The Competence Matching Tool provides a user 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 document provides an overview of current standards in Job search and competence matching and describes the implementation of the TENCompetence Competence Matching Tool.
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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 be 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 document is organized as follows. In the next section we discuss the current practice of recruitment on the Web. In section 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 3 we describe the editors for job profiles and job seeker’s competence profiles. In section 4 and 5 we discuss the user interaction design and the implementation of the Competence Matching Tool. We end with a number of conclusions.

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.
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.

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).
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.
Figure 2: Online Resume in Monster

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).
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 *faceted 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].

**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 simplicity.

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.

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 4. We adhered to the de-facto standard approach in order to maximize usability.
In addition to these basic fields, the user can select relevant competences and required competence levels that a successful applicant should meet – see Figure 5. 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 4 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 6 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.
3. **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.

**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.

**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 7: 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.

4. 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.

A Competence Matching Portlet

The competence matching portlet\(^1\) 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

\(^1\) The code of the Competence Matching Portlet can be found at http://tencompetence.cvs.sourceforge.net/viewvc/tencompetence/wp7/CompetenceMatcher/
exploring jobs: one is text-based (as shown in Figure 9) and the other follows the approach of two-dimensional presentation described earlier in Section 5.3.2. The two dimensions considered for search 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 8.

![Figure 8: User interface for specifying a job search query](image)

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 leaner 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 $n_{\geq}^u$ 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, if 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 8 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.
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 9) and the other one is a two-dimensional plot representation of the results (as shown in Figure 10). The user can switch between both views easily by activating the respective tab (see list/plot tab selection on the top of Figures 9 and 10).

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 \textit{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 10 for example, the language skills are deactivated resulting in a result visualization where the language skills of the learner are not considered.
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 10).

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.

**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 called 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 11: Architecture of the Competence Matching Tool](image)

5. 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.