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Abstract (for dissemination)
Summary of the results of TENCompetence WP7 between M30 and M42. Update of the Learning Path Description and the development of a Learning Path Editor. Evaluation and redesign of the Graphical PDP Planning tool, integrated with the PDP Tool and the Hybrid Personalizer. Design and implementation of the Competence Matching Tool.

Keywords List
Learning Path Description, Learning Path Editor, Graphical PDP Planning Tool, Hybrid Personalizer, Competence Matching Tool
# Table of Contents

EXECUTIVE SUMMARY .................................................................................................................. 2

1 INTRODUCTION .......................................................................................................................... 3

2 LEARNING PATH SPECIFICATION ............................................................................................. 4
   2.1 INTRODUCTION ...................................................................................................................... 4
   2.2 LEARNING PATH SPECIFICATION ....................................................................................... 5
   2.3 PRACTICAL IMPLICATIONS .................................................................................................. 8
   2.4 CONCLUSIONS ...................................................................................................................... 9

3 LEARNING PATH EDITOR .............................................................................................................. 11
   3.1 BASIC CONCEPTS OF THE LEARNING PATH EDITOR ......................................................... 11
   3.2 USER INTERFACE AND INTERACTION RUN-THROUGH ....................................................... 12
      3.2.1 Master View – Overview of available learning paths .................................................. 12
      3.2.2 Metadata view ................................................................................................................ 13
      3.2.3 Design view ..................................................................................................................... 15
   3.3 CONCLUSIONS ...................................................................................................................... 17

4 GRAPHICAL PDP PLANNING TOOL (GPT) ................................................................................ 18
   4.1 FIRST DESIGN OF THE GRAPHICAL PLANNING TOOL ...................................................... 18
      4.1.1 Existing approaches ......................................................................................................... 19
      4.1.2 A first graphical approach ............................................................................................. 19
   4.2 EVALUATION OF THE GRAPHICAL PLANNING TOOL ....................................................... 21
      4.2.1 Description of the user study ......................................................................................... 21
      4.2.2 Results and Discussion ................................................................................................. 22
   4.3 THE ENHANCED VISUAL TOOL ........................................................................................... 23
      4.3.1 New Graphical Design .................................................................................................. 24
      4.3.2 Integration of the GPT with the PDP Tool ..................................................................... 25
      4.3.3 Personalization provided by the Hybrid Personalizer ................................................... 26

5 COMPETENCE MATCHING ......................................................................................................... 28
   5.1 RECRUITMENT ON THE WEB .............................................................................................. 28
   5.2 JOB SEEKING ON THE WEB ............................................................................................... 29
      5.2.1 The format of online vacancies ..................................................................................... 30
      5.2.2 The format of online resumes ....................................................................................... 31
      5.2.3 Searching and Browsing for Jobs .................................................................................. 31
      5.2.4 The role and format of competences ............................................................................ 32
   5.3 EDITORS FOR COMPETENCE AND JOB PROFILES ........................................................... 33
   5.4 JOB SEARCH AND EXPLORATION ....................................................................................... 36
      5.4.1 Occasional Discovery ....................................................................................................... 37
      5.4.2 Explorative and goal driven Job Search ......................................................................... 37
   5.5 IMPLEMENTATION .................................................................................................................. 38
      5.5.1 A Competence Matching Portlet .................................................................................... 38
   5.6 CONCLUSIONS ....................................................................................................................... 43

6 CONCLUSIONS .............................................................................................................................. 44

REFERENCES .................................................................................................................................... 45

APPENDIX 1 (TO CHAPTER 2): LEARNING PATH INFORMATION TABLES ..................................... 48
Executive Summary

In this deliverable we report the progress of WP7 on various independent but highly related tracks. Based on preliminary evaluation results and peer review of the schema, a second iteration of the **Learning Path Specification** has evolved. Its applicability and benefits are currently demonstrated by the development of a **Learning Path Editor**, which allows authors to create learning paths that are structured according to the learning path specification. These learning paths are used by the PDP Planning tool for presenting lifelong learners with a personal development plan that they can further edit toward their needs. This process is supported by the **Graphical PDP Planning Tool** and the **Hybrid Personalizer**, both of these tools have been evaluated in the context of the project. Finally, in order for lifelong learners to become aware and further specify their learning goals, a **Competence Matching Tool** is developed that allows learners to explore job vacancies, to compare to what extent they match their current competences and preferences, and to learn which competences they need to acquire in order to qualify for these jobs.

**ID 7.11** – Completed user study and report on the graphical planning tool
- *Covered in chapter 4*

**ID 7.12** – Revised version of the learning path description and validation plan
**ID 7.13** – Validation of learning path description
- *Covered in chapter 2*

**ID 7.14** – Editors for competence and job profiles
**ID 7.15** – Orchestration of services for competence gap matching
**ID 7.16** – Implementation of the Competence Matching Tool as a Web application
- *Covered in chapter 5*

**ID 7.17** – Implementation of the Learning Path Manager and Editor
- *Covered in chapter 3*
1 Introduction

In this deliverable we report the progress of WP7 on various independent but highly related tracks. The main focus of WP7 is to provide teachers, authors and lifelong learners alike with powerful tools for creating, managing and using their personal development plans (PDPs). These PDPs may be authored to be followed by a larger audience, or created to fit the particular needs of an individual user.

The Learning Path Specification (LPS) is the data model that is used for modeling PDPs. In chapter 2 we describe the background of the second iteration of the Learning Path Specification, which is more concise than the previous one and has more elaborated metadata. We also discuss issues that may arise when deploying the learning path specification in tools to be developed to describe learning paths.

Together with the development of the new Learning Path Specification, a Learning Path Editor (LPE) has been developed, which is presented in chapter 3. The Learning Path Editor offers authors an overview of learning paths they have created and learning paths they are co-editors of. They can add and edit metadata and are provided with a graphical interface to create learning paths using drag-and-drop. The Learning Path Editor is the author interface that hides the complexities of the Learning Path Specification to the user and at the same time provides sufficient flexibility to create custom learning paths.

The Graphical PDP Planning Tool (GPT) enables lifelong learners to graphically explore existing learning paths organized according to their goals and preferences and to create their personal plans (PDPs). In chapter 4 we discuss the results of a user evaluation of the first design of the GPT. Based on these results, the tool has been substantially improved. We end the chapter with a presentation of the new version of the GPT and discuss how it has been integrated with the Planning Tool and the Hybrid Personalizer.

In order to allow users to plan their personal development plans in an effective way, the user first should know his or her competence development goals. The Competence Matching Tool (CMT), which is presented in chapter 5, allows users to explore which job profiles match their competences and which additional competences are required or desired for certain jobs. This functionality is similar to common job boards, such as Monster and Hotjobs. In contrast to these job boards, the Competence Matching Tool compares the user’s competence profile with the competence profile that is required for the job and indicates potential gaps between the current abilities of the user and the ones required for the job. This way, learners can identify future learning goals and can explore the job market from a competence-oriented point of view. Relevant job advertisements are ranked and visualized on a two-dimensional grid: the vertical axis represents how close the match of an advertisement is with the user’s competence profile and the horizontal axis represents the match with the user’s preferences (for example in terms of job location or industry).
2 Learning Path Specification

In this chapter we present the next iteration of the Learning Path Description, which from now on will be called Learning Path Specification (LPS). The previous iterations of the LPS, which were well received by the community, are described in D7.1\(^1\) and D7.2\(^2\). Rather than drawing a subset from IMS-LD\(^3\), it was decided to create a new model, in order for the specification to stay lean and concise. This also allowed for some of the terminology of the specification to be adapted, more closely in line with common concepts regarding paths generally, e.g. ‘start’ and ‘finish’ rather than ‘prerequisites’ and ‘learning objectives’. A schema was developed based on this second iteration of the specification.

Along with the new specification, a tool has been developed that allows human resource managers and others involved in the creation of competence development programs to create learning paths, which are used by lifelong learners to create their competence development programs. This tool – the Learning Path Editor, described in chapter 3 – provides a practical user interface that hides the complexity of the specification from the authors.

This chapter is structured as follows. In the first introductory section we shortly introduce the theory and concepts behind the learning path specification. In section 2.2 the LPS is described in detail, including an overview diagram and references to the XML schemas, which can be found in the appendix. In section 2.3 we discuss deployment issues of the LPS, to further clarify the scope of the LPS and the way it should be used. We end this chapter with a concluding section.

2.1 Introduction

Educational and training opportunities available to lifelong learners have 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 Internet. By far the largest part of adult and lifelong learning though occurs informally, in day to day practice [1-3]. The Commission of the European Communities [4] describes informal learning as “a natural accompaniment to everyday life” which is not necessarily intentional learning. Finally, non-formal learning 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 contrast, formal learning is learning that occurs in education and training institutions, which leads to recognised diplomas and qualifications.

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 [5, 6]. This problem exists not only in formal education, where increased modularization necessitates navigation support [7-9], but also in non-formal and informal learning [10]. 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 (April 2009) results in over 70 thousand hits, referring to all kinds of interior design courses and pages referring to these courses, at varying levels, some accredited others not, with different price tags attached, with varying study load, etcetera. This clearly represents a case of information overload, even though to a novice in the field some course titles might offer a hint (‘introduction’, ‘basics’). Though adding ‘basics’ to the query reduces the number of hits considerably, there are still 9000 left.

\(^1\) http://dspace.ou.nl/handle/1820/1002
\(^2\) http://dspace.ou.nl/handle/1820/1311
In order to enable lifelong learners to compare and select suitable learning paths, a learning path specification was developed. Learning paths are defined as sets of one or more learning actions leading to a particular learning goal. They 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 and may describe for instance actions taken to develop interior design skills oneself: books read, simulations used, lectures attended, exhibitions visited.

Requirements for the specification have been formulated based upon a review of literature on curriculum design and an analysis of different approaches to support comparison and/or selection of courses and programmes. The same study revealed that we might draw on the existing IMS Learning Design specification [15] to describe learning paths [25]. However this would entail including a number of constructs which the learning path specification itself does not require, but which would be required 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 was developed, less closely connected to IMS-LD and its terminology. The new conceptual (UML) model presented in section 2.2 looks different from the initial model but has not changed fundamentally. The new model more explicitly shows 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. The learning path specification distinguishes itself from related specifications in the field, which also aim at supporting learners in finding suitable learning opportunities, like XCRI (eXchanging Course-Related Information) [12], CDM (Course Description Metadata) [13] and MLO-AD (Metadata for Learning Opportunities - Advertising) [14], because 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 has clear links with the IMS-LD (IMS Learning Design) [15] specification [16], 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 that describe 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.

### 2.2 Learning Path Specification

The learning path specification was developed to support comparison and selection of possible ways to develop oneself by describing learning paths in a generic and formal way. Like any path, a learning path has a Start (prerequisites) and a Finish (learning goals). As Figure 1 illustrates, both start and finish are defined in terms of (a set of one or more) competences and associated levels of proficiency (CompetenceLevel). The model does not distinguish a separate class ‘competence’ because it is the combination of a competence with the associated level of proficiency that allows for a meaningful interpretation of the goal (finish) of the learning path and its constituent actions.
**Competence** is defined as the ability of a person to act effectively and efficiently in an ecological niche (e.g. occupation, hobby, sport, etc.) [20]. 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 competence profile.

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 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. 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. The methodical description of competences and associated levels of proficiency is 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 [18-20]. The relation between different levels (e.g. attainment of Competence X level 3 is preceded by...
attainment of levels 1 and 2) might be made explicit in the learning path through a sequence of actions or through specification of a Start, but there are no built in constraints in this respect. A learning path is further described by a set of metadata specifying content, process, and planning information (e.g. title, description, assessment, tutoring, delivery mode, contact hours), which are relevant to the process of choosing a learning path.

The learning path specification is meant to support a number of processes:
1. Description of lifelong learning paths
2. Selection of suitable learning paths
3. Navigation of learning paths (i.e. following the designated steps)
4. Personalisation of learning paths (reckon with learners’ entry levels).

When learning paths and learning actions are described as proposed by the specification (i.e. connected to standardised competence descriptions, with metadata, and explicating distinct steps as well as how they are related) computer supported selection, navigation and personalisation of learning paths can be realised. 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), visualisation of learning paths (optional and mandatory parts, fixed orders) can be automated in support of navigation, and learning paths can be personalised for instance by setting some learning actions to ‘completed’ when the learner already has attained the associated competence levels through prior learning. Another interesting service that could be realised through wider adoption of the learning path specification is recommendation of learning paths that build upon competence levels already attained by a learner.

Both learning paths and their constituent action are described by a set of metadata specifying content, process, and planning information (e.g. title, description, assessment, tutoring, delivery mode, contact hours). Some of these metadata are compliant with the IEEE Learning Object Metadata [24] (e.g. identifier, title, language, description, version, further information, typical learning time, cost) while others are specified in addition (uri, start conditions, recognition, delivery mode, guidance, teaching place, start date, end date, contact hours, assessment, completion, type, number to select).

These metadata are assumed to play a role in learners’ process of choosing a learning path. Their (relative) importance is currently investigated through semi-structured interviews with lifelong learners who recently decided upon a new learning path.

The XML schema was developed using the Free Community Edition of the Liquid XML Studio 6.1.18.0 software. The more detailed information tables of the schema are described in Appendix 1. The learning path model of Figure 1 was initially created in UML (Unified Modelling Language), as a means for graphical representation to facilitate communication about the model. For the technical implementation of the model in a binding we used XML (eXtensible Markup Language) which enables interoperability. The XML schema was developed using the Free Community Edition of the Liquid XML Studio 6.1.18.0 software. The more detailed information tables of the schema are described in Appendix 1.

The Learning Path XML schema is based on the UML model provided in Figure 1 but is not an exact match. For pragmatic reasons (i.e. readability and usability of the schema) some regrouping has been done. For instance the attributes from the UML model have been grouped in a container element ‘Metadata’. Start, Finish and LearningActions have been grouped in an element ‘Learning Path Design’. These results in a schema which at the highest level distinguishes between metadata, design and the building blocks which are referenced in the design: CompetenceLevels, LearningActions and LearningActionsClusters.
2.3 Practical implications

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

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 [26], 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 IEEELOM [24] 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:

<table>
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<tbody>
<tr>
<td>Id</td>
<td>1.1 Identifier</td>
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<tr>
<td>Title</td>
<td>1.2 Title</td>
</tr>
<tr>
<td>Language</td>
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<tr>
<td>Version</td>
<td>2.1 Version</td>
</tr>
<tr>
<td>Workload</td>
<td>5.9 Typical Learning time</td>
</tr>
</tbody>
</table>

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 consist 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.

How and when do I add Rules?
The expression of rules is out of scope of the learning path specification. Existing script languages might be used for this purpose. A 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.

A Learning Path Editor is currently being developed which enables referencing to standardised competence descriptions and also supports adding of metadata both at the learning path level and the level of constituent actions, as the following section describes.

**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 highest 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. The assumption is that external competence descriptions enable referencing to this particular combination: competence + level.

At the LearningPath level the 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 LearningActions level 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 highly 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.

When I want to describe a LearningPath that is offered in two different forms, 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.

### 2.4 Conclusions

Though the investigation of lifelong learners’ choice processes has not been finalised yet and several more interviews are still to be conducted, initial findings have given no indication that crucial metadata are missing from the currently defined set. Interestingly a number of interviewees reported that other learners’ experiences had been important in deciding upon a particular learning path. Though this is not information that can be described beforehand, it suggests an additional metadata field much like the LOM ‘annotation’, might provide a desirable addition to be used to enable learners to describe their experiences with a learning path retrospectively.
Meanwhile a Learning Path Editor is being developed which relies on the specification to enable
description of learning paths. We expect to finalise the investigation of learners’ choice processes in
time to implement necessary changes to the metadata form used in the Learning Path Editor.
An important asset of the learning path specification and of the Editor is the fact that they draw on
standardised competence descriptions, which not only serves to guide the design of learning paths but
also to enhance comparison, choice and personalisation of learning paths. Both the specification and
the tool assume that competence profiles have been described and can be included by reference.
3 Learning Path Editor

The Learning Path Editor is the tool that is being developed within the TENCompetence project to enable creation of learning paths according to the learning path specification, as described in the previous chapter. The Learning Path Editor is designed as a tool to be used by ‘experienced authors’. Even if the specification is to be used to describe informal learning paths as well, it is not evident that learners will do this themselves since it appears hard for instance in workplace learning to separate learning activities from actual work [2].

So who are these ‘experienced authors’, the targeted end-users of the Learning Path Editor? First of all they could be teachers or study counsellors employed by educational institutions or education and training brokers [9] 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 that make considerable investments in training and workplace learning. Finally they could be professionals employed by local social services to advise unemployed citizens on opportunities for further professional or personal development. They all might use the Editor 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.

In the next section we introduce the basic concepts of the Learning Path Editor – a bird’s eye view on its functionality. In section 3.2 the user interface and its intended usage are explained in more detail. In the concluding section 3.3 we discuss the connection with the Learning Path Specification and explain how the editor will be used for the evaluation of the specification.

3.1 Basic Concepts of the Learning Path Editor

The Learning Path Editor was developed to support experienced authors in describing learning paths. The Learning Path Editor consists of three different ‘views’. The first master view provides an overview of all learning paths the author has (co-)created. From this view the author can zoom in on a particular learning path or add new learning paths, which will activate the metadata view which presents the metadata connected to the learning path. Here the author describes a learning path in terms of goals (competence profile) and other metadata. The competence profile (a set of Competences at particular levels of proficiency) is selected from a standardised competence description. The design view finally enables the author to describe and organise the actions to be performed for the learning path to be completed.

The graphical user interface of the design view was developed by extending the interface of the tool developed to visually support the creation of personal development plans by learners (Melero, Hernández-Leo, Arroyo, Aguilar, & J., 2009). The interface combines aspects of concept mapping with a ‘bubble metaphor’: both competences and learning actions are represented by bubbles and they constitute a match when they have the same colour. With visual cues like these the interface supports the functionality in a straightforward way. The learning actions to be used for a selected competence are organised in sequences and selections by dragging and dropping them into a separate area in the interface describing the learning path. In the design view the author can select from existing actions but also can add new actions as well as edit the metadata for both existing and new actions.
3.2 User Interface and Interaction Run-Through

The user interface of the Learning Path Editor provides three different views:

- The **master-view** page lists all learning paths created by an author with and indication of whether or not a path is shared with other users (i.e. other users can co-edit the learning path asynchronously). Besides the overview separately lists learning paths which others have shared with the author.

- The **metadata view** is responsible for presenting a form describing information about a particular learning path. Here the author describes a learning path in terms of goals (competence profile) and other metadata (title, description, prerequisites and startconditions).

- The **design view** shows the competences (related to the competence profile selected in the metadata view) addressed by the learning path, the learning actions used for attainment of these competences, and the way these learning actions are organised/ordered in a workflow.

The following sections describe each of these views in more detail.

3.2.1 Master View – Overview of available learning paths

The overview of all learning paths distinguishes between learning paths owned by the author and those the author has co-created (Fig. 2). Both types of learning paths can be edited and copied, whereas only owned learning paths can be deleted and shared with others. For each learning path, some key information is provided through the collapse/expand controls:

a. description
b. delivery-mode
c. workload
d. names of co-authors.

When an author chooses to edit a learning path (by clicking Edit) or to create a new learning path (by clicking New) the metadata view is activated first.

The master page (Overview, Figure 2) offers an overview of all learning paths created by an author with an indication of whether or not a path is co-edited by other users (a-synchronously). Besides the master page separately lists learning paths owned by others and co-edited by this author.
Figure 2: overview of learning paths

The current state of the master-view page provides the ability to show both the owned and co-edited lists, the control to expand/collapse each row to access to show some key information (description, delivery-mode, names of co-authors, workload), the possibility to create new learning paths and copy an existing learning path. Besides, on our agenda we have extensions towards ordering the lists of learning paths alphabetically or according to date.

3.2.2 Metadata view

The metadata view provides a ‘form’ which contains information about the learning path (Fig. 3).

In case the author clicked “New Learning Path” to create a new learning path from the master-view page, the form is empty and the author first has to minimally specify a title, description and competence profile before he or she can actually start selecting and organising learning actions in the design view.

Straightforward though the metadata view may seem, it merits a closer look before directing our attention to the design view. Table 1 describes all the metadata defined through the metadata view. (Note that the screenshot of Fig. 3 allows only a partial view on the set of metadata). Several other metadata (ID, URI, and Creator) are generated automatically and remain in the background.
Metadata | Description
---|---
**Title** | Title of the learning path.
**Description** | Short general description of the learning path.
**Competence profile** | One or more competences and associated proficiency levels which constitute the targeted endpoint of the learning path.
**Prerequisites** | One or more competences and associated proficiency levels which the learning path presumes the learner has already attained.
**Start conditions** | Specification of practical, pedagogical and technical issues that must be satisfied to be able to follow the learning path, e.g. minimum age, minimum group size, computer equipment.
**Workload** | Estimated workload of the learning path specified in hours.
**Costs** | Total costs of enrolment and specific expenses (books, tools, et cetera). The Costs element contains an attribute ‘currency’.
**Start date** | Optional attribute to specify fixed starting dates for the learning path.
**End date** | Optional attribute to specify fixed end dates for the learning path.
**Completion** | Specifies whether it is up to the learner to decide the learning goals have been reached or whether some kind of assessment is in place.
**Language** | Language of the learning path.
**Provider** | Provider of the learning path. If the learning path involves more than one provider this element contains the main provider.
**Delivery mode** | Mode(s) used for the delivery of the learning path: distance learning, face-to-face, or mixed.
**Recognition** | Specifies whether successful completion of the learning path leads to a formally recognized diploma or certificate.
**Guidance** | Description of available support in terms of tutoring, counselling, feedback, et cetera.
**Attendance hours** | Estimation of number of hours for real-time learner attendance the learning path requires. Note that attendance may be on location or virtual.
**Assessment** | Description of the formative and/or summative assessments available to determine to what extent the learner has acquired the competence(s) at the specified level.
**Further information** | Description of more detailed information on the learning path (may contain URL’s).

Table 1: Metadata of the learning path

It is noteworthy that the metadata from Table 1 serve various functions in the processes of designing, selecting and presenting learning paths. The title of a learning path for instance will be used for keyword search and for the presentation of the learning path for instance in search results. Costs might be used in an advanced search to enable learners to specify maximum costs they are willing to pay. Workload might be used in the same way by both learners and authors: to filter the amount of learning actions possibly suitable when only the competence profile is taken into account. Start conditions on the other hand, provide crucial information for learners, but can hardly be used in an advanced search since they vary widely and are hard to categorise. Still this information can be crucial for a learner to decide the learning path is not suitable despite the fact that it constitutes a match in terms of the competences and levels it helps to attain.

An important feature of the metadata view, hinted at earlier, is the fact that the competence profile addressed by the learning path is selected and included from an external source. A competence profile must be selected before a learning path can be designed because the design view needs this information in order to present relevant learning actions, as will be further illustrated in the next section.
D7.3: Competence Matching and PDP Planning, aggregates internal deliverables ID7.11-ID7.16

Regarding the functionalities of the metadata view, currently it allows filling each field of the form, selecting a competence profile from a repository, and it also advises the author in case he/she didn’t select at least one competence profile. In this case, following message appears: “A competence profile must be selected before a learning path can be designed”. Besides, we are considering extending the functionality of this view by having further information in the sense that upon selection of a competence profile, the interface shows all (most popular/highest rated...) ‘public’ (reusable) learning paths related to this profile, as well as key metadata about these learning paths (description, provider, workload, delivery mode) similar to the list of learning paths in the Learning Path Editor (with collapse and expand control).

3.2.3 Design view

The design view is responsible for the creation of learning paths in a way of sequences and selections. The activities for creating each learning path are related to the competences of the selected competence profile from the metadata view. For this reason, When a competence profile is selected in the metadata view this will result in an import of the competence profile in the Learning Path Editor in such a way that:

- the competence profile field of the metadata view (Fig. 3) is filled with the title of the competence profile
- the profiles competences and associated proficiency levels are presented in the top pane of the design view (Fig. 4)
- available learning actions leading to the attainment of these competences and associated proficiency levels are presented in the left hand pane of the design view.
The graphical user interface of the design view (Figure 4) was developed reusing the interface of the tool developed to visually support the creation of personal development plans by learners [21]. The interface combines aspects of concept mapping with a ‘bubble metaphor’: both competences and learning actions are represented by bubbles and they constitute a match when they have the same colour. With visual cues like these, the interface supports the functionality in a straightforward way.

This view is divided into three panes: the top pane containing the competences related to the competence profile selected in the metadata view; the left hand pane which contains the activities related to each competence: and, the right hand pane where the paths of activities would be created. Moreover, moving the mouse over a competence in the top pane, highlights the coloured circle that represents it as well as the learning actions in the left hand pane which have the same colour, i.e. which lead to attainment of the selected competence. When clicking on a learning action, a small pop-up window appears providing a short description of the learning action, its workload, delivery mode, start date, and start conditions (if specified).

Note that the Learning Path Editor relies on a repository of metadata describing learning actions to fill the left hand pane with learning actions that match with the competences of the competence profile selected in the metadata view. The author can further filter the learning actions shown in the left hand pane by clicking the button ‘filter’ which enables specification of the language, delivery mode, location, workload, recognition, provider, and start date for the learning actions to be shown in the left hand pane. Especially when large numbers of learning actions are available this offers a means to select learning actions in line with the author’s intentions and learner preferences. One by one the author selects the competences in the top pane as well as learning actions to be used in this learning path for the attainment of this competence. The learning actions to be used for a selected competence are dragged and dropped to the right hand pane describing the learning path. Here the learning actions are organised in sequences and/or selections. Switching to another competence the filter can be used again if necessary to specify different requirements for the actions desired for this other competence.
Thus a learning path can consist of a mixture of formal and non-formal and informal learning actions, or a learner can be offered a choice from these for the development of particular competences.

By default the sequences and selections that are subsequently modelled constitute overall a sequence, but the author can change this into a selection by setting ‘Fixed Order’ to ‘off’.

### 3.3 Conclusions

The Learning Path Editor is a tool that enables the description of all kinds of personal and professional development, whether consisting of formal, non-formal or informal learning, in accordance with the learning path specification. An important asset of the learning path specification and of the Editor is the fact that they draw on standardised competence descriptions, which not only serves to guide the design of learning paths but also to enhance comparison, choice and personalisation of learning paths. Both the specification and the tool assume that competence profiles have been described and can be included by reference. The tool further relies on a repository of metadata that describe and point to learning actions.

Further functionality we plan to implement in the design view is recommendation of a learning action in case it addresses the competence currently being designed while it has been included in the learning path already to cover a previous competence. This learning action will then be recommended for the current competence, since this would increase efficiency for the learner.

In addition we will improve the functionality of the Learning Path Editor by promoting reuse of learning paths: upon selection of a competence profile in the metadata view the interface shows all (most popular/highest rated) existing learning paths related to this profile as well as key metadata about these learning paths. The author wants to create a learning path for this competence profile, but maybe a suitable learning path already exists which could be used perhaps with some minor adaptations. Selecting an existing learning path will result in an imported copy of this learning path and the author can subsequently adapt its metadata and/or design.

We are currently developing a framework for the evaluation of the learning path specification, based on theories and research regarding conceptual model quality [22]. This framework starts from the familiar distinction between syntactic, semantic and pragmatic quality of conceptual models [23]. A current investigation of lifelong learners’ choice processes using semi-structured interviews was designed to assess semantic quality: does the learning path specification address key aspects of these choice processes without being redundant? The Learning Path Editor described in this paper will serve to evaluate pragmatic quality of the learning path specification: is the specification easy to understand/apply and is it considered useful? Inevitably, this represents a situation not unlike Plato’s allegory of the cave, for the Learning Path Editor is merely a reflection or representation of the learning path specification rather than its ‘real’ Form, as was illustrated in this paper. In other words, we will have to rely on users’ evaluation of the purpose of the learning path specification as conveyed by the Learning Path Editor to assess its pragmatic quality. The challenge will be to disentangle evaluation of the specification, the functionality of the Editor, and the user interface.
4 Graphical PDP Planning Tool (GPT)

In this chapter we describe the Graphical PDP Planning Tool (GPT), which is the result of several iterations, some of which have been described in D7.1 and D7.2. The GPT is intended for visually supporting learners in the creation of personal learning plans. The approach combines the usage of the concept mapping method, the bubble metaphor, the tooltip graphical user interface element, and the computations provided by the Hybrid Personalizer (see D7.2).

The Graphical PDP Planning Tool enables users to graphically explore existing learning paths organized according to their goals and preferences and to create their personal plans (PDPs). In section 4.1 we present the first design of the GPT. In section 4.2 we discuss the preliminary evaluation. The findings resulting from the user study show that we should continue working in the proposed direction, but that we should make more iterations in the design and evaluation of the tool. The current version of the GPT, in which the findings from the evaluation have been incorporated, is presented in section 4.3, along with the integration of the GPT with the PDP Planning Tool and the Hybrid Personalizer.

The integration of this graphical approach in the TENCompetence infrastructure will provide us with interesting opportunities to evaluate the tool in authentic lifelong learning scenarios for competence development.

4.1 First design of the Graphical Planning Tool

An important research line in the educational technologies field is devoted to support teachers when planning learning processes [5]. Some researchers have also recognized the need of providing solutions that enable learners to inspect and reflect on the learning plans designed by experts (typically teachers) [2, 11]. However, there are not many efforts explicitly considering the role of the learners in the creation of their own learning paths. This support is especially relevant in lifelong learning scenarios where learners have different backgrounds, motivations or experiences [13] and should not be forced to follow a learning path that does not suit their specific learning needs, hinders their competence development or limits their cognitive abilities [11].

A Personal Development Plan (PDP) is defined in [12] as “a structured and supported process undertaken by an individual to reflect upon their own learning, performance and/or achievement and to plan for their personal, educational, and career development.” Moreover, [14] identifies the potential benefits of PDPs in terms of: enhanced learner motivation and confidence; greater sense of ownership of the learning process; improved decision-making skills; and clear progression paths.

Some authors propose the use of Mindtool approaches when learning plans are combined with online learning environments that imply learner thinking [2]. Mindtools are applications used by learners to represent their knowledge in concept maps. This engages them in critical thinking about the content they are studying [9]. Concept mapping is a process by which learners represent their understanding of a specific knowledge domain in a graphical way, using nodes to represent ideas and links to represent the relationships that connect ideas. The result is a map or a graph that visually represents the way in which a learner organizes a set of related concepts or ideas [1, 4].

In this section we borrow the main ideas of concept mapping to facilitate the potential benefits of PDPs by proposing and preliminary evaluating a visual authoring tool (a planner) for learners to explore existing learning paths and to plan and create their own PDP. The first experiments conducted in the TENCompetence project have shown that using the concept of PDPs (learners were able to create and reflect on their PDPs, though not visually) had positive effects such as:

- learners feeling in control in their own learning;
- learners feeling that they learn exactly what they want;
- learners have insight into how their learning progress [13].
4.1.1 Existing approaches

The design and use of interactive information visualization tools, such as e-learning editors, have been widely studied in the past. As advised by (Schneiderman et al, 2000) visual tools should be designed to be both, displays and search tools at the same time.

Some visual schemes generate only one view per information space, but allow the user to zoom in and out, rotate, or, in general, change her viewpoint on the visualization. The approach to visualize information spaces often makes it difficult for users to isolate, identify, and analyze parts or aspects of the information space. Users should be allowed to customize and control how the tool at hand addresses information spaces. Moreover, users should be able to specify which part of the information space is visualized in a dynamic manner. Therefore, making browsing or re-querying information spaces a process of switching between different views and viewpoints. The latter approach is not only based on the fact that tools should allow free browsing, but also on the general need of users to identify relations within the information space and between information spaces as well.

The efficiency of tools is derived from the ability of humans to assimilate to them and to work efficiently with them. With tailoring these applications and schemes to the user taking into account the human cognitive process and, at the same time, its limitations and powers, designers can maximize the tool’s utility. A visualization that overwhelms human sensors will only frustrate its users. Consequently, users will become largely prompt to erroneous behavior and discontinuity with the information’s context. The failure to take human physiological properties into consideration may be the explanation behind the failure of many complex information schemes in achieving high usability levels.

4.1.2 A first graphical approach

After several iterations regarding the prototype of the graphical approach, we designed the visualization tool shown in Figure 5 by adopting the approach of concept mapping [1, 4] and the “bubble” metaphor [6]. Bubble-based interfaces enable the flexible and user-friendly visualization of abstract information as nodes in a map relying on colour cues based on categories, importance, or urgency; thus making navigation easier [6]. In our case, bubbles represent competences and learning activities or courses building up a learning path.

The interface is organized in three main areas. The area situated at the top of the interface contains the competences related to a competence profile (set of competences that define the requirements for achieving a learning goal). Each competence is visualized as a bubble with a different colour depending on the topic area (see Figure 5, a). If a learner puts the mouse over a competence, the bubble and the learning activities or courses that facilitate the development of this competence are highlighted (see Figure 5, e).
Figure 5: Screenshot of the tool for the graphical creation of PDPs

The activities and courses (that build the information space referred to before) are situated in the main area of the interface (Figure 5, b). These bubbles are organized in a way that provides recommendations of learning paths (proposed plan). The proposed plan is calculated using a service developed within the TENCompetence project called the Hybrid Personalizer [8]. It computes each bubble’s position taking into account

1. the learning goals;
2. other learner’s behaviour in a similar situation;
3. the preferences of a learner and, as a result.

It suggests the learner a possible path (central darker area in form of a triangle, Figure 5) which can be followed in order to acquire a specific competence profile. The path is organized among two axis: a vertical axis which is a “temporal line” based on the activities’ relations, and a horizontal axis which takes into account the learner’s preferences.

That is, bottom and top of the vertical axis represent “initial activities” and “advanced or later activities”, respectively; and, with the horizontal axis, we specify the position of the bubbles more suitable to the learner’s preferences and situation (derived from other learner’s behaviour). In addition, each bubble has an alpha level (transparency) which depends on how close the learning activity is to the centre of the proposed plan area: the closer the learning activities are to the centre, the less transparent they are (Figure 5, f). This main area of the interface (Figure 5, b) can be used for exploring the suggested learning activities or courses. Each bubble has associated a “tooltip” (a small window that pops-up when a user clicks on the bubble, see Figure 5, d) where learners can find the details of the learning activity (see Figure 5, d).

In the right area of the interface, learners can create their own personal plan by dragging and dropping the bubbles from the proposed plan area to this area. The personal plan area is split in three sections according to the time when the learner will perform the chosen learning activities. More specifically, these sections are labelled as short term, middle term and long term (see Figure 5, c).
4.2 Evaluation of the Graphical Planning Tool

With the aim of obtaining the first evaluation results of our approach we conducted a preliminary user study [16]. The main questions of interest were:
1. Do users realize the purpose of the tool and use it properly?
2. Do users understand what is shown in the interface?
3. Which changes and additions will improve the usability of the tool?

4.2.1 Description of the user study

The scenario was focused on a competence profile around “learning how to drive”. It was realistic and complex enough in the sense that the profile comprised seven different competences, and a total of 50 activities or courses shaped the proposed learning paths shown by the tool.

We defined two potential “user profiles” (a “farmer” and an “executive”) for a predefined suggestion offered by the tool. Both user profiles had the same learning goal (driving) and shared the same preferences (practical activities, location of the courses and language). The predefined suggestion took into account these common preferences (according to the algorithms of the Hybrid Personalizer). This suggestion was therefore the same for both user profiles (see Figure 5). However, each user profile had additional preferences not considered by the tool: the “farmer” required cheap courses and was only aiming at being able to drive within the farm (no need for an official license); the busy “executive” was interested in short courses with a low number of participants, aimed at the driving license and had already attended some related theoretical lessons in the past. Using the predefined suggestion as a starting point together with the interactive functionalities of the tool, the users (adopting one of the profiles) were expected to flexibly create the development plans most appropriate to their profile. For each profile, we classified each activity or course into the following four categories: expected (in the most appropriate plan according to all the preferences), may be expected, might be expected and unexpected. Table 2 summarizes the different data sources considered in the evaluation.

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Type of Data</th>
<th>Labels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Questionnaire</td>
<td>Quantitative ratings and qualitative opinions, 14 different participants</td>
<td>[Quest-all]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[Quest-farmerX]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[Quest-executiveX]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Where X is the number of the user, from 1 to 7</td>
</tr>
<tr>
<td>Observations during the pilot</td>
<td>Record of direct observations during the experience by 2 different researchers</td>
<td>[Observer1]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[Observer2]</td>
</tr>
<tr>
<td>Differences between the expected and created plans</td>
<td>Quantitative data measuring the number and type of differences between the expected plan and the final outcomes of the users</td>
<td>[diff-farmerX]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[diff-executiveX]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Where X is the number of the user, from 1 to 7</td>
</tr>
</tbody>
</table>

Table 2: Data sources for the evaluation

14 users participated in the study; each of them used the tool for the first time. We randomly assigned the “farmer” profile to half of them and the “executive” profile to the other half. After a brief explanation of 5 minutes, users read the description of their assigned profiles and used the tool to create personal plans. It took them 40 minutes on average.

Two researchers were recording observations on how the participants used the tools, any incidents or emerging comments. The resulting plans were collected to evaluate the differences between the expected and the actually created plans. Finally, a test with closed and open questions about the experience was completed by the participants. Due to the characteristics of the user study, we followed a mixed evaluation method [3] combining and triangulating [7] the qualitative and quantitative data.
obtained from the different sources listed in Table 1. The quantitative data was considered useful for showing tendencies. The qualitative results, in contrast, were used to confirm or reject those tendencies, to understand them and to identify emergent outcomes.

4.2.2 Results and Discussion

Table 3 shows the differences between the expected and the created plans of each user according to the measures explained in the previous section. Table 4 summarizes the results related to each question of interest for evaluation. Some of the results are discussed in more detail in this section.

<table>
<thead>
<tr>
<th>Farmer</th>
<th>++</th>
<th>+</th>
<th>-</th>
<th>--</th>
<th>Executive</th>
<th>++</th>
<th>+</th>
<th>-</th>
<th>--</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Differences between the expected and the created plans (++ expected, + may be expected, - might be expected, -- unexpected)

Table 4: Questions of interest and main results achieved in the user study
Regarding the 1) question (see Table 4) we can say that most users understood the aim of the tool and found it flexible enough for planning and creating their learning paths. In fact, despite the limited time devoted to familiarization and the unexpected selections done by users (many of those due to misunderstandings about the name of the activities – selection of activities with similar names in case they embrace different content or not selection of activities because they can have overlapping topics- and not to the tool itself), 85% of participants choose more than a half of the activities we expected [diff-all], with no significant difference between [diff-farmers] and [diff-executives]. Moreover, 69% of the participants rated the interaction with the interface higher than 4 (in a range of 0 – difficult– to 6 – easy–). 78% of the participants would recommend the tool to others because they think the tool facilitates the planning task [Quest-all]. Several persons indicated “It is a quite good graphical tool and it can help people to plan in this kind of situations” [Quest-executive2]; “The interface facilitates the task and the organization of the information is logical” [Quest-farmer3].

With regard to the understanding of the interface (question 2), the results are globally positive (57% understood the precise meaning of the X axis [Questall], they also explained “It computes suitable courses” [Quest-executive5]”, “The position of the activities depends on whether they are more or less suitable to your profile” [Quest-farmer3]; and the majority had an idea of the connotation of the Y axis, as they said “It classifies the activities in initial and advanced [Quest-farmer1-farmer6-executive3-executive4]”, “From more general to specific [Quest-executive1]”, “From less to more difficulty [Quest-executive2]”).

However, more efforts should be devoted towards a more precise understanding of the recommendations along the Y axis and highlighting the role of the X axis. For example, Executive7 did not understand any of the axis as it was seen in the answers provided in [Quest-executive7]. This issue also justifies his/her unexpected selections [diff-executive7]. These efforts should also consider solutions for those circumstances in which much information needs to be visualized. Though its organization is appreciated by the users, sometimes the overlapping of elements (bubbles) hinders a satisfactory use of the tool. As some participants mentioned “Too much information, and sometimes overlapped [Quest-farmer2]”, “Some bubbles were too close… [Quest-executive2]”.

Another result related to the changes that could improve the usability of the tool (question 3) emerged from the common opinions of the participants [Quest-all] of avoiding the use of the scrollbar and providing always a complete overview of the information space. A garbage bin for deleting the unwished bubbles or enabling users to move away the bubbles without them slipping back to their original place were among the suggestions [Quest-all]. Besides that, most users expected that selecting a competence results in the related activities appearing in the same colour [Quest-all]; [Observer1] also supported this result by indicating “After clicking on each competence, students expected that the bubbles related to this competence kept highlighted using the same colour.” Users also stressed the necessity of improving the management of tooltips. For example, [Quest-executive4] mentioned “Sometimes it’s difficult to keep control over the tooltips because you don’t know which tooltip belongs to which activity.” This result is also supported by [Observer2]: “Some students opened the tooltips (by clicking on the bubbles) but they did not know how to close them.”

### 4.3 The enhanced visual tool

In the previous section we described a study carried out for analysing the understanding of the tool’s purpose, the suitability of the graphic elements shown in the interface, and the changes or additions that would improve the usability and functionality of the tool. The findings were generally positive (participants found quite easy the use of the tool, they found that the tool facilitates the planning task, etc.), despite some problems learners had (using the scrollbar for seeing all the information, not being able to delete activities, difficulties for discerning the activities related to a competence, etc). This represents a step forward for better satisfying the learners’ needs in the creation of PDPs.
Table 5 summarizes the solutions for improving the tool’s usability according to the most important findings of the user study presented in the previous section.

<table>
<thead>
<tr>
<th>Problem in GPT 1.0</th>
<th>Solution in GPT 2.0</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using of the scrollbar for seeing all the information of the interface.</td>
<td>Visualizing all the information in one page by resizing the tool according the browser’s window.</td>
<td>[sol1]</td>
</tr>
<tr>
<td>Difficulties for discerning the activities related to a competence.</td>
<td>Doing a click on a competence, the activities related to it keep highlighted with the same color.</td>
<td>[sol2]</td>
</tr>
<tr>
<td>Bubbles come back at the original place every time the learner drops them.</td>
<td>Enabling to move away the bubbles without having to come back at the original place.</td>
<td>[sol3]</td>
</tr>
<tr>
<td>Difficulties in closing the tool-tips (by doing a click on the related activity).</td>
<td>Adding a cross button to each tooltip for closing it.</td>
<td>[sol4]</td>
</tr>
<tr>
<td>Difficulties for understanding the “long-mid-short term” areas.</td>
<td>Adding a calendar for having and overview of the planned activities.</td>
<td>[sol5]</td>
</tr>
<tr>
<td>The unwished activities cannot be deleted.</td>
<td>Including a garbage bin for dropping the unwished activities.</td>
<td>[sol6]</td>
</tr>
</tbody>
</table>

Table 5: Changes (derived from the user study) that improve the usability of the GPT 1.0

In this section we introduce the new graphical design, based on the results of the preliminary evaluation. Further, we discuss how the GPT has been integrated with the PDP Planning Tool and how both tools now benefit from the personalization support of the Hybrid Personalizer.

### 4.3.1 New Graphical Design

The interface, organized in four areas, shows all the information in one screen, avoiding the use of the scrollbar [sol1]. At the top, there is a list containing the competences related to a competence profile. Depending on the topic area, each competence has a different colour (see Figure 6a), and doing a click on a competence, the activities related to it change into the same colour of the competence (see Figure 6) [sol2].

The learning activities are situated in the main area of the interface (Figure 6b). This area contain the personal plan computed using the Hybrid Personalizer (see section 4.3.3). It suggests the learner a possible path which can be followed in order to acquire a specific competence profile. The path is organized among a vertical axis based on the activities’ relations, and a horizontal axis which takes into account the learner’s preferences and the behaviour of other learners. The main area (Figure 6b) can be used for exploring the suggested learning activities by dragging and dropping each bubble wherever the learner wants [sol3]. Each bubble has again associated a tooltip where learners can find a description of the learning activity. Further, the learner can specify the start and end dates determining when they have planned to do the specific activity. For closing each tooltip, the learner can click on the red-cross [sol4].

A calendar, located at the top-right area (see Figure 6d), contains an overview of the planned activities [sol5]. Doing a click on a dark-blue coloured day, a tooltip shows the information of the planned activities for that day (see Figure 6e). Besides that, in the bottom-right area, there is a garbage bin (see Figure 6f) which contains the learner’s unwished bubbles [sol6].
4.3.2 Integration of the GPT with the PDP Tool

The PDP Tool (a more detailed description in D3.9) supports the lifelong learner by monitoring his progress of a selected competence profile, which fits best her goals. The PDP does not only place the lifelong learner in this competence profiles but also assists in acquiring any missing proficiencies for this profile. This is accomplished by letting the lifelong learner select specific learning activities, which help him in acquiring these missing proficiencies.

After having selected the learning goal and a self-assessment, the lifelong learner is provided a tab in which he can plan his learning activities that will help acquiring the required proficiency levels for the relevant competences (see Figure 7). An initial plan is generated by pressing the generate plan button, which automatically adds learning activities to the plan. These activities are selected from the competence development plans available for each competence. If desired, the user may modify these learning activities by removing or adding learning activities.
The PDP Tool has been extended to incorporate the opportunity to graphically create competence development plans. Now it is possible to call the Graphical Planning Tool from the PDP Tool in Liferay. For this, a button has been added to the PDP Tool that opens the Graphical Planning Tool showing the Learning Activities of concern. The session metadata such as learner status, competences selected, are transmitted in XML to the GPT flash application.

If a learner is overloaded with the opportunities the listed learning activities in the PDP offer him, the GPT provides an overview of the activities in a personalized fashion. This makes it easier for the learner to organize the learning activities since the graphical interface provides a holistic overview and shows better the relations among the items. It further offers drag-and-drop planning functionality and is more intuitive to use. On the other hand, the rather administrative interface of the PDP allows for adding and removing items and is better suitable for inspecting individual activities.

4.3.3 Personalization provided by the Hybrid Personalizer

The presentation of the learning activities in the PDP Tool has to be personalized to the learner. Without the incorporation of the learners status and preferences, the learning activities will not be organized and their relationship will not be easy to grasp. To provide a user-oriented presentation and organization of the learning activities, the Hybrid Personalizer Service is used in the latest version of the PDP Tool.

In D7.2 we presented the Hybrid Personalizer, which provides rates and ranks learning activities, making use of four atomic recommendation services: a positioning service, a navigation service, algorithmic curriculum planning and preference-based selection. The Hybrid Personalizer evaluates the learner’s metadata and the available learning activities to be presented in the PDP and returns an order that first follows the relationships among the learning activities (which competences are provided by which learning activity that in turn are required by another learning activity) and second...
incorporates all other knowledge exposed to the Hybrid Personalizer to adopt the order to the learner’s preferences and to the learning network’s behaviour. For more detailed descriptions of these services, we refer to D7.2.

**Technical Details**

The atomic services together with the integrated service on the one side and the graphical user interface of the PDP Planning Tool on the other are separated conceptually. That is, Java interfaces as well as Web Service interfaces ease the communication between the components and allow for ad-hoc adoption to new data or systems (e.g., the forthcoming integration into the PCM). Moreover, a configuration component allows a fine-grained tuning and adoption of how the returned values of the atomic services are used to compute a single personalization value. By this means, the strategy of the hybrid personalization can be modified easily.

This new functionality of the Hybrid Personalizer has been added to the existing Web Service interface available at the Sofia Server (http://62.44.100.145:8000/HybridPersonalizer?wsdl).

The interface call has to obey the following signature:

```
getOrderOfLearningActivities(ids, metadata, learnermetadata, type)
```

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>String ids</td>
<td>a comma-separated list of learning activity ids</td>
</tr>
<tr>
<td>String metadata</td>
<td>a comma separated list of xml descriptions of the learning activities metadata</td>
</tr>
<tr>
<td>String learnermetadata</td>
<td>Xml description of the metadata available about the learner</td>
</tr>
<tr>
<td>String type</td>
<td>the type of recommendation the Hybrid Personalizer should use (e.g., only based on ratings or based on time) – realized as a reference to the Hybrid Personalizer’s configuration framework.</td>
</tr>
</tbody>
</table>
5 Competence Matching

An important first step in self-directed, lifelong learning is to specify your learning goals. For employees and self-employed these learning goals are typically motivated by changes in job requirements that require new or updated knowledge and skills, or by the desire to apply for a different position – be it a vertical move (e.g. a promotion) or a horizontal move (e.g. a career change).

Similarly, for human resource managers it is a challenge to find the right people for the right job. During the recruitment process several questions should by addressed, such as [3]: what type of individual does the organization want to recruit (in terms of knowledge, skills and abilities); where should one recruit and what recruitment sources should be used to reach the desired application population.

Typically, job advertisements convey an idealized picture of the job and the organization, as this increases the likelihood that people will apply for the job. However, as the recruitment process itself is costly as well, one has to balance between quantity (higher number of applicants) and quality (targeted applications). Realistic job previews have been shown to be effective for this purpose [3]: the first-year retention rate is positively affected by individuals having had accurate job information during the recruitment process, even when the job was not their first choice. Ideally, the job preview should convey sufficient information to estimate whether one would be fit for the job – possibly after having acquired additional knowledge and skills.

The Competence Matching Tool provides an interface to search for job advertisements, making use of various criteria. This functionality is similar to common job boards, such as Monster and Hotjobs. In contrast to these job boards, the Competence Matching Tool compares the user’s competence profile with the competence profile that is required for the job. Thus – in a few words – the Competence Matching Tool adds the competence dimension to nowadays job search tools and allows the learner to see her abilities in context. It gives the learner the possibility to judge her position and potentially required competences for the labor market. In the CMT relevant job advertisements are ranked and visualized on a two-dimensional grid: the vertical axis represents how close the match of an advertisement is with the user’s competence profile and the horizontal axis represents the match with the user’s preferences (for example in terms of job location or industry).

This chapter is organized as follows. In the next section we discuss the current practice of recruitment on the Web. In section 5.2 we explore how users currently search for jobs, what their online resumes look like, how organizations format their online job advertisements and the role of competence profiles in this process. In section 5.3 we describe the editors for job profiles and job seeker’s competence profiles. In section 5.4 and 5.5 we discuss the user interaction design and the implementation of the Competence Matching Tool. We end with a number of conclusions.

5.1 Recruitment on the Web

In the past few decades, the Web has become the major recruitment source for external hires. According to statistics from [1], the Web attributed for over 32% of all job vacancies that were filled by external people in 2008. The other major source for external hires is referrals (existing contacts with current employees or management or contacts established through social networking, 27%). By contrast, print media only attributed for 3.5% of external hires.

The most important Web resource for external hires is the company’s corporate Website, covering about two-third of all external hires that were mediated through the Web. Most companies have a page or section on their Website dedicated to vacancies and job offers. It should be noted that jobseeker who read a company’s vacancies have been led to the corporate Website in one way or another. There are no hard statistics on how they came to visit the company’s Website in the first place: most likely
this is a combination of recommendations from friends and colleagues, references in print and digital media and Web search.

General-purpose job boards (most notably Monster, CareerBuilder and HotJobs, but there is a very long tail of local and niche sites) played a smaller yet still important role. However, according to [1] the role of third parties, including general-purpose job boards is diminishing in favor of referrals. In the past few years, social networking sites – such as Facebook, LinkedIn, MySpace, Xing, Hyves – have gained much in popularity. Companies ensure more and more their visibility particular on the more career-oriented sites, such as LinkedIn and Xing, and referrals are increasingly initiated by social networking. It should be noted that most contacts are established on a person-to-person basis, often long before a concrete job opening appears. In this sense, we can consider social networking as a complementary, preparing step in the hiring process: via their social network, people learn about open positions or are recommended for a certain position, which initiates the actual recruitment process. Further, companies seem to shy away from using these social networking sites, as they simultaneously often block these sites for some or all employees.

The above methods can mainly be categorized as you-find-us approaches: the initiative to apply lies with the potential job applicant. The alternative we-find-you approach (active recruitment) plays a far less significant role, though [4], most likely due to the higher costs associated with actively searching for potential applicants and lack of HR personnel (in particular in SMEs).

The above statistics mainly consider external hires. However, a large portion (39%) of job vacancies are filled by internal hires, which are mainly internal (horizontal) transfers and promotions [1]. Arguably, these internal transfers show the organizations’ commitment to development and their aim to ensure strong retention levels for their most capable staff members. In combination with the importance of corporate Web sites in the recruitment of staff, we think a major application domain of the Competence Matching Tool will be the facilitation of internal transfers, by showing employees further career perspectives, in combination with recommendations which competences they should further develop, in order to reach their ambitions. The tool can also be very useful for niche-specific job boards, but we do not think it will be suitable to replace either large job boards such as Monster or social networking sites such as LinkedIn. These arguments correspond with the scope of TENCompetence, which has a focus on SMEs.

Summarizing the above, we define the scope of the competence matching tool as follows:
- the tool should allow employees to explore and search for career perspectives within their own organization or niche
- the tool should provide feedback on the competences that employees might need to acquire in order to remain up-to-date with their current jobs or to qualify for a new job
- by facilitating the above, human resource departments will benefit from increased internal transfers, so that the right people will be at the right position and be part of the most suitable team.

5.2 Job Seeking on the Web

In order to design the Competence Matching Tool, we explored the current practices, as can be observed in general-purpose boards and career-oriented social networking sites. Our overview consists of the following aspects:
- how do organizations advertise their vacancies
- what do online career-related user profiles and resumes look like
- how do users search for suitable jobs
- what is the role of competences.
5.2.1 The format of online vacancies

As indicated above, the most common sources of online vacancies are companies’ Web sites and job boards. We analyzed several of these boards (including www.monster.co.uk, www.vacaturebank.nl, http://hotjobs.yahoo.com/ and www.linkedin.com) to find the most common elements of a job advertisement. Formats of the job advertisements differed slightly, but they all were quite similar to the traditional paper job advertisements and included the following categories:

- Company Name
- Company URL
- Location
- Industry (choose from list – accounting, banking, IT, airline, …)
- Job Title
- Job Function ((choose from list – administrative, engineering, design, customer care, …)
- Job Type (full-time, part-time, etc.)
- Salary
- Free-text job description.

The free-text job descriptions typically included a short organization profile, a detailed description of the job, the future tasks of the successful applicant, required or desired skills and background (in terms of education and work experience), secondary benefits and instructions on how to apply.

It is an interesting observation that the required skills and educational and professional background are typically described in free-text form and that they do not follow a standard format. We suppose that this is due to the fact that these requirements are often very domain-specific and that there is no specific standard format to list these items. It is up to the potential candidates to determine whether they qualify or not, based on the description given.

Smaller SMEs typically have a listing of all available vacancies. Larger organizations additionally allow the potential candidates to filter the potentially long list of vacancies by location, department, job function, job type and required educational background (typically a generic list of country-specific types of higher education).

Figure 8: job listings of a Dutch energy provider (left) and a job vacancy of a German software company (right)
5.2.2 The format of online resumes

Online resumes can be found on people’s personal or professional Web sites. Job boards also allow users to fill out their resume – which is often called ‘profile’. The specific format differs slightly per country, but most resumes follow the typical Anglo-Saxon standard to include the following items:

- name, address, marital status, picture, …
- education history
- current and past positions
- statement of skills and interests
- language skills
- awards and grants
- references.

In addition, career-oriented social networking sites also provide options to indicate whether you are currently actively looking for a new job, or whether you are interested in receiving any proposals, or whether you would like to be contacted for business or project proposals, personal reference requests or questions in your expertise domain.

![Online Resume in Monster](image)

Figure 9: Online Resume in Monster

5.2.3 Searching and Browsing for Jobs

All job boards provide the opportunity to search for jobs. The basic search typically allows you to enter some keywords and a location. The advanced search offers additional options:

- occupation (a.k.a job category)
- company name
- industry (select from list)
- job function
- job type / number of working hours
- education (prompts a list of types of higher education, country-dependent)
- experience level (ranging from intern to senior)
- type of employment (full time, part time, temporary).
Figure 10: Advanced Job Search in LinkedIn

This list is not exhaustive and is only meant to illustrate the range of options that a user can fill in. Many differences can be observed between the career sites in the labelling and ordering of these items. Further, the predefined lists for industry, job functions and education also differ per site. This type of searching can be seen as *facetted search*, in which you indicate all kinds of orthogonal preferences/requirements for a job.

Some, but not all, job boards also provide the possibility of *browsing*, which typically requires the user to iteratively narrow down the result set by specifying their criteria (in terms of occupation, location, etcetera). During this procedure, no interim results are shown, but the number of matches. Once the number is low enough, the user can proceed to the result page.

It is apparent that all attributes (or search options) are given the same importance by the job boards – the order in which they are presented is different for each board and no prioritization can be observed. The only attribute that stands out is *location*, which has been shown to be the single most important factor in online job seeking [2].

5.2.4 The role and format of competences

In current job boards, competences are not directly taken into account. Instead, indirect indicators such as educational background and work experience are given. In addition, some sites allow the user to indicate her skills, interests, awards and other relevant proofs/indicators of her competences. These lists of skills or interest are generally free-form and do not make use of a standardized competence ontology.

In order to allow for competence gap analysis, a well-defined competence model and an agreed-upon ontology is needed. In earlier work [6] we presented a data model that associates competences with a
context and a proficiency level. These competences can recursively be grouped into composite
competences. In the paper, we showed how this model effectively can be used for matching job
profiles with personal competence profiles. The TENCompetence Domain Model [5] is a simplified
form of this profile in the sense that it does not allow for recursive groupings of competences: instead,
it supports the grouping of competences into competence profiles (which cannot be embedded in
higher-level competence profiles). The latter model provides less flexibility, but has the advantage of
similarity.

More important than the actual scheme or model is the availability of the data and an agreed upon
competence ontology. Currently, several initiatives toward such ontologies can be observed, but it is
still in its infancy. As an example, in the Netherlands the Colo initiative has defined a standard
structure for qualifications in Dutch vocational education ‘Middelbaar Beroepsonderwijs’ [8, 9]. For
development and test purposes, we created a translated subset of this structure and mapped this onto
the TENCompetence Domain Model.

5.3 Editors for Competence and Job Profiles

For matching, a lifelong learner’s competence profile is considered which provides evidence on which
competences the learner has acquired. Job profiles are equipped with the job’s required competences.
Currently, we use a subset of the Colo database that is used in Dutch vocational education.
Competence profiles are provided as well. If needed, mappings between competence profiles from
different domains/systems could be exploited.

In order to allow organizations to create job vacancies and job seekers to create their competence
profiles, two editors have been created.

The first editor, the Job Profile Editor, targets human resource departments of organizations. The job
profile editor provides similar fields as can be found in job boards (see previous section): title,
location, category, type of job, occupation, salary and a free-text description – see Figure 11. We
adhered to the de-facto standard approach in order to maximize usability.
Figure 11: Creating a new job description.

In addition to these basic fields, the user can select relevant competences and required competence levels that a successful applicant should meet – see Figure 12. These competence levels will be taken into account during the job matching process – as will be described in the next paragraph.

Conforming to the TENCompetence Domain Model, competences are grouped into competence profiles. These profiles include generic competences and skills - such as language skills, management skills and sales skills - and job-specific competences, such as cooking and baking.

The user can select and add a competence profile from the combo box at the top of the page and then fill out the required competence levels for the relevant competences within this profile (as an example, in Figure 11 the profile ‘language skills’ contains the competences German, English and French). Non-relevant competences can be left blank.
Following these basic steps, job vacancies and job profiles can be created or modified. Note that we assume that a competence ontology is given (see the discussion in Section 5.2.4). For the context of the TENCompetence project we use an adapted subset of the Dutch Colo initiative, but this can be easily exchanged by alternative, domain-specific competence ontologies.

Employees, job seekers and lifelong learners can create and edit their competence profiles using the Competence Profile Editor. These competence profiles extend the online resumes in regular job boards, as discussed in Section 5.2.2. Job seekers can select the competence profiles that match their resumes (as said before, this includes general profiles such as language skills and sales skills, but also job-specific profiles such as cooking and baking). For each profile, the proficiency levels of each relevant competence can be set.

This is a form of self-assessment that is similar to the approach found in job boards. In addition, the provided structure of competence profiles and competences allows a direct comparison between job profiles and the job seeker’s competence profile – which would not be possible using the free-form approach of sites such as Monster. Further, job seekers can add evidence to support the self-assessments – for example scanned copies of certificates.

Figure 13 shows a screenshot of the competence profile editor. Using the combo box at the top, a user can add a competence profile (in this example ‘Workplace Skills’). Competence profiles can be removed at a later stage, if desired. Subsequently, the user can rate his competences and provide evidence, if relevant. In this example, the user provides a certificate of the German DAAD to support his claimed high proficiency level in German.
**5.4 Job Search and Exploration**

Lifelong learners will use the system to explore job opportunities and to find out which competences they need to acquire to keep qualified for their current position or to be eligible for a new position. Roughly, job descriptions can be classified as:

- jobs that are below his current competence level
- jobs that fit his current competence level
- jobs that are fit, given some additional courses/learning activities
- jobs that are reachable after having followed an intensive program.

The border between ‘some additional courses’ and ‘an intensive program’ is not yet set. The criteria could be set beforehand (e.g. maximum 20 hours) or manually set by the user.

Searching for Jobs as part of competence development is a highly interactive process. A learner typically follows three strategies: first, occasionally discovering, second, exploring the opportunities and, third, a goal-driven search process. For all three ways of job discover we provide solutions in the following.

It is unlikely that there will be exact matches and most likely there will be several ‘equivalent’ solutions (each solution may have its own advantages, but in general they are comparable). This
implies that this usage profile needs to support ‘searching for an optimal solution’, making use of both automatic/intelligent methods and iterative user feedback.

5.4.1 Occasional Discovery
Searching jobs is not always a goal driven process. As such, matching job profiles to a competence profile should not only happen on request but should be a background process that pops up to recommend potential interesting jobs. At the same time, in a real life learning process the issue of finding relevant jobs does not only happen in a purely goal-driven manner. More often than not, people occasionally discover job opportunities and then, potentially, adopt the development plan accordingly. To support this process we used a job recommendation approach that suggests job vacancies retrieved from a database that match a learner’s competences and learning behavior. Such recommendations could be shown as advertisement surrogates in the learning platform – for example LearnWeb 2.0.

5.4.2 Explorative and goal driven Job Search
For the second and third way of job discovery we developed an approach that combines a search interface with an explorative 2-dimensional visualization of the search space. Here, it is a challenge to provide an overview of potentially many jobs matching a learner’s competence profile. Following the ideas of [9] we developed a user interface that allows the learner to explore the search space. The main idea behind our approach is that a single ranked list of search results does not always provide the intended ranking that is meant by the user. Borrowing the ideas from the Hybrid Personalizer and the Graphical Planning Tool, the search space visualization arranges surrogates representing job vacancies in a two-dimensional area. The placing of the surrogates in the area depends on the learner’s competences and on the search query she posed. Again, as in the approach of the Hybrid Personalizer, the two axis of the area follow different semantics.

- **Competence-driven placing**: The y-axis location of a surrogate is determined by the number of matches between the competences the learner gained and the competences required for the job. The computation of the y axis location can be further refined by the learner by selecting from the options:
  1. my competences and competence levels are roughly similar to the vacancy’s required competences
  2. my competence levels are the same or higher as for the competences in the vacancy
  3. my competence levels are exactly the same as for the competences in the vacancy.
  Switching to a higher level among these three options will let vacancies that do not exactly meet my competence profile will be shown as more inaccurate.

- **Metadata-driven placing**: The x-axis location of the surrogates is determined by the amount of matches between the search query constraints and the vacancies. The more a vacancy matches the search constraints, the better ranked it is according to the x-axis.

Our two-dimensional approach allows separating orthogonal dimensions of the search. One axis is governed by the competences of the user. The other axis separates this search criterion from other constraints set up by the learner such as salary or location of the job. And, in case one criterion turns out to be too restrictive, it can be de-activated in the user interface thus providing a broader view on the job opportunities available.
Figure 14: Placing job surrogates to visualize competence gaps and preference matching at the same time.

Obviously, the approach of placing vacancies according to two dimensions as described serves the second and the third search paradigm. It serves the explorative paradigm since the options selected in a search query are considered soft constraints: jobs not exactly matching all the constraints will still appear but they may appear lower ranked if jobs exist that match better the query. The goal-driven search is served since the best match will still catch the learner’s attention: it is placed as first ranked result.

5.5 Implementation

The job matching usage profile has been implemented as a Liferay portlet empowered with a Java servlet computing the matching probability and an Ajax service that dynamically controls the placing of the surrogates in the result space. A user is enabled to enter a job specification and search for jobs matching her competences as well as her search constraints.

5.5.1 A Competence Matching Portlet

The competence matching portlet allows the learner to define a search query and to change her competences and competence levels considered for a job search. Currently, there are two ways of exploring jobs: one is text-based (as shown in Figure 16) and the other follows the approach of two-dimensional presentation described earlier in Section 5.3.2. The two dimensions considered for search

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4 The code of the Competence Matching Portlet can be found at http://tencompetence.cvs.sourceforge.net/viewvc/tencompetence/wp7/CompetenceMatcher/
are the learner’s competences and her preferences concerning a new job (e.g., salary, job location, etc.). The first dimension, the competences, is stored in the user profile of TENCompetence and is accessed by the portlet. The second dimension, the desired attributes for the job are to be provided by the user in the search interface depicted in Figure 15.

Figure 15: User interface for specifying a job search query

5.5.1.1 Matching users and jobs

The Competence Matching framework is – in contrast to classical job search platforms – not interested in returning a list of results that match a search query but in determining how much a job vacancy fits the current situation and the wishes of a learner. For determining those matching values, we developed three matching algorithms, one for matching the jobs metadata and a learner’s search request and two for matching a learner’s competence profile with the required competence profile of a job vacancy.

Matching Competences

For matching required competences of a job with a competence profile we only considered those competences that are offered by the job and not other competences the user may have but the job does not require. In general, a job matches worse a user’s competence profile if, first, some competence profiles required for the job are not listed in the learner’s portfolio, and if, second, for some required competences, the user only shows a lower proficiency level. The matching similarity should always be normalized by the number of competences required for the job, otherwise jobs with many competences get ranked worse only because the probability that less competences are met by the learner is higher.

The resulting matching similarity values are numbers between 0 and 1, where
- 1 represents a match, i.e., the user’s competences completely match the job description and
- 0 represents no match at all, i.e., the learner has none of the competences required for the job.
We implemented a so-called strict matching similarity measurement and a fair measurement that considers required competences showing lower proficiency in the learner’s profile still better than required competences missing in the profile.

**Fair**
The fair matching algorithm computes the matching value $m$ as the number of user competences with higher or equal proficiency levels $n_\geq$ plus the number of lower levels $n_<$ divided by two minus the number competences the user does not have $n_{not}$. This value is normalized by the number of competences required for the job $n_{Job}$.

$$m = \frac{n_\geq + \frac{1}{2}n_< - n_{not}}{n_{Job}}$$

Although the fair matching value counts competences with a lower level still better than competences not provided by the user at all, it puts an additional penalty for those competences that are not provided. That means, of no competence is met by the user, 0 is returned, if all competences are met (with higher or equal level), 1 is returned. If only half of the competences are met and the others or not part of the learner’s portfolio, 0 is returned as well.

**Stricter**
The stricter matching measurement considers only those competences of the learner that are actually equal or better compared to the ones in the job profile.

$$m = \frac{1}{n_{Job}} \cdot n_\geq$$

The stricter matching algorithm iterates over all competences of the job and for every competence where the user has a higher or equal level, $1/n_{Job}$ is added to 0. That is, if no competence is met, 0 is returned. If all competences are met, 1 is returned. If half of the competences are met, 0,5 is returned.

**Matching Learner Preferences**
As described above, the preferences defined in the search form depicted in Figure 15 are not considered hard constraints strictly filtering out jobs that do not meet the preferences. Despite this, those preferences are used to compute a matching value representing the probability that a job vacancy meets the defined preferences. This matching value is computed by the number of properties of a job that match the user’s query divided by the number of all properties defined in the query.
5.5.1.2 Two ways of presenting a result list

The portlet features two interfaces to show the list of matching jobs to the user. One is the classical ranked result list (as shown in Figure 16) and the other one is a two-dimensional plot representation of the results (as shown in Figure 17). The user can switch between both views easily by activating the respective tab (see list/plot tab selection on the top of Figures 16 and 17).

The two-dimensional plot presentation shows on both axes the resulting values of the respective matching algorithm (y-axis: competence matching; x-axis: preference matching). Further, the plot view allows the user to manually include/exclude search constraints that are considered in computing the locations of the surrogates. This selection is provided by the combo boxes placed close to the axes. If, for example, the user selects salary in the combo box close to the x-axis, only the matching of the jobs according to the user’s salary constraint are considered for computing the matching value. Hence, if the user wants to explore the search space, she can interactively activate or deactivate search constraints from the x-axis. Therefore getting an idea of questions like “what if I abandon my salary constraint; which jobs would then match best?”. The second combo box allows to refine the competences considered during matching. In Figure 17 for example, the language skills are deactivated resulting in a result visualization where the language skills of the learner are not considered.
Figure 17: The two-dimensional representation of matching job vacancies.

By default, all entries in both combo boxes are activated which lets the location computation consider all constraints provided in the search interface. For every change in the constraint selection the locations of the surrogates are recomputed and, subsequently, the surrogates slight to their new locations. That way, a visualization of how much worse or better a certain job became according to the new constraint setting is provided.

The bird view area on the left provides an overview of the whole search space. There, the user can paginate the results by dragging the yellow box in the search space area. Paginating is also allowed by scrolling along the two axes (see yellow scroll bars in Figure 17).

Job details are shown in the area on the right. The area is updated by either double clicking on a surrogate or by dragging and dropping a surrogate to the details area.

5.5.1.3 Architecture

Since the re-computation of the locations in the two-dimensional result representation has to be shown dynamically for every new selection of constraints, we decided to use Ajax for retrieving the new location values. For this, we developed in addition to the portlet a servlet that resides in the same Tomcat container as Liferay and serves as a Location Computation Servlet that is caught from the portlet’s JavaScript.
The Location Computation Servlet receives a description of the attributes selected and starts a new computation of matching values for each job. For this, the search query is not re-issued to the data set but the jobs selected by the search query are assigned new matching values. The new matching values are computed for both dimensions: according to the user’s competences and according to the preferences described in the search query.

Figure 18: Architecture of the Competence Matching Tool

5.6 Conclusions

In this chapter we introduced the Competence Matching Tool. The design of the tool is inspired by extensive background research on current practices in the field and allows for interactive visual comparison of job profiles with personal competences and preferences.

We consider corporate Websites and niche job boards as the main application areas of the Competence Matching Tool – using these means, HR managers can stimulate employees to be open to new internal career opportunities, provide perspectives for further education and thus ensure retention of capable staff.

In order for the tool to work in practice, companies should agree upon standardized competence models. Whereas some initiatives are currently being executed (such as for the Dutch vocational education), we think it is more realistic to expect organizations and specialization areas to create their own, limited models. As the Competence Matching Tool is not designed to replace general-purpose job boards but to support job transfer within organizations or specialization areas, we do not consider this a problem.
6 Conclusions

In this deliverable we have discussed the progress of WP7 on various independent but highly related tracks. Based on preliminary evaluation results and peer review of the schema, a second iteration of the Leaning Path Specification has evolved. Its applicability and benefits have been demonstrated by the development of a Learning Path Editor, which allows authors to create learning paths that are structured according to the learning path description. These learning paths are used by the PDP Planning tool for presenting lifelong learners with a personal development plan that they can further edit toward their needs. This process is supported by the Graphical PDP Planning Tool and the Hybrid Personalizer, both of these tools have been evaluated in the context of the project. Finally, in order for lifelong learners to become aware and further specify their learning goals, a Competence Matching Tool is developed that allows learners to explore job vacancies, to compare to what extend they match their current competences and preferences, and to learn which competences they need to acquire in order to qualify for these jobs.

As there are currently no current practices on computer-supported competence development programs, the work in WP7 has deliberately been exploratory, aiming at proofs of concepts rather than tools that can be put in the market. A major focus in WP7 has been on the development of graphical user interfaces and the combination of various techniques for providing lifelong learners, with different needs and backgrounds, with the tools that they need.

In the past couple of years, some tools have gone through sufficient iterations to become sufficiently mature for incorporation in the TENCompetence infrastructure – the Graphical Planning Tool and the Hybrid Personalizer. The work on the Learning Path Editor and the Competence Matching Tool has started at a later point in the project and, as a consequence, have not yet reached a sufficient level of maturity for integration in the infrastructure. However, both tools are built based on extensive background research and current practices, and evaluation is planned or currently being carried out – and will be reported in the final WP7 deliverable D7.4 at the end of the project.
References

Chapter 2 and 3

**Chapter 4**

11. W. Pan, and M. Huang, “A visual interface to assist learners to inspect learning plans”, In Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications, USA, 2006, pp. 703-710
Chapter 5


4. Veger, M. How does Internet recruitment have effect on recruitment performance? Proc. 4th Twente Student Conference on IT, 2006

5. TENCompetence Domain Model. http://hdl.handle.net/1820/649


Appendix 1 (to Chapter 2): Learning path information tables

This appendix provides a detailed description of the learning path schema by presenting a number of information tables revealing different levels of detail of the schema: Learning Path, Metadata, Learning Path Design, CompetenceLevel, Learning Action and Learning Actions Cluster.

1. Information table Learning Path

<table>
<thead>
<tr>
<th>Name</th>
<th>Explanation</th>
<th>Req</th>
<th>Mult</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>LearningPath</td>
<td>Specification of a set of 1 or more learning actions and the way they are</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>structured, leading to a defined set of one or more competences at</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>particular proficiency levels.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metadata</td>
<td>Container element for data which provide content, process and planning</td>
<td>M</td>
<td>1</td>
<td>sequence</td>
</tr>
<tr>
<td></td>
<td>information on the LearningPath.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LearningPathDesign</td>
<td>Container element for specification of the Finish and Start (optional) of</td>
<td>M</td>
<td>1</td>
<td>sequence</td>
</tr>
<tr>
<td></td>
<td>a LearningPath in terms of CompetenceLevels as well as the steps (LearningActions) that lead to the Finish.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CompetenceLevels</td>
<td>Container element for specification of CompetenceLevels which are referenced</td>
<td>M</td>
<td>1</td>
<td>sequence</td>
</tr>
<tr>
<td></td>
<td>in the LearningPathDesign.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning Actions</td>
<td>Container element for specification of LearningActions which are referenced</td>
<td>M</td>
<td>1</td>
<td>sequence</td>
</tr>
<tr>
<td></td>
<td>in the LearningPathDesign.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2 Information Table ‘Metadata’

<table>
<thead>
<tr>
<th>Name</th>
<th>Explanation</th>
<th>Reqd</th>
<th>Mult</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metadata</td>
<td>Container element for data which provide content, process and planning information on the LearningPath.</td>
<td>-</td>
<td>-</td>
<td>container</td>
</tr>
<tr>
<td>Id</td>
<td>Identifier of the LearningPath (local)</td>
<td>M</td>
<td>1</td>
<td>ID</td>
</tr>
<tr>
<td>URI</td>
<td>Uniform resource identifier of the LearningPath</td>
<td>M</td>
<td>1</td>
<td>anyURI</td>
</tr>
<tr>
<td>Title</td>
<td>Title of the LearningPath</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>Version</td>
<td>Version of the LearningPath; necessary to allow for updates of LearningPaths and to enable identification of specific versions.</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>Language</td>
<td>Language of the LearningPath. Can be derived from the language attributes of the subsequent LearningActions; the value is a generated enumeration of all unique</td>
<td>O</td>
<td>0..*</td>
<td>language</td>
</tr>
<tr>
<td>Name</td>
<td>Explanation</td>
<td>Req</td>
<td>Mult</td>
<td>Type</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----</td>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>Description</td>
<td>Short general description of the LearningPath.</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>Provider</td>
<td>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.</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>DeliveryMode</td>
<td>Mode(s) used for the delivery of the Learning-Path: distance learning, face-to-face, or mixed.</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>Recognition</td>
<td>Specifies whether successful completion of the LearningPath leads to a formally recognized diploma or certificate.</td>
<td>O</td>
<td>0..1</td>
<td>boolean</td>
</tr>
<tr>
<td>Guidance</td>
<td>Description of available support in terms of tutoring, counselling, feedback, et cetera.</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>AttendanceHours</td>
<td>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.</td>
<td>O</td>
<td>0..1</td>
<td>integer</td>
</tr>
<tr>
<td>RunInformation</td>
<td>Container element grouping metadata which are connected to a specific ‘run’ of a LearningPath: Location, StartDate, Enddate.</td>
<td>O</td>
<td>1</td>
<td>sequence</td>
</tr>
<tr>
<td>Location</td>
<td>Optional element for specification of the physical location for face-to-face meetings.</td>
<td>O</td>
<td>0..*</td>
<td>anyType</td>
</tr>
<tr>
<td>StartDate</td>
<td>Optional attribute to specify fixed starting dates for the LearningPath.</td>
<td>O</td>
<td>0..1</td>
<td>date</td>
</tr>
<tr>
<td>EndDate</td>
<td>Optional attribute to specify fixed end dates for the LearningPath.</td>
<td>O</td>
<td>0..1</td>
<td>date</td>
</tr>
<tr>
<td>Assessment</td>
<td>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.</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>FurtherInformation</td>
<td>Description of more detailed information on the LearningPath (may contain URL's).</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>StartConditions</td>
<td>Specification of practical, pedagogical and technical issues that must be satisfied to be able to follow the LearningPath.</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>Workload</td>
<td>Estimated workload of the LearningPath specified in hours; the value of this attribute is the generated summation of the workload attribute values of all LearningActions within the LearningPath.</td>
<td>O</td>
<td>0..1</td>
<td>integer</td>
</tr>
<tr>
<td>Costs</td>
<td>Total costs of enrolment and specific expenses (books, tools, et cetera). The Costs element contains an attribute ‘currency’.</td>
<td>O</td>
<td>0..1</td>
<td>integer</td>
</tr>
<tr>
<td>Completion</td>
<td>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.</td>
<td>O</td>
<td>1</td>
<td>string</td>
</tr>
</tbody>
</table>
3 Information Table ‘LearningPathDesign’
### LearningPathDesign

<table>
<thead>
<tr>
<th>Element</th>
<th>Explanation</th>
<th>Reqd</th>
<th>Mult</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>LearningPathDesign</td>
<td>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.</td>
<td>-</td>
<td>-</td>
<td>sequence</td>
</tr>
<tr>
<td>Start</td>
<td>Container for specification of one or more CompetenceLevels which constitute the starting point of the LearningPath.</td>
<td>O</td>
<td>0..1</td>
<td>sequence</td>
</tr>
<tr>
<td>- Id</td>
<td>An identifier for the Start specified for this Learning Path which is unique within the LearningPath.</td>
<td>O</td>
<td>0..1</td>
<td>ID</td>
</tr>
<tr>
<td>- Title</td>
<td>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.</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>- URI</td>
<td>Uniform resource identifier to be used for referencing existing profile definitions outside the LearningPath as the Start for the LearningPath.</td>
<td>O</td>
<td>0..1</td>
<td>anyURI</td>
</tr>
<tr>
<td>CompetenceLevelRef</td>
<td>Reference to a competence at a particular level.</td>
<td>M</td>
<td>1..*</td>
<td>Idref</td>
</tr>
<tr>
<td>Finish</td>
<td>Container for specification of one or more CompetenceLevels which constitute the targeted endpoint of the LearningPath.</td>
<td>M</td>
<td>1</td>
<td>sequence</td>
</tr>
<tr>
<td>- Id</td>
<td>An identifier for the Finish specified for this LearningPath which is unique within the LearningPath.</td>
<td>M</td>
<td>1</td>
<td>ID</td>
</tr>
<tr>
<td>- Title</td>
<td>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.</td>
<td>O</td>
<td>0..1</td>
<td>string</td>
</tr>
<tr>
<td>- URI</td>
<td>Uniform resource identifier to be used for referencing existing profile definitions outside the LearningPath as the Finish for the LearningPath.</td>
<td>O</td>
<td>0..1</td>
<td>anyURI</td>
</tr>
<tr>
<td>CompetenceLevelRef</td>
<td>Reference to a competence at a particular level.</td>
<td>M</td>
<td>1..*</td>
<td>Idref</td>
</tr>
<tr>
<td>LearningActions</td>
<td>Container element used to reference one or more Learning Actions, Learning Actions Clusters or LearningPaths.</td>
<td>M</td>
<td>1</td>
<td>Choice</td>
</tr>
<tr>
<td>LearningActionRef</td>
<td>Reference to a LearningAction to be performed by a learner which has been declared elsewhere within the LearningPath (see LearningPath - LearningAction).</td>
<td>M</td>
<td>0..*</td>
<td>Idref</td>
</tr>
<tr>
<td>LearningActions ClusterRef</td>
<td>Reference to a collection of LearningActions which has been declared elsewhere within the LearningPath (See LearningPath - LearningActionsCluster).</td>
<td>M</td>
<td>0..*</td>
<td>Idref</td>
</tr>
<tr>
<td>LearningPathRef</td>
<td>Reference to an existing LearningPath to be included.</td>
<td>M</td>
<td>0..*</td>
<td>anyURI</td>
</tr>
</tbody>
</table>
4 Information Table ‘CompetenceLevels’

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

5 Information Table ‘LearningActions’
### Learning Actions

<table>
<thead>
<tr>
<th>Name</th>
<th>Explanation</th>
<th>Req</th>
<th>Mult</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>LearningActions</td>
<td>Container element used to group all LearningActions, LearningActionsClusters or LearningPathRefs which are referenced in the LearningPathDesign. The LearningActions element also appears in the LearningActionsCluster to indicate that a LearningActionsCluster always contains at least two components which can be either a LearningAction a LearningActionsCluster or a LearningPathRef.</td>
<td>-</td>
<td>-</td>
<td>choice</td>
</tr>
<tr>
<td>LearningActionsCluster</td>
<td>Collection of LearningActions with specification of order rules (Type: sequence, selection, parallel).</td>
<td>M</td>
<td>1..*</td>
<td>sequence</td>
</tr>
<tr>
<td>Metadata</td>
<td>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).</td>
<td>M</td>
<td>1</td>
<td>sequence</td>
</tr>
<tr>
<td>Type</td>
<td>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).</td>
<td>M</td>
<td>1</td>
<td>string</td>
</tr>
<tr>
<td>NumberToSelect</td>
<td>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.</td>
<td>O</td>
<td>1</td>
<td>integer</td>
</tr>
<tr>
<td>TargetCompetenceLevel</td>
<td>Element to specify the CompetenceLevel which successful completion of the LearningActionsCluster will contribute to.</td>
<td>O</td>
<td>0..*</td>
<td>idref</td>
</tr>
<tr>
<td>RequiredCompetenceLevel</td>
<td>Element to specify the CompetenceLevel a learner is expected to have mastered before starting the LearningActionsCluster.</td>
<td>O</td>
<td>0..*</td>
<td>idref</td>
</tr>
<tr>
<td>Rule</td>
<td>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.</td>
<td>O</td>
<td>0..*</td>
<td>sequence</td>
</tr>
<tr>
<td>LearningAction</td>
<td>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.</td>
<td>M</td>
<td>1..*</td>
<td>sequence</td>
</tr>
<tr>
<td>Metadata</td>
<td>Container element for data which provide content, process and planning information on the LearningAction (Id, Title, Version, Language, Description, Provider, DeliveryMode, Recognition, StartConditions, Guidance, AttendanceHours, RunInformation, Assessment, Workload, Completion).</td>
<td>M</td>
<td>1</td>
<td>sequence</td>
</tr>
<tr>
<td>TargetCompetenceLevel</td>
<td>Identification of the CompetenceLevel successful completion of the LearningAction will contribute to.</td>
<td>O</td>
<td>0..*</td>
<td>idref</td>
</tr>
<tr>
<td>Name</td>
<td>Explanation</td>
<td>Req</td>
<td>Mult</td>
<td>Type</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>RequiredCompetence Level</td>
<td>Identification of the CompetenceLevel a learner is expected to have mastered before starting the Learning Action</td>
<td>O</td>
<td>0..*</td>
<td>idref</td>
</tr>
<tr>
<td>LearningPathRef</td>
<td>Reference to an existing LearningPath to be included in the current LearningPath. Though the specification places no constraint on referencing only one LearningPath it does not make sense to do so; it would only result in wrapping an existing LearningPath in an extra layer of metadata.</td>
<td>M</td>
<td>0..*</td>
<td>anyURI</td>
</tr>
</tbody>
</table>