, simply because the learning paths were more or less identical in this respect, or because the learning outcomes were less important than acquiring the associated diploma or certificate. Similarly, language was not mentioned as a criterion in the decision making process simply because all learning paths considered were in Dutch. In fact, in these cases the characteristic has played an (implicit) role in the process of screening.

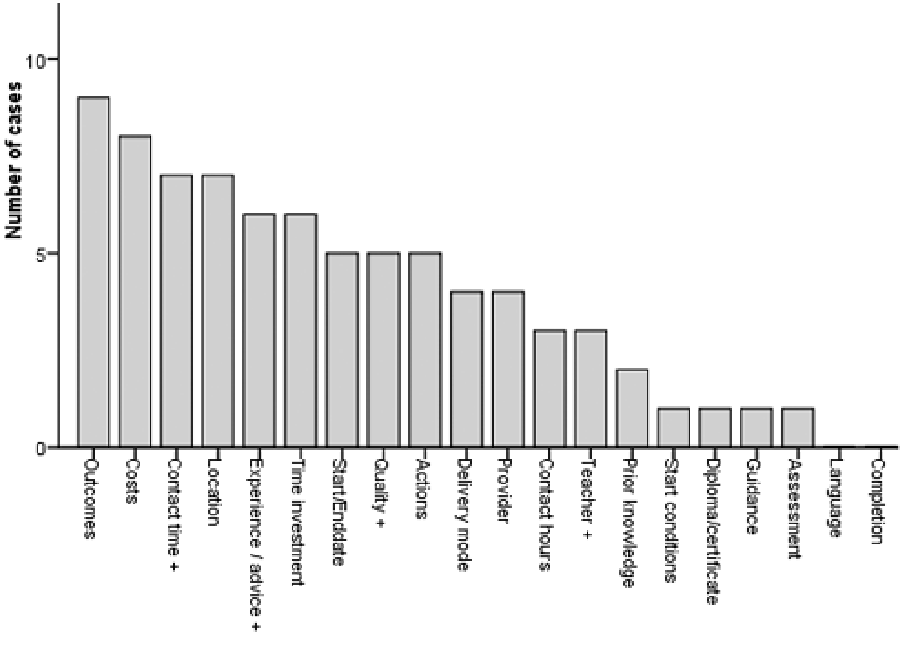


Figure 4.3. Characteristics taken into account based on spontaneous recall

Based on spontaneous recall the following learning path characteristics played a role in at least one third of the cases: learning outcomes, costs, contact time, location, experience/advice, time investment, start date/end date, quality, and activities. Contact time, experience/advice, quality, and teacher require some further explanation as they came up in addition, suggesting the specification is incomplete.

Experience/advice: six participants remarked they had been keen to acquire information on other peoples' experiences concerning the options they were considering. Preferably people they were acquainted with so that their judgement could be appraised, but otherwise in the form of Internet forums.

Teacher: three respondents compared information on the teacher involved, placing different accents: two were merely interested in teaching experience (number of years) and the third considered it very important that the teacher had practical work experience in the subject area (Law).

Contact time: contact time involves the question at what time of the week face-to-face meetings take place. Scheduling information is multi-faceted as is already expressed by a number of characteristics included in the specification: start/end date, delivery mode (contact: yes/no), and contact hours (amount of contact). Now additional information is called for regarding the time of the week contact takes place. The indication 'part-time/full-time', which is sometimes used, was not included in the specification because it is too general to be informative. This is confirmed by the specifications from participants in this study: "Not on Wednesdays", "Only evenings or weekends, depending on how far I have to travel", etc. What is required is a categorisation that is specific enough to be informative, yet general enough to be practical.

Quality: five respondents said they had taken into account the quality of learning paths. When asked how they had established quality, a variety of aspects was mentioned: pass/fail rates, 'does the website look professional', and quality of learning materials (e.g. up-to-date content).

Aided recall

As mentioned aided recall was measured using a set of cards, each card defining one characteristic through a label and a brief description. Participants were asked to consider each card carefully to see whether the characteristic was clear to them. Despite the brief explanation offered on the cards the characteristics were not always clear and unambiguous. However, this seemed somewhat intrinsic to the domain, as several characteristics included in the specification are closely related, nuances tended to get lost, for instance, regarding the concepts 'assessment', 'completion', and 'recognition'. Assessment describes the types of assessment(s) included in the learning path, and completion indicates whether there is a formal end to the learning path (set by an assessment or time limit for instance) or whether it is up to the learner to decide whether the learning goals have been reached. Though both concepts are clearly related to recognition, they are not identical: recognition is independent of types of assessment and does not necessarily mean deadlines.

In those cases where the characteristics themselves are clear and unambiguous, the role of the characteristic in comparing and selecting learning paths may not be unambiguous. Indeed plain and simple characteristics like costs and time investment could lead respondents to ponder: of course, generally speaking, you would want to reduce costs as much as possible, but then again 'quality comes with a price'. Similarly, several respondents struggled with the role of 'prior knowledge' as it could be interpreted in two ways: 'Does the learning path build on what I already know rather than teach me things I already know' or 'Do I have the knowledge the learning path considers known'.

Figure 4.4 compares the results for spontaneous recall (s) with the results based on aided recall (a).

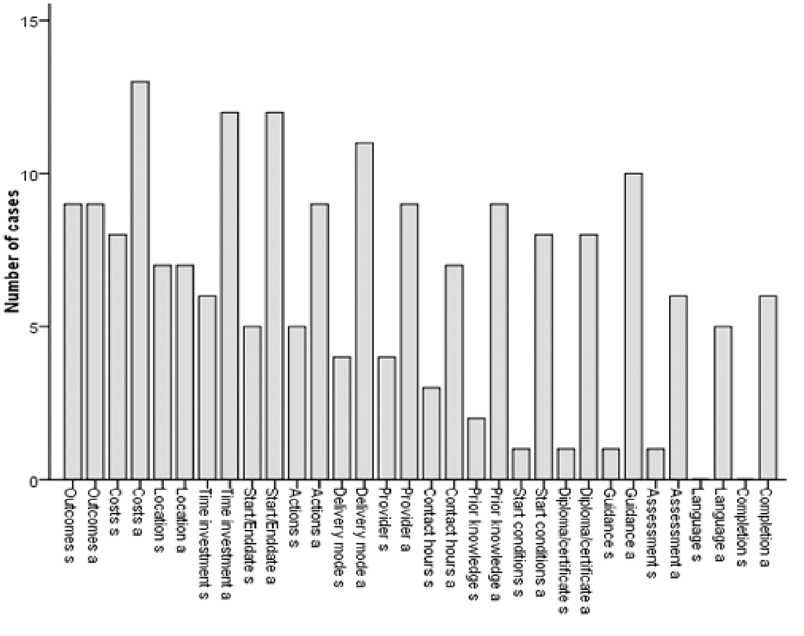


Figure 4.4. Characteristics taken into account: spontaneous recall (s) vs. aided recall (a)

Figure 4.5 makes clear that none of the characteristics included in the Learning Path Specification is considered superfluous. This suggests the risk of information overload resulting from the number of attributes taken into account in a choice process is real.

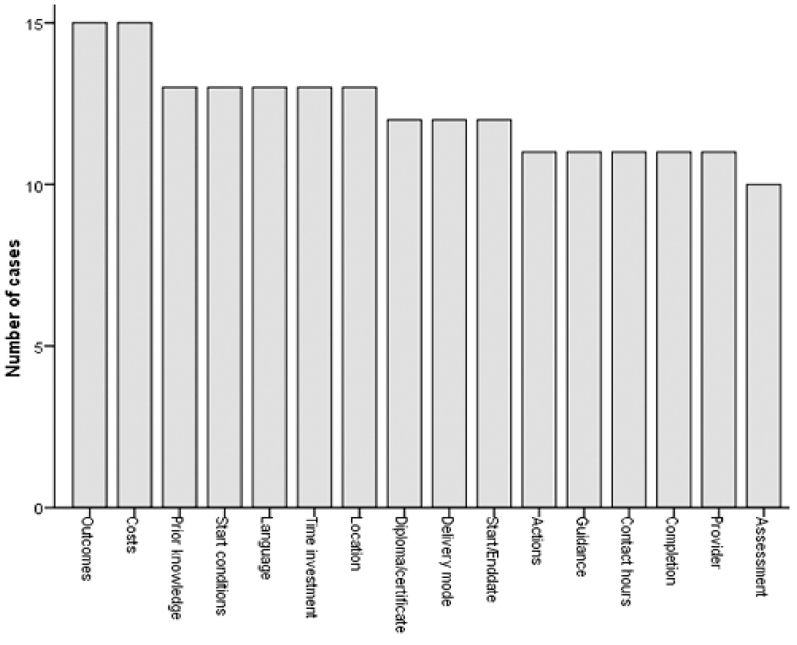


Figure 4.5. Information participants want to have in general

Apparently quite a number of characteristics are prone to be overlooked in spontaneous recall. In fact, only the results for outcomes and location appear remarkably stable. Our aim never was to compare spontaneous recall and aided recall, as the former step was directed mainly at detecting omissions, but figure 4.4 serves to illustrate how certain characteristics are more often taken into account in the process of selecting a learning path than reports based on spontaneous recall would suggest. Some of these characteristics were taken into account implicitly, without the learner being consciously aware of it (e.g. delivery mode, completion). In other cases the characteristics had been consciously considered, and subsequently forgotten as they had not constituted an issue: "Yes, I recall looking at this information, but it was ok . . ." (e.g. prior knowledge, start conditions, guidance).

Several respondents commented that they had not seen any information regarding certain characteristics (e.g. assessment, actions, prior knowledge, and guidance). Thus, results may to some extent reflect the availability of information. Hence, the need for the third step of asking participants whether they want to have information on each characteristic when deciding upon a learning path.

8. Conclusions and discussion

We investigated 15 choice processes involving a broad variety of learning paths, with the aim to evaluate semantic and pragmatic quality of the Learning Path Specification: are characteristics included in the specification to support comparison and selection of a learning path clear, sufficient, and without redundancies?

Regarding clarity our study showed that related characteristics (e.g. delivery mode and contact hours) sometimes got mixed up. However, this can be solved by presenting them in combination and with possible values.

None of the characteristics included in the specification appeared redundant. Instead, several characteristics were mentioned in addition, suggesting that the characteristics included in the specification are not sufficient. We will discuss each of these briefly with respect to the question whether or not they should be included in the specification. Several participants made an initial selection of learning paths based on provider names and associated reputation. Still, even in these cases of well-known providers, additional information is sought on learner experiences with these learning paths. However, information on learner experiences can not be included in the specification, because the description of learning paths is made by the provider and the information on experiences is only of value when it is completely independent. Alternative solutions might be found in adding annotations or ratings provided by users, or in providing recommendations through collaborative filtering, e.g. 'Your profile most closely matches the profile of learners choosing learning path X' (Drachsler, Hummel, & Koper, 2008). However, participants expressed a preference to hear about experiences from people they know so as to be able to appraise their judgement. Further research is needed to establish whether the proposed solutions are viable alternatives.

In three cases information was sought on the teacher (number of years in teaching or practical professional experience in the subject area). The question is whether this information should be provided through one or even two separate characteristics in the specification, or whether this is typical information a learner should be able to find through the link provided via 'further information'. Though teacher information can be decisive, it will hardly play a role at the stage of screening but rather towards the end of the process in the comparison of a limited set of options. This is not the case for the information regarding contact time, i.e. the scheduling of meetings associated with a learning path: this information will help to distinguish suitable learning paths at the very start of the decision making process. Including this element in the specification is therefore likely to contribute considerably to efficiency. So bearing in mind the notion of feasible completeness the element 'contact time’ will be added to the specification. Seeking a balance between the level of detail some participants described and considerations of what is practical, two dimensions will be distinguished: weekdays/weekend and daytime/evenings.

Finally, the aspect of ‘quality’ was mentioned, referring to a variety of indicators: pass/fail rates, a probe of learning materials (up-to-date), or impressions of professionalism. This type of information can not be grasped simply by adding another learning path element, but has to be sought in addition, through independent sources.

Though several participants hinted at information overload regarding the number of learning paths to consider (mainly in relation to Internet searches for appropriate learning paths), one respondent specifically hinted at the risk of overload due to the number of criteria taken into account. She said her choice process had taken the shape of a funnel regarding the number of learning paths to compare, though not, unfortunately, regarding the number of criteria taken into account. Further quantitative research is required to investigate solutions aimed at reducing the risk of information overload by distinguishing between more and less important characteristics.

Chapter 5

Assessing the Learning Path Specification: a pragmatic quality approach

Janssen, J., Berlanga, A. J., Heyenrath, S., Martens, H., Vogten, H., Finders, A., Herder, E., Hermans, H., Melero, J., Schaeps, L., Koper, R. (submitted). Assessing the Learning Path Specification: a pragmatic quality approach.

Abstract

Finding suitable ways to achieve particular learning goals is not an easy task, both in initial education and lifelong learning. To facilitate selection, personalisation and navigation of learning paths we propose to describe learning paths in a formal and uniform way by means of a learning path specification. This paper explains the rationale behind the Learning Path Specification. Based on a framework developed for the evaluation of the specification the paper describes a study that was carried out to establish pragmatic quality, i.e. whether stakeholders can understand and use the specification. The paper explores the relationship between the concepts *pragmatic quality*, *usability*, and *desirability,* and distinguishes first-order and second-order pragmatic quality, relating it to different stakeholders: software developers and end-users. First-order pragmatic quality of the Learning Path Specification was evaluated during the process of developing a tool that describes learning paths according to the specification: the Learning Path Editor. Second-order pragmatic quality was evaluated through workshop sessions with end-users involving some hands-on experiences with this tool. The paper describes adaptations made to the specification in the process of developing the Editor. End-user evaluations were quite positive, leading to one more adaptation.

1. Introduction: rationale behind the Learning Path Specification

Learning paths are defined as sets of one or more learning actions that lead to a particular learning goal. These learning actions can be formal, non-formal, informal or a combination of these and can vary from a relatively small activity like reading a book or taking a course to following an entire programme or curriculum (Janssen, Berlanga, Vogten, & Koper, 2008; Janssen, Berlanga, & Koper, submitted).

The number of learning opportunities available to lifelong learners has greatly increased in recent decades: educational institutions traditionally focusing on initial education have made a shift to target lifelong learners as well, the training market has expanded and more and more courses have become available through the Internet. Especially when learners seek to develop skills or gain knowledge in a relatively unknown field or when they are faced with numerous ways to learn something, they need help to chose a suitable way to reach their learning goals (Chen, Fan, & Macredie, 2006; Lea, Stephenson, & Troy, 2003). This problem exists not only in formal education, where increased modularization necessitates navigation support (Kilpatrick, Fulton, & Johns, 2007; Simpson, 2004; Yorke, 1999), but also in non-formal and informal learning (van der Klink, Boon, Schlusmans, & Boshuizen, 2009). The following example will illustrate the problem: a person who is interested in interior design and who would like to develop her competences in this direction might have a look to see what courses are available, for instance through a search on Internet. Deciding upon a course means that a particular learning path is chosen. The search entry 'interior design course' in Google presently (February 2010) results in over 70 million hits, referring to all kinds of interior design courses, at varying levels, some accredited others not, with different price tags attached, with varying study loads, etcetera. This clearly represents a case of information overload, even if to a novice course titles might offer a clue through words like 'introduction' or 'basics'.

Comparison and selection of suitable learning paths can be facilitated if learning paths are described in a formal and interoperable way: i.e. a way that specifies a learning path's constituent parts and characteristics in a language that is amenable to computer processing and intelligible across systems. Such a *Learning Path Specification* was developed within the context of the European FP6 TENCompetence Integrated Project (TENCompetence, 2005). Requirements for the specification were derived from a review of literature on the nature of formal and informal learning as well as an analysis of current practises that aim to support learner choice (Janssen et al., 2008).

The Learning Path Specification distinguishes itself from related specifications in the field, which also aim at supporting learners in finding suitable learning opportunities but which focus on formal education (CDM, 2004; CEN, 2008; XCRI, 2006). The Pspex project (Oussena & Barn, 2009) also focuses on formal programmes, more specifically on the rules for programme assembly and versions. In an earlier publication (Janssen et al., 2008) we explained how the Learning Path Specification has clear links with the IMS-LD specification (IMS-LD, 2003). However IMS-LD provides a detailed description of the activities, assignments and materials involved in the learning process, whereas the Learning Path Specification is merely a vehicle to describe and connect learning actions, which might in fact be an IMS-LD unit-of-learning, but could also be a workshop, a manual, a video, a classroom course, a blog, etc.

In order to assess the quality of the Learning Path Specification an evaluation framework was developed, based on theories and research regarding conceptual model quality (Janssen, Berlanga, & Koper, submitted). The framework starts from the familiar distinction between *syntactic*, *semantic,* and *pragmatic* quality of conceptual models (Leung & Bolloju, 2005). The work presented in this paper focuses on the evaluation of *pragmatic quality* of the Learning Path Specification: how easy is it for stakeholders to understand and use the specification?

The remaining sections of this paper are structured as follows. Section 2 of this paper briefly describes the Learning Path Specification. Section 3 zooms in on pragmatic quality as a particular dimension of conceptual model quality and describes the connection between pragmatic quality and the related concepts of usability, and desirability. Section 4 describes the method used to evaluate the pragmatic quality of the Learning Path Specification, including a description of the Learning Path Editor. Section 5 describes the results of the study. Finally, section 6 describes the conclusions and discusses the implications of the results for future work.

2. Model and model quality

The purposes of conceptual models can vary widely: enhance communication, document the current state of knowledge, guide system development, exploration, prediction, decision support (Beck, 2002; Moody, 2005). The ‘immediate’ purpose of the Learning Path Specification is to support the following processes:

1. Description of lifelong learning paths
2. Selection of suitable learning paths
3. Personalisation of learning paths (taking into account learners’ entry levels)
4. Navigation of learning paths (i.e. following the designated steps).

2.1. Learning path conceptual model

The conceptual model of the Learning Path Specification (Janssen et al., 2008) is shown in figure 5.1. A learning path has a Start (prerequisites) and a Finish (learning goals) which are defined in terms of (a set of one or more) competences and associated levels of proficiency (CompetenceLevel). Competence is defined as the ability of a person to act effectively and efficiently in a particular situation, e.g. performing a job, hobby, sport, etc. Whereas specification of the path's finish is mandatory, specification of prerequisite competence levels by defining a start is optional. Both start and finish could be as elaborate as a job profile.

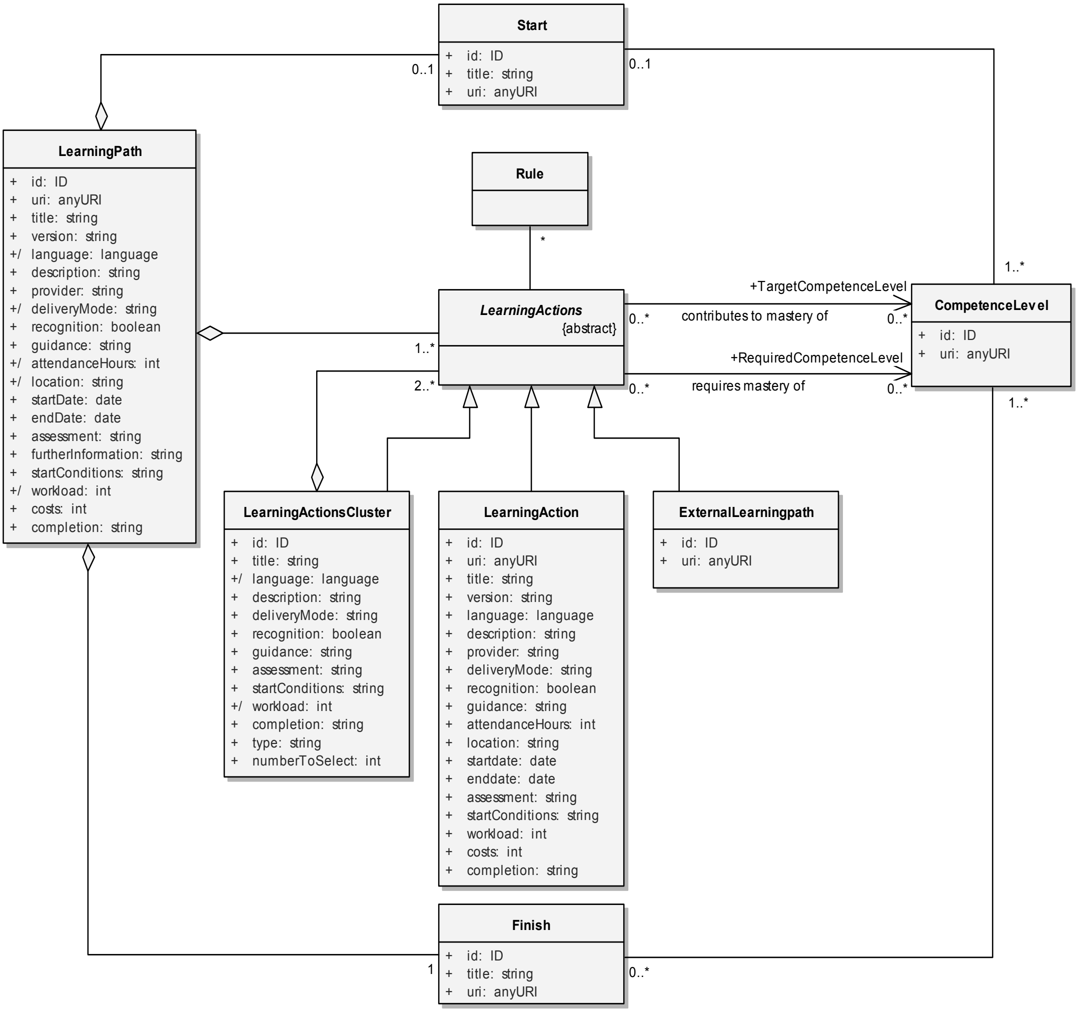


Figure 5.1. Learning path conceptual model

A learning path further defines the steps (LearningActions) that lead from the start to the finish, i.e. to attainment of specific competences at specific levels. These steps may involve:

- a single learning action (LearningAction: 'workshop X', 'course Y', 'consult expert Z', 'read A')
- a cluster of learning actions which are related (LearningActionsCluster: 'chose one of the following actions', 'perform the following actions sequentially')
- a reference to an existing learning path (LearningPathRef: this enables nested structures of learning paths, e.g. in formal settings one leading towards the Bachelor degree and the other leading to the Masters degree).

Each learning action may contribute to mastery of one or more competences and may require mastery of one or more competences at a particular level. Note that the relation between learning actions and competence levels is a very loose one: possibly even non-existent. This was done deliberately in order to avoid the specification to become too rigid. The methodical description of competences and associated levels of proficiency has deliberately been put out of scope for the Learning Path Specification. The model assumes that competences and their levels are described elsewhere in a standardised way that can be referenced (Kickmeier-Rust, Albert, & Steiner, 2006; TENCompetence, 2006; Van Assche, 2007). A learning path is further described by a set of metadata that specify content, process, and planning information (e.g. title, description, assessment, tutoring, delivery mode, attendance hours), which are relevant to the process of choosing a learning path.

The learning path conceptual model presented in figure 5.1 was created using the Unified Modelling Language (UML, 1997) for graphical representation in order to facilitate communication about the model. The implementation of the model in a binding was realised using XML, Extensible Markup Language (W3C, 2008), so as to meet technical requirements of formality and interoperability.

The model was designed to meet a number of requirements related to the characteristics of learning paths that should be taken into account e.g. modular composition, nested composition, learning outcomes, optional parts, sequencing etc (Janssen et al., 2008).

When learning paths and learning actions are described as proposed by the specification it becomes possible to support selection, navigation, and personalisation of learning paths in a (semi-) automated way: search engines can be developed that enable learners to specify criteria for the selection of suitable learning paths (e.g. costs, start date, delivery mode, location), learning paths can be automatically visualised (optional and mandatory parts, fixed orders) in support of navigation, and learning paths can be personalised by identifying learning actions as 'completed' when the learner already has attained the associated competence levels through prior learning.

Figure 5.2 describes the processes to be supported by the specification, the required tools, and their outputs. The numbers of the tools pictured in the figure correspond with the numbering of the processes described earlier: 1. description, 2. selection, 3. personalisation, and 4. navigation of learning paths. As figure 5.2 illustrates, the description of learning paths precedes all the other processes (search, personalisation, and navigation) as these follow-up processes require the availability of learning path descriptions in line with the specification. Hence, for the evaluation of pragmatic quality a tool that enables description of learning paths in line with the specification was the most likely choice.

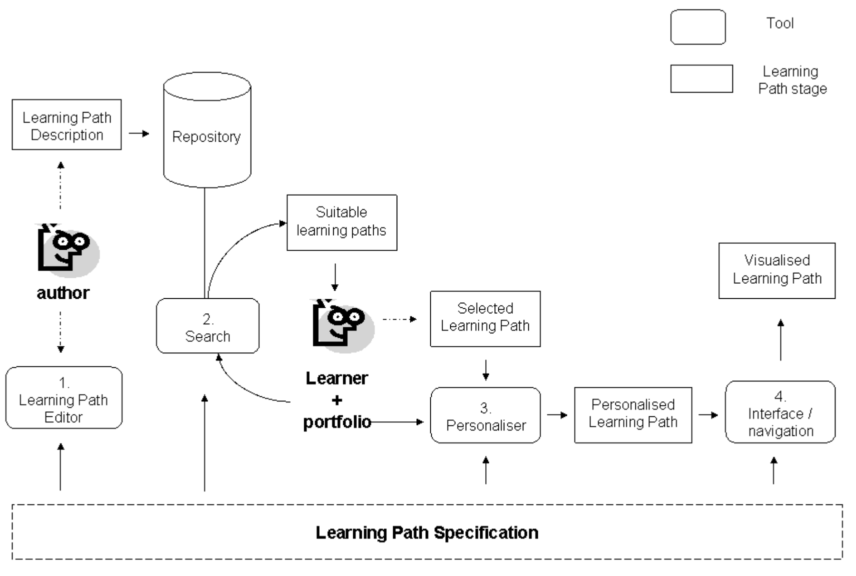


Figure 5.2. Tools building on the Learning Path Specification

2.2. Model quality

The framework developed for the evaluation of the Learning Path Specification (Janssen et al., submitted) identifies three aspects of model quality:

1. Semantic quality: does the model represent essential features of the phenomenon under study?
2. Syntactic quality: does the model express what it intends to express in a correct way, i.e. in accordance with the syntax rules of the modelling language?
3. Pragmatic quality: is the model easily comprehended and used by the stakeholders in ways that are commensurate with its intended purpose?

Though 'ease of use' is often associated with the notion of usability, the concepts of pragmatic quality and usability are not synonymous, as will become clear later on. A specification is used in the first place by software programmers who develop tools that draw on the specification. They are the primary, direct users and their evaluation of the specification's pragmatic quality is therefore referred to as 'first-order' pragmatic quality. However, ultimately they develop these tools for end-users who want to deploy the specification. This means we have to rely on users' evaluation of the Learning Path Specification *as conveyed by the tools that deploy the specification*, to assess second-order pragmatic quality.

The framework identifies a number of stakeholder groups: lifelong learners, learning designers, study advisors, educational providers, and software developers. The focus here is on pragmatic quality and the stakeholder groups of software developers and end-users. Even if the specification is to be used to describe informal learning paths as well, it is not evident that lifelong learners will do this themselves because of the reflective and learning design skills required to separate, for instance in workplace learning, the learning activities from actual work activities (Skule, 2004). We therefore expect learning paths to be described by trained professionals. These experienced users could be teachers, learning designers or study counsellors, who are employed by educational institutions or education and training brokers (Kilpatrick et al., 2007) to design curricula and provide study guidance to students. Or they could be human resource consultants and trainers employed by large companies and non-governmental organisations which make considerable investments in training and workplace learning. Finally, they could be professionals employed by local social services to advise the unemployed regarding opportunities for further professional or personal development. They all might want to document formal, non-formal and informal learning paths which seem interesting or have proved successful, so that they become readily available for the purpose of recommending them to others.

2.3. Pragmatic quality, usability and desirability

Pragmatic quality of a model is influenced by a number of characteristics (Janssen et al., submitted). Pragmatic quality is high when the model is:

a. unambiguous (i.e. concepts and relations have a clear single meaning);
b. internally consistent (i.e. the model does not contain contradictions);
c. general (i.e. concepts are as independent as possible from any specific application or domain).

Krogstie (1998) defines pragmatic quality as “the correspondence between the model and the audience’s interpretation of it”. He further distinguishes social quality as “agreement among participants interpretation” (p. 87). However, this distinction between pragmatic quality and social quality appears rather artificial if we take into account that it is highly unlikely that an audience’s interpretation fits the model when there is no agreement among the audience. We therefore prefer to consider agreement among participants as an indicator of the pragmatic quality of a model, more specifically of it being unambiguous. Others distinguish between technical pragmatic quality and social pragmatic quality, indicating whether the model is correctly (and easily) interpreted by tools and human users respectively (Nelson, Poels, Genero, & Piattini, 2005). This distinction resembles the distinction we made between first-order and second-order pragmatic quality, with this difference that clearly in our view technical quality involves human users, i.e. software developers.

The criteria identified above as indicators of pragmatic quality apply equally to first-order and second-order pragmatic quality, e.g. creating learning path descriptions will be easier when concepts used in the model and subsequent tools are general, clear and applied consistently. However, assessing pragmatic quality is not merely a matter of asking users how they evaluate the specification regarding these criteria. Though software developers will understand these criteria and will be able to identify a specification’s flaws related to these criteria at face value (i.e. merely by reading the specification), more flaws are likely to come to light in the process of building a tool that draws on the specification. Users involved in the assessment of second-order pragmatic quality can be expected to identify flaws in using the tool as well but, as was stated earlier, they cannot be expected to identify whether these flaws relate to the specification or the tool, nor to interpret them in terms of the rather abstract criteria of pragmatic quality in the same process. The model quality framework therefore suggests indicators like perceived ease of use, perceived usefulness, and intention to use as measurements of pragmatic quality. Indicators which are closely related to the concepts of usability and desirability (Benedek & Miner, 2002; Hornbæk, 2006; ISO, 1998). Whereas aspects like perceived usefulness and intention to use do not directly constitute an issue for the stakeholder group of software developers, they do become important with end-users. After all they may find it easy to use the specification, but if they see no added value in doing so, there is something amiss still with the pragmatic quality of the specification. The purpose of our study is not to evaluate the usability of the finished product (the Learning Path Editor), but rather the pragmatic quality of the Learning Path Specification. This then requires a more profound understanding of the rationale behind the Learning Path Specification: its intended use and desired effects. As Moody (2005) points out, the evaluation of a conceptual model is less straightforward than the evaluation of a finished product (a software system). Whereas a finished product can be evaluated against initial requirements, evaluation of a conceptual model/specification also involves (tacit) needs, desires, and expectations. The concept of pragmatic quality is thus linked not just to 'usability' but to 'desirability' as well.

Taking into account the above considerations the evaluation of second-order pragmatic quality involves a number of successive steps as will be further explained in the Method section.

3. Method

The Learning Path Specification's pragmatic quality was assessed distinguishing between first-order and second-order pragmatic quality (figure 5.3).

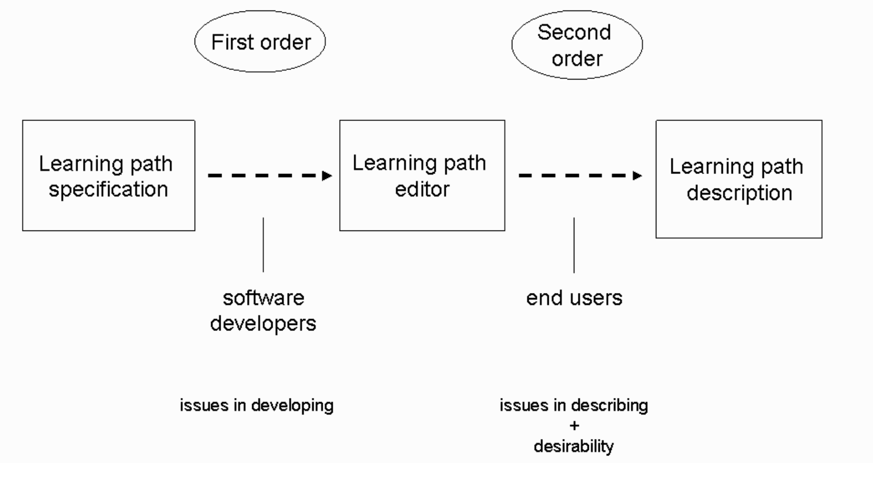


Figure 5.3. First-order and second-order pragmatic quality assessment

First-order pragmatic quality was assessed through the process of developing a reference implementation; in our case a tool that describes learning paths in line with the specification. The software developers involved in developing the tool had not been involved in the development of the specification. They had to rely on the information contained in the schema and the information model (Janssen, Hermans, Berlanga, & Koper, 2008). During this process some issues arose concerning the interpretation of the schema which lead to adaptations and a new release of the schema. These issues have been analysed and will be described in terms of the criteria for pragmatic quality in the Results section. Whereas first-order pragmatic quality was assessed basically by logging usability issues that arose during the software development process and analyzing these issues in terms of pragmatic quality criteria, second-order pragmatic quality was assessed beyond mere ‘usability’, incorporating the desirability of the approach and purposes implied by the Learning Path Specification. For this second-order quality assessment prospective users were invited to a hands-on workshop. The more detailed workshop proceedings are described in section 3.2, following a brief description of the Learning Path Editor in section 3.1.

3.1. The Learning Path Editor

The Learning Path Editor is a software programme that enables description of learning paths that are in line with the Learning Path Specification (Melero et al., 2010). The programme was developed to function as a portlet within the Liferay environment (Liferay, 2000) and consists of three different ‘views’ that correspond to different tasks related to the description of learning paths:

1. Handling of learning paths, i.e. keep an overview, choose to change existing learning paths or to create a new learning path (Master view);
2. Describing the characteristics of a learning path (Metadata view);
3. Modelling a learning path (Design view).

In the Metadata view (figure 5.4) the author enters a title and short description of the learning path and selects the competence levels which are attained upon completion of the learning path. The competence levels displayed in the metadata view are predefined and made available through another portlet within the Liferay Environment.

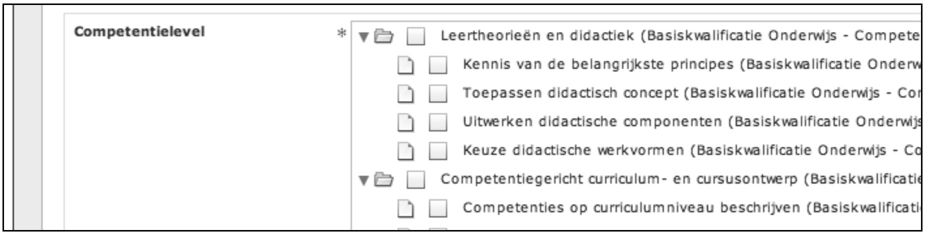


Figure 5.4. Learning Path Editor Metadata view: competence levels

Additional characteristics of the learning path used by learners in the process of searching a suitable learning path, e.g. language, costs, delivery mode etcetera, are specified through a form. When the necessary information has been provided the author clicks ‘save’ and returns to the Master view, which now includes the newly created learning path. For the actual modelling of the learning path the author clicks ‘Design’.

In the Design view (figure 5.5) the author can add actions or existing learning paths and group them in clusters to specify particular subsets, e.g. sequential ordering, choice options, etc. Note that the user has to specify whether the learning path (top level) constitutes a sequence, free-order (Dutch: 'selectie') or parallel grouping of learning actions.

Figure 5.5. Learning Path Editor Design view

To add an Action the author clicks the 'Add action' button. Next a dialogue box appears which asks to provide a title and a web address for the action. This web address may refer to all kinds of actions: a simple instruction to read a book, a complete course, a game or simulation, a test etc. The author can also choose to include existing learning paths in the design, for instance to express that a university degree is built up out of a bachelor programme and a master programme, each of which has been designed as a separate learning path (please note that we use an example from formal learning only because it makes for an easier explanation; this action applies to non-formal learning situations equally well, but is harder to describe as no commonly understood paths exist there).

To group actions and/or existing learning path descriptions into a cluster the author clicks 'Add Cluster' and again a dialogue box appears, in which she can specify what type of cluster she wants to create: Free-order, Sequence or Parallel (figure 5.6).

Once the cluster has been added the author can drag and drop the required actions to the cluster.

Figure 5.6. Learning Path Editor Design view: Add Cluster

As already mentioned, the Learning Path Editor was developed as part of the TEN-Competence integrated infrastructure, which aims at supporting lifelong competence development. To this end, the infrastructure comprises a set of services through portlets like the Competence Editor, Profile, and Activity Navigator. The Learning Path Editor interacts and depends particularly on two portlets: the Competence Editor, for creating standard competence descriptions, and the Activity Navigator, for the presentation of learning paths to learners.

3.2. Evaluation

First-order pragmatic quality was assessed in the process of developing the Learning Path Editor. Eventually six software developers worked more or less closely with the specification; four of them directly in relation to the Learning Path Editor and two from the perspective of presenting learning paths to learners through the Activity Navigator. Clarifications were requested on a number of issues, often involving extensive discussions, which led to several minor and some more profound adaptations of the schema (binding).

The evaluation of second-order pragmatic quality required some specific instrumentation. Workshop sessions were organised to find out if the specification was easy to understand and to use by end-users of the Learning Path Editor. For the workshop sessions a demo was developed that offered a brief explanation of the Learning Path Specification - its rationale and main features - followed by a demonstration of how an existing learning path can be described in the proposed way, using the Learning Path Editor (Janssen, 2010). As an example of a learning path, the Open University of the Netherlands Basic Teaching Qualification (BTQ) was used, because it seemed particularly suitable as an authentic case, which represents several requirements the specification is meant to meet (i.e. it represents a competence based, modular, nested learning path).

Participants (*n*=16) were recruited from two types of employees at the Open University of the Netherlands: those involved in advising students (study advisors), and those involved in designing learning (educational technologists). For the latter group an additional criterion was that they had no prior knowledge of Educational Modelling Language or IMS Learning Design, as such prior knowledge could help their understanding of the Learning Path Specification.

Participants were asked to watch the demo and to identify any unclear issues. Subsequently they were asked to use the Learning Path Editor to adapt the example learning path from the demo. The adaptations they were asked to make involved: 1. change the learning path so that an action that was part of a free-order cluster now becomes an action that can only be done after all the other actions of the cluster have been completed. 2. Add a last action 'Final Assessment'. 3. Indicate that the final assessment can be taken either in location X or in location Y. Each workshop session involved two participants who were instructed to work individually. Requests for support or clarifications were noted down for later analysis.

At the end of the workshop participants were asked to evaluate their experiences using the Online Desirability Toolkit (ODT) (Storm & Börner, 2009). The ODT is an online adaptation of the Desirability Toolkit developed by Benedek and Miner (2002). This Desirability Toolkit uses the product reaction cards methodology involving a set of 118 word cards, containing words like 'relevant', 'exiting', 'useful', 'stressful', 'time consuming', etc. Users were asked to pick a number of cards which most closely reflect their experience with the product. However, the particular selection of words is not that important: having selected the cards users were asked to explain their choice of cards in an interview. The cards merely function as prompts for these more in-depth explanations. This methodology allows users to describe and evaluate their experiences independent of any predefined notions, scales, criteria, etc. considered important by the researcher. The cards contain both 'neutral to negative' and 'positive' adjectives in proportions that reflect average results in usability studies of 60% positive and 40% neutral to negative feedback (Benedek & Miner, 2002). The Online Desirability Toolkit follows the same methodology: users were asked to select 6 cards from a total of 118 cards, which were now spread out on a screen rather than on a table. Having selected 6 cards users were asked to explain each choice in writing, rather than in an interview.

Though the Desirability Toolkit was designed for product evaluations, the particular features described above, e.g. leaving it to the users to decide which issues are relevant for the evaluation and stimulating negative feedback, make it a suitable instrument for our purpose of assessing pragmatic quality of the Learning Path Specification. In our study the Online Desirability Toolkit was used to ask participants to evaluate the 'approach of describing learning paths according to a specification as you have come to know it through the demo and the hands-on experience'. The data gathered during the workshop sessions were used as follows:

a. Questions and problems that arose during the introduction and hands-on session were recorded and interpreted in terms of the criteria clarity, ambiguity, and generality.
b. Online Desirability Toolkit data were used to assess the Learning Path Specification approach more generally: do prospective users consider it desirable to describe learning paths as proposed by the specification?

4. Results

4.1. First-order pragmatic quality

In the process of developing the Learning Path Editor several issues arose regarding the interpretation or use of the specification. These issues led to minor as well as more profound changes. Minor changes:

- For reasons of consistency the element LearningPathRef was changed into the element ExternalLearningPath and an ID was made mandatory for this element, as Actions and Clusters are also 'declared' separately and then referenced internally through an ID.
- In the first version of the schema metadata were grouped in a container element called Metadata. One of the software developers proposed to take the metadata element ID out of the container element, so that the related entity (Action, Cluster or Path) would become more directly accessible.
- The element Learning Actions as container element within the LearningActionsCluster element was removed because it appeared superfluous and therefore confusing. The schema now indicates that a LearningActionsCluster contains one or more LearningActionsRefs, LearningActionsClusterRefs, or ExternalLearningPathRefs.

Three more profound changes were made, of which the first two are related to the rendering of a learning path to students:

- The metadata element 'Title', optional in the first version of the specification, was made mandatory to enable proper rendering in the Activity Navigator.
- An attribute AdvisedOrder was added to the LearningActionsCluster, which provides information on how the Cluster should be presented to learners. The attribute specifies whether the order in which LearningActions are included in

the cluster is mandatory or merely recommended, enabling the author to indicate to what extent navigation of the actions ought to be restricted.
- The restriction that a LearningActionsCluster contains at least two elements was removed. Though there is some logic to the restriction, e.g. it hardly makes sense to define a group of 1, it is not necessary and indeed undesirable to specify such a restriction, as the Cluster element is also used to specify the overall ordering of a LearningPath and it should be possible to create a LearningPath consisting of a single action.

What we called minor changes are changes concerning the translation of the specification into this specific schema rather than the specification itself. The term 'specification' is somewhat confusing in this respect, as it is used both for conceptual models (e.g. a UML model) and the technical implementation of these models in a schema using a particular syntax, in our case XML (cf. Klein, Fensel, Harmelen, & Horrocks, 2000). As is the case in natural language, the things we want to express can be expressed in many different ways grammatically, representing different nuances perhaps, but still bearing the same message/meaning. Similarly, the minor adaptations made to the schema represent 'grammatical' or 'syntactical' changes. Nevertheless, even if we call these changes minor, they clearly brought about an important improvement in terms of pragmatic quality, in the sense that these changes made it easier for software developers to read, interpret, and deploy the specification.

4.2. Second-order pragmatic quality

Twelve participants thought the demo was clear and had no further questions concerning its contents. Four participants did have difficulties understanding the demo, more particularly the explanation of different ways learning actions can be grouped into clusters. One of them said she would need to see more examples. The other three felt it was just too confusing; that the terminology (e.g. 'sequence') was not clear, or that it was hard to make the mental switch of viewing things in this way. Interestingly though, one of these participants was actually the only one who correctly adapted the example learning path without any assistance. So although most participants considered the explanations provided through the demo satisfactory, they had difficulties making the adaptations to the learning path they had watched being modelled. Especially the first adaptation posed a challenge: re-design the learning path so that one of the learning actions included in a selection has to be done after the selection has been completed. Most participants moved the learning action so that it became the last action in the cluster, possibly confused by the demo which had explained that in a sequence the order the learning actions are shown in the cluster is the order in which they have to be completed. However, this is typically not the case for a free-order cluster. Adding an action ‘Final Assessment’ posed no problem, though several participants included the information on the location in the ‘description’ field, rather than in the designated field ‘Location’.

Following these experiences participants were asked to evaluate the approach of describing learning paths according to a specification, by selecting six adjectives they consider to best describe the approach and to further motivate their choice of words. Despite the large number of cards available, participants’ choice of cards showed some overlap.

Table 5.1 offers an overview of ‘positive’ and ‘neutral to negative’ words that were selected.

Table 5.1. Positive and neutral/negative words selected overall

Positive	***n***		**Neutral/negative**	***n***	
Usable	8		Organized	4	
Useful	7		Complex	3	
Helpful	5		Confusing	3	
Professional	5		Time consuming	2	
Timesaving	4		Hard to use	1	
Efficient	4		Uncontrollable	1	
Valuable	3		Too technical	1	
Appealing	3		Frustrating	1	
Customizable	3		Difficult	1	
Understandable	3		Patronizing	1	
Stimulating	2		Unpredictable	1	
Attractive	2		Integrated	1	
Accessible	2		Personal	1	
Clear	2		Controllable	1	
Relevant	2		Secure	1	
Convenient	2				
Easy to use	2				
Effective	1				
Essential	1				
Flexible	1				
Advanced	1				
Low Maintenance	1				
Comprehensive	1				
Inviting	1				
Desirable	1				
Inspiring	1				
Innovative	1				
Impressive	1				
Friendly	1				
Simplistic	1				
Motivating	1				
Total	73	(76%)		23	(24%)

Table 5.2 shows the selection of negative/neutral words across participants and indicates that the majority of participants selected no (*n*=3) or a single (*n*=7) negative/neutral card.

Table 5.2. Number of negative/neutral words selected by participants

Number Negative/neutral	n
0	3
1	7
2	4
3	1
4	0
5	1
6	0
Total	16

However, rather than the exact choice of words, the motivations provided for these choices matters. The term ‘organized’, for instance, is a neutral term which was chosen by four participants, one of whom motivated the choice in a way that indicates the adjective was interpreted as a positive characteristic: ‘*well considered and set up*’. This explains why, for instance, the word ‘simplistic’ does not appear in the ‘neutral to negative’ column, as the motivation provided with this adjective was quite positive. The participant who chose this word, in fact provided two different positive motivations for this adjective: ‘*easy to maintain’* and ‘*making it easier to find suitable learning paths*’.

There are more incidences of participants giving more than one reason for choosing a particular adjective, so that numbers in the following analysis of motivations may diverge slightly from the numbers provided in table 5.1.

Analysing the motivations or explanations provided in words, it appears that participants have selected adjectives in connection with four different issues:

1. *General perception of the approach and its intended effects*
a. Positive evaluations (*n*=17): useful (3x), usable (2x) (‘*with respect to the goal*’), attractive (2x) (‘*many will easily understand the benefits*’), appealing (2x), advanced, time-saving, stimulating, relevant, innovative, convenient, flexible, stimulating;
b. Neutral/negative evaluations (*n*=4): patronizing (‘*less easy to customize because of use of standards*’), integrated (‘*everything is connected*’), organized, time-consuming (‘*the idea is good, but implementing it will be time-consuming’*).

2. *The impact of the approach on the provision of learning paths*
a. The provision of information on offerings becomes more structured (*n*=9). This particular effect was described as: organized (3x), time-saving, controllable, efficient, relevant, understandable, professional.
b. The information provided can be easily adapted (*n*=4): low maintenance, usable, customizable, and simplistic (*'easy to maintain'*).

3. *The impact of the approach on learner experiences*
a. It will become easier for students to find suitable learning paths (*n*=15). Participants selected the following adjectives to express this: efficient (2x), useful (2x), appealing, accessible, usable, professional, time-saving, organized, usable, simplistic (*'easy to find required information'*), convenient, helpful, and valuable.
b. Learners get an overview of their learning path and how to follow it (*n*=24): helpful (4x), efficient (3x), useful (2x), organized (2x), understandable (2x), valuable (2x), effective, easy to use, motivating, customizable, usable, controllable, relevant, desirable, inspiring.

4. *Workshop experiences: demo and adaptation of learning path*
a. Positive evaluations (*n*=17): usable (4x), professional (3x), customizable (2x) (*'easy to manipulate', 'you can add a lot of information')*, easy to use (2x), friendly, accessible, understandable (*'it is easy to use'*), useful (*'easy to work with'*), inviting, comprehensive ('*everything I needed was more or less on the same screen*').
b. Neutral/negative evaluations (*n*=13): complex (3x), confusing (3x), uncontrollable, too technical, difficult (*'it takes time to learn'*), frustrating, hard to use, time-consuming (*'in the beginning'*), secure (*'requires precision'*).

The above categorization of motivations makes clear that end-users have not only understood the main purposes of the specification, but also find them desirable: expected impacts of the approach on provision of learning paths as well as learner experiences are solely described in positive terms. Though the workshop experiences were often evaluated in positive terms as well, participants were divided as to how easy it is to model learning paths using the specification's building blocks. The main problem concerned the interpretation and modelling of cluster types. Though it was regularly mentioned that it would be merely a matter of time to become acquainted with the approach and to develop some routine, we also concluded that the specification would become easier to understand if the term originally used to indicate a sequence of activities ('sequence') would be replaced by 'fixed order'. So the values of the attribute 'cluster type' were changed to 'free-order', 'fixed order', and 'parallel'.

5. Discussion

The Learning Path Specification's pragmatic quality was evaluated in two distinct steps. As always 'the proof of the pudding is in the eating', but it is the cook who gets to taste first. In the case of the Learning Path Specification software developers were the first to 'get a taste' of the specification in the process of developing tools that enable description and presentation of learning paths based on the specification. First-order pragmatic quality of the specification was assessed in the course of this process. Second-order pragmatic quality was evaluated through workshop sessions involving prospective users of the Learning Path Editor.

Adaptations made to the specification in the course of both evaluations illustrate how different aspects of quality are intricately connected: both syntactic and semantic quality issues may be discovered in the process of assessing pragmatic quality, and once resolved clearly contribute to improved pragmatic quality as well. As was stated already in developing the framework for the evaluation, syntactic quality and semantic quality precede pragmatic quality. If a specification lacks clarity or completeness or if it is poorly expressed in UML, XML or any other language, this will affect pragmatic quality, i.e. whether the specification is (easily) understood. In other words, semantic quality and syntactic quality are a prerequisite (but not sufficient) condition for pragmatic quality. However, paradoxically, some semantic and syntactic flaws are likely to become visible only in the process of deploying the specification. This means that the evaluation of model quality is inevitably an iterative process.

Duval and Verbert (2008) formulate the rule of thumb that a specification should be implemented at least by two independent development teams and evaluated in at least two independent user studies before it is ready for a process of standardization. Our study clearly indicates that both perspectives (implementation and user studies) are invaluable in the development of a specification. First-order pragmatic quality assessment (implementation) and second-order pragmatic quality assessment (user study) provide quite different results and insights. As for the criterion that these implementations and user studies should be independent, the question arises what exactly is meant by 'independent'. In our study some 'independence' was achieved by making sure that the software developers involved in the implementation of the specification had not been involved in the development of the specification. However, the evaluations and adaptations were instigated and carried out by the people who developed the specification. In practice it will be very hard to maintain a strict independence here as it requires a profound understanding of the specification and its aims. Third parties are not likely to engage in the process of implementing and evaluating the specification unless they have the same or similar aims.

A specification such as the Learning Path Specification is meant to be implemented in a number of different tools. Experiences with the development and deployment of tools designed to find, adapt, and present learning paths will lead to further evaluations that can enhance the quality of the specification, be it by independent third parties or by the team who developed the specification.

Chapter 6

General Discussion

'Education is about the provision of learning whereas learning is about consumption.' *(Jarvis, 2002, p. 60)*

The work presented in this thesis was inspired by the question 'How can we support lifelong learners in finding learning actions and learning paths that best meet their needs?' We started from a learner (consumption) perspective, rather than a provider (provision) perspective. This approach has led the Learning Path Specification to distinguish itself from other specifications that aim to describe learning opportunities or learning objects to support retrieval and reuse of learning opportunities or learning objects, such as IEEE LOM, Dublin Core Education Application, XCRI, MLO-AD (DCMI, 2006; IEEE/LOM, 2002; MLO-AD, 2008; XCRI, 2006).

The Learning Path Specification is meant to support way finding in formal, non-formal and informal learning. The benefits of using the specification would augment if the Learning Path Specification became more widely adopted, as this would offer the added value of exchange of learning paths between institutions and systems. Discussing ways forward for lifelong learning Colardyn (2002) states that not only the visibility but also the portability and transferability of any form of learning should be ensured to further the European lifelong learning agenda. The Learning Path Specification could support this agenda if it became widely used, i.e. if it were to develop into a standard. In this final chapter we discuss the work presented in this thesis, its strengths and weaknesses, simultaneously assessing the prospects of the Learning Path Specification to become widely adopted.

So what are the chances that the specification will be widely considered a good way forward? Rogers (1995) identifies five perceived characteristics of an innovation which affect its chances of gaining adoption:

1. *Relative advantage*: the innovation is perceived as having an advantage compared to the current situation
2. *Compatibility*: the innovation is perceived as consistent with existing values, past experiences and needs of potential adopters
3. *Complexity*: the degree to which an innovation is perceived as difficult to understand and use
4. *Triability*: the degree to which an innovation may be experimented with
5. *Observability*: the degree to which the results of an innovation are visible.

In the remainder of this chapter we will discuss the Learning Path Specification with respect to these characteristics, drawing both on our own findings and related research areas.

Relative advantage

The approach proposed by the Learning Path Specification has several advantages over the current situation and indeed related specifications. The first and principal advantage of the Learning Path Specification is that it facilitates comparison (hence selection) of a learning path as well as navigation through a learning path in an automated way. A second advantage lies in the fact that the Learning Path Specification proposes to draw on standard competence descriptions (Kickmeier-Rust, Albert, & Steiner, 2006; Van Assche, 2007), which furthers not only comparison but also exchange. Current, provider-based, way finding support focuses on catalogue information such as course titles, subject descriptions, and difficulty levels. It is also led by marketing considerations: providers of education and training seek niche markets to distinguish themselves from others. Though this may help to cover the needs of the knowledge society and its demands for increased provision and diversity, it does not help to increase transparency regarding exchangeability of offerings.

Thirdly, the learning path metadata provide scheduling information. As the results of the study described in chapter 4 indicate, this information is paramount in establishing suitability of a learning path. Existing metadata standards like LOM (IEEE/LOM, 2002) and the Dublin Core Education Application Profile (DCMI, 2006) do not include scheduling information. Other specifications that enable descriptions of learning opportunities (XCRI /MLO AD) do include scheduling information, but focus on the selection of formal courses and programmes rather than on provision of navigation support through a programme, as the Learning Path Specification does.

This brings us to the fourth distinguishing characteristic of the Learning Path Specification: it is sufficiently generic to include informal and non-formal learning. The generality of the specification becomes clear, for instance, in the use of element labels such as ‘workload’ to express the number of hours it takes to complete a learning path, rather than ‘study hours’ or ‘credits’. Equivalent credits can easily be derived from the hours it takes to complete the learning path (EC, 2009). The specification does of course require that learning paths are described in terms of specific competences and proficiency levels which they help to attain. Even learning that was not intentional, could in hindsight be described in terms of the actions that contributed to particular learning outcomes. The advantages of documenting informal learning paths, or learning paths that consist of a combination of formal, non-formal, and informal learning, could serve a variety of purposes, such as storage in an e-portfolio, as learning evidence, or storage in a repository in order to make them available as an example to others.

Studies in the field of knowledge management and workplace learning use the term codification (Bartholomaei, 2005; Foray & Lundvall, 1998; Kessels, 1999; Sørensen & Snis, 2001; Unwin et al., 2007). '*Where pedagogical practices are visibly encouraged and valued in workplaces, they may be underpinned by the codification of relevant knowledge and skills into a workplace curriculum. Typically this will take the form of workbooks for apprentices, training manuals and other artefacts*' (Unwin et al., 2007, p. 339). The Learning Path Specification could be taken as an instrument to codify a particular kind of knowledge: knowledge about pathways to personal competence development. This way unarticulated, not yet codified, tacit knowledge becomes available as *information* to others (Boekhorst, Koers & Kwast, 2000). Both the production and interpretation of codified knowledge requires a codebook (Bartholomaei, 2005). The Learning Path Specification could be considered just that: a codebook for the codification of learning paths. The added value of using a learning path specification for the codification of a workplace curriculum again lies in the fact that it provides links with formal competence descriptions, thus contributing to visibility and transparency of workplace learning. As Fuller and Unwin (2003) have pointed out, both the mapping of knowledge, skills and tasks in a workplace curriculum, and the codification of knowledge and competence in formal qualifications, are important sources of reification (concretisation) of learning.

Further research is needed to shed light on the question to what extent the Learning Path Specification is perceived to offer relative advantages by various stakeholders in the context of workplace learning, e.g. employers, employees, human resource managers, training providers.

Our evaluation of second-order pragmatic quality (the extent to which end users consider it desirable and doable to describe learning paths according to the specification) showed that potential end users of the Learning Path Editor clearly perceived relative advantages, especially the fact that a learning path specification enables comparison of learning paths on relevant characteristics as well as provision of automated navigational support (chapter 5). Some of them expressed a confidence that the benefits were obvious, judging by comments like: "Many will easily see the benefits", or "This is the innovation students have been waiting for". Several participants commented that description of learning paths in line with the specification will be time-consuming. However, in formal education the information needed to describe learning paths has to be provided for diverse purposes. When this information is described in XML, using the Learning Path Specification, it can be reused in many contexts, e.g. search engines, marketing, course catalogues etc. Some participants seemed to perceive this advantage by describing the approach as low maintenance pointing out that the structured and uniform description of this information makes it easier to update.

Compatibility

To what extent can the Learning Path Specification be considered as consistent with existing values, past experiences and needs of potential adopters? The need for navigational support became clear through other studies, most notably studies regarding student drop-out (chapter 2). The initial solution, providing recommendations based on collaborative filtering, made clear that provision of navigational support helps to foster learner progress. Additionally the Learning Path Specification was developed to enable to describe learning paths and to define relations between learning actions.

Trying to establish to what extent the Learning Path Specification is consistent with needs of potential adopters is less straightforward, and carries a risk not uncommon to needs assessment generally. This is perhaps best illustrated by a well known tale of a bygone era, which recounts of two employees of a shoe manufacturer, who are sent to Africa to investigate the market. Whereas the first employee reports back: 'In these parts people do not wear shoes, so no market for us here', the second one concludes 'People here hardly wear shoes, yet: great market potential!'

A similar ambivalence was visible in our study of lifelong learners' decision making processes (chapter 4): if we had drawn conclusions solely on the base of an investigation of current practice of selecting a learning path, we would have underestimated lifelong learners' information needs, because quite regularly information was not taken into account simply because it was not available. Extending the investigation using aided recall and information needs more generally, led us to conclude that the learning path characteristics included in the specification are relevant. Besides, it made clear that additional scheduling information (contact-time) was required to further enhance the specifications compatibility with learners' information needs.

Finally, our evaluation of second-order pragmatic quality of the Learning Path Specification (chapter 5) revealed that study advisors and learning designers clearly consider the specification to meet learners' needs for navigational support, both in selecting and following a learning path.

However, when it comes to adoption of the Learning Path Specification, learners, learning designers and study advisors are not the key agents at the outset. Rather, this will be experts and organisations that are directing the future of education and learning in Europe. Important questions concerning the role of these potential adopters are still unanswered. Given the fact that the knowledge economy encourages competitiveness too in the realm of educational and training, one question that arises is how reluctant providers will be to offer as much transparency as the Learning Path Specification requires. However, despite the competition, calls are heard as well for further collaboration, for example in a recent White Paper published jointly by CAUDIT, EDUCAUSE, JISC, and SURF, “The Future of Higher Education: Beyond the Campus” (CAUDIT, EDUCAUSE, JISC, & SURF, 2010). This report mentions developments such as “above the campus” provisioning of technology and associated services, and increased openness and transparency of developing structures and sustainability models. According to the authors some of these developments mean that institutions need to focus more on access than on ownership. Open educational resources potentially change the way higher education is delivered. Though the move towards open educational resources still faces some hurdles, for instance because the sources and oversight of resources vary considerably, it is expected to free institutions to shift their focus from developing educational content to programs and activities that improve competence development. Against this background it will be interesting to see which lessons can be drawn from further deployment of the Learning Path Specification and Editor in the context of the Open Educational Resources initiative of the Open University of the Netherlands.

Trying to assess the compatibility of the Learning Path Specification with values and past experiences of potential adopters we can not ignore the fact that so far, standards have not been uncontroversial: ‘*On the one hand, cost-reduction, secure investments, and new market potentials are expected. On the other hand, there is the fear of limitations for creative solutions. Standards are often misunderstood, especially in the education community. They are perceived as restricting flexibility or creativity or huge additional effort.’* (Ehlers & Pawlowski, 2006, p. 5).

Though this controversy was not paramount in our evaluation of second-order pragmatic quality, one of the study advisors did select the adjective ‘patronizing’, explaining his choice by saying that it will become less easy to customize learning paths because of the use of standards.

With Ehlers and Pawlowski we maintain that it is a misunderstanding to think that standards reduce flexibility. However, it seems crucial to further probe these opposing views, and to ask what we and others mean by flexibility: flexibility of what and for whom? The fear that technology may restrict individual creativity and personal influence is to some extent understandable. Learning technology standards have been developed to increase flexibility, but with the further aim of increasing efficiency. This means that although the technology in itself increases flexibility, actual deployment policies often place the technology in the context of increasing efficiency, streamlining, etc. Computer-supported customization of learning paths is a case in point, leading to concerns such as: What happens when a learner wants to negotiate exceptions regarding specific learning actions? We would maintain that the Learning Path Specification and standards more generally, are not meant to deal with or solve exceptions. In this respect nothing changes: the learner will still have to get in touch with a study advisor, tutor, or other intermediary. However, this example also illustrates that it is a misunderstanding that standards are restrictive, though policies surrounding them might be, for instance, when the learner from our example has nowhere to turn to with her request.

The Learning Path Specification increases flexibility for learners, for instance in the sense that it facilitates exchange of learning actions and paths by linking them to standard competence descriptions. Besides, the specification offers flexibility in describing and combining formal, non-formal, and informal learning. We already identified this point as a distinguishing feature. Finally, chapter 5 explained how the specification ensures that learning paths can be modelled in a flexible way because learning actions are not strictly connected with competences. This deliberately reflects the fact that in practice learning actions tend not to be linked to competences in a simple 'one on one' base, and enables to even define learning actions that leave it to learners to decide upon the learning outcomes they want to achieve. Though internal validity of a learning path is of course a point of concern, research indicates that a rigid internal logic which prevents integration of actors' interests, values, and beliefs potentially undermines external validity (Kessels & Plomp, 1999).

Paradoxically, enabling this kind of flexibility implies that in order to achieve a different kind of flexibility, e.g. automated adaptation of a learning path based on prior learning or exchange of particular elements between learning paths (cf. chapter 1: 'boarding on another train'), relevant parts have to be modelled as learning paths within the overall learning path in order to enable strict matching based on attained competence levels.

So the Learning Path Specification offers and supports flexibility in a variety of ways. Nevertheless, we should keep an open mind to potentially restrictive effects in the use of technology. In the case of the Learning Path Specification and indeed the recommender system described in chapter 2, for instance, further research is needed to establish how navigational support regarding learning paths or a next step in a learning path is best presented. Although recommendations are optional, leaving it up to learners whether or not to the follow the advise provided (Drachsler, 2009), they may be restraining in other respects, which need further clarification. It is not really clear, for instance, whether learners would prefer to be presented a number of options, call it a 'prepared choice', rather than a single recommendation. Nor is it clear how much information should be provided along with a recommended option and possible alternatives. As we have pointed out elsewhere (Janssen, Berlanga, & Koper, 2009), navigational support is meant to reduce learners' disorientation, but should still enable self-directed learning: "a form of study in which learners have the primary responsibility for planning, carrying out and evaluating their own learning experiences" (Merriam & Caffarella, 1991, p. 41). Further research is needed on how recommendations and learning paths can be best presented so that they help learners develop a structural representation of the knowledge domain (Chen, Fan, & Macredie, 2006) and/or competence map.

This brings us to another controversy and therefore potential compatibility issue, which concerns the fact that competence-based education and learning has not been undisputed (Betts & Smith, 1998; Kessels, 1999; Voorhees, 2001). However, though the learning path proposes to rely on standard competence descriptions, any other approach to the definition of learning outcomes could be used as well. Hence, we do not believe a real compatibility issue exists here.

Complexity

Prospective end-users do not consider the specification complex when it is explained to them, but tend to change their mind when they actually try to work with it (chapter 5). The clustering of learning actions, in combination with the fact that overall a learning path represents a cluster too, appeared somewhat difficult to grasp. However, participants tended to regard this indicative of a need for more examples and more practice to acquire some routine. The basic cluster types are fairly easy to understand. It is the nesting of clusters that proved challenging. In this respect it should be noted that the Learning Path Specification alone does not enable modelling of complex learning paths that require specification of rules (e.g. learning action A is selected from cluster B, it should no longer be presented in cluster C). For this a rule language is required in addition (Oussena & Barn, 2009).

Though the Learning Path Specification itself is not very complex, our experiences in the course of designing and piloting studies for the evaluation of the Learning Path Specification have made us aware that a description of informal learning paths is not an easy task to perform by learners themselves, due to the fact that it requires both sufficient distance to reflect on the learning path and the skills to distinguish between learning actions and learning outcomes, in sum learning design skills. An interesting line of inquiry would be to what extent learning paths can be derived in a semi-automated way, for instance, from portfolios.

Triability

We expect perceived triability of the Learning Path Specification to be very low for a number of reasons. First of all providers will be reluctant to try it out unless it becomes clear that a critical mass can be attained. Secondly, the Learning Path Specification does not stand on its own. This has become clear, in particular, in the description of the Learning Path Editor; its integration in a wider infrastructure, for necessary interactions with portlets (services) that have been developed for the description of competences and the presentation of learning paths to learners. However, further deployment of this TENCompetence/Liferay infrastructure, as for instance the case in the Open Educational Resources initiative, can set an example and encourage others to follow. Triability would certainly increase if these services were provided 'above campus' (CAUDIT et al., 2010) and made freely available. 'Above campus' provision will be a necessity at any rate as the way finding problem extends beyond a single institution and even country. Ideally, other services are provided alongside, e.g. services that enable enrolment, accreditation, development of joint programmes, etc. (Pawlowski & Adelsberger, 2002). Our investigation of lifelong learners' information needs (chapter 4) indicates that services enabling use of subjective metadata (Hodgins, 2006; Manouselis & Vuorikari, 2009) would be appreciated too.

Observability

In the introductory chapter of this thesis we referred to specifications and standards as 'hidden technology'. Heddergot (2006) notes in this respect: *"Discussing standards in e-learning means talking about a matter, that mostly cannot be recognised at first sight – from a learner or customer view, one is talking about an "invisible subject". Generally, most standards are for developers only. (..) this is because most benefits of standards indeed are created underneath in the thicket of markup languages." (Heddergott, 2006, p. 185)*

In fact our research design demonstrates the fact that the observability of the Learning Path Specification is low. Chapter 5 has made clear how the lack of observability of the Learning Path Specification affected our evaluation of pragmatic quality. It led us to distinguish first-order and second-order pragmatic quality in relation to two types of users: software programmers who use the specification in a direct way and end users who engage with tools that are developed to deploy the specification. Besides, it led us to evaluate second-order pragmatic quality using both a demo and the Learning Path Editor. The demo was needed to communicate the purpose and intended use of the specification. A point of concern regarding the evaluation of second-order pragmatic quality was how to make sure that it would be an evaluation of the specification, rather than this particular implementation: the Learning Path Editor.

Duval (2004) discusses this problem stating: *"A difficult problem is that specifications cannot be validated with end users as such. Rather, the interoperability specifications will give rise to specifications of software tools that will offer a set of functionalities to the end user. (..) End users can then make use of the tool in prac-*

tice and that use can be evaluated. The evaluation results need to be analyzed in detail to assess whether eventual problems are caused by the interoperability specifications, or rather by the functionality provided by the tool or the user interface through which the functionality is made available to the end user. This is clearly a complicated task, and standards development is often hindered by a lack of experimentation of this kind." (Duval, 2004, p. 37).

Though we agree with Duval's problem analysis, we have not chosen to restrict our evaluation to use of the tool, but to extend the evaluation to the specifications wider purposes (chapter 5). This makes sense not only because use of the tool, the Learning Path Editor, represents only an 'intermediate' step (i.e. describing learning paths with a further aim), but is also in line with our perception of a specification as a conceptual model (chapter 4). After all, one of the purposes of a conceptual model is to enable communication (Moody, 2005). This approach implies that the results of an innovation may not be observable yet, but might still be anticipated. Our approach enabled us to gather data on usability as well as desirability, though a limitation of our data concerns the fact that the hands-on experiences of participants have not been very extensive. Further deployment of the Editor involving a varied range of learning paths could still raise new issues.

In sum, our reflections on the Learning Path Specification in relation to five perceived characteristics influencing an innovations chances of gaining wide adoption, lead us to a number of conclusions.

Firstly, the specification has a number of relative advantages compared with the current situation: it supports selection and comparison of learning paths in an automated way, facilitates exchange by linking learning paths to standard competence descriptions, provides scheduling information that otherwise requires considerable effort to find, and enables descriptions of formal, non-formal, and informal learning paths or any combination of these. Perhaps a more important question though is: advantages to whom and at whose expense? While providers should benefit from the use of a learning path specification as it is expected to increase efficiency (by reducing the costs of study guidance) and to increase effectiveness (by increasing retention), it also requires some investments on their part. For learners there only seem gains involved, though they might be charged higher fees for better service.

Secondly, the specification is in line with lifelong learners' information needs, and is considered to address an existing, strong need for way finding support. Our investigation of lifelong learners' information needs showed that the learning path characteristics identified by the specification are central to the process of selecting a learning path. Study advisors and learning designers who worked with the Learning Path Editor welcomed the structured approach and the opportunities it opens up.

Thirdly, although the specification itself is not very complex, its dependencies, e.g. on competence descriptions, presentation tools, etc., might result in low triability of the specification. However, it could still be interesting for a single larger institution to adopt the approach for the benefit of providing automated navigation support to its learners. In any case 'above Campus' provision and triability of the infrastructure would help lower the barriers for experimentation.

Fourthly, if the Learning Path Specification is going to gain adoption, it will still be a long way before the results will become observable. However they can be made visible and communicated as anticipated results, prior to their realisation. An evaluation of end users experiences with the Learning Path Editor, for instance, makes little sense unless further purposes and future results are explicated.

Finally, we have identified a number of areas for follow-up investigations: further validation of the Learning Path Specification in the context of workplace learning; integration of the Learning Path Specification in recommender systems; the presentation of learning paths and learning path recommendations in a way that helps learners develop a structural representation of a particular area of competence development; extended evaluations of the Learning Path Editor including a broad variety of learning paths; possibilities of semi-automated generation of learning paths.

The field of learning technology specifications and standards is a tremendously rich learning environment. Painstaking though it may be to work these fields, it offers plenty of opportunity for personal competence development; take patience, for instance. It requires patience and meticulous attention to read, interpret, translate, and discuss requirements, models, and languages back and forth. At the same time this is perhaps the most rewarding aspect of this line of work: the fact that it is a joint effort, involving many different stakeholders, aiming for goals far into the future, which appear worth the effort. We are not building a tower into heaven; we are merely re-claiming the use and convenience of a common language.

Genesis 11:6, *"If as one people speaking the same language they have begun to do this, then nothing they plan to do will be impossible for them."*

APPENDIX

Learning Path Information Model

Version 1.3
March 2010

Janssen, J., Hermans, H., Berlanga, A.J., & Koper, R. (2008). Learning Path Information Model. Retrieved from http://hdl.handle.net/1820/1620

1. Introduction

The European TENCompetence Integrated Project (TENCompetence, 2005) focuses on building an infrastructure for lifelong learning. This entails for instance development of tools to support lifelong learners in finding suitable ways to develop themselves professionally or personally, in a formal educational setting or informally, etcetera. A learning path can be defined as a set of one or more learning actions that help to achieve particular learning goals. In order to support lifelong learners in finding, comparing, selecting, and navigating learning paths that best meet their needs, it is necessary to describe them in a formal and uniform way (Janssen, Berlanga, & Koper, 2009). For this purpose a learning path specification was developed which aims at describing both the contents and the flow of any kind of learning that takes place, be it formal, non-formal, informal, or a mixture of these. Whether or not a learning path meets the needs of a learner does not solely depend on its learning goals, but is determined by a mixture of variables: learning goals, delivery mode, planning, costs etc. A need for the specification was felt, for instance, in a pilot from UNESCO in which competence development plans (i.e. learning paths) were modelled based on existing modules. Some of these modules had to be studied in a fixed order, others could be studied randomly and again others represented a choice. The specification enables to organise these types of structures and represent them to learners for navigation purposes. Requirements for this specification have been formulated based upon a review of literature on curriculum design and an analysis of different approaches to support selection of courses and programmes (Janssen, Berlanga, Vogten, & Koper, 2008). The same study revealed that we might draw on the existing IMS Learning Design specification (IMS-LD, 2003) to describe learning paths. However this would entail including a number of constructs which the Learning Path Specification itself does not require, but which are needed to ensure compliancy with IMS-LD.

Eventually, it was decided not to use a subset of IMS Learning Design to specify learning paths but to develop a new 'lean' specification. A new learning path model has been developed, less closely connected to IMS-LD and its terminology. The Learning Path Specification has clear links with IMS-LD, but distinguishes itself from this specification because it does not provide a detailed description of the actual learning process: the activities, assignments, and materials involved. Instead the Learning Path Specification is a vehicle to connect 'units' (i.e. learning actions) that describe learning processes and activities in more detail. A unit or learning action might be an IMS-LD unit-of-learning, but might also be a workshop, a manual, a video, a classroom course, a blog, and so forth. The specification intends to organise learning actions into learning paths and to provide 'meta-metadata' as it were over the entire path, following the premise that the whole might be greater than the sum of its parts. Though existing specifications like IEEE-LOM (2002), DCMI (2006), CDM

(2004), XCRI (2006), MLO-AD (2008) which aim at description of learning objects, learning opportunities, courses, programs, etc., may also be used to describe relations between 'units' their main focus seems to be on 'units' and on formal learning.

The revised conceptual (UML) model presented in section 2 looks different from the initial model but has not changed fundamentally. The new model shows more explicitly that a learning path has a start (formerly 'prerequisites') and a finish (formerly 'learning objectives') which are to be defined in terms of competences at particular levels of proficiency. A learning path further defines one or more learning actions that lead from the start to the finish, i.e. to attainment of specific competences at specific levels. Each action is further described by a set of metadata specifying content, process, and planning information (e.g. title, description, assessment, tutoring, delivery mode, attendance hours). These metadata are assumed to play a role in learners' processes of choosing a learning path. Their (relative) importance is currently investigated through semi-structured interviews with lifelong learners who recently have been searching for suitable learning opportunities. The results of this study may lead to adaptations of the learning path metadata in a next version of this document. The underlying document first describes the conceptual model of the Learning Path Specification (section 2). This model has been transformed into an XML schema using the Free Community Edition of the Liquid XML Studio 6.1.18.0 software. The more detailed information model of this schema is described in section 3. Finally section 4 addresses several deployment issues.

2. Conceptual Model

The basic pattern for learning paths is that a path has a start and a finish and describes the steps that must be taken to reach the finish. As figure 1 illustrates, a **LearningPath** describes a set of 1 or more LearningActions, including the way they are related, leading to attainment of a set of one or more **CompetenceLevels** which constitute the path's **Finish**.

CompetenceLevels specify competences at a particular level of proficiency. So the Finish, i.e. the targeted endpoint of a Learning Path is defined in terms of competences with related proficiency levels. Competence is defined as the ability of a person to act effectively and efficiently in an ecological niche (e.g. occupation, hobby, sport, etc.). The methodical description of competences and subsequent proficiency levels is out of scope for the Learning Path Specification: the model assumes that competences and their levels are described elsewhere and can be referred to internally by the *Id* attribute and externally by the *URI* attribute. Section 4 briefly discusses the implications of this choice for deployment of the specification.

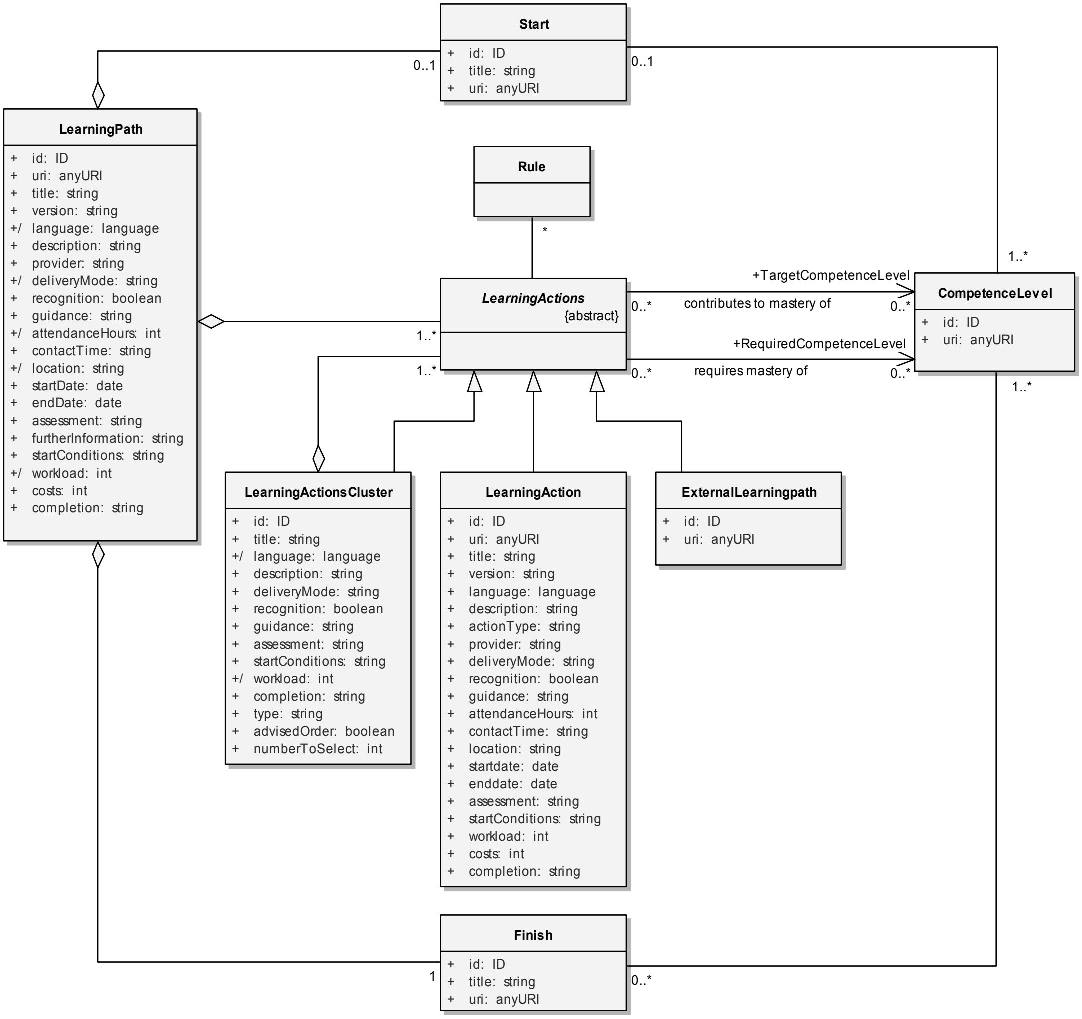


Figure 1. LearningPath conceptual model

Whereas specification of the path's Finish is mandatory, specification of prerequisite competence levels by defining a Start remains optional. Note that both Start and Finish could be as elaborate as a job profile.

Most importantly a LearningPath specifies the steps that have to be taken to reach the Finish: the **LearningActions** that lead to attainment of the CompetenceLevels one aims for. LearningActions can be:

a. an existing learning path: **ExternalLearningPath**;
b. a **LearningAction** (e.g. 'take workshop X', 'do course Y', 'consult expert Z', 'read manual A');

c. a **LearningActionsCluster** (e.g. 'choose one action out of the following set of actions', 'complete action X before you do action Y').

A LearningActionsCluster can be of different *types*: the LearningActions it contains may constitute a free order, a sequence or a set of actions that have to be performed in parallel. Each LearningAction may contribute to mastery of one or more CompetenceLevels and may require mastery of one or more Competences at particular levels of proficiency.

Certain **Rules** may pertain to inclusion of LearningActions in the LearningPath, e.g. LearningAction X is only an option if choice X is made earlier in the LearningPath. Expression of these Rules is out of scope of the Learning Path Specification and will require reliance on a script language.

LearningActions and LearningPaths are further characterised by a number of metadata: the attributes of the classes in figure 1. Some of these metadata are compliant with the IEEE Learning Object Metadata (IEEE/LOM, 2002) (e.g. *identifier, title, language, description, version, typical learning time)* while others are specified in addition (*URI, provider, start conditions, recognition, delivery mode, guidance, location, start date, end date, attendance hours, assessment, further information, completion, type, number to select*).

Based on figure 1 we developed a LearningPath XML binding (schema) to have an interoperable format to describe and interpret learning paths. The metadata of the LearningActions are included in the XML binding, for they represent information on the LearningActions *in the context* of the particular LearningPath they constitute part of. The schema will be described in the next section.

3. Information Model

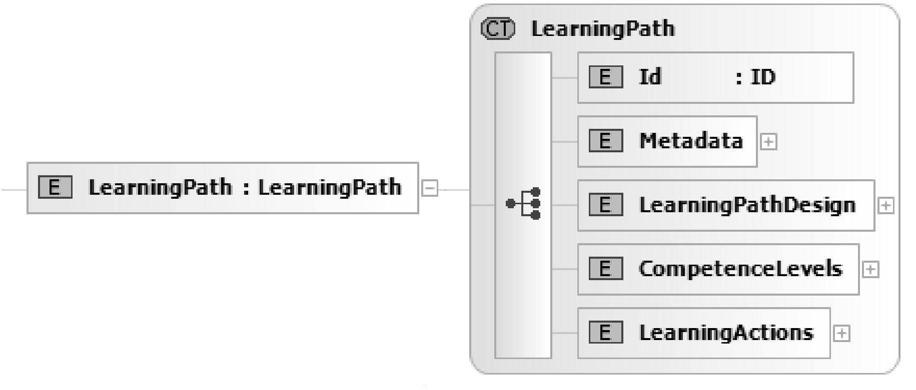
The LearningPath XML schema is based on the UML conceptual model but is not an exact match. For pragmatic reasons some regrouping has been done. For instance, the attributes from the UML model have been grouped in a container element 'Metadata' in the schema. Start, Finish and LearningActions have been grouped in an element 'LearningPathDesign'. Thus at the highest level the schema distinguishes between:

1. Metadata - providing information about the LearningPath
2. LearningPathDesign – describing the structure of the LearningPath
3. CompetenceLevels – the stepping stones constituting a blueprint for the LearningPath Design
4. LearningActions - the actual steps the LearningPath proposes to the learner (in an order specified in the LearningPathDesign).

In other words: CompetenceLevels and LearningActions constitute the 'ingredients' of the LearningPathDesign. The LearningPathDesign can be considered the 'recipe' that describes how and in which order the ingredients are mixed.

The schema will be explained by presenting information tables for each of the elements mentioned above: LearningPath, Metadata, LearningPathDesign, CompetenceLevels, and LearningActions.

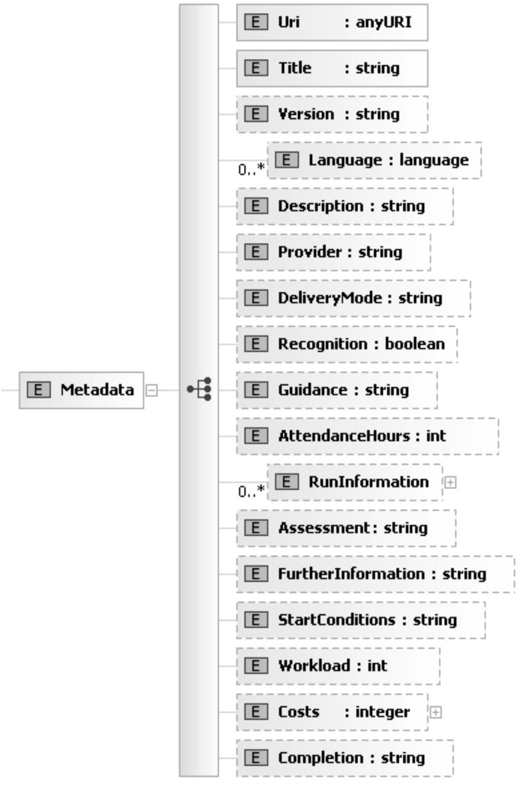
3.1. Information Table 'Learning Path'



Learning Path

Name	Explanation	Reqd	Mult	Type
LearningPath	Specification of a set of 1 or more learning actions and the way they are structured, leading to a defined set of one or more competences at particular proficiency levels.	-	-	sequence
Id	Identifier of the LearningPath (local)	M	1	ID
Metadata	Container element for data which provide content, process and planning information on the LearningPath.	M	1	sequence
LearningPathDesign	Container element for specification of the Finish and Start (optional) of a LearningPath in terms of CompetenceLevels as well as the steps (LearningActions) that lead to the Finish.	M	1	sequence
CompetenceLevels	Container element for specification of CompetenceLevels which are referenced in the LearningPathDesign.	M	1	sequence
LearningActions	Container element for specification of LearningActions which are referenced in the LearningPathDesign.	M	1	sequence

3.2. Information Table 'Metadata'

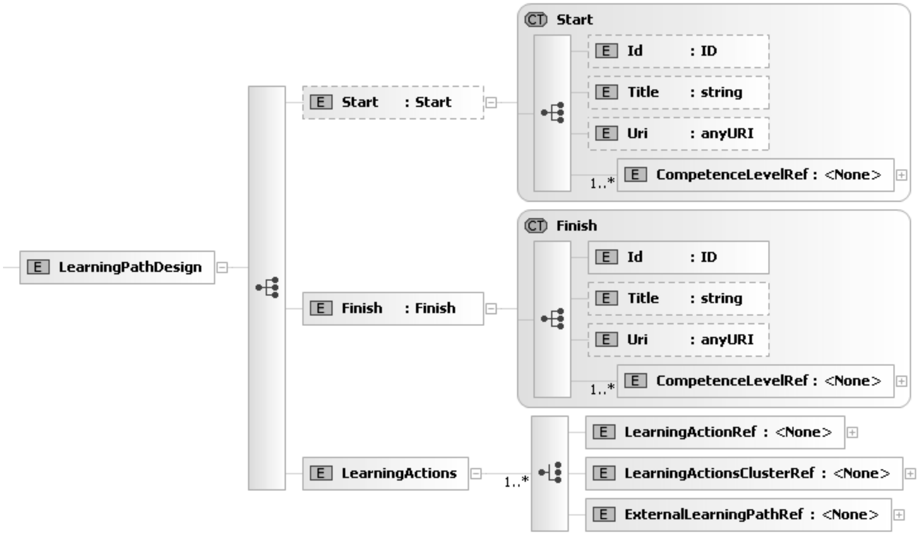


Metadata

Name	Explanation	Reqd	Mult	Type
Metadata	Container element for data which provide content, process and planning information on the LearningPath.	-	-	container
URI	Uniform resource identifier of the LearningPath	M	1	anyURI
Title	Title of the LearningPath	M	1	string
Version	Version of the LearningPath; necessary to allow for updates of LearningPaths and to enable identification of specific versions.	O	0. .1	string
Language	Language of the LearningPath. Can be derived from the language attributes of the subsequent LearningActions; the value is a generated enumeration of all unique languages specified within the LearningActions (language attribute).	O	0. .*	language
Description	Short general description of the LearningPath.	O	0. .1	string

Name	Explanation	Reqd	Mult	Type
Provider	Provider of the LearningPath. If the LearningPath involves more than one provider this element contains the main provider. Other providers can be specified through the metadata linked to separate LearningActions.	O	0. .1	string
DeliveryMode	Mode(s) used for the delivery of the Learning-Path: distance education, face-to-face, or mixed.	O	0. .1	string
Recognition	Specifies whether successful completion of the LearningPath leads to a formally recognized diploma or certificate.	O	0. .1	boolean
Guidance	Description of available support in terms of tutoring, counselling, feedback, et cetera.	O	0. .1	string
AttendanceHours	Estimation of number of hours for realtime learner attendance within the LearningActions; the value is the generated summation of the AttendancetHours of all LearningActions within the LearningPath. Note that attendance may be on location or virtual.	O	0. .1	integer
RunInformation	Container element grouping metadata which are connected to a specific 'run' of a LearningPath: Location, StartDate, Enddate.	O	0. .*	sequence
Location	Optional element for specification of the physical location for face-to-face meetings.	O	0. .*	anyType
StartDate	Optional attribute to specify fixed starting dates for the LearningPath.	O	0. .1	date
EndDate	Optional attribute to specify fixed end dates for the LearningPath.	O	0. .1	date
Assessment	Description of the formative and/or summative assessments available to determine to what extend the learner has acquired the competence(s) at the specified level.	O	0. .1	string
Further-Information	Description of more detailed information on the LearningPath (may contain URL's).	O	0. .1	string
StartConditions	Specification of practical, pedagogical and technical issues that must be satisfied to be able to follow the LearningPath.	O	0. .1	string
Workload	Estimated workload of the LearningPath specified in hours and ECTS; the value of this attribute is the generated summation of the workload attribute values of all LearningActions within the LearningPath.	O	0. .1	integer
Costs	Total costs of enrolment and specific expenses (books, tools, et cetera). The Costs element contains an attribute 'currency'.	O	0. .1	integer
Completion	Specification of the rule(s) for completion of the LearningPath, e.g. does it involve formal completion via a test, or is it up to the learner to decide the Finish has been reached.	O	0. .1	string

3.3. Information Table 'LearningPathDesign'



LearningPathDesign

Element	Explanation	Reqd	Mult	Type
LearningPath-Design	Element specifying the Finish (and possibly Start) of a Learning Path in terms of Competences at particular levels as well as the steps (Learning Actions) to be taken to reach this Finish.	-	-	sequence
Start	Container for specification of one or more CompetenceLevels which constitute the starting point of the LearningPath.	O	0. .1	sequence
Id	An identifier for the Start specified for this Learning Path which is unique within the LearningPath.	O	0. .1	ID
Title	Optional attribute for the title of a set of competences at particular levels that are prerequisite to start the LearningPath. This may be an existing competence profile or a job profile.	O	0. .1	string
URI	Uniform resource identifier to be used for referencing existing profile definitions outside the LearningPath as the Start for the LearningPath.	O	0. .1	anyURI
Competence-LevelRef	Reference to a competence at a particular level.	M	1. .*	Idref
Finish	Container for specification of one or more CompetenceLevels which constitute the targeted endpoint of the LearningPath.	M	1	sequence

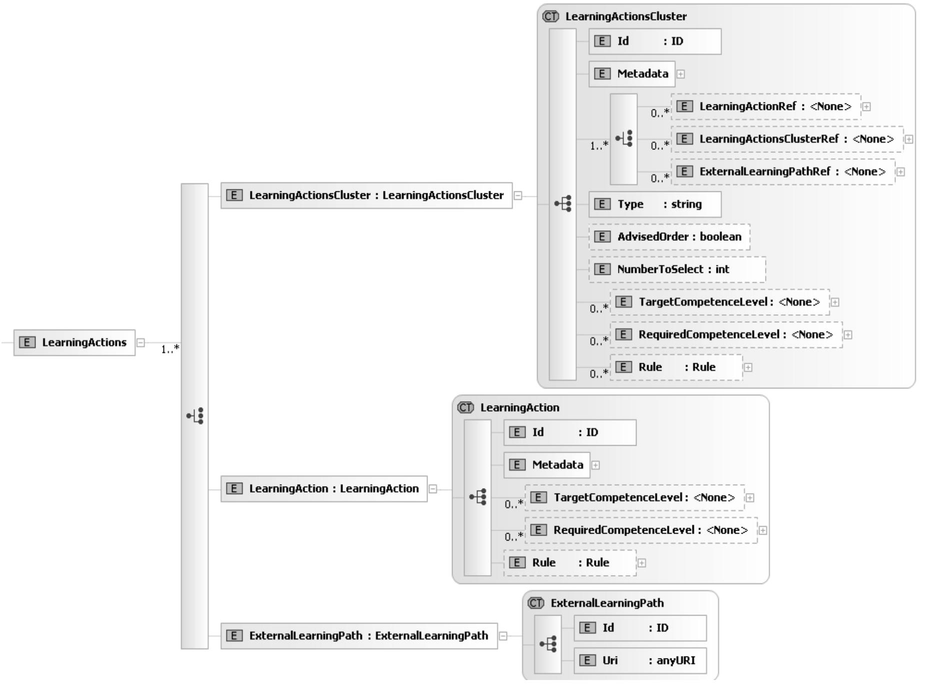
Element	Explanation	Reqd	Mult	Type
Id	An identifier for the Finish specified for this LearningPath which is unique within the LearningPath.	M	1	ID
Title	Optional attribute for the title of a set of competences with specific proficiency levels the LearningPath helps to attain. This may be an existing competence profile or a job profile.	O	0. .1	string
URI	Uniform resource identifier to be used for referencing existing profile definitions outside the LearningPath as the Finish for the LearningPath.	O	0. .1	anyURI
Competence-LevelRef	Reference to a competence at a particular level.	M	1. .*	Idref
LearningActions	Container element used to reference one or more Learning Actions, Learning Actions Clusters or LearningPaths.	M	1	Choice
LearningAction Ref	Reference to a LearningAction to be performed by a learner which has been declared elsewhere within the LearningPath (see LearningPath - LearningAction).	M	0. .*	Idref
LearningActions ClusterRef	Reference to a collection of LearningActions which has been declared elsewhere within the Learning Path (See LearningPath - LearningActionsCluster).	M	0. .*	Idref
ExternalLearning-PathRef	Reference to an existing external LearningPath to be included.	M	0. .*	Idref

3.4. Information Table ‘CompetenceLevels’

CompetenceLevel

Name	Explanation	Reqd	Mult	Type
CompetenceLevels	Container element for specification of CompetenceLevels which are referenced in the LearningPathDesign.	-	-	container
CompetenceLevel	Element to declare a competence at a particular level of proficiency which is referenced in the LearningPathDesign.	M	1. .*	sequence
Id	Identifier (local) of the CompetenceLevel.	M	1	ID
URI	URI of the addressed CompetenceLevel; the assumption is that each combination of competence and proficiency level actually has an URI that can be addressed.	M	1	anyURI

3.5. Information Table 'LearningActions'



Learning Actions

Name	Explanation	Reqd	Mult	Type
LearningActions	Container element used to group all LearningActions, LearningActionsClusters or ExternalLearningPaths which are referenced in the LearningPathDesign.	-	-	choice
LearningActions-Cluster	Collection of one or more LearningActions with specification of order rules (Type: sequence, free order, parallel).	O	0. .*	sequence
Id	Identifier of the LearningActionsCluster (local)	M	1	ID
Metadata	Container element for data which provide content, process and planning information on the *LearningActionsCluster* (Id, Title, Language, Description, DeliveryMode, Recognition, StartConditions, Guidance, Assessment, Workload, Completion).	M	1	sequence
Type	Specifies whether the LearningActions within the LearningActionsCluster have to be performed in a certain order (sequence or parallel) or can be done in a random order (free order).	M	1	string

Name	Explanation	Reqd	Mult	Type
AdvisedOrder	Specifies whether the order in which LearningActions are included in the cluster is the recommended order to study them in. When the Cluster is of the type ‘sequence’ or ‘parallel’ ‘Yes’ means that the learner can diverge from the presented order. ‘No’ means that the order is mandatory. When the type is ‘free order’ ‘Yes’ means that the learning actions in the cluster should be presented as a recommended order (though the learner could still diverge from it). ‘No’ means that they can be presented and followed in a random order.	O	1	boolean
NumberToSelect	This element is used to specify a choice from the collection of LearningActions within the LearningActionsCluster. When this element is not specified, all LearningActions within the LearningActionsCluster should be completed.	O	1	integer
TargetCompetence-Level	Element to specify the CompetenceLevel which successful completion of the LearningActionsCluster will contribute to.	O	0. .*	Idref
RequiredCompetence-Level	Element to specify the CompetenceLevel a learner is expected to have mastered before starting the LearningActionsCluster.	O	0. .*	idref
Rule	A Rule specifies how to handle a LearningAction within the LearningPath when instantiated for a specific learner. Rules refer to characteristics (e.g. background, mastered competences, preferences, performance) of the learner and may pertain to: - inclusion of the LearningAction - version of the LearningAction - delivery of the LearningAction - etcetera.	O	0. .*	sequence
LearningAction	Any action to be performed by a learner with the aim to develop one or more competences. The element contains a sequence of elements to describe the LearningAction.	O	0. .*	sequence
Id	Identifier of the LearningAction (local)	M	1	ID
Metadata	Container element for data which provide content, process and planning information on the *LearningAction* (Id, URI, Title, Version, Language, Description, ActionType, Provider, DeliveryMode, Recognition, StartConditions, Guidance, AttendanceHours, RunInformation, Assessment, Workload, Completion).	M	1	sequence
TargetCompetence-Level	Identification of the CompetenceLevel successful completion of the LearningAction will contribute to.	O	0. .*	Idref

Name	Explanation	Reqd	Mult	Type
RequiredCompetence-Level	Identification of the CompetenceLevel a learner is expected to have mastered before starting the Learning Action	O	0. .*	Idref
ExternalLearningPath	An existing LearningPath to be included in the current LearningPath. Though the specification places no constraint on including only one LearningPath it would only result in wrapping an existing LearningPath in an extra layer of metadata.	O	0. .*	Idref

4. Deployment issues

Deployment of the learning path schema is likely to raise some questions. Some questions we anticipated will be addressed in this section.

4.1. Can I combine different modes of a learning path in one description?

When you want to describe a LearningPath that is offered in two different ways, e.g. part-time and fulltime or face-to-face and at a distance, can I express this in one LearningPath description? Though the Metadata set allows specification of different runs of a program (Location, Startdate, Enddate), the element DeliveryMode and AttendanceHours have a maximum occurrence of 1. This means that for each different type of delivery a new learning path description has to be made. It is assumed that different modalities are likely to involve different LearningActions as well, making it necessary to include different LearningPathDesigns as well. In that respect creating a new LearningPath is likely to be easier and more straightforward than trying to include several modalities in one description.

4.2. How does it work: referring to CompetenceLevels?

Competence descriptions are out of scope of the Learning Path Specification. However, CompetenceLevels are referred to at different points within the LearningPath: at the macro level of the LearningPath, but also at the level of LearningActions. Ideally standardised competence descriptions are available and can be referenced through an URI. The element CompetenceLevel indicates a competence at a particular level of proficiency. This assumes external competence descriptions which enable referencing to this particular combination: competence + level.

The *LearningPath's* mandatory element Finish can also be used to reference to an existing competence profile or job profile. This should lead to automated import of the related competences + levels into for instance a learning path editor. Such an editor should enable import of these descriptions and render them for example as a competence map or a dropdown list to facilitate referencing / selection of relevant competences and related proficiency levels by a single click.

At the micro level of *LearningActions* required CompetenceLevels and targeted CompetenceLevels can be identified optionally. The TargetCompetenceLevel is optional since a LearningAction can also consist of a reference to an existing LearningPath which already has a Finish. It is recommended though that LearningActions and LearningActionsClusters are associated with at least one or more TargetCompetenceLevels. Despite this recommendation no constraints should be placed on the relation between competences referenced at this lower level and the competences referenced in the Finish and possibly Start of the LearningPath, since these relations are rarely an exact one-to-one match.

4.3. When do I use LearningActionsClusters?

Usually a LearningPath consists of more than one LearningAction, and you will have to specify how these LearningActions are related: can they be studied in a random order or is it necessary that they are completed sequentially or in parallel? This is why overall, a LearningPath is modelled as a LearningActionsCluster.

LearningActionsClusters can also be used to define a subset of LearningActions which have to studied in a particular order or a subset which the learner can choose from. They could also be used simply to group a set of learning actions under one meaningful header.

4.4. Which Metadata should I add?

Metadata are crucial when it comes to supporting search of learning paths. So even though only few metadata are mandatory it is recommended that all relevant metadata are added.

Some learning paths may involve face-to-face meetings at a particular location or fixed start and end dates. These more dynamic metadata which refer to a particular occurrence of for example a program, workshop or course are grouped in the container element RunInformation: Location, StartDate and EndDate. Location is defined as anyType because several standards might be used to specify a location. GeoRSS Simple (GeoRSS, 2007), for instance, offers a lightweight solution in those cases where Location element is used to enable a search engine to identify learning paths with face-to-face meetings within a limited distance from the users location.

The metadata referring to the learning process show limited overlap with the main standard in this area, the IEEE LOM (2002) metadata. So rather than name spacing the IEEE LOM metadata set, a set of metadata elements has been specified of which the following can be directly mapped on the IEEE LOM metadata:

Element label	**IEEE LOM element**
Id	1.1 Identifier
Title	1.2 Title
Language	1.3 Language
Description	1.4 Description
Version	2.1 Version
Workload	5.9 Typical Learning time

Though the LOM metadata also contain an element Cost, this element is used to indicate whether or not use of the Learning Object is free of costs, whereas the metadata element Cost of the Learning Path Specification is used to specify total costs involved in following the learning path.

Metadata can be specified at the level of the LearningPath as well as the level of its constituent LearningActions. When a LearningPath consists of a single LearningAction the Metadata for the LearningPath are in fact identical to the LearningAction Metadata.

When a LearningPath consists of a sequence of LearningActions some Metadata at the LearningPath level may be automatically derived from the Metadata of its constituent LearningActions, e.g. the workload of the LearningPath is the sum of the workload of the LearningActions, the language of the LearningPath is a list of all the languages mentioned in the Metadata of the LearningActions etcetera. However, there are some limitations to automatically deriving LearningPath Metadata. A first limitation consists of the fact that no or not all Metadata may be specified at the LearningAction level. A second limitation arises in the case of a LearningActionsCluster, which consists of a set of LearningActions the learner can choose from. To the extent that the constituent LearningActions have different metadata values associated to them, the higher level LearningPath Metadata cannot automatically be derived. In those cases a solution might be found in specifying an 'average' number.

4.5. How and when do I add Rules?

As was stated in section 2 of this document the expression of rules is out of scope of the Learning Path Specification. Existing script languages might be used for this purpose (Oussena & Barn, 2009).

Another deployment issue relating to the Rule element is that the possibility to express rules will only be required in those cases where the Learning Path Specification is used to recommend a specific route through a learning path or otherwise support navigation – i.e. when the specification is deployed to support a particular learning path instantiation. To the extent that the Learning Path Specification is used to inform comparison and selection of learning paths, the Rule element is not needed. To the extent that rules pertaining to a particular learning path are relevant to the process of comparing and selecting learning paths they will be described through Metadata like StartConditions or Completion.

5. Worked out example


```xml
<?xml version="1.0" encoding="utf-8"?>
<ns:LearningPath xmlns:ns="http://tencompetence.org/lp" xmlns:xsi="http://www.w3.org/
 2001/XMLSchema-instance">
    <Id>FR1</Id>
    <Metadata>
        <Uri>http://mirror.mricon.com/french</Uri>
        <Title>Rapid Language Learning - French</Title>
        <Language>English</Language>
        <Description>Faced with a task of quickly learning French to pass a standardized
        test, this tried and tested method using easily-accessible technology together with
        cheap or free resources, will give you a few pointers on how to achieve that goal
        using the things I have found useful for myself.</Description>
        <DeliveryMode>mixed</DeliveryMode>
        <Recognition>0</Recognition>
        <Guidance>None</Guidance>
        <AttendanceHours>0</AttendanceHours>
        <Assessment>There are no formal assessments included in this learning path, but
        several suggestions are made as to how to assess your progress. </Assessment>
        <FurtherInformation>http://mirror.mricon.com/french</FurtherInformation>
        <StartConditions>computer and Internet access</StartConditions>
        <Costs Currency="EURO">60</Costs>
        <Completion>Though designed to pass a standardized test, more specifically TEF,or
        Test d'Evaluation de Français, the test does not constitute part of this learning
        path.</Completion>
    </Metadata>
<LearningPathDesign>
```

```xml
    <Finish>
        <Id>FIN-BF</Id>
        <Title>Basic Level French</Title>
        <Uri>http://french.about.comp/</Uri>
        <CompetenceLevelRef ref="FrenchReadingSkill-1"/>
        <CompetenceLevelRef ref="FrenchSpeakingSkill-1"/>
        <CompetenceLevelRef ref="FrenchWritingSkill-1"/>
    </Finish>
    <LearningActions>
        <LearningActionsClusterRef ref="DIY-French-1"/>
        </LearningActions>
    </LearningPathDesign>
<CompetenceLevels>
    <CompetenceLevel>
        <Id>FrenchReadingSkill-1</Id>
        <Uri>http://french.about.comp/</Uri>
  </CompetenceLevel>
    <CompetenceLevel>
        <Id>FrenchSpeakingSkill-1</Id>
        <Uri>http://french.about.comp/</Uri>
  </CompetenceLevel>
    <CompetenceLevel>
        <Id>FrenchWritingSkill-1</Id>
        <Uri>http://french.about.comp/</Uri>
  </CompetenceLevel>
</CompetenceLevels>
<LearningActions>
    <LearningActionsCluster>
        <Id>DIY-French-1</Id>
        <Metadata>
                <Title>Rapid Language Learning</Title>
        </Metadata>
        <LearningActionRef ref="FBR-act1"/>
        <LearningActionRef ref="FBR-act2"/>
        <LearningActionRef ref="FBS-act1"/>
        <LearningActionRef ref="FBR-act3"/>
        <LearningActionRef ref="FBR-act4"/>
        <LearningActionRef ref="FBW-act1"/>
        <LearningActionRef ref="FBS-act2"/>
        <LearningActionRef ref="FBS-act3"/>
        <LearningActionsClusterRef ref="FB-conversation"/>
        <Type>sequence</Type>
    </LearningActionsCluster>
    <LearningAction>
        <Id>FBR-act1</Id>
        <Metadata>
```

```
                <Uri>http://mirror.mricon.com/french/french.html#introduction</Uri>
                <Title>Introduction</Title>
                <Description>Some basic knowledge of grammar to begin
                with.</Description>
                <Costs Currency="EURO">30</Costs>
            </Metadata>
            <TargetCompetenceLevel ref="FrenchReadingSkill-1"/>
    </LearningAction>
    <LearningAction>
            <Id>FBR-act2</Id>
            <Metadata>
                <Uri>http://mirror.mricon.com/french/french.html#id2696762</Uri>
                <Title>Learn to Read French</Title>
                <Description>Learn by reading and using free tools on
                Internet.</Description>
            </Metadata>
            <TargetCompetenceLevel ref="FrenchReadingSkill-1"/>
  </LearningAction>
    <LearningAction>
            <Id>FBS-act1</Id>
            <Metadata>
                <Uri>http://mirror.mricon.com/french/french.html#id2697140</Uri>
                <Title>Pronunciation is easy</Title>
                <Description>This brief text explains French pronunciation.</Description>
            </Metadata>
            <TargetCompetenceLevel ref="FrenchSpeakingSkill-1"/>
  </LearningAction>
    <LearningAction>
            <Id>FBR-act3</Id>
            <Metadata>
                <Uri>http://mirror.mricon.com/french/french.html#id2697322</Uri>
                <Title>Flip-card strategy</Title>
                <Description>Using cards to learn words and noun
                genders.</Description>
            </Metadata>
            <TargetCompetenceLevel ref="FrenchReadingSkill-1"/>
  </LearningAction>
    <LearningAction>
            <Id>FBR-act4</Id>
            <Metadata>
                <Uri>http://mirror.mricon.com/french/french.html#id2758549</Uri>
                <Title>Phrases and expressions</Title>
                <Description>More reading... and use these tools to find out about
                phrases and expressions you don't understand.</Description>
            </Metadata>
            <TargetCompetenceLevel ref="FrenchReadingSkill-1"/>
```

```
</LearningAction>
  <LearningAction>
      <Id>FBW-act1</Id>
      <Metadata>
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          <Title>Writing French</Title>
          <Description>Developing French writing skills from exercises in a
          book.</Description>
      </Metadata>
      <TargetCompetenceLevel ref="FrenchWritingSkill-1"/>
</LearningAction>
  <LearningAction>
      <Id>FBS-act2</Id>
      <Metadata>
          <Uri>http://mirror.mricon.com/french/french.html#id2758747</Uri>
          <Title>Listening and speaking exercises</Title>
          <Description>Drill and practice listening and speaking through audio
          material.</Description>
          <Costs Currency="EURO">30</Costs>
      </Metadata>
      <TargetCompetenceLevel ref="FrenchSpeakingSkill-1"/>
</LearningAction>
  <LearningAction>
      <Id>FBS-act3</Id>
      <Metadata>
          <Uri>http://mirror.mricon.com/french/french.html#id2758858</Uri>
          <Title>Stay away from French audio books!</Title>
          <Description>Finding the right material to train your audial recognition
          skills.</Description>
      </Metadata>
      <TargetCompetenceLevel ref="FrenchSpeakingSkill-1"/>
</LearningAction>
  <LearningActionsCluster>
      <Id>FB-conversation</Id>
      <Metadata>
          <Title>Conversation - one way or the other</Title>
      </Metadata>
      <LearningActionRef ref="FBS-act4a"/>
      <LearningActionRef ref="FBS-act4a"/>
      <Type>free order</Type>
      <NumberToSelect>1</NumberToSelect>
  </LearningActionsCluster>
  <LearningAction>
      <Id>FBS-act4a</Id>
      <Metadata>
          <Uri>http://mirror.mricon.com/french/french.html#id2759115</Uri>
```

```xml
                <Title>Face-to-face conversation</Title>
                <Description>Practice your French speaking skills in face-to-face
                conversations.</Description>
        </Metadata>
        <TargetCompetenceLevel ref="FrenchSpeakingSkill-1"/>
  </LearningAction>
    <LearningAction>
        <Id>FBS-act4b</Id>
        <Metadata>
                <Uri>http://mirror.mricon.com/french/french.html#id2759115</Uri>
                <Title>Conversation through teleconferencing</Title>
                <Description>Practice your French speaking skills through
                teleconferencing.</Description>
                <StartConditions>Computer with audio set. Internet
                access.</StartConditions>
        </Metadata>
        <TargetCompetenceLevel ref="FrenchSpeakingSkill-1"/>
  </LearningAction>
</LearningActions></ns:LearningPath>
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Summary

Problem analysis

The need for flexible lifelong learning has led to increased provision as well as modularisation of education and training opportunities. This in turn has increased the challenge for lifelong learners of finding their way through all available options and selecting a learning path that best meets their needs. In this thesis a learning path is defined as a set of one or more learning actions that help attain particular learning goals.

Way finding or navigational problems occur at two levels. Firstly, in the process of selecting suitable learning paths and secondly, in the process of deciding in which order to complete the learning actions within a chosen learning path. Though different in terms of timing and scope, these two processes basically require the same decision: 'Taking into account what I have learned so far, what I want to learn, and the options available to me, how best to proceed?'

Efficient and effective lifelong learning requires that learners can make well informed decisions regarding the selection of a learning path and the best way to proceed along a chosen path. The problem addressed in this thesis is:

> *How to support learners in finding suitable learning paths and in navigating a chosen path?*

The thesis describes the development, implementation and evaluation of two different approaches to solve the way finding problem. The first, inductive approach, involves a recommender system based on indirect social interaction. The second, prescriptive approach entails the development of a learning path specification.

Technology development and research

a. Recommender system

The first approach to solving the way finding problem was inspired by the principle of indirect social interaction and provides a recommendation through collaborative filtering: analysing the paths followed by learners in the past and feeding this information back as advice to learners currently facing the same decision. The recommender system was developed and tested in an educational setting, containing 11 on-line learning activities and 808 learners who were randomly assigned to a control group and an experimental group. Upon login both groups received an overview of the learning activities, indicating which activities were not yet completed. For both groups the order of the list was randomly generated upon access so as to avoid the suggestion of a particular order. Learners in the control group would select an activity from this list. Learners in the experimental group would receive a recommendation 'Continue with', which they were advised to follow.

The recommender system appeared successful in that it significantly enhanced effectiveness: the experimental group achieved more progress (average number of completed activities) and a significantly higher proportion of the learners in this group completed all learning activities. No significant effects were found for efficiency, i.e. the time taken to complete all 11 activities.

Though results were promising, the experimental setting was a specific one, involving a learning path consisting of 11 learning activities that could be studied in any order. Wanting to take this first approach a step further and applying it in settings where learning activities are not independent, presents us with the question how to incorporate known, pre-defined relations (e.g. a learning activity builds on knowledge acquired in another; or learning activities constituting alternatives), into the recommendation? Hence, our focus shifted from the inductive approach to the prescriptive approach, more particularly, to the question: how can we describe learning paths and learning actions in a way that makes them amenable to computer processing, so that optional, alternative and mandatory parts can be incorporated in systems providing way finding support to learners?

b. Learning Path Specification

The second approach to solving the way finding problem entailed development of a Learning Path Specification, which enables to describe both the contents and the structure of any learning path, be it formal, non-formal, informal, or indeed a combination of these. The role of the Learning Path Specification is to enable transparent descriptions of possible ways to attain a particular learning goal, so that:

1. it becomes easier for learners to compare and select learning paths
2. it becomes possible to automate navigation support for a chosen learning path
3. it becomes easier to see which parts of a learning path (i.e. which learning actions) can be substituted by other learning actions (e.g. prior learning).

Requirements for the Learning Path Specification were drawn from literature in the field of curriculum design and lifelong learning, as well as recent initiatives to enhance comparability and exchangeability of learning actions.

In sum the requirements state that the Learning Path Specification should enable description of: learning outcomes and entry requirements, modular and nested compositions, mandatory and optional parts, ordering of parts, alternatives, completion requirements, and conditions. Further technical requirements were that the specification should enable to describe learning paths in a formal and interoperable way.

Though initially two existing specifications designed to describe learning programmes, eXchanging Course-Related Information (XCRI) and IMS Learning Design (IMS-LD), were investigated to see whether they could fulfil the identified requirements, it became soon clear that a new 'lean' specification was required. A conceptual model of the Learning Path Specification was developed in UML, and subsequently implemented in a binding using XML, so as to meet the technical requirements of formality and interoperability.

The model states that a learning path has a start and a finish which are defined in terms of competences at particular levels of proficiency. A learning path further defines one or more learning actions that lead from the start to the finish. Both the learning path and its actions are further described by a set of metadata specifying content, process, and planning information (e.g. title, description, assessment, tutoring, delivery mode, attendance hours). These metadata are assumed to play a role in the process of choosing a learning path.

For the evaluation of the specification we developed a framework based on theories of model quality. The framework distinguishes three aspects of quality:

1. Syntactic quality: does the specification express what it intends to express in a correct way, i.e. in accordance with the syntax rules of the modelling language?
2. Semantic quality: does the specification represent essential features?
3. Pragmatic quality: is the specification easily comprehended and used by the stakeholders for its intended purpose?

Three successive studies were carried out to assess and improve the quality of the specification, especially semantic and pragmatic quality. Syntactic quality is at stake mainly in the process of modelling the specification in UML and in translating the specification to a binding, and is to a certain extent covered by validations the modelling tools provide.

First a case study was carried out to investigate both semantic and pragmatic quality of the Learning Path Specification, more particularly the question whether the metadata included in the specification are clear and whether they reflect the characteristics that play a role in lifelong learners' choice processes. Choice processes were studied retrospectively through semi-structured interviews with learners (n=15) who recently decided upon a learning path having compared at least two different options. The interviews focused on identifying characteristics which played a role in the comparison and selection of learning paths, relying first on spontaneous recall, followed by a more structured approach of aided recall. Results indicate that the specification does not contain any redundant information. Rather the study has led to further refinement of scheduling information, through addition of an element contact time, thus improving the specification's semantic as well as pragmatic quality.

Next we focused on pragmatic quality, i.e. the question whether stakeholders can understand and use the specification. We distinguish first-order and second-order pragmatic quality, concerning two different types of users and usage of the specification. Firstly, software developers who use the specification directly, i.e. implement the specification in tools and, secondly, end-users of tools that enable deployment of the specification. First-order pragmatic quality of the Learning Path Specification was evaluated during the development of a tool that describes learning paths according to the specification: the Learning Path Editor. This second study involving software developers implementing the specification led to three minor and three major changes to the specification, which all contributed to improved pragmatic quality of the specification in the sense that these changes made it easier for software developers to read, understand and implement the specification.

A third study was carried out to assess second-order pragmatic quality through a number of workshop sessions involving 16 prospective end users (study advisors and educational technologists). The workshop sessions entailed a video explaining the purposes of the Learning Path Specification including a demo of the Learning Path Editor. Next, participants gained some hands-on experience with the Editor through three small tasks involving the adaptation of the learning path description they had watched being created in the demo. Finally, they were asked to evaluate their experiences taking a broad perspective: i.e. considering the entire approach of describing learning paths through a learning path specification in the proposed way and its intended effects. The evaluation was carried out using an online adaptation of the Desirability Toolkit. Drawing on the product reaction cards methodology the toolkit allows respondents to select six cards (from a set of 118 cards containing positive and negative adjectives) which best express their experiences and evaluation of the proposed approach. It is not so much the precise set of selected adjectives, as the motivations provided along with them, which clarify users' views on both usability of the tool and desirability of the approach suggested by the Learning Path Specification. Results indicate that the nested structure of learning actions clusters within the learning path as an overall cluster, posed somewhat of a challenge. However, participants were confident this was only a matter of practice and developing some routine. As some participants found the term selection (indicating a particular type of cluster) confusing, a final change was made to the specification, replacing this term by 'free order'. Participants' motivations provided along with selected cards underlined that they consider the approach to increase transparency and efficiency, both for providers and learners.

In sum, this thesis describes two different approaches to way finding support: an inductive approach of providing recommendations based on collaborative filtering and a prescriptive approach of the Learning Path Specification. Both approaches can be considered complementary, as inductive techniques can be used to generate or validate prescriptive learning paths, and the Learning Path Specification can be used to identify areas where inductively generated recommendations can provide added value. Besides, collaborative filtering techniques could be used to provide recommendations in selecting prescriptive learning paths. Further research is needed to investigate integration of these approaches.

Following the observation that the benefits of the Learning Path Specification would further increase if it were to become widely used, the general discussion explores the chances of the Learning Path Specification gaining wide adoption. In this discussion the specification is assessed in light of five perceived characteristics of innovations which affect an innovation's chances of adoption: relative advantage, compatibility, complexity, triability, and observability. Topics of interest for further research identified in this general discussion include validation of the Learning Path Specification in a variety of contexts (e.g. work place learning) and tools (e.g. learning path presentation tools).

Samenvatting

Probleemstelling

In de afgelopen decennia is de aandacht voor flexibel leven lang leren toegenomen. Het aanbod aan opleidingen, trainingen en cursussen is niet alleen fors gegroeid, maar ook sterk geflexibiliseerd door toenemende modularisering en het gebruik van e-learning. Deze gunstige ontwikkeling kent echter ook een keerzijde: voor de lerende wordt het steeds moeilijker om zich een weg te banen door het uitgebreide en gevarieerde aanbod en daaruit die leerpaden te selecteren die het best aansluiten bij de eigen behoeften en wensen. Dit proefschrift richt zich op de vraag:

> *Hoe kunnen we leven lang lerenden ondersteunen bij de keuze van een leerpad en het doorlopen van een gekozen leerpad?*

Een leerpad is een set van één of meer leeractiviteiten die bepaalde leerdoelen helpen realiseren.

De omvang en modularisering van het aanbod versterkt de behoefte aan ondersteuning bij het zoeken naar en doorlopen van leerpaden; zogenoemde navigatieondersteuning. De behoefte aan navigatieondersteuning speelt op twee niveaus. Allereerst bij het *selecteren* van een geschikt leerpad en vervolgens bij het *doorlopen* van een eenmaal geselecteerd leerpad. In het laatste geval speelt de vraag in welke volgorde de verschillende onderdelen (leeractiviteiten) het best kunnen worden afgerond. Hoewel de twee niveaus verschillen in bereik en chronologie, hebben zij beide betrekking op een in wezen gelijke beslissing: Wat is, gezien hetgeen ik tot nu toe heb geleerd en nog wil leren en gezien de alternatieven die mij op dit moment ter beschikking staan, de beste vervolgstap? Efficiënt en effectief leven lang leren vereist dat lerenden over voldoende informatie beschikken om weloverwogen keuzes te kunnen maken.

Dit proefschrift beschrijft de ontwikkeling, implementatie en evaluatie van twee technologische oplossingen die het probleem van navigatieondersteuning vanuit verschillende perspectieven benaderen. De eerste oplossing, een adviessysteem, volgt een inductieve benadering en genereert een advies/ aanbeveling op basis van indirecte sociale interactie. De tweede oplossing volgt een prescriptieve benadering en richt zich op het gebruik van een leerpadspecificatie.

Technologieontwikkeling en evaluatie

a. Adviessysteem

Het adviessysteem is geïnspireerd door principes van indirecte sociale interactie en collaborative filtering: informatie over keuzes die anderen in het verleden maakten, wordt in de vorm van een advies teruggekoppeld aan lerenden die voor dezelfde keuzes staan. Het door ons ontwikkelde adviessysteem is getest in een experimentele setting waarbij 11 online leeractiviteiten werden aangeboden aan 808 lerenden, die willekeurig waren toegewezen aan een controlegroep en een experimentele groep. Bij het inloggen kregen beide groepen steeds opnieuw een overzicht van alle leeractiviteiten met een indicatie van de actuele stand van zaken rond afgeronde en nog openstaande leeractiviteiten. Het overzicht van activiteiten die nog niet waren afgerond, werd willekeurig gegenereerd om de suggestie van een specifieke volgorde te vermijden. In de controlegroep kozen lerenden naar eigen inzicht een volgende activiteit. In de experimentele groep werd bij het overzicht een advies gegeven (‘Ga verder met […]’) en werd iedereen aangeraden dit advies ook op te volgen.

De resultaten van het experiment laten zien dat het adviessysteem bijdraagt tot een meer effectief leerproces. De experimentele groep rondde significant meer leeractiviteiten af. Tevens lag het aantal deelnemers dat alle leeractiviteiten had afgerond significant hoger. Wat betreft efficiëntie - de benodigde tijd om alle 11 activiteiten af te ronden - werden geen significante effecten gevonden.

Hoewel deze resultaten positief zijn, moeten we constateren dat de experimentele setting zeer specifiek was: één leerpad bestaande uit 11 leeractiviteiten die in principe in willekeurige volgorde konden worden bestudeerd. De verdere ontwikkeling en vertaling naar een meer levensechte setting waar voortdurend nieuwe leeractiviteiten en leerpaden worden toegevoegd en waar leeractiviteiten niet onafhankelijk zijn van elkaar, leidde tot een aantal kritische vragen. Bijvoorbeeld de vraag hoe in het advies rekening kan worden gehouden met van tevoren vaststaande relaties, zoals in het geval van een leeractiviteit die kennis veronderstelt uit een andere activiteit, of activiteiten die onderling uitwisselbaar zijn. Deze vragen leidden tot de conclusie dat een inductieve benadering alleen onvoldoende is. Ter aanvulling is daarom de focus verlegd naar een prescriptieve benadering: de ontwikkeling van een leerpadspecificatie. De vraag die vervolgens centraal stond was: Hoe kunnen we leerpaden en leeractiviteiten zodanig beschrijven dat een computer ermee kan werken en verplichte, optionele en alternatieve onderdelen van een leerpad kunnen worden geïncorporeerd in geautomatiseerde navigatieondersteuning?

b. Leerpad Specificatie

De Leerpad Specificatie maakt het mogelijk om zowel de inhoud als de structuur van alle mogelijke leerpaden te beschrijven; of het nu gaat om formeel leren, non-formeel leren, informeel leren of een combinatie van deze. Doel van de Leerpad Specificatie is om transparante beschrijvingen van leerpaden te creëren, zodat:

1. het eenvoudiger wordt om leerpaden te vergelijken en te selecteren
2. het mogelijk wordt om navigatieondersteuning te automatiseren
3. het gemakkelijker wordt leerpaden aan te passen rekening houdend met eerder verworven competenties.

Vereisten waaraan de specificatie moet voldoen zijn ontleend aan literatuur op het gebied van onderwijsontwerp en leven lang leren en aan huidige praktijk op het gebied van vergelijken en uitwisselen van leerpaden. Samengevat zijn de vereisten dat de Leerpad Specificatie het mogelijk moet maken om de volgende karakteristieken uit te drukken: leerdoelen en ingangseisen, modulariteit en geneste structuren, verplichte en optionele onderdelen, ordening van leeractiviteiten, keuzes, afrondingsvereisten en condities. Daarnaast zijn er de technische vereisten van formaliteit en interoperabiliteit.

In eerste instantie is gekeken in hoeverre twee bestaande specificaties (eXchanging Course-Related Information (XCRI) en IMS Learning Design (IMS-LD)) aan de gestelde eisen voldoen, maar al snel werd duidelijk dat de ontwikkeling van een nieuwe meer compacte specificatie nodig was. Een conceptueel model van de Leerpad Specificatie werd ontwikkeld en beschreven in UML, en vervolgens geïmplementeerd in een XML binding waarmee aan de vereisten van formaliteit en interoperabiliteit is voldaan. Het conceptueel model geeft aan dat een leerpad een finish en mogelijk een expliciete start heeft die beide worden beschreven in termen van competenties en daaraan gekoppelde beheersingsniveaus. Een leerpad omvat één of meer leeractiviteiten die helpen de leerdoelen te realiseren. Zowel het leerpad als de daarin opgenomen leeractiviteiten worden verder beschreven door metadata die informatie geven over inhoud, leerproces en planning (bijvoorbeeld titel, taal, begeleiding, toetsing, contact uren). Deze metadata spelen een rol bij de keuze voor een leerpad.

Voor de evaluatie van de Leerpad Specificatie is een raamwerk ontwikkeld op basis van theorieën op het gebied van modelkwaliteit. Dit raamwerk onderscheidt drie kwaliteitsaspecten:

1. Syntactische kwaliteit: is datgene wat de specificatie uitdrukt correct volgens de syntax regels van de gekozen modelleertaal en in overeenstemming met wat bedoeld is?
2. Semantische kwaliteit: beschrijft de specificatie alle essentiële aspecten?
3. Pragmatische kwaliteit: is de specificatie, gegeven de doelstellingen, eenvoudig te begrijpen en te gebruiken door belanghebbenden?

De kwaliteit van de Leerpad Specificatie is in drie opeenvolgende studies geëvalueerd en verbeterd. Daarbij lag de nadruk op semantische en pragmatische kwaliteit. De syntactische kwaliteit speelde vooral een rol in een eerder stadium, bij het uitdrukken van de specificatie in UML en de latere vertaling naar XML. Syntactische kwaliteit wordt daarbij deels bevorderd door in de gebruikte tools ingebouwde validatieprocedures.

De eerste studie richtte zich op de vraag of de in de specificatie opgenomen metadata duidelijk zijn (pragmatische kwaliteit) en ook die kenmerken beschrijven die een rol spelen in het keuzeproces van leven lang lerenden. Daartoe werden deze keuzeprocessen retrospectief bestudeerd door middel van semi-gestructureerde interviews met lerenden (*n*=15) die recent een keuze maakten voor een leerpad en daarbij minimaal twee verschillende opties hadden overwogen. De interviews waren erop gericht kenmerken van leerpaden te identificeren die een rol spelen in de vergelijking en selectie van leerpaden. In eerste instantie werden deze kenmerken geïnventariseerd op basis van spontane herinnering en vervolgens meer gestructureerd op basis van geholpen herinnering. De resultaten van deze evaluatie laten zien dat de specificatie geen overbodige elementen bevat, maar daarentegen verdere verfijning vraagt van de planningsinformatie door toevoeging van een element ‘contact tijden’ (week/weekend en avond/dag). Deze toevoeging draagt bij aan zowel de semantische als de pragmatische kwaliteit van de specificatie.

De hierop volgende studies richtten zich op evaluatie van de pragmatische kwaliteit: begrijpen belanghebbenden de specificatie en kunnen zij deze gebruiken? Daarbij onderscheidden we pragmatische kwaliteit van de eerste en van de tweede orde, afhankelijk van twee typen gebruikers van de specificatie: softwareontwikkelaars die de specificatie heel direct gebruiken en implementeren in programma’s, en eindgebruikers van die programma’s. Pragmatische kwaliteit van de eerste orde werd geëvalueerd tijdens de ontwikkeling van een programma waarmee leerpaden kunnen worden beschreven volgens de specificatie: de Leerpad Editor. Deze tweede evaluatie resulteerde in drie kleine en drie grotere aanpassingen van de specificatie, die het lezen, begrijpen en implementeren van de specificatie vergemakkelijken.

Een derde studie werd verricht om pragmatische kwaliteit van de tweede orde te evalueren. Daartoe werden workshop sessies georganiseerd met 16 potentiële eindgebruikers: studieadviseurs en onderwijstechnologen. Tijdens de workshop keken de deelnemers eerst naar een video die de doelen van de Leerpad Specificatie toelicht en tevens het gebruik van de Leerpad Editor demonstreert. Vervolgens gingen deelnemers zelf aan de slag met de Editor aan de hand van drie kleine taken. Deze taken behelsden aanpassingen van de leerpadbeschrijving waarvan de ontwikkeling stapsgewijs in de video gedemonstreerd was. Tot slot werden deelnemers gevraagd een oordeel te geven over de voorgestelde werkwijze: het beschrijven van leerpaden volgens de specificatie, de daarmee beoogde effecten en de praktische implicaties. Voor de evaluatie werd gebruik gemaakt van een online versie van de Desirability Toolkit. Deze toolkit, die is gebaseerd op de methode van product-reactie-kaarten, laat respondenten zes kaarten selecteren die het best hun ervaringen en meningen ten aanzien van de voorgestelde benadering weergeven. De zes kaarten worden geselecteerd uit een set van 118 kaarten met positieve, neutrale en negatieve bijvoeglijke naamwoorden. Daarbij is het niet zozeer van belang welke subset van bijvoeglijke naamwoorden precies gekozen is, maar welke uitleg bij de geselecteerde kaarten wordt gegeven. Uiteindelijk zijn het deze toelichtingen die verhelderen wat eindgebruikers vinden van de voorgestelde benadering en van het programma om leerpaden volgens de specificatie te beschrijven.

De resultaten uit de workshopsessies maakten duidelijk dat de geneste structuur van clusters van leeractiviteiten binnen het leerpad als overkoepelend cluster, niet eenvoudig werd doorzien. De deelnemers waren er echter van overtuigd dat dit een kwestie was van wat meer oefening en het ontwikkelen van enige routine. Omdat enkele deelnemers de term ‘selectie’ (de aanduiding voor een bepaald type cluster) verwarrend vonden, werd deze term vervangen door ‘vrije volgorde’. De bij de geselecteerde kaartjes gegeven toelichtingen maken duidelijk dat respondenten van oordeel zijn dat de voorgestelde benadering leidt tot grotere transparantie en efficiëntie aan de kant van zowel aanbod als vraag.

Samenvattend beschrijft dit proefschrift twee verschillende oplossingsrichtingen voor navigatieondersteuning: een inductieve oplossing die aanbevelingen genereert op basis van collaborative filtering en een prescriptieve oplossing die gebruik maakt van een Leerpad Specificatie. Beide benaderingen moeten als complementair worden gezien, aangezien inductieve technieken gebruikt kunnen worden om prescriptieve leerpaden te genereren of te valideren, en vice versa de Leerpad Specificatie gebruikt kan worden om te zien waar inductief gegenereerde aanbevelingen een toegevoegde waarde kunnen leveren. Daarnaast kan collaborative filtering worden ingezet om aanbevelingen te geven voor de selectie van prescriptieve leerpaden. Verder onderzoek moet duidelijk maken hoe de integratie van beide benaderingen het best kan worden gerealiseerd.

De voordelen van het gebruik van een leerpadspecificatie nemen toe naarmate de specificatie breder wordt geadopteerd. Deze redenering volgend, richt de algemene discussie zich op de vraag wat de kansen zijn dat de Leerpad Specificatie brede toepassing zal vinden. Bij de beantwoording van die vraag baseren we ons op vijf gepercipieerde kenmerken van innovaties, die de kansen dat een innovatie wordt geadopteerd, beïnvloeden. In hoeverre kunnen we, op basis van onze eigen bevindingen en onderzoek elders, verwachten dat de Leerpad Specificatie zal worden gezien als: a. voordelen biedend, b. aansluitend bij de huidige situatie, c. complex, d. eenvoudig uit te proberen en e. zichtbaar? De algemene discussie maakt tevens duidelijk waar verder onderzoek wenselijk is, zoals de validatie van de specificatie in uiteenlopende settings (bijvoorbeeld werkplek leren) en programma's (bijvoorbeeld programma's om leerpaden visueel weer te geven).

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