DOKUZ EYLÜL UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

ADVANCED SKILL MANAGEMENT IN WORKFLOW SYSTEMS

by

Volkan ABUR

March, 2011

İZMİR

ADVANCED SKILL MANAGEMENT IN WORKFLOW SYSTEMS

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by

Volkan ABUR

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Ph.D. THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"ADVANCED SKILL MANAGEMENT IN WORKFLOW SYSTEMS"** completed by **VOLKAN ABUR** under supervision of **PROF. DR. ALP KUT** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy.

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ADVANCED SKILL MANAGEMENT IN WORKFLOW SYSTEMS

ABSTRACT

The human factor has been still playing a considerable role in the business processes most of which are handled via electronic workflows. Since the Workflow Management Systems deal with organizational models and resource allocation problems, the operations of human resources in any enterprise are also included in the design and implementation phases of workflows. Skill management is one of the application areas that is used to track the skills of human resources for the allocation of the appropriate tasks and their career planning in the organization.

In this thesis, a knowledge-based system approach, e-Worter, which combines both Workflow and Skill Management disciplines, is introduced. Its own workflow model that is integrated with a skill model is described and the proposed methods regarding the definition, assignment and analysis of the skills are discussed.

The model is simulated in an academic department, The Computer Engineering Department of Dokuz Eylul University, to show how such a combined system can improve the educational and decision making processes of the department, how it affect the quality of business processes and how it can meet the basic standards of accreditation of engineering education.

Keywords: Workflow; Competence; Skill management; Resource management; Human management; Engineering education.

İŞ AKIŞI SİSTEMLERİNDE GELİŞMİŞ YETENEK YÖNETİMİ

ÖZ

İnsan faktörü, çoğunluğu elektronik iş akışları aracılığıyla yürüyen iş süreçlerinde önemli rol oynamayı hala sürdürmektedir. İş akışı Yönetim Sistemleri, organizasyon modelleri ve kaynak atama problemleriyle ilgilendiği günden bu yana kurumların insan kaynakları süreçleri, iş akışlarının tasarım ve işleyiş fazlarında yer almaya devam etmektedir. Yetenek Yönetimi, kişileri uygun işe atama ve organizasyon içindeki kariyer planlama işlemleri için, yetenek takibi amacıyla kullanılan insan kaynakları uygulama alanlarından birisidir.

Bu tezde, İşakışı ve Yetenek Yönetimi disiplinlerini birleştiren bilgi tabanlı bir system yaklaşımı, e-Worter, tanıtılmaktadır. Yaklaşımın kendi iş akışı modeliyle entegre edilmiş yetenek modeli gösterilmektedir ve yeteneklerin tanımlanması, atanması ve analiz edilmesi üzerine önerilen yöntemler tartışılmaktadır.

Model, Dokuz Eylül Üniversitesi Bilgisayar Mühendisliği Bölümünde uyarlanarak böylesine bütünleşik bir sistemin bölümün eğitim süreçlerini ve karar verme mekanizmalarını nasıl iyileştirdiği, süreçlerin kalitesini nasıl etkilediği ve mühendislik eğitimi akreditasyonu için gereken temel standartları ne şekilde karşıladığı gösterilmektedir.

Anahtar sözcükler: İş akışı; Yetkinlik; Yetenek yönetimi; Kaynak yönetimi; İnsan kaynakları; Mühendislik eğitimi.

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CHAPTER ONE
INTRODUCTION

1.1 General

The organizations execute different types of methods and use many calculations to do the best for their business processes. The rapid and successful achievement of each process is aimed by the management of any enterprise. Since the computer technology has been incredibly evolving, the requirements have increased and a powerful automation of work has become more vital to go on in the marketplace. It is now a fact that design and implementation of processes in terms of automation improve efficiency and effectiveness of business operations. That is exactly what workflows engage. As a leading committee that was founded to build a standard framework for workflows, Workflow Management Coalition (WfMC) defines workflow as it follows: *"The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules"* (Workflow Management Coalition (WfMC), 1999). The definition indicates that people still play a key role as they participate in automated workflows to complete their tasks.

Workflows are good for companies, customers and users as Plesums (2002) states. In addition to the organizational benefits such that decreasing costs, managing documents and controlling the processes, workflows also improve the quality of service by responding more quickly with the best person available. Who is the best person, indeed? The answer depends on a determination process that is capable of finding who is available to perform the work, whether the resource is allowed by the supervisors and procedures and how good the resource is at that work. Calculation of resource availability, definition of business requirements and integration of organizational models, policies and procedures are usually executed by many workflow based systems. Large enterprises use some process driven architectures such as enterprise resource planning (ERP) tools that are integrated with Human

Resources (HR) modules and support employees (Leyking, Chikova & Loos, 2007). Moreover, some complex ways such as balanced scorecards, key performance indicators and return on investment metrics can be used to improve the speed and quality of business operations (Gilger, 2003). Even those help the management of resources, finding a resource that is good at work needs more than a standard workflow or ERP system exposes. The organizations are therefore expected to know what their resources are qualified for in detail.

Skills of resources are valuable and have strategic importance of competition for any enterprise (Benger, Uslar & Wollkopf, 2004). If the social and technical background of resources are known well then it can strongly be possible to allocate them for ongoing or future processes based on their capabilities. Nowadays, detailed and time consuming survey processes or products in the digital world such as e-mails or forms are generally used to elicit the skills and competencies of which level of interest are measured rather than level of expertise (Ackerman, McDonald, Lutters & Marumatsu, 1999). That elicitation process is difficult to manage because finding a resource that has more experienced on specific technical concepts needs not only a detailed determination mechanism but also a detailed skill storage, assignment and maintenance approaches.

A Skill Management System (SMS) here seems to be a redemptive area that is defined as the management of the qualifications, experiences and knowledge of the people (Beck, 2003). The Human Resources (HR) departments of many companies try to manage, improve and deploy the right skills (Holland & Peitzsch, 2005). As a matter of fact, the skill management systems have been used for HR processes such as personnel planning, recruiting, selection and development operations (Beck, 2003; Hiermann & Höfferer, 2003) and is also important for knowledge-intense companies (Benjamins, et al., 2003).

1.2 The Purpose of the Thesis

The main purpose of this study is to build a bridge between Skill Management and Workflow Management disciplines to complete the parts of both missing. Since workflows can be used to automate knowledge-exposing processes, it should also be possible to see them as the products in a knowledge market in which many skills are sold and bought. Even using process modeling seems to be the most effective way to manage the skills of people, it is seldom rarely used as yet (Gronau & Uslar, 2004b). Throughout the study, the main steps of proposed model are detailed to show how the quality of not only resource recognition and allocation but also decision making, tracking and management processes can be improved using skill integrated workflows. The model currently being modelled for an academic area, The Computer Engineering Department of Dokuz Eylul University, in which academicians and students are involved in many academic or bureaucratic processes and improve their skills and competencies according to the educational needs. Because both Workflow and Skill Management are business-independent disciplines, the model is also applicable to any business with the integration of Enterprise Resource Applications (ERP) as it will be also briefly discussed.

1.3 Thesis Organization

The thesis consists of 6 chapters.

Chapter 1 presents the general information about two disciplines: Workflow management and skill management. Firstly, the need of using workflows in terms of resource allocation is explained. Consequently, the importance of skill management is introduced. The purpose of combining these disciplines is then described.

In Chapter 2, Skill Management is discussed with its concepts, current studies and difficulties. This chapter also shows how the traditional workflow systems and organizational models use skills and what the dismissed points of skill approach in workflows are.

In Chapter 3, a new model is presented with a proposed approach, e-Worter (Electronic Work, Resource and Time Manager) with its general components and three steps of skill integration: SCPP (Skill Catalogue Population Process), SAAP (Skill Assignment and Assessment Process) and SPCP (Skill Power Calculation Process). In this chapter, the capabilities and commitment of a central service, SRS (Skill Research Service), are also discussed.

Chapter 4 describes the academic domain, The Computer Engineering Department of Dokuz Eylul University, with the reasons of why the implementation of workflows with skill management is required for academic units. Some surveys and research studies are also mentioned to strengthen the proof of the importance of skill integrated workflows. Some simulated data is analyzed to show how such a combined system improves the quality of business and decision-making processes. The opinions of academicians are outlined at the end of this chapter.

The application of the model in an Information Technologies (IT) company within an ERP application, SAP, is described in Chapter 5. The opinions of managers and employee from a company about e-Worter approach are also outlined at the end of this chapter.

After an overall summary and a conclusion are oexplained in Chapter 5, as appendices some main structures e-Worter uses, the methodology for research studies, applied surveys and some master data may be found.

CHAPTER TWO
SKILL MANAGEMENT: STUDIES AND ISSUES

2.1 The Concept of Skill and Skill Management

Skill Management is being focused in recent years. The central key underlying the discipline is the skill. The alternate associations and synonyms widely used instead of skill are competency, experience, expertise, capability, ability, knowledge, talent and proficiency. The common classification of skills depends on professional, methodical and social differences as Benger, Uslar and Wollkopf Endicott (2004) state. For example, "C++ knowledge" can refer to a professional skill while "leadership" attitude is defined as a social skill. The other classification depends on the provability (Benjamins, et al., 2003). Professional skills are the job-specific and easily-proven skills so they can also be called as hard skills. On the other hand social skills are assumed as soft skills, which are observable skills and based on subjective opinions rather than hard skills.

Skill Management deals with skills of the resources due to the targets of human resources processes as mentioned in the previous chapter. Figure 2.1 shows the application areas of a Skill Management System in a company.

Figure 2.1 Application Areas of a Skill Management Service in a Company

One of the major functions of a Skill Management System is narrowing or balancing the skill gaps in most of the processes of the organization by employing the right staff. Both Human Resources and Business departments work together in order to narrow the gaps and find the right person for the right position or job. The expectations of skills are compared with the background of candidates and/or resources. After such cooperation, the decision can be made. By the way, the top managers do not attent to details regarding the skill gaps, they track whether the processes are performed as they need and the targets are accomplished considering the factors such that the customer satisfaction, cost, performance and time.

Skill Management is a detailed discipline including some phases working in parallel. Figure 2.2 shows the three basic processes of an SMS. If one of them is absence or not executed well, skill management could not be succeed as the reasons are going to be detailed in the next sections.

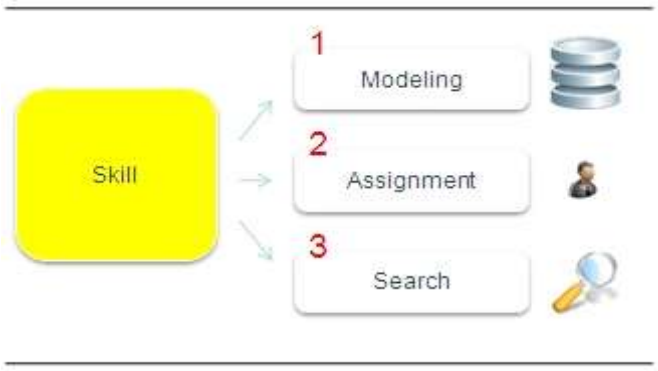

Figure 2.2 Three Processes of a Skill Management System

2.1.1 Skill Modeling

Skill Modeling includes the skill catalogue building with its structure and content. There are two main steps for skills definition: Defining attributes first and the designing and populating the catalogue.

2.1.1.1 Skill Attributes

Hiermann and Höfferer (2003, 2005) define skill with its necessary attributes of name, version, function group, experience, last used, scale of expertise, set of links and primary skill which are used during administration, matching and visualization steps of skill management. Those are the key factors that the employment services, human resources and business departments also need for any resources. Table 2.1 shows an example about the attributes of a hard skill, HTML, for a person.

Table 2.1 An example to Hiermann and Höfferer's skill attributes

Name	HTML
Version	3.0
Function Group	Web Technologies
Experience	5 years
Last Used	3 months ago
Scale of Expertise	Good
Set of Links	DHTML, Jscript, CSS
Primary Skill	Yes

Hiermann and Höfferer define the attribute of "Function Group" as the category of a skill. "Set of Links" attribute includes the related skills to the given skill. "Primary Skill" defines whether the skill has a priority for the user or not.

Once the attributes of skills are determined, the way of how they are stored should be determined. In other words, the catalogue of skills should be designed.

2.1.1.2 Skill Catalogues

Skill catalogue is a repository database including all the skills to be tracked of which the management and population may expose major problems. Figure 2.3 shows the catalogue with its expected features and also those problems that Gronau and Uslar list (2004b), if the catalogue is not well-designed. Once those features are

considered well during the design phase, the population and maintenance of skill catalogue would be better and therefore the management of skills would be more successful.

Figure 2.3 The Key Factors of a Skill Catalogue as Gronau and Uslar highlights (2004): Once they are considered well, the population and maintenance of the catalogue would be easier and manageble.

Skills are represented within trees in an SMS (Benjamins, et al., 2003). Top elements of a skill tree are used to cluster the low-level elements. The lowest elements of a skill tree can be called as leaf skills. Parent-child relationships of the skills are the same within trees. Figure 2.4 shows an example branch of a skill tree.

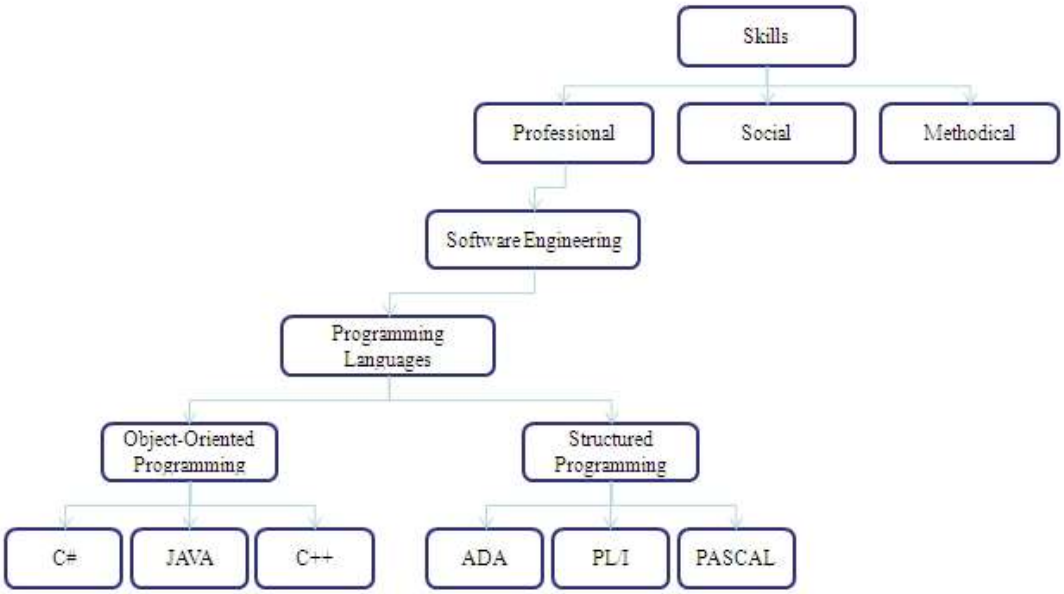

Figure 2.4 An example branch of a skill tree: Programming Languages with its parents and children

2.1.2 Skill Assignment

As Sure, Maedche and Staab indicate (2000), intelligent people finder systems with usage of Artificial Intelligence (AI) are used for many systems which are developed by huge organizations such that HP, Microsoft, NASA, etc, that support the finding and revealing of hidden skill knowledge.

For many skill management systems, a resource first selects his or her skills from the skill catalogue and then determines the level of experience on those. In some cases, the managers, partners or Human Resources experts can determine the levels instead of resources themselves. This skill selection process can be called as self-evaluation (Benjamins, et al., 2003) or self-assessment (Gronau & Uslar, 2004). The users rank the level of experience while they select the skills. The level scale depends on the design of system itself. For example, Swiss Life defines the level range over four steps from “elementary knowledge” to “expert”. (1-to-4 scale) (Reich, Brockhausen, Lau & Reimer 2002). It is also possible to use 3-point, 4-point, 5-point, 7-point, 10-point scales depending on the granularity needed.

In addition to skill levels, an SMS also allows the people to define interest and importance levels for each skill. Interest rates are marked by the knowledge sellers, while the importance of skills is determined by the knowledge buyers such as project managers or employers (Benjamins, et al., 2003).

Table 2.2 Three levels of skills considered by Skill Management Systems

Skill	Experience	Interest	Importance
UNIX Administration	3/5	4/5	5/5

2.1.3 Skill Search

Once the levels of experience and interest are defined for every member of organizations, these levels can be used as the input factors for matchmaking algorithms to solve best resource problems. Those algorithms may also get in conjunction with the availability, the needs of buyers and other factors such as location; cost (Benjamins, et al., 2003). The results of skill search process can be viewed via different output types: graphs, reports or lists.

2.1.4 Open Issues and Difficulties

Even many organizations need skill management they do not prefer to use it because of maintenance, assignment and assessment problems of competencies and skills as Gronau and Uslar state (2004a). There are a lot of challenging issues causing nonexistence of skill management systems in many enterprises due to the maintenance of skill trees. Some skills may be shared by different business context with different meanings. That results to a conflict about where a skill is represented in the whole tree. Secondly, skills may have versions; tracking the versions needs extra effort. The depth of the tree is another problematic topic. It can be limited according to the requirements of the related business (Leyking, Chikova & Loos, 2007). To tackle such type of problems, ontology is being widely used to build more structured trees for not only taxonomy needs, but also some advanced functionalities for skill definition (Lau & Sure, 2002; Reich et al., 2002). However, as Reich

mentions, browsing skills via ontology also exposes a problem for end users because of their complexities. Such reasons result to the standardization studies of consortiums as mentioned in the previous page which are being widely used by enterprises to handle the classification problems.

One of the challenges for most of those skill management based studies is providing a good motivation for their members in order to get more efficient and effective results (Reinhardt & North, 2003). The users can hesisate to fill surveys and forms while they are evaluating their skills. Neverthless, they may not be aware of importance of skills for their organization and they may not know how they select and evaluate their skills. For those cases, the gathered skill data may not be actual and reliable thus they result to unsuccessful management of skills. At this point, it can be stated that workflows can be used to strengthen an SMS by minimizing the role of users especially in assessment phases. Workflows are excellent which know what skills are going to be gained in which conditions at which time, how and by whom. So all the resources of an organization are not needed for extra selection and evaluation processes for their skills; the motivation and involvement is indirectly supplied via an automated workflow system.

2.1.5 Current Studies

In recent years, the number of studies in Skill Management area has been exponentially increased. Most of them are about building skill catalogue and matchmaking applications. An ontology-based skill management system called *SkiM*, developed at Swiss Life, has been evaluating in a pilot phase with 150 users including 700 concepts of skills. SkiM uses ontology for skill definition and provides the up-to-dateness of skill descriptions by text mining operations on the documents on the intranet (Reich, et al., 2002). A web-based software product, SkillMan, was built to manage skills in knowledge-intensive organizations in on Java environment (Benjamins, et al., 2003). Dingsøyr and Røyrvik present a skill management system in a medium-sized software consulting company called Alpha, and describe how it is used (Dingsoyr & Royrvik, 2000). Beck studied on a pilot project including a SMS

on a middle-sized manufacturer of Top-Class Concrete Pumps and Plastering Machines, Putzmeister, Inc./Germany (Beck, 2003). An application called *ProPer* and its extended prototype called *OntoProper* provide compensatory (approximate) profile matching and weighting, reveal hidden skills of organization and improve maintenance of skill data in more comprehensive and easier way (Sure, Maedche and Staab indicates (2000). Semantic-based automated Skill Management uses Description Logic to formulate competency search and creation processes (Colucci, Di Noia, Di Sciascio, Donini, & Ragone, 2007). A semantic based search engine, with a graphical user interface (GUI) for query formalization, supporting the process of retrieving professional knowledge is proposed by (Colucci, Di Noia, Di Sciascio, Donini, & Ragone, et al., 2007). Holland and Peitzsch used Bayesian network to represent the skills of employees which are based on XML structure profiles (Holland & Peitzsch, 2005). The contribution of Hockemeyer, Conlan, Wade and Albert (2003) showed how skill management is applied using knowledge space theory and eLearning applications. The direct role of knowledge mapping, a common context to access the expertise and experience, is also detailed by Eppler (2001), Klamma and Schlaphof (2000) to make the knowledge visible in companies. Eppler also lists types and techniques of the knowledge maps with their advantages and disadvantages.

All above studies stand as independent studies and neither assessment nor assignment processes of skills are performed within workflows, they use traditional methods for skill gathering. A few studies including the process-driven approaches for an efficient skill management arise. A study, completed in German Research Center for Artificial Intelligence, demonstrated that business process models can also serve for defining competencies. The products, Prolix and Explain, define a process and competency-driven framework which links business process tools with knowledge management and learning environments (Leyking, Chikova & Loos, 2007). On the other hand, Gronau and Uslar (2004b) worked on the integration of knowledge and business process modeling to build skill catalogues via KDML (Knowledge Modelling Description Language) and a visualization tool for that language called K-Modeler. In that study, process modeling is accepted as the best

method to track the skills of employees by comparing other methods of gathering from post requirements and optical character recognition processes. In another study, Won and Pipek (2003) used competence-indicated events which can be collected, stored and executed by the system without any effort of users in an expertise awareness system.

2.1.6 Standardization on Skill Catalogues

Introducing an SMS effectively, it is necessary to have a meaningful model for the system introduction (Gronau and Uslar, 2004a). Nowadays some project groups such that The Skills Framework for the Information Age (SFIA) Foundation and Employing and Training Administration of United States Department of Labor (ETA) are working on their own models providing a standard and easy-to-manage framework for skill and competency management. Those groups can help building a basis which can be used when the competency and skill data are needed to be exchanged among different systems and compaines (Gronau and Uslar, 2004b).

2.1.6.1 SFIA

SFIA is an effective tool produced by SFIA Foundation for the industry. SFIA deals directly with skills, not jobs or positions. Improving business effectiveness, optimizing and planning resources, outsourcing are some key benefits that SFIA engages. SFIA is a two-dimensional matrix; it provides the most widely accepted description of skills, across 7 levels of experience (Skills Framework for the Information Age (SFIA), n.d.a). Table 2.3 shows those 7 levels.

Table 2.3 SFIA 7 Experience levels for skill definition (SFIA, 2008b)

	SFIA Level	**SKILL DEFINITION**
1	Set strategy / inspire	
2	Initiate / Influence	
3	Ensure / Advise	
4	Enable	
5	Apply	
6	Assist	
7	Follow	

SFIA Foundation provides a sustainable framework chart including 6 main categories of IT-related skills (SFIA, n.d.e). Table 2.4 shows those categories with the number of belonging sub categories ans skills. The organizations using this chart do not deal with any catalogue design problems any more. But the leaf nodes are not included in this design, only the parent subjects are categorized in a standard and common way. The skills then can be evaluated with the SFIA levels listed in Table 2.3.

Table 2.4 SFIA Framework Chart (SFIA, n.d.e)

Category	**# of Sub Categories**	**# of Skills**
Strategy and Architecture	4	23
Business Change	3	11
Solution Development and Implementation	3	18
Service Management	4	19
Procurement and management support	4	16
Client Interface	2	4

SFIA Foundation builds a steering group in which the representatives of some organizations such as IBM, Microsoft Training, PA Consulting, Irish Computing Society are included to recommend the strategies (2008c). The framework has been

already carried out by organizations such that British Computer Society, Microsoft, IBM, Fujitsu Services, Department of Trade and Industry, Norwich Union, UK Academy for Information Systems, etc (n.d.d). On the other hand, von Konsky, Hay and Hart (2008) worked on SFIA Framework chart to define the skills required by software engineers at various levels of experience. As it can be seen, the framework can be executed by any different areas because of its standardized and central structure.

SFIA (n.d.b) lists some case studies to show how the users are experienced on the framework for their own skill approaches. In one of those, Peter Lawson, IT Services People Manager, mentions the impacts of using SFIA as it follows:

> It is good to see the University of Plymouth using SFIA within the curriculum. SFIA is an important part of profiling roles at the Met Office. Having access to students who are already aware of SFIA and know their capability against SFIA skill definitions is a great step forward in aligning Higher Education with the needs of employers (SFIA, n.d.b).

Russell Willis from Stage 2 BSc who is now working as a web application developer explains his experience on SFIA usage at the University of Plymouth:

> I had only a small idea of how my career in IT would begin and an even smaller idea of what progression was available. Being able to map my current competencies against the requirements of certain paths meant I was then in a position to flesh out where I would like to be in five years time and how to expand my skills in the correct direction. Along with the lecture guidance the framework has been a real boon in opening my eyes to all the opportunities available in the IT workplace (SFIA, n.d.b).

Dr Andy Phippen, Senior Lecturer from School of Computing, Communications and Electronics describes the benefits of using SFIA as it follows:

SFIA is a fantastic tool to raise awareness of the breadth of careers and skills within the IT sector. A challenge I face with new recruits to our degrees every year is changing the perception that IT is a solely technical discipline. There is a need from day one to ensure students are aware that professional and interpersonal skills are equally important. SFIA, and its visibility in the IT profession, provides me with a clear model to articulate the breadth of the sector and also to help students appreciate their own development through their degrees (SFIA, n.d.b).

2.1.6.2 ETA

ETA developed a comprehensive competency model framework for many industrial areas. The information technology industry is one of those of which competency model is defined with 9 building blocks, called as tiers (Employing and Training Administration of United States Department of Labor (ETA), 2008). Table 2.5 shows the example categories belonging to each tier. The tiers are corrsponding to the classification of the skills; academic, social and professional skills are distributed into related tiers.

Table 2.5 ETA Building Blocks for Competency Model (ETA, n.d.)

Competency Blocks	**Example Categories**
Personal Effectiveness	Interpersonal Skills & Teamwork, Integrity, Ethics, Flexibility, Professionalizm
Academic	Reading, Writing, Analytical Thinking, Speaking, Basic Computer Skills
Workplace	Collaboration, Planning, Organizing, Innovative Thinking, Working with Tools
Industry-wide Technical	Information Management, Software Development, Digital Media, Network & Mobility
Industry-sector Technical	Custom
Occupation-specific Knowledge	Custom
Occupation-specific Technical	Custom
Occupation-specific Requirements	Custom
Management	Custom

The 4th tier, tier of Industry-wide technical competencies, is for the organizations from Information Technologies area, corresponding to what it actually deals with to define all skills in an effective, clear, modifiable and standardized way. That tier includes 8 categories with the number of work functions and technical areas defined for each particular category.

Table 2.6 ETA – Tier 4: Chart (ETA, 2008)

CATEGORY	# of Work Functions	# of Technical Content Areas
Principles of Information Technology	9	6 / 33
Information Management	9	3 / 18
Networks & Mobility	5	1 / 10
Software Development	5	5 / 30
User & Customer Support	6	2 / 17
Digital Media	3	1 / 11
Compliance	4	3 / 09
Security & Data Integrity	5	4 / 19

The 5th tier and above are based on specific skills on the sector. If the sector is related with banking or financial processes, the occupation based skills regarding those subjects can be defined under the top tiers.

2.2 Skill Management in Workflow Systems

A Workflow Management System (WfMS) is a system that defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications (WfMC, 1999).

A WfMS usually deals with two concepts while it is focusing on the resources: organizational models and allocation techniques. Both include further definitions and examples about the integration of skills but it still seems to be insufficient because of the lack of a fully-integrated Skill Management approach.

2.2.1 Organization Models and Participants in Workflow Systems

A workflow application coordinates the business processes and its participants. Workflows comprise a number of activities and each activity can be executed by resources (Allen, 2001). A workflow participant, whose synonyms are actor, agent, user etc., is a resource which performs the work represented by a workflow activity (WfMC, 1999). Even the workflow participants are evaluated under four different types (human, machine resource, role, organizational unit*)* within the WfMC (1998b) Process Definition Meta-Model, a participant is generally applied to a human resource (WfMC, 1998b).

A WfMS is supported by definition and implementation tools for the business processes and the participants. Process definition is the core part of a WfMS that is the representation of a business process which gives detailed information about its route, restrictions, participants, documents, associated applications, restrictions, authority and security issues. WfMC proposes Process Definition Meta-Model, which identifies the top level entities within the process definition phase (WfMC, 1998a).

Figure 2.5 draws a combined picture showing the relation between workflow process and organizational model. Process Definition may have a relationship with an Organizational Model which allows to define the hierarchical structure of an organization in terms of its members and their relationships (WfMC, 1998a).

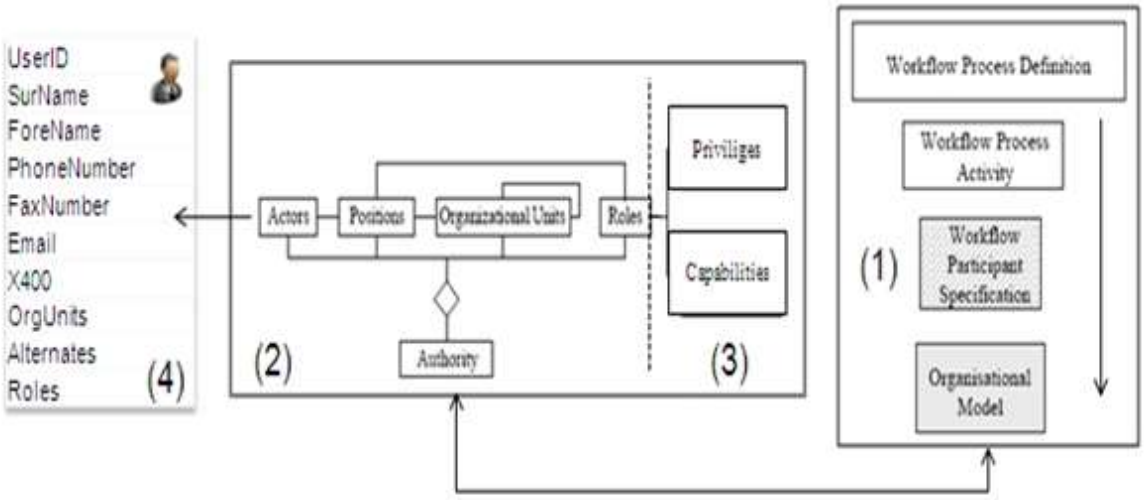

Figure 2.5 A combined picture of (1): A Part of WfMC Process Meta Model (adapted from (WfMC, 1998a)), (2): Basic Elements of Organizational Models (adapted from (Klarmann, 2001)), (3): New entities suggested for Organizational Models (adapted from (zur Muehlen, 2004), (4): Attributes of actors (adapted from (WfMC, 1998b)).

The entity of Workflow Participant Specification from the figure above gets the necessary attributes of the participant via the organizational model. When a workflow process has just been initiated, the WfMS can obtain details of participants matching the attributes from the Organizational Model. The part (4) shows the attributes of resources stated by WfMC Organizational Model definition (WfMC, 1998b). There are many resource and organization modelling studies (Rosemann & zur Muehlen, 1998; zur Muehlen, 1999) having common characteristics based on the organizational structure. The commonly used entities being used by those models are used in the part (2) of the figure above (Klarmann, 2001).

"A role is a group of participants exhibiting a specific set of attributes, qualifications and/or skills" (WfMC, 1999). Roles can represent the qualifications and competencies of resources and they can also be associated with the organizational positions (zur Muehlen, 2004). Most of the organizational models do not exactly deal with the changes of the skills of resources. Which capabilities are needed for resources and organization, how they are defined, analyzed, tracked and managed are not taken into account so much. Instead, skills and qualifications are

evaluated under the position and role definitions. Muehlen uses the entity of priviliges and capabilities as new extensions in his proposal of workflow organizational meta model. Priviliges define the actions which the resource is allowed to do. Capabilities show the qualification and knowledge information with their experience levels about the resource. The capabilities are the direct properties of resources (zur Muehlen, 2004) and can change in anytime. The resources get or lose their experiences of capabilities. They can improve their capabilities via the knowledge-intensied processes inside the enterprise or outside activities. On the other hand, the roles and positions, the traditional elements of organizational models, can change according to the organizational policies and decisions and do not actually show which resources improve themselves on which skills.

Figure 2.6 shows the elements of organization models including privilige and capacity (skill) information for a user. This is such a personnel recognition card for the user.

Figure 2.6 A personnel card with all elements of the organizational models with Muehlen's offerings: Priviliges and capabilities (skills)

2.2.2 Studies on Resource Allocation

"In a highly idealised world, each activity of a process could be allocated to a specific agent (or role) specialised in the particular task." (Governatori, Rotolo & Sadiq, 2004) Since workflow systems deal with finding best resource problems, huge number of allocation techniques have been applied according to the needs.

2.2.2.1 Workflow Capability Patterns

Workflow Patterns Initiative (n.d.) lists various ways for the workflow researchers and executives to assign and utilize the resources who can be employed by workflows. These ways are called as Resource Patterns (Russell, van der Aalst, ter Hofstede & Edmond, 2004) and they are designed as independent patterns from any workflow models and the technologies. Direct allocation of users, role based allocation, delegation, assignment of last-experienced users, position or capability-based allocation are some examples of resource patterns.

Capability-based allocation pattern states that the activities can be assigned to the resources based on their specific capabilities. A matching algorithm tries to match the requirements of the activity with the resource capabilities and offers best resources and/or allocate them for these activities. In this pattern, the capabilities are generally formed in key-value pairs and the key dictionary includes unique capability name and the possible range of values for each human resource.

2.2.2.2 Muehlen's Experience Approach on Workflows.

Muehlen emphasizes that the change of a user's *experience* level can be very useful to track, in order to increase resource allocation in a WfMS (zur Muehlen, 2004). Muehlen answers the question of how experience level of resources can be calculated by taking consideration of workflows. Two ranking methods are proposed by Muehlen being used for resource allocation problems: Ranking by experience and ranking by efficiency.

2.2.2.2.1 Ranking by Experience. Ranking resources by experience considers the number of executed activities. If more workflow activities of same type are executed, the owner resources improve their experience for further executions of same activities. Figure 2.7 shows this type of ranking. After four different activities with same skills are completed successful, the rank of a resource will be 4.

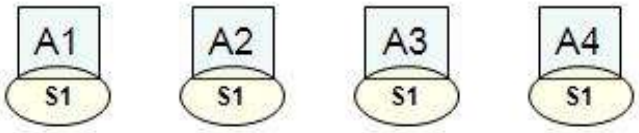

Figure 2.7 Counting executed activities gives the rank by by experience

2.2.2.2.2 Ranking by Efficiency. Ranking resources by efficiency highlights the importance of the total spent time rather than the number of workflow activities. Figure 2.8 shows this type of ranking. In the figure, four activities seem to be completed in 4t times, while only the activity A5, which is the same type with the types of first four activities, is completed in 4t times again.

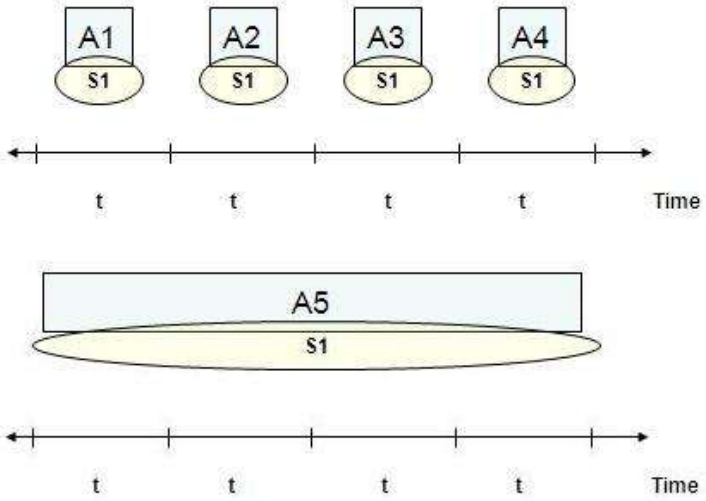

Figure 2.8 Ranking by efficiency considers total spent time rather than number of activities.

2.2.2.3 Other Studies

There are a few studies using the concepts of capability and experience for resource allocation.

Momotko and Subieta (2002) developed a new approach to extend Workflow Participant Assignment (WPA) that is proposed by WfMC. In this study, WPA Language (WPAL) is introduced for complex resource allocation. As an example, the people who are experts on Java and XML technologies are represented by WPAL as it follows: WPA = Expert (“Java“)*Expert (“XML“).

Additionally, Huang and Shan (1998) from Software Technology Laboratory of Hewlett Packard defined some qualification policies for workflows and used “Experience” criteria in their custom queries to find experienced users according to the given level.

2.2.3 Open Issues and Difficulties

Muehlen’s approach accentuates the experience level on activities of course, but they do not render an opinion about the experience level on skills exposed by these activities. Technology-driven processes may have many sub tasks and expose a lot of skills improving the experience of resources. As an example, if a web application project is evaluated as a whole workflow, the activities belonging will expose many skills for the developers such that programming languages, platforms and tools. It is therefore a fact that those developers are experienced on not only developing a web application itself but also the attached skills.

The other studies focusing on resource allocation improve queries by means of experience of skills. But they do not give any idea about how skill and experience information are being gathered and consequently stored. All those assume that the experience data had been once gathered. But, who is experienced on what becomes still a major problem and therefore capability based resource allocations may not be executed as it is expected due to the lack of strong skill management approach.

CHAPTER THREE
E-WORTER: A MODEL ABOUT SKILL-INTEGRATED WORKFLOW SYSTEMS

3.1 What is e-Worter?

e-Worter has been designed as an approach to improve skill management capability of a workflow-based system. That approach can be applied to different types of business because of its standard and applicable structure. In addition to traditional WfMS components, skill management integration shows the considerable and valuable feature of e-Worter. Figure 3.1 shows general components of e-Worter for an academic unit.

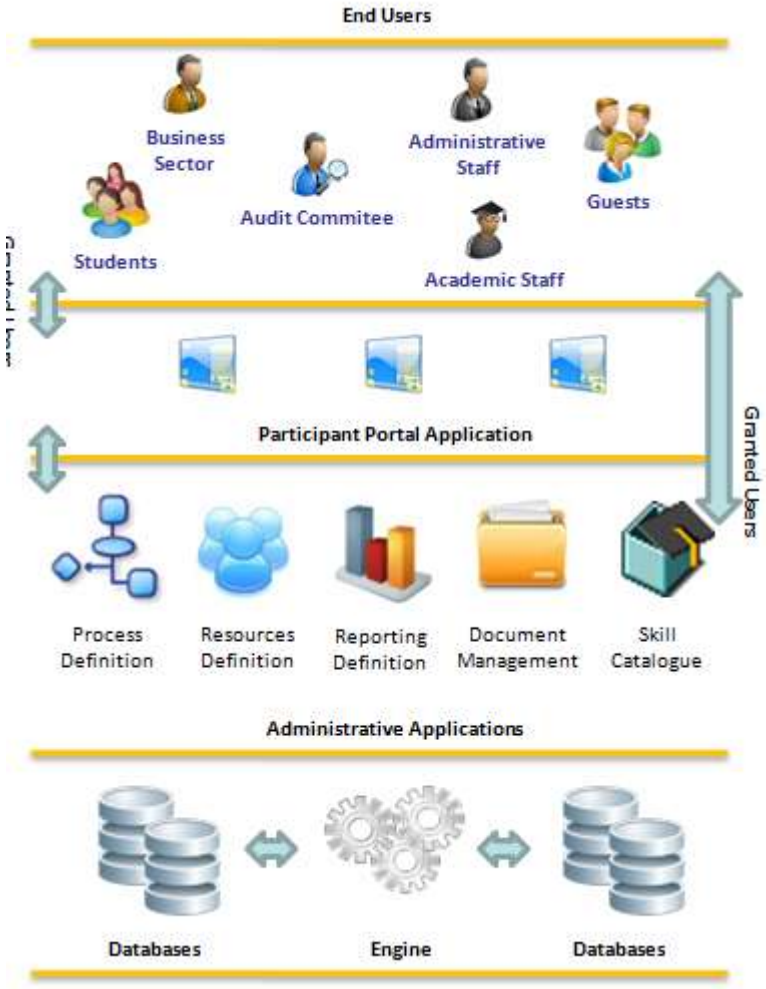

Figure 3.1 General Components and Users of e-Worter System (For academic units)

The e-Worter engine includes all database manipulation and retrieval operations for workflows, organizational model and skills. It also has some functionality regarding finding required resources; definition, assignment and calculation of the skills. Engine is related with participant portal and other administrative applications such as Workflow Definition, Resource Definition, Skill Catalogue, etc. and has its own security access strategy for the system participants. Figure above shows the relations of e-Worter components with all participants from academic area.

3.2 Skill Management with E-Worter

e-Worter deals with traditional problems of SMS, which were declared by Granau and Uslar (2004) as it is mentioned in the previous sections, by getting the advantages of workflow management systems. It executes three main processes for effective and efficient use of skills within workflows: The processes of Skill Catalogue Population (SCPP), Skill Assignment and Assesment (SAAP) and Skill Power Calculation (SPCP).

Before the explanation of those processes, general e-Worter rules regarding skills will be listed in the following section.

3.2.1 General e-Worter Rules

There are some basic rules about skills and skill integration to workflow activities.

3.2.1.1 Rule 1: Skills have attributes

Skills have important attributes that are defined, gathered and analysed. e-Worter uses most of the attributes Hiermann and Höfferer (2003; 2005) define: Name, version, scale of expertise (refers to power), last used (refers to last experience date), function group (refers to parent skills), primary key (refers to interest rank), experience (referss to experience time) and set of skills (refers to relatives).

In addition to these attributes, skills have other details that may be important in some analysis. For example Visual Studio .NET is a tool created by Microsoft Corporation. The resource experiencing on this tool can also increase his/her experience on Microsoft development products. Therefore skills may have two additional attributes: Type (tool, technology, thoery) and producer (Microsoft, HP, Oracle).

3.2.1.2 Rule 2: Skills may have parent, sibling and child skills

Skills are stored in a tree structure as it is declared in the previous chapters. As Figure 3.2 shows, each level of nodes may have any child and sibling nodes, but they all have only one parent.

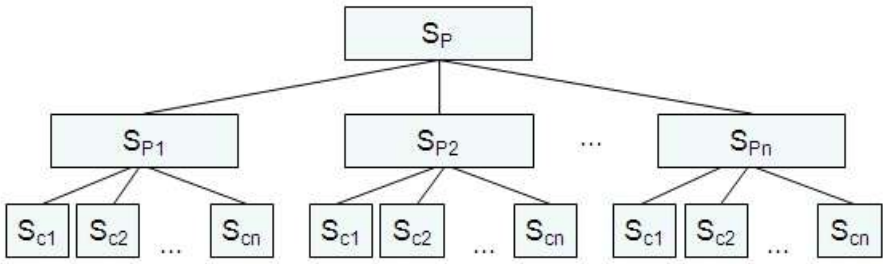

Figure 3.2 Skill Tree: Parent and Child Nodes

3.2.1.3 Rule 3: Skills may have relations with other skills of branches

Even some skills have different parents; they may have closer relationship because of their application areas. For example, the person having the knowledge of Java has probably the knowledge of “Object Oriented Programming”. Figure 3.3 shows the relations between the skills from different branches.

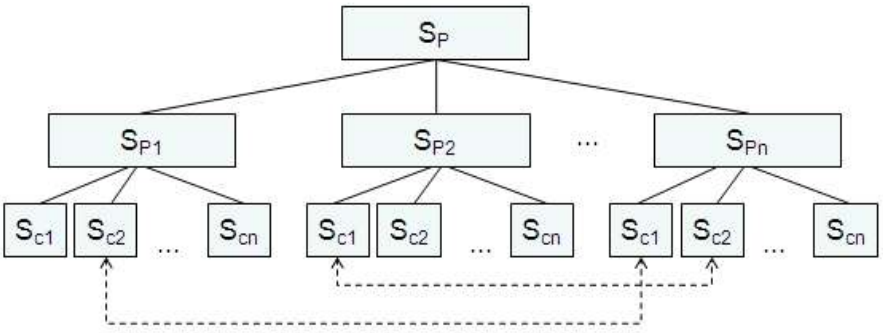

Figure 3.3 Skill Tree: Related skills of which parents are different

3.2.1.4 Rule 4: Some activities expose a set of skills

Some workflow activities may not expose any skills but some may. It depends on what the activity definition requires. Figure 3.4 shows an example workflow including some activities exposing skills.

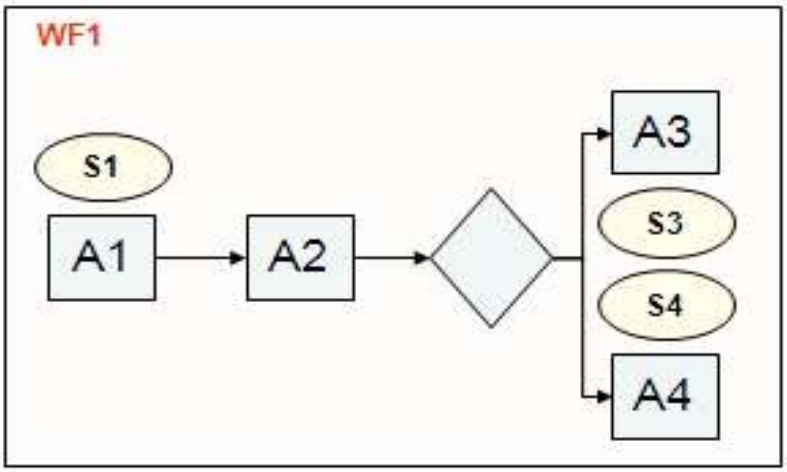

Figure 3.4 Three activities, A1, A3 and A4, of workflow, WF1exposes a set of skill while only A2 does not expose any skills.

For example, an example homework about OpenGL standards to develop high performance graphics can be designed as an activity that exposes a skill set including many technical skills such that OpenGL, programming language of C++, the product of Visual C++ 5.0 etc. Consequently, an approval activity can be added to the workflow standing as a post-activity which does not expose any skill set.

3.2.1.5 Rule 5: Different activities may expose same set of skills

Different type of activities may naturally expose same skills. For example, two different projects may improve the experience of C# skills of the developers. C# is the common exposed skill for these projects.

3.2.1.6 Rule 6: Workflows expose the union set of skills of their activities

Since a workflow has at least one activity, the total set of skills of it is the union of the exposed skills of each belonging activity. For example, the course of "Programming Languages" may have at least 4 homework activity two of which expose C++, one exposes Java and one exposes Visual Basic .NET language to the attendees.

3.2.2 Skill Catalogue Population Process (SCPP)

Determination of skill model is the first step for SCPP. Once the model has been selected and adapted into company, the second step, the population and maintenance of all skill catalogues, has been executing continuously. In fact, the categories from the standard skill models rarely change. However, the leaf skills representing the technology, product and tools, which are not listed in the source skill model, should be continuously tracked, added and updated for a robust skill management system. Hiermann and Höfferer (2003) suggest a new internal position for the organizations, called Skill Manager who manages the skill catalogue. Those managers have the responsibility for adding new skills to the catalogue, deleting or deactivating existing ones. They get in communication with other departments or sources to see what the new skills are, which existing skills are out-of-date or if they have a newer version. However, reserving that position on a *fulltime* basis will increase the personel expenditure; the allocation of fulltime skill managers effects cost, resource and time management processes of organizations.

3.2.2.1 Skill Catalogue Structure

e-Worter uses the 4th tier of competency model, the tier of Industry-wide technical competencies, defined by ETA as detailed previously.

As it was represented in Table 2.6, the model has 8 categories with many number of technical areas which is defined as parent skills in the skill catalogue. The categories and sub categories of this model is listed in Appendices part.

3.2.2.2 Methods of Skill Catalogue Population

Figure 3.5 shows all possible cases of SCPP in e-Worter.

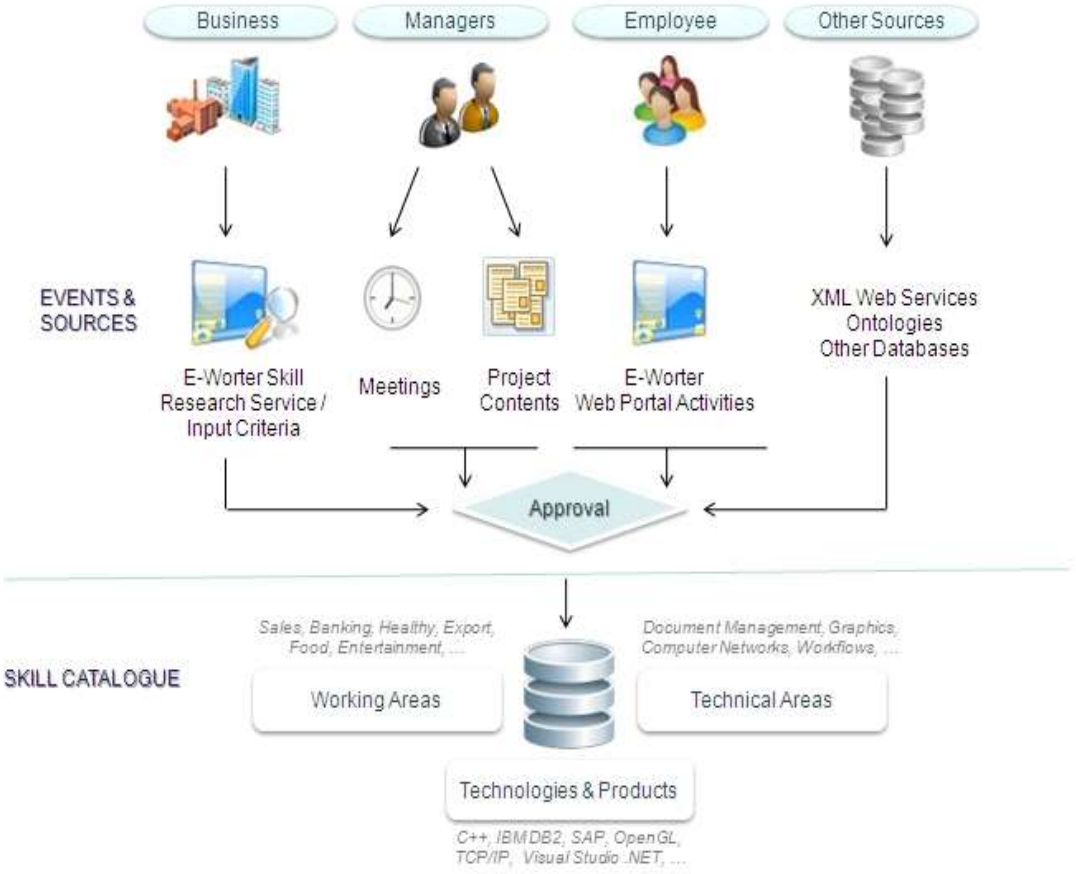

Figure 3.5 The Sources and Events for Skill Catalogue Population Process (SCPP)

There are many people acting as a skill manager in e-Worter. The people from business or guests are the external participants who may use SRS (Skill Research Service) component of e-Worter to search qualified resources. During this search process, the skill keys which they are looking for may be new to skill catalogue. Each new skill, which does not match the existing skills from the catalogue, are logged by the e-Worter engine and sent to a workflow process for approval. Once

new skills are approved by the responsible supervisors, they can be attached to any workflow activities then. Second, the academicians can prepare some meetings to review the skill catalogue to determine which skills are not usable any more, of which versions should be updated or if they are actually granular and unique as expected. The third resource for skill populations are students. They may define new skills while they are working on their activities. For example a student may use new version of *Eclipse* platform to develop a *Java bean* and this version information has not been noticed by the skill catalogue yet. The student enters it as a free text in the activity detail screen of e-Worter participant portal and after the supervisor approves it, the catalogue is populated. Additionally, the popular career sites building a bridge among the employers and employee candidates store all common technical skills. On the other hand, in the future some ontology and XML template files can be a source for e-Worter skill catalogue. e-Worter system is designed and still being developed to be capable of integration with such sources. The supervisors track and use these sources and execute an approval mechanism whenever they need.

3.2.3 Skill Assignment and Assessment Process (SAAP)

Skills are owned by people and exposed by business processes. The IT managers and employees use their skills to achieve their projects; the students use their skills to complete their lab experiments. All those people also improve the experience level of their skills during the activities they are belonging to are prosessing. For that reason, the business processes can be defined as *knowledge sellers* (Benjamins, et al., 2003). In fact, the sold thing is not only knowledge, the behaviors and personal capabilities are also the products of processes therefore the subject of *skill seller* seems better. An academic department of a university or an IT department of a company are examples to *skill markets* in where a set of skills, even hard or soft, are sold to their resources or *customers* (students, employees, etc).

Skill markets have their own strategies regarding the skill distribution to their customers. For example, a student dreaming of being a good C# programmer would

prefer a course of which activities improve C# programming skill. In other words, the student buys a product with a skill he/she desires to own.

Figure 3.6 represents this approach showing the relations among business processes, skills and people.

Figure 3.6 The relations among processes, skills and people.

Skill Assignment and Assessment Process (SAAP) of e-Worter defines the way how the skills are related with the workflow processes during the design and execution phases. Figure 3.7 shows the interaction between assignment and assessment phases.

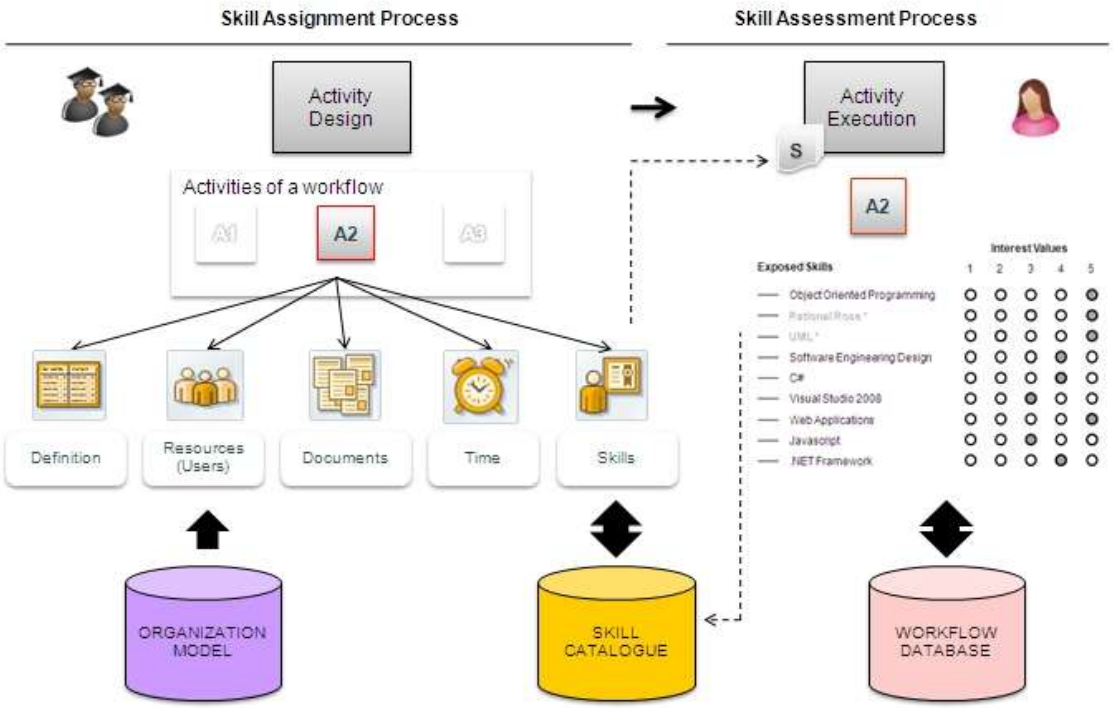

Figure 3.7 Skill Assignment and Assessment Processes within Activity Design and Execution

3.2.3.1 Skill Assignment

Skill assignment does not mean that the skill is completely owned by the resources. It is the first phase of SAAP that is the prior to Skill Assessment phase. It can be accepted as a planning phase about the resources' development on skills. In other words, it is a declaration for the workflow activities to show which people are required for them or have enough capability to do them. Therefore this phase is the place where the communication between skills and workflows are built.

Assignment phase works in parallel with activity design process and needs the answers of such questions:

- What skills are exposed by the activity?
- Which users do that activity?
- When does the activity start and finish?
- What other conditions and features are defined for the activity?

This phase for the activities exposing skills can be classified as "Direct" and "Indirect".

3.2.3.1.1 Direct Assignment. A set of skill is directly attached to a activity which may be a training, a problem solving, a part of a project or a research study.

In this case, skills are directly attached to activities instead of workflows and this process does not need extra resources in design-time. Skill Assigner may be the person having the role of Workflow Designer. Even the assigner and the designer are not the same people, they should be aware of what they are doing. Figure 3.8 shows the designer's (and also skill assigner's) role in workflow design.

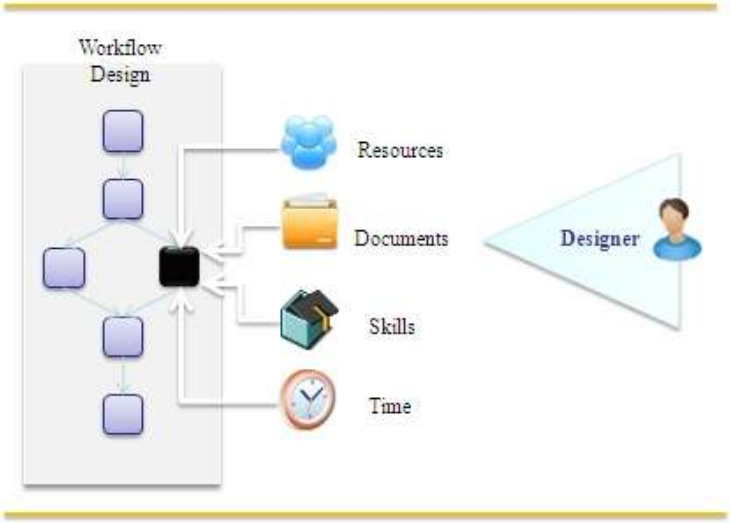

Figure 3.8 Main operations of Workflow Designer role (Direct Skill Assessment)

For example, an academic course as a workflow is designed by the academicians, research assistants or the responsible users having the detailed knowledge of the course content. They define the workflow for a 4-month period with all activities including the resources, related documents, exams, project deadlines and other necessary information. They are also aware of which activity exposes which set of skills.

3.2.3.1.2 Indirect Assignment. In this case, the activity hasn't any skill attached. But it is designed as a form application to gather the opinion of the user about the skills of other users. When the designer design such a form and attaches it to the activity, the skills will be indirectly assigned to the activity for the users to be evaluated. The traditional methods such as paper-surveys or interviews are also evaluated under indirect assignment of skills. Figure 3.9 shows the role of Workflow Designer for this case.

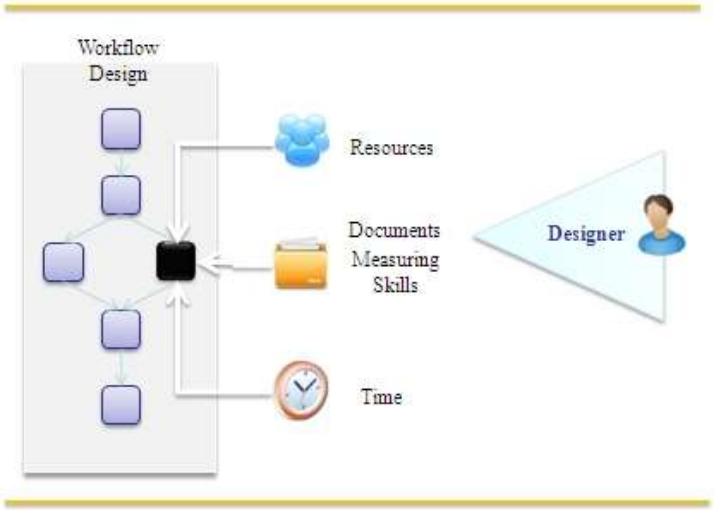

Figure 3.9 Main operations of Workflow Designer role (Indirect Skill Assignment)

3.2.3.1.3 Other Operations. Skill assigner is also responsible to define planned start date and end date for the activity, the relations with other activities, whether the activity has an approval mechanism, users to whom the set of skill is attached, the approvers, the conditions, roles and required priviliges, the notification issues, related documents and forms. Skill set depends on the content activity.

3.2.3.2 Skill Assessment

When a set of skill is assigned to an activity by workflow designer, it is also assigned to the resources of that activity. However, this would not be a complete assignment. After the activity is instantiated in the planned start time, the skill set is actually ready to be owned by the resources. The set is completely owned when the activity succeeds. Assessment of skill is completely done after the execution of workflow activity.

3.2.3.2.1 The Role of Activity Status. Assessment of a skill means that a skill is exactly owned by the owners of activities. It can be handled using activity status information. The following table shows all possible cases of skill assessment in terms of activity status in runtime.

Table 3.1 The relations between Hiermann's attributes and SPCP Factors

Activity Status	**Assessment of skills**
Waiting	- Not yet
Pending	- Not yet
Completed	+ Owned
In Approval	- Not yet
Rejected	- Not yet
Canceled	+/- (Based on the opinion of supervisor)

If the activity is instantiated, but has not been taken by the resource yet, its status remains as "Waiting". The attached skills therefore are not owned yet.

If the activity resource is absent, the status of the activity remains in "Pending" status. The fact is that the activity has not been completed so the attached skill set has not been owned by the absent resource.

If a resource completes the activity which does not need an approval step activity status is automatically set to "Completed". It means the attached skill set is immediately assigned to the resource.

If an activity requiring an approval has just been completed, it waits to be approved then. If it has not approved by the supervisor yet, the attached skill set is still not owned by the resource either. Its status remains as "In Approval" until the supervisor changes it.

If an activity with "In Approval"status is rejected by the supervisor, the skill set of the activity would not be owned by the activity resources. The activity status is set to "Rejected"and it is needed to be recompleted or canceled.

The activities which stay in "Canceled"status may improve their owners'experience on the attached skill set according to the supervisor's opinion.

3.2.3.2.2 Interest Ranking. The activity owner can see the details of assigned activities with their attached skills list. The resources may rank and/or review the skills on a scale of 1 to 5 according to their interests while they are working on their activities. Interest ranks of skills can be changes during the parent activity life time, but in fact they are generic values, are not directly attached to the activity.

3.2.4 Skill Power Calculation Process (SPCP)

SPCP can be executed by any clients requiring the experience level of skills for any users. As its name suggests, it calculates the power of a skill for a person. In fact, it draws the knowledge map of a user in terms of skills. It is designed to extend ranking approach of Muehlen that has been detailed in the previous sections.

3.2.4.1 Factors

SPCP uses some factors for the power calculation. Some of those have corresponding definition to the skill attributes of Hiermann and some are indirectly used to calculate the power. What SPCP exactly does is to determine Hiermann's "Scale of Expertise" attribute of a skill using the workflow data and/or the data from other sources. Table 3.2 shows the relations between Hiermann's skill attributes and SPCP factors.

Table 3.2 The relations between Hiermann's attributes and SPCP Factors

Hiermann's	**Example**	**SPCP Factors**	**SPCP Source**
Experience	2 years	Total Experience Time	Workflow Database
Last Used	6 months ago	Distance	
Scale of Expertise	Good	Number of works Total Experience Time Distance Rank of Interest Score Opinions	Workflow Database HR Database Other Databases

As Table 3.2 figures out, 6 factors can be used to find out the scale of expertise for a skill by SPCP. Those factors can be individually used or included into the calculation process altogether.

3.2.4.2.1 Number of works. The skill power for a skill can be defined as the number of completed activities to which that skill is attached. That is exactly the first proposal of Muehlen: "Ranking resources by experience". The unit of this factor is "number".

3.2.4.1.2 Total Experience Time. The skill power for a skill can be defined as the total duration time of all completed activities to which that skill is attached. That is exactly the second proposal of Muehlen: "Ranking resources by efficiency". The factor of "Total Experience Time" is represented with any unit of time such as minute, hour, day or week.

Two different experience times can be discussed here: *Planned Experience Time* is the total duration time of related activities of which planned time attributes are used. The designers of activities define it for each initiated activities. *Actual Experience Time* is the total duration time of related activities of which actual time attributes are used. The owners of activities define it for their each assigned activities.

In fact, "Total Experience Time" shows how many hours or days the users spent on a skill. Gathering this information from workflow activities gets more reliable

3.2.4.1.3 Distance. The time distance for a skill shows the total time between the current date and the end date of the last completed activity to which that skill is attached. As for the factor of "Total Experience Time", the "Distance" factor is also represented with any unit of time.

Two different distances can be listed: *Distance to First Experience Date* gives the distance to the arrival date of the first activity to which the related skill is attached.

That indirectly matches to Hiermann's "Experience" attribute. *Distance to Last Experience Date* gives the distance to the completion date of the last activity to which the related skill is attached. That matches to Hiermann's "Last Used" attribute.

The concept of "Distance" seems to be important for some people in Skill Management because the users get more experience on a skill if they are still working on it. Otherwise, both the experience and interest values on that skill may decrease. But this is not an exact rule, indeed. Some people think that a little memorizing research can callback the knowledge and experience from the past for a skill that was used to once. But some people do not. The importance of distance depends on the supervisors' or users' decisions.

Three factors defined above are pointed out in the Figure 3.10 with an example scenario. According to the scenario, three different programmers have been experienced on C++ programming in the given time period. Even the first one worked on more different activities, the second spent more time than the first. On the other hand, the third programmer worked 4t units on a C++ related activity but the working time is -10t before from now on. Assume that the total completion time is calculated based on actual experience time.

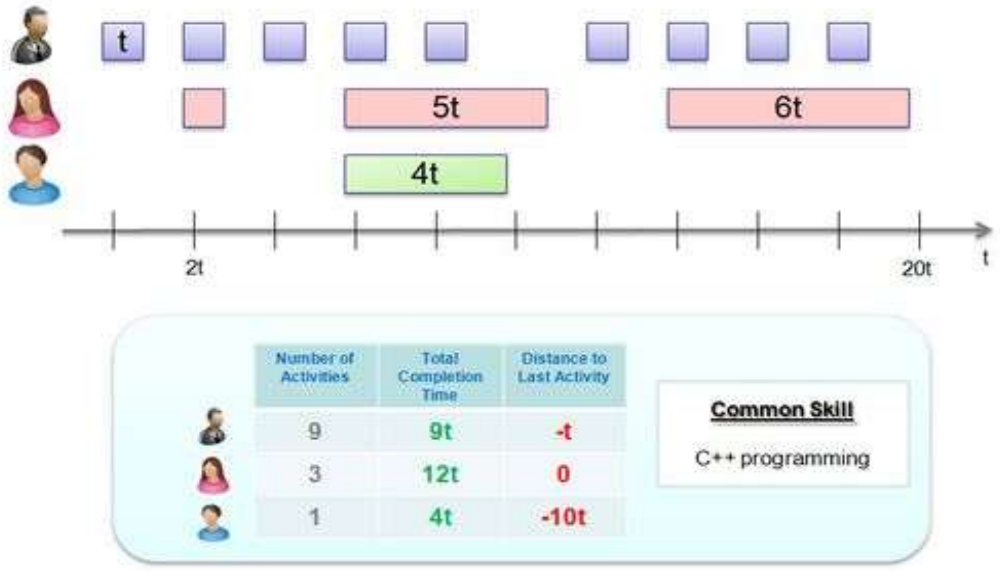

Figure 3.10 A scenario regarding the three factors for three users experienced on C++ skill.

3.2.4.1.4 Rank of Interest. The interest rank for the skill is directly attached value to the skill. Ranking is not required as an activity-dependent action; it can be performed by the user via a form any time. That means the source database for interests is a different database than workflow database, probably the organizational database or a custom database.

The rank of "Interest" factor can be defined with any x-to-y rating scale (e.g. 1-to-5 scale). The table below shows an example, filled form for a skill group named "Relational Database Management Systems" which can be used to gather the interests of users on belonging skills.

Table 3.3 1-to-5 scale of interest ranking for a skill groups

Interest Ranking of Relational Database Management Systems	**Not**	**Might**	**Likely**	**Very Likely**	**Sure**
	1	2	3	4	5
Oracle Corporation	o	o	o	o	X
Microsoft SQL Server	o	o	o	x	o
IBM DB2	o	o	o	x	o
Oracle mySQL	o	o	x	o	o
Sybase ADS	o	o	o	o	X

3.2.4.1.5 Score. Both academic units and Information Technologies companies prepare some evaluation activities (exams, projects, quizzes, homeworks …) to measure how the members (students or employees) are experienced on the required skills. Evaluations can include many questions and/or parts from different type of skills. An evaluation can measure a lot of skills and a skill can be attached to more than one evaluation. The results of evaluations are usually in 1-to-100 scale and they

have a validity period. Validity means that once the exam is expired, its score should not be reflected to its attached skills any more.

Each score may have a weight coefficient in a whole workflow. Therefore the score regarding any skills are calculated using weighted sum operations. Table 3.4 shows two different exam activities about training about C# programming. Both activities expose same skills such as C#, Active Data Objects.NET (ADO.NET) and Object Oriented Programming (OOP) and also different skills (3-days training includes labs about Windows Applications while 5-days training includes web services). The weighted scores are attached to related skills and resulted score is calculated based on those. It is important to say that, if a skill only exists in one activity, the weight of the skill will be 1 then.

Table 3.4 The Weighted Score for Different Activities and Their Exposed Skills

Workflow: Technical Training and Development of Users				
Activity	**Exposed Skills**	**Exam Score**	**Weight**	**Weighted Score**
Introduction To C# Programming, (3-days training)	C#, OOP, Windows Applications, ADO .NET	68/100	0,3	20,4
Advanced C# Programming (8-days training)	C#, OOP, ADO.NET, Serialization, File Operations, Web Services, Web Applications, .NET Roles	55/100	0,7	38,5
Resulted Exam Score for C#, OOP and ADO.NET (2 activities)				58,9
Resulted Exam Score for Windows Applications (1 activity)				68
Resulted Exam Score for Web Applications (1 activity)				55

3.2.4.1.6 Opinions. The opinion of supervisors can directly affect the experience level of a skill. If it is not possible to get the workflow data for the factors described above, the opinions can be used by SPCP, then. This data are retrieved from different type of sources (e.g. custom databases, paper forms, survey applications, etc.). System can let three different types of opinions for a skill: One from supervisor and the other from customers and other members of the organization.

3.2.4.2 The Necessity of Factors

The six factors of SPCP is not mandatory factors every time. That means SPCP can use those factors according to some definition. The necessity of a factor for a skill depends on skill type and the opinions of managers who track the skill map of users

3.2.4.2.1 Skill Type. This is a design-time configuration. If the skill is a hard skill, SPCP can use any factors for that skill. However, if the skill is a soft skill, some of the factors will be meaningless, so they should not be required by SPCP anymore.

3.2.4.2.2 The Opinions of Managers. This is run-time operation for the people who are reviewing the skills of the users. Some managers may prefer the factor of total experience time rather than the number of related works. However, another manager may only highlight the factor of interest rate for a specific time period because of a career-planning operation. So the system let the responsible people to include any factors according to their needs for SPCP phase.

Table 3.5 show the difference of number of used factors for different types of skills. The skill of “Team Study” is a soft skill and there is no exact relation with workflow activities. Therefore the factors of which sources are workflow database should not be included by SPCP for this type of skill. However, the opinion of supervisor and other team workers play a role to get the level of skill experience so these factors are included. For the hard skill of ABAP, all the factors are available.

Table 3.5 Different units of factors for SPCP of ABAP Programming (*: X_S means opinion of supervisor, X_P means opinion of partner)

Skills	**Factors of SPCP**					
	Number of works	Total Experience Time	Distance	Interest	Score	
					Exam	Opinions
Source	Workflow	Workflow	Workflow	Other	Other	Other
ABAP (Hard Skill)	X	X	X	X	X	X_S *
Team Study (Soft Skill)	-	-	-	-	-	$X_S X_P$ *

3.2.4.3 The Absenceness of Factors

Even a factor is included by SPCP; there may not be any data it represents. Then default values for those factors should be used in the calculation process. These defaults are determined by the managers.

Table 3.6 shows how SPCP treats for absent factors.

Table 3.6 Absenceness of Factors

SPCP Factor	**Value when no data is found**
Number of Works	0
Experience Time	0
Distance Time	0
Interest	3/5
Score	100/100
Opinion of Supervisor / Partner / Customer	3/5

3.2.4.4 The Normalization of Factors: Master Scale of SPCP

The factors have their own units. If only one factor is used to calculate the skill power, it will be easier to discuss what the level of experience for a user is. However, if SPCP deals with more than one factor, taking the arithmetic average of those needs a normalization operation that results to usage of a common unit.

"Master scale" is the scale to which different units of factors should be converted during the calculation process. It is the unit of experience level, in other words skill power. Table 3.7 lists the statements of 1-to-5 master scale used to represent skill power.

Table 3.7 Experience Levels of 1-to-5 Master Scale

Experience Levels	
1-to-5 Equivalence	**Statement**
1	Very Little
2	Little
3	Good
4	Very Good
5	Excellent

Table 3.8 below shows an example of different units of factors for a user, U1. After the master scale is determined, each factor should be converted to their new value using unit conversion rules.

Table 3.8 Different units of factors for SPCP of ABAP Programming

User U1	**SP results for the skill: ABAP Programming Language**					
	Number of works ***(Number)***	Total Experience Time ***(Days)***	Distance ***(Years)***	Interest ***(1-to-5)***	Status	
					Exam ***(1-to-100)***	Opinion of Supervisor ***(1-to-5)***
Values	6	4	0,3	5	72	4

There are 3 different conversion approaches in normalization process:

3.2.4.4.1 Scale-To-Scale Normalization. It is a basic conversion including basic multiplication or division operations. One scale is directly proportional with other scale. As an example, 3 of 5 in a 1-to-5 scale can be converted into 60 of 100 for a 1-to-100 scale. On the other hand, the converted values may have some rounding. For example, 78 / 100 is converted to 3.9 ~ 4 / 5 if the rule of directly proportional conversion is applied. Rounding is defined as an optional operation that means it is based on configuration.

3.2.4.4.2 Time-To-Time Normalization. It is also a basic conversion; however the relations among different time units are based on working day rules. The equivalence of "1 year = 52 weeks = 260 working days = 2340 hours" can be used during conversion operation.

3.2.4.4.3 Time-To-Scale Normalization. This depends on the scale that the responsible users (e.g. the managers) define. Both total experience time and distance factors need this type of conversion if they are included in SPCP process.

Table 3.9 shows the 1-to-5 scale equivalence of activity completion time and last activity date. This is determined with the members of Human Resources department and the manager of Information Technologies department of a company.

Table 3.9 Different units of factors for SPCP of ABAP Programming

Total Completion Time		**Distance**	
1-to-5 Equivalence	**Total Completion Time**	**1-to-5 Equivalence**	**Last Activity Date**
1	1-3 days	1	Before 3 years
2	4-10 days	2	1-3 years
3	11-20 days	3	31-52 weeks
4	21-40 days	4	5-30 weeks
5	41 days and more	5	0-4 weeks

After all the conversions are performed according to the defined master scale, the normalization process for SPCP will be accomplished. Table 3.10 below shows the equivalence, normalized table of Table 3.8 in which the factors have been set in different units.

Table 3.10 Normalized units of factors for SPCP of ABAP Programming

User U1	**SP results for the skill: ABAP Programming Language**					
	Number of works ***(Number)***	Total Experience Time ***(Days)***	Distance ***(Years)***	Interest ***(1-to-5)***	Status	
					Exam ***(1-to-100)***	Opinion of Supervisor ***(1-to-5)***
Values	6	4	0,3	5	72	4
Normalized (1-to-5)	2/5	2/5	4/5	5/5	4/5	4/5

3.2.4.5 Weighting of Factors

Some SPCP factors may be more meaningful than the others according to the needs of managers. So weighting operation is also defined for SPCP. In default, every included factor has the equal weight of which sum is 1. Weighting is defined per skill and/or skill group in design-time. The sum of coefficients for each factor should be 1.

Table 3.11 shows the example regarding the skill of ABAP programming language with the distribution of weight coefficients to each factor.

Table 3.11 Normalized units of factors for SPCP of ABAP Programming

	SP results for the skill: ABAP Programming Language					
	Number of works ***(Number)***	Total Experience Time ***(Days)***	Distance ***(Years)***	Interest ***(1-to-5)***	Status	
					Exam ***(1-to-100)***	Opinion of Supervisor ***(1-to-5)***
Weights	0	0,5	0,1	0,2	0,1	0,1

3.2.4.6 General Formula of Skill Power

After discussing all the factors used by SPCP, the general formula indicating the weighted sum of all factors can be written as it follows:

Let *n* be the n^{th} skill from a skill set.

$$SP_n = W_{Nn}.N_n + W_{En}.E_n + W_{Dn}.D_n + W_{In}.I_n + W_{Xn}.X_n + W_{Pn}.P_n + W_{Sn}.S_n + W_{Cn}.C_n$$

Table 3.12 describes all notations and sub formulas of general formula.

Table 3.12 SP Notations and Sub Formulas

Factors of SPCP	**Weight Coefficients**	**Normalized Values**	**Sub Formula**
Number of works	W_{Nn}	N_n	I
Total Experience Time	W_{En}	E_n	$\sum_{j=1}^{i} (tE_j - tS_j)$
Distance	W_{Dn}	D_n	$t_C - tE_{Last}$
Interest Rank	W_{In}	I_n	-
Score (Exam)	W_{Xn}	X_n	$\sum_{j=1}^{k} (\mu_j . w_j)$
Opinion of Partner	W_{Pn}	P_n	-
Opinion of Supervisor	W_{Sn}	S_n	-
Opinion of Customer	W_{Cn}	C_n	-

Let

- s (A) = i be the number of activities that the skill n is attached.
- k be the number of activities that the skill n has score factor, k <= i.
- a_j be the j^{th} activity where $a \in A$, $j \in N^+$
- tS_j be the actual start time; tE_j be the actual end time for j^{th} activity.
- $(tE_j - tS_j)$ be the actual duration for j^{th} activity instance.
- $(t_C - tE_{Last})$ be the time distance to the last activity where t_C is current date and tE_{Last} is the actual end time of last related, completed activity.
- $(\mu_j . w_j)$ be the weighted value of score of j^{th} activity.

Table 3.13 shows the all steps detailed above. For the user U1, the experience level of ABAP Programming Language is found after the normalization, necessity and weighting operations. The result is evaluated in 1-to 5 scales and the statement of 'GOOD' for that skill is reached. In this example all the factors except "Number of works" is used for the calculation.

Table 3.13 An Example to Skill Power Calculation of "ABAP Programming" Skill

User U1	**SP results for the skill: ABAP Programming Language**					
	Number of works	Total Experience Time	Distance	Interest	Score	
					Exam	Opinion of Supervisor
Unit of Factor	Number	Days	Years	1-to-5	1-to-100	1-to-5
Values	6	4	0,3	5	72	4
Normalized (1-to-5)	-	2/5	4/5	5/5	4/5	4/5
Included?	-	X	X	X	X	X
Weight	0	0,5	0,1	0,2	0,1	0,1
Weighted Score	0	1	0,4	1	0,4	0,4
SP (Skill Power)	3,2 / 5 = GOOD					

Another example is for the soft skill of "Team Study" that has been mentioned above. As it can be seen in the table below, for the user U1, the power of "Team Study" is found after the normalization, necessity and weighting operations again. The result is evaluated in 1-to 5 scales and the statement of 'VERY GOOD' for that skill is reached. This example uses only two factors for the SPCP.

Table 3.14 An Example to Skill Power Calculation of "Team Study" Skill

User U1	**SP results for the skill: Team Study**					
	Number of works	Total Experience Time	Distance	Interest	Status	
					Opinion of Partner	Opinion of Supervisor
Unit of Factor	Number	Days	Years	1-to-5	1-to-100	1-to-5
Values	-	-	-	-	72	4
Normalized (1-to-5)	-	-	-	-	3,83/5	4/5
Included?	-	-	-	-	X	X
Weight	0	0	0	0	0,5	0,5
Weighted Score	0	1	0,4	1	1,92	2
SP (Skill Power)	3,92 / 5 = 4 = VERY GOOD					

3.2.5 Skill Research Service (SRS)

SRS services as a search engine to find about not only the skills, users, workflows, activities but also the experience and interest levels of skills. It communicates with SPCP and gets the results in the view the user selects. It is the central service of e-Worter easing the management of the users and processes of the organization in terms of skill management. It is the effective, easily connectable and well-documented product of workflow-integrated skill management approach of e-Worter.

SRS has been developed using Microsoft .NET Framework and its standard libraries. It retrieves the summarized data collected from both workflow databases and other sources.

Figure 3.11 shows signature of GetList method of SRS.

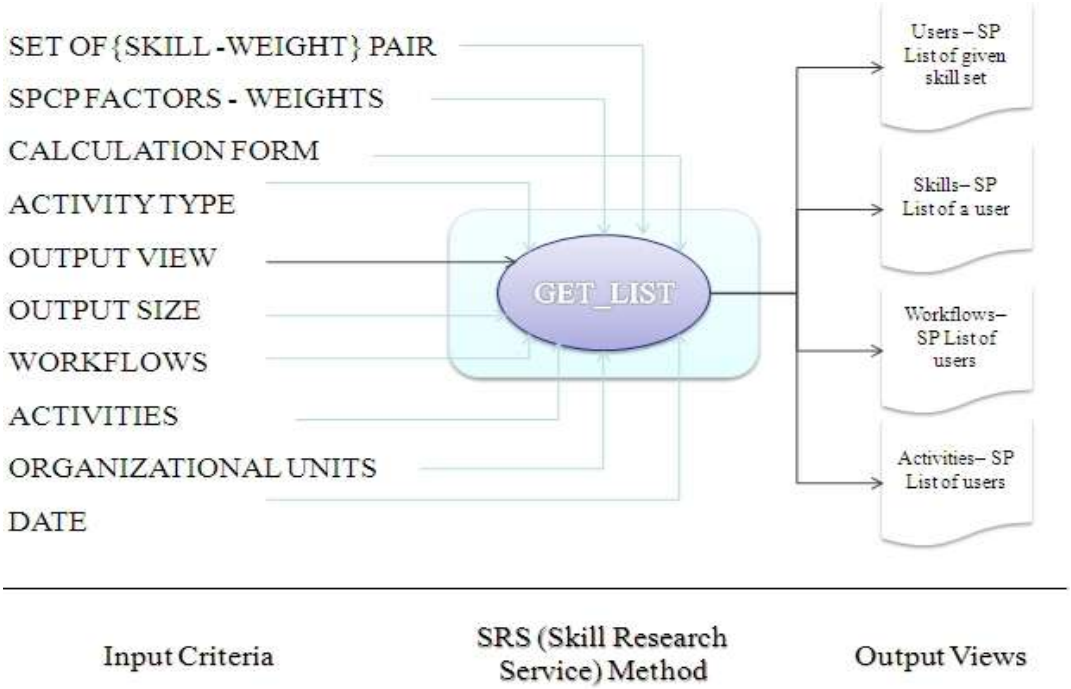

Figure 3.11 Get_List method of SRS with its input criteria and possible output views

Following is the input criteria that SRS needs to list any output for the users.

3.2.5.1 Skills and Weights

The service can execute either for only one skill or a set of skills with their weighting values. This is useful for the employment and assignment processes to find the best user matching the required skills of which weights are also defined. Weighting of skills here depends on the users' demands. In default, all weights are assumed to be equal.

Let *n* be the number of skills to be evaluated and μ_n is the demanded weight of the skill. SP_u gives the power of skill set for the user *u*.

$$SP_u = [\sum_{i=1}^{n}(SP_n) \cdot \mu_n]$$

Table 3.15 shows an example output to a set of weighted skills.

Table 3.15 An Example to Set of Multiple Weighted Skills as a Criteria of SRS and the Resulting Power

User: U1			
Skill	**Demanded Weight**	**SP**	**Weighted SP**
C#	0,2	4	0,8
.NET Framework	0,2	3,8	0,76
Java	0,5	2	1
Delphi	0,1	0	0
Result	2,56 ~ 3 = GOOD		

3.2.5.2 Factors and Weights

The users define the factors and their weights by obeying the rules described in the topic of necessity of skills. The system has a predefined variant as a suggestion for the users. However, the pre-included factors can be removed from the SPCP definition or non-existing factors can be added to see how different combinations affect the skill power of users.

3.2.5.3 Calculation Forms

Two forms of calculation works for SPCP: Normal form and Sibling Inherited Form.

3.2.5.3.1 Normal Form. In default, when the users initiate SPCP, they initiate the "Normal" form of the process indeed. It means that all rules just described is completely applied.

3.2.5.3.2 Inheritance Form. The other form of SPCP, "Sibling Inheritance", is an alternate way serving as a miner for a set of skills. It is approximately guessing the possible power of the skill traversing the similar nodes which are belonging to same parents.

If one of the demanded skills as an input criteria to SRS is completely absent for a user (e.g. there is no activities, scores, opinions and interest ranks for that skill), the SPCP exactly returns “0” in the normal form. Sibling inheritance form traverses all sibling nodes, finds their powers, calculates the weighted average of them and presents the result at the end. Figure 3.12 shows when and how sibling inheritance form works.

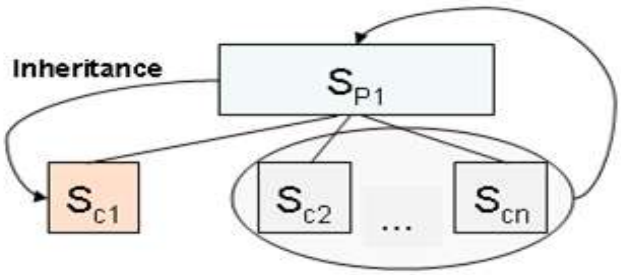

Figure 3.12 Sibling Inheritance Form for Skills:
S_{p1}: Parent Skill; Sc_1, Sc_2.. S_{cn}: Children (Sibling) Skills

Following is the formula representing sibling inheritance for the non valuable skills.

Let n be the number of children skills, c_1 be the skill, $c_2,\ldots, c_n$ be the sibling skills.

$$SPc_1 = \left[\sum_{i=2}^{n} (SPc_n) \right] / (n - 1)$$

In Table 3.15, the SP of Delphi programming language is 0. It means there is no collected data of that skill. However, if the SRS user thinks that the experience level of “Programming Languages” skill group gives an approximate idea about Delphi, “Sibling Inheritance” form can be executed. The theorem is basic: “The person who knows many programming languages may be also accepted as an expert for Delphi”. The SP of Delphi and the new calculated power are shown in the table below.

Table 3.16 An Example to Set of Multiple Weighted Skills as a Criteria of SRS and the Resulting Power. For Delphi skill, “Sibling Inheritance” form of SPCP executes.

User: U1			
Skill	**Demanded Weight**	**SP**	**Weighted SP**
C#	0,2	4	0,8
.NET Framework	0,2	3,8	0,76
Java	0,5	2	1
Delphi	0,1	**3,27**	**0, 33**
Result	2,89 ~ 3 = GOOD		

3.2.5.4 Activity Type

Activity type restriction shows the exact borders between theoretical and practical activities on the skills. Training or a research activity improves theoretical knowledge of people. On the other hand, developing a project improves the skills practically. Another classification is based on the planned dates of activities. If an activity is a 3-month activity then its importance is usually higher than an activity taking only 2 hours.

The user can define one of 4 types as a criteria for SRS:

- Theoretical activities
- Practical activities, planned as less than 5 days
- Practical activities, planned as more than 5 days
- All (Default)

3.2.5.5 Output View

There are various views of output for SRS. This improves the effectiveness and the usability of service because many different variations of data can be converted to any desired format.

The views of output are following:

- Users – SP View for a given skill set
- Skills – SP View for a given user
- Workflows – SP View for a given user
- Activities – SP View for a given user

3.2.5.6 Output Size

The SRS users would like to see the whole or restricted list of users with their powers on given skills. Here are some choices regarding output size:

- All users with their powers on a given set of skills
- Best user (TOP 1) of a given set of skills
- Worst user (BOTTOM 1) of a given set of skills
- TOP 10 or BOTTOM 10 users of a given set of skills
- Randomized number of users of a given set of skills
- All skills of a given user
- TOP 5 skills of a given user …

3.2.5.7 Organizational Units

The output including users with their power on skills can be restricted with the criteria of organizational unit of users. According to the unit, department and / or position information for which users SPCP will be executed is determined.

3.2.5.8 Workflow and Activities

The output can be restricted with the criteria of workflows and activities. The user may only demand to see which workflows expose which skills and what the power of those are.

3.2.5.9 Date

Date is the last criteria to restrict range of the output list. A pair of start and end date is defined by the user and then SPCP filters the data using these criteria for each factor listed below:

- Planned start and end date of activities belonging to the range of given criteria are considered.
- Actual start and end date of activities belonging to the range of given criteria are considered.
- Interest ranks defined in the range of given date criteria are collected.
- The scores and the opinions that are defined in the range of criteria are gathered. The validity date definition of those factors if exist are also mentioned.

CHAPTER FOUR
E-WORTER IN AN ACADEMIC DEPARTMENT

4.1 The Current Life of a Computer Engineering Department

This study has been designed and proposed for Computer Engineering of Dokuz Eylul University. As an academic unit in an engineering faculty, the department has 14 faculty members, 10 research assistants, 3 supporting staff, 158 current and 358 graduated students by taking consideration of the 4-year degree engineering program at the start of 2009 fall semester. The department applied to an accreditation committee, The Association for Evaluation and Accreditation of Engineering Programs (MÜDEK), almost 4 years ago to enhance and standardize the business processes and to be labeled as accredited. MÜDEK (n.d.) audits and accredites the engineering departments according to those criteria including students, educational objectives, program outcome and asssesment, academic staff, facilities, etc.

4.1.1 The Role of e-Worter for Accreditation Programs

Information retrieved and calculated by e-Worter approach can be used for MÜDEK accrediatiton reports to summarize how the courses behave in different academic years about the methodology of education. The questions such that which courses expose what kind of skills to the students, how many activities the courses complete, what changes occur among the different years for the same courses can be answered using e-Worter data. The following questions are meaningful questions that e-Worter can answer it by aggregating actual flowing and historical data.

- Do the requirements of companies match with the educational program?
- Do the requirements of companies match with the background of faculty members?
- How is the communication between the chair of department and the companies?
- How is the communication between the students and the companies?

- Are the interests of students gathered periodically?
- Are the interests of students highlighted by the management?
- Do the faculty members meet the suggestions of the students as soon as possible?
- How the satisfactions and dissatisfactions of the students affect the program?
- Does the department know his students well?
- Does the department know his graduated students well?
- How are project teams built in the department?
- Who gives any feedback about the educational program to improve the quality?

Once an academic department can answer most of those questions without any subjective opinions, the quality of academic processes and the output would increase, therefore the faculty, business sector and students would be more satisfied because of reaching their targets as they expected.

4.1.2 Research Studies about Skill Management in the Department

Even there have been a lot of formal documents and prepared reports for auditors about how the program is executed, how processes are performed, which resources have been used for what, what the students and academic staff have offered and how the management of department have answered those, most of the reports have been based on the subjective opinions, conversations and surveys rather than any stored, electronic and reportable data. Therefore, whether a student is experienced on the most technical areas what a computer engineer is expected to know cannot be rapidly gathered; even it is gathered via traditional ways, no one guarantee that the revealed information is reliable and actually usable.

Three research studies are applied to 3rd, 4th years and graduated students of The Computer Engineering department. 2 of them are designed as surveys that the participants fill the blanks or choose the best, 1 is about the catalog investigation.. Both surveys were prepared as basic open-ended questions to get more qualitative results.

4.1.2.1 Gathering the Technical Background and Interests of Students via Surveys

The survey was participated by 3rd year students and addresses more common educational perspective. 27 students were asked to write down all the technical skills they had experienced during their whole education of engineering. We asked them to rank those skills again to see how much they were interested in each and to write how many related projects they were involved in for each.

Figure 4.1 shows that C# and Java seem as the most declared, experienced skills among the 3rd year students. These are based on the declaration of students in free texts. Even, that does not an ideal result regarding the experience, it shows that the the department focuses on these two programming languages comparing with other skills.

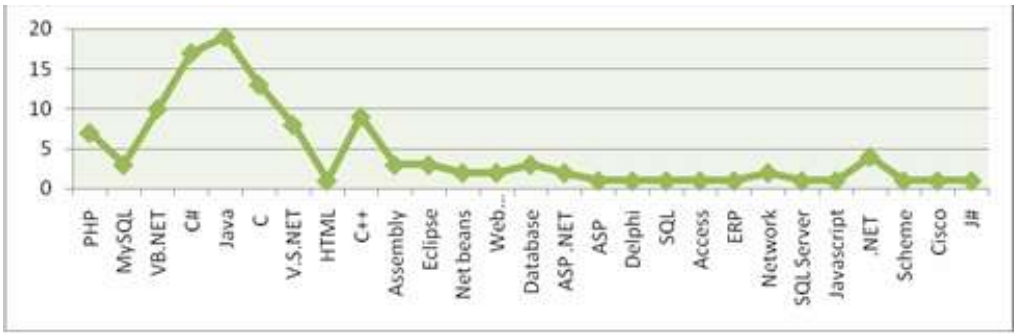

Figure 4.1 The number of highligted skills: Java and C# seem to be the most experienced skills

Figure 4.2 shows the participants who declared different skills than the most of other participants. This figure is also important to show different students with different experience and interest levels in a whole class. We can easily see that 2 of 27 students have got a CISCO CCNA certificates; only one student deals with J#, Delphi is mentioned by only one another student, etc. All of that information is so important for the cognition process of the department.

S1	HTML
S2	Netbeans & Eclipse: Summer Intemship PROJECT
S3	Delphi: Desktop Applications PHP
S4	ERP; SQL; Network CCNA certificates
S5	PHP / Javascript: 2 web application
S6	Eclipse & Java: 2 projects; CISCO (CCNA) 4 certificates
S7	J#; 4 console applications

Figure 4.2 The students writing less commonly used skills

Figure 4.3 shows the interest values on highlightes skills. Red bars show the rate over all participants for each skill and the light blue bars show the rate over who highlightes that skill. We can extract that HTML is highlighted by a few participants and their average rank of interests is also lower comparing with other skills. However, even Cisco is also selected by a few students; its average interest value is higher.

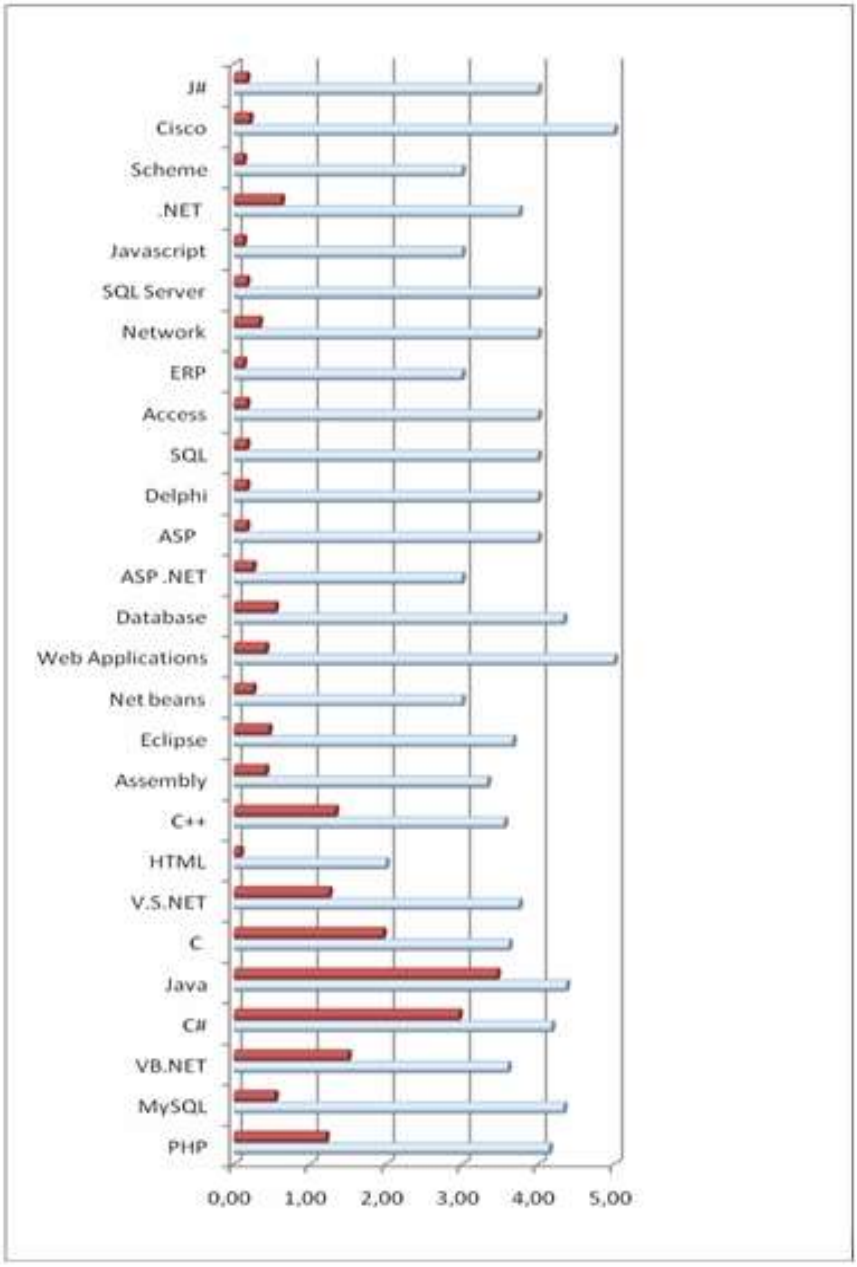

Figure 4.3 The rate of highligted technical skills with their interest rates

4.1.2.2 Gathering the Technical Background and Interests of Students by Comparison

The survey was participated by 3rd year students by a comparison operation between two related technical skills. This is easier way to see which student is focusing on any technical skills comparing with other related skills. Figure 4.4, figure 4.5, figure 4.6 and figure 4.7 shows some example graphical output regarding

comparison operation. This type of survey assists what kind of technologies, tools and subjects should be included into the educational program.

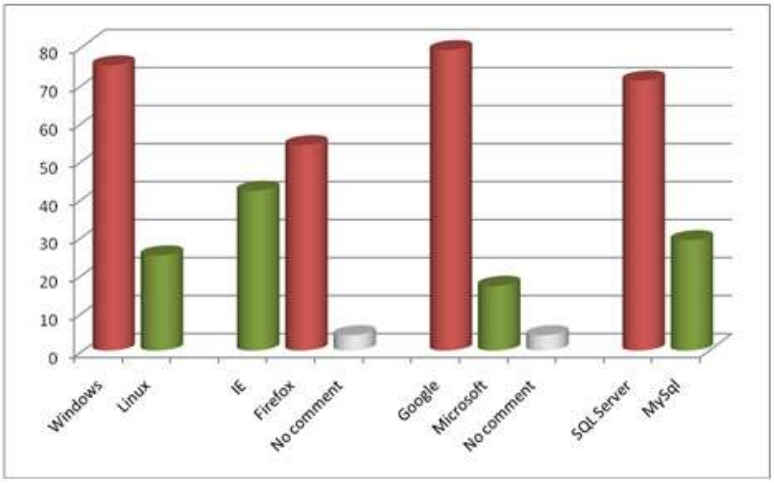

Figure 4.4 Interest comparison of tecnologies / tools / companies.

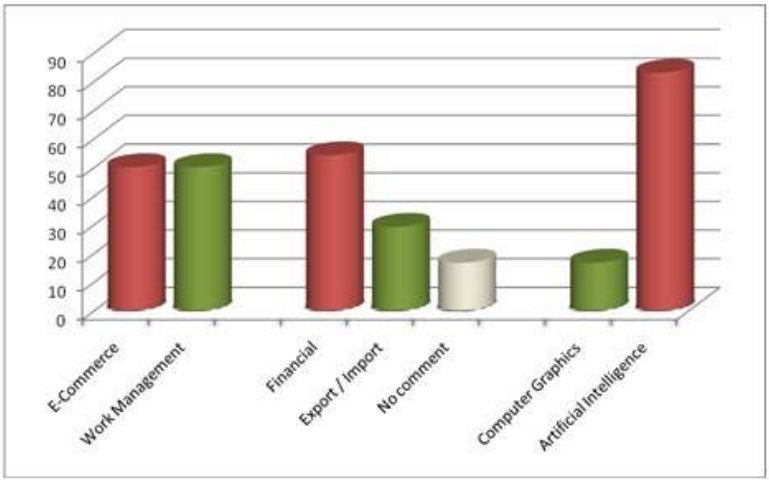

Figure 4.5 Interest comparison of technical & business areas.

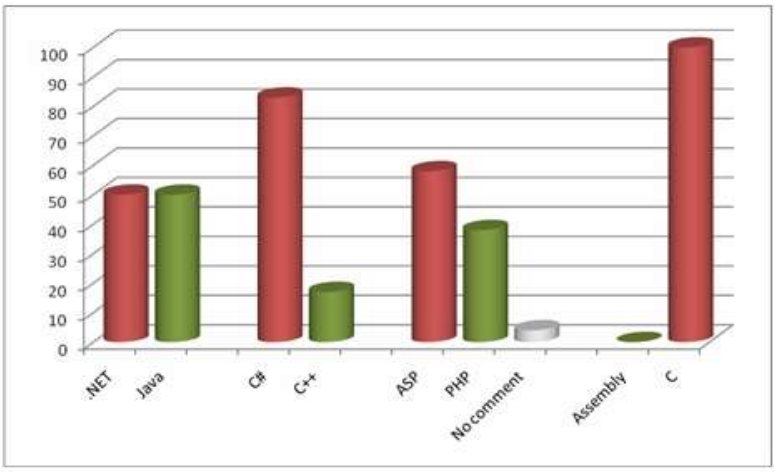

Figure 4.6 Interest comparison of programming languages.

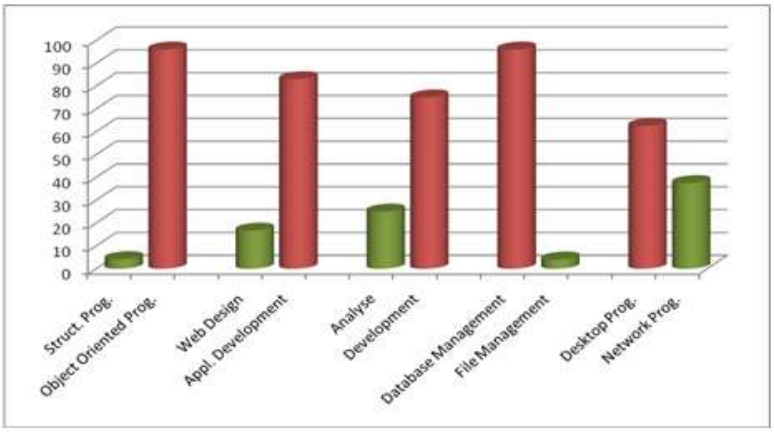

Figure 4.7 Interest comparison of programming and software concepts

.NET	LINUX
13 STUDENTS	5 STUDENTS
	ACADEMIC
	3 STUDENTS

Figure 4.8 Classification of 3rd years students according to their interests.

Figure 4.8 shows a classification example extracted from the comparison method. The students interested in .NET, Linux and academic studies are easily obtained.

4.1.2.3 Gathering the Technical Background and Interests of Students via Lectures

The survey is applied to 4th year students to retrieve most interested software-based skills that they used to develop a project in „Introduction To Data Mining“course. There were 17 students attending that course and we asked them to list all technical concepts, technologies and products they used during the project. They also rated each concept using 5-point scale to show how much they were interested in for each.

Figure 4.9 shows the whole skills experienced during the project with their interest ranks. Notice that only a project of an elective course expose 12 skills 4 of which represents the tools and frameworks of Microsoft, most of other which are about programming languages and concepts.

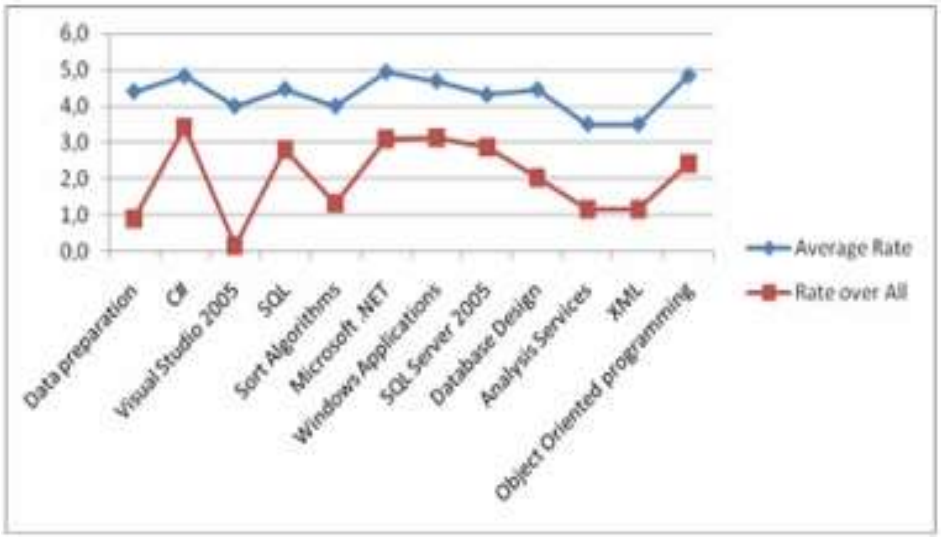

Figure 4.9 The interest rank of exposed skills of a term project

In this questionnaire, the participants are also requested to write down the references (source books and URL links) and tools that they used during the project

implementation. Figure 4.10 shows all the references and tools gathered from all the participants. ClbLengenPro and its related URL link are only used by a participant, while MSDN URL link seems to be used by the most of the participants.

Used Tools / Products

- Visual Studio .NET 2003
- Visual Studio .NET 2005
- Microsoft SQL Server 2000
- Microsoft SQL Server 2005
- SQL Server Analysis Services
- Rational Rose
- Special Class Generator: CLBLENGENPro

(From the form that the students filled in)

References

- msdn2.microsoft.com
- www.csharpnedir.com
- www.codersource.net
- www.microsoft.net
- Cs.deu.edu.tr/courses/cse/sqltut.html
- http://www.lbgen.com/pages/tutorial.aspx
- Microsoft Press: Developing C# Applications
- Microsoft Press: Introduction To SQL Server 2005
- Microsoft Course Materials
- MSDN Help

Figure 4.10 The references and used products for a homework

4.1.2.4 Gathering the Technical Background and Interests of Graduates via Catalogues

In the graduation catalogue (Dokuz Eylül Üniversitesi Bilgisayar Mühendisliği Bölümü, 2008), which was published in June 2008, including the technical background information for 4th year students of The Computer Engineering Department, it can be extracted that the number of declared experienced and interested skills have been varying per student. In the catalogue, one page was reserved for each 27 graduates including their brief educational history, technical experiences, interests and hobbies. As a result of this research, only two graduates

had drawn up more than 20 experienced technical skills and three of all had listed more than 20 interested technical skills. On the other hand, a student stated only two technical skills that she had been interested in: *C# and Java*. Figure 4.11 shows the number of interested and experienced skills of 27 graduates.

Student	Interested	Experienced
S1	8	3
S2	1	10
S3	5	9
S4	2	15
S5	2	15
S6	49	6
S7	7	3
S8	7	2
S9	4	2
S10	7	2
S11	3	9
S12	11	3
S13	2	4
S14	22	3
S15	12	16
S16	6	3
S17	4	3
S18	7	37
S19	3	8
S20	5	23
S21	5	22
S22	8	8
S23	5	11
S24	11	6
S25	5	6
S26	2	3
S27	21	8

Figure 4.11 The number of interested and experienced skills of 27 graduates from the catalogue.

Figure 4.12 shows the difference of the experienced skill declaration among the 3rd year and 4th year students.

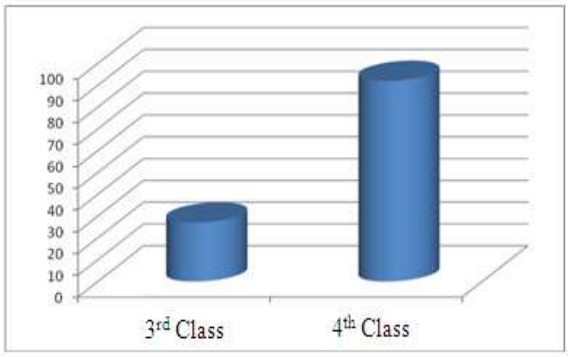

Figure 4.12 The difference of number of experienced skills among 3rd and 4th year students

Figure 4.13 shows interested skills of which number is at least 2 extracted from the catalogue.

Embedded Systems	4	14,81
Artificial Intelligence	4	14,81
Veri Madenciliği	6	22,22
Machine Learning	6	22,22
Software Verification	3	11,11
Image Processing	2	7,41
Project Management	9	33,33
OO Programming	12	44,44
System Analysis	2	7,41
Software Engineering	**11**	**40,74**
Linux / UNIX	6	22,22
Windows / OS	3	11,11
SQL Server	4	14,81
Oracle	3	11,11
Access	2	7,41
Eclipse	2	7,41
.NET	5	18,52
Pascal	3	11,11
VB6	3	11,11
Web Applications	6	22,22
LAN/WAN	2	7,41
TCP/IP	2	7,41
C	6	22,22
C++	6	22,22
Java	5	18,52
C	6	22,22
Assembly	3	11,11
PHP	2	7,41
JSP	2	7,41
ASP	3	11,11
HTML	3	11,11
SQL	4	14,81
XML	2	7,41
Javacript	2	7,41
ERP	3	11,11
RUP	2	7,41
Web Tech	2	7,41
Network Prog.	2	7,41
Game Prog.	2	7,41
GCC	2	7,41

Figure 4.13 The number of experienced skills from the catalogue.

4.1.2.5 Discussing the Results of Research Studies

Those three types of research show the students‘experiences and interests. Table 4.1 evaluates those studies by listing the benefits and open issues exposed.

Table 4.1 The benefits and open issues of used three research studies regarding the skills of academic units.

Benefits	• The technical background of the students is gathered. • The technical areas in which the students are interested are revealed.
Issues & Problems	• The data are not periodically collected because these studies were applied for only once. Therefore the results are only applicable in the period in which the research is executed. • The results are completely based on subjective opinions of the participants. • The contents of filled forms of many participants seem so similar (some answers are completely copied versions of other answers) • The range of participants is small: That does not give any idea of whole department's technical background. • Some of the skills which are written as free texts have grammar errors; some have not any version information.

These are completely subjective thoughts and do not show any exact information about not only their technical background but also the methodology of engineering education of the department. These opinions actually depend on how the graduates and/or students want to present themselves or what they remember in the time they faced with such surveys.

What do the educational processes do in fact? Table 4.2 draws the definition of an elective course from the same department, Visual Programming Applications with Databases. 30 students registered for that course for the spring term of 2008-2009. As it can be pointed, only that course of over all exposes 28 skills. Many numbers of

lectures, short-term assignments and one long-term project was accomplished during the term.

Table 4.2 The whole definition of an elective course: Exposed skills, number of projects, homeworks, exams, text books, references and lectures

CSE 444 - Visual Programming Applications with Databases			
# of Skilled Technical Keys: 28, **# of Projects:** 1, **# of Assignments:** 5, **# of Exams:** 2, **# of Text Books:** 2, **# of Materials:** 10 **# of Lectures:** 36 hours in an academic term			
Exposed Technical Skills			
Visual Prog.	OOP	GUI	Interface Design
.NET Framework	Visual Studio	Windows App.	SQL Server OLE
Active X	SQL Server	Database	DBMS
Query Building	Web Prog.	Web Design	C#
Visual Basic .NET	Reporting	PHP	MySQL
Web Services	XML	XSL	Oracle
OO DB	Java	E-Commerce	Web Security

Comparing with the self opinions gathered via time consuming surveys or catalogues, it can be expressed that tracking all the academic processes would cause more observable, effective and exact results.

4.2 Equivalent Workflow Terminology

e-Worter uses the workflow terminology corresponding to the academic terminology as shown in the Table 4.3. All courses and other long-time activities are seperate workflows in which related activities are completed consequently based on the educational program. Each course workflow includes number of activities many of which are theoretical. Theoretical activities improve theoretical skills while the practical ones improve practice for each assigned skill.

Table 4.3 The whole definition of an elective course

Academic Terminology	**Workflow Terminology**
Course / Lecture Summer Training Thesis Project	Workflow Groups
Course Objective	Workflow Definition
Faculty Members Staff Students Graduates Guests	Workflow Participants, Resources
Course Documents	Workflow Documents
Course Time	Activity Start Time
Deadline / Due Date	Activity End Time
Course (C) Seminar (S) Homework (H) Lab (L) Quiz (Z) Exam (E) Research (R) Task (T) Approval (A) Meeeting (M)	Activity Types

Figure 4.14 shows an example activity flow for an academic course. Each different types of activities (courses ~ lectures, labs, homeworks, quizes, exams) require an approval prosess. Even they expose a set of skill; the post approval activities do not expose any skills. They only give a score to the activity or set the absenceness value for the activity.

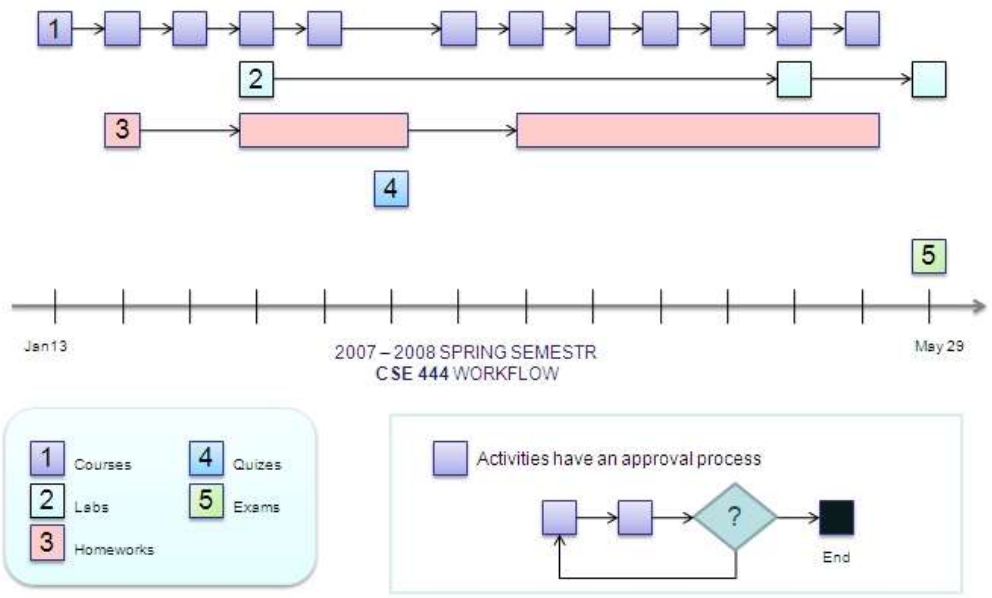

Figure 4.14 An example of academic workflows: Each different type of activities require an approval prosess.

4.3 SCPP in the Department

The academic staff attend to meetings at the beginning of each semester to discuss about the plannings of the closer academic term and also the content of courses. The maintenance of skill catalogue can be done via those discussions and self population of skills via SRS and activities.

4.4 SAAP in the Department

Skill assignment is mostly performed by the academicians, while assessment operation is for not only the academicians but also the students.

4.4.1 Skill Assignment via Administrative Processes

The definition of workflows, activities, users is performed by the defined supervisors having some priviliges. Those users are also defined with the role of "Skill Manager" therefore they can be capable off attaching any sets of skills to the

activities according to the definition of workflows. These may be different windows or web applications supporting skill catalogues and other sources.

4.4.2 Skill Assessment via Portal Application

The enterprise portal was developed as a web application on .NET Framework in C# programming. Because of being developed within common technologies and products and having flexible architecture, e-Worter tools shold be open to source modifications, any reports required by academic management or audit commitee can be easiliy developed by the expert internal resources.

4.4.2.1 Participants and Login

Figure 4.15 Login screen to participant portal

Figure 4.15 shows the login page for these participants. The suggested participant portal of e-Worter can be used by various participant types. Portal is available to 6 types of participants. 3 of are the external participants whose access are restricted to only some reports and descriptive pages regarding the academic life of the department. Table 4.4 shows the basic roles of external participants.

Table 4.4 The roles of external participants in the proposed e-Worter portal application

The External Participants	**Roles**
Audit Experts	Retrieval of some output to ensure that the educational targets of academy is applicable with the criteria of educational standards.
	Checking whether the system works properly or not.
Business	Viewing the technical background of the academic department.
Guests	Viewing the technical background of the academic department, courses, and academic staff. The participant portal is like an official web site of the department for those types of users.

Table 4.5, 4.6 and 4.7 list the roles of students, management staff and favulty members as the internal participants of the proposed portal application.

Table 4.5 The roles of students in the proposed e-Worter portal application

The Internal Participants	**Roles**
Students	Listing all courses with their objectives, books, references, planned activities and exposed skills.
	Listing their all pending tasks and future activities belonging to different courses via a common page.
	Viewing the documents, references and skills the activity owners (instructors) defined for each activity.
	Viewing the location, time and necessary material information for the activities if they are defined.
	Adding new documents, web references and explanatory notes to each assigned activity.
	Viewing and ranking exposed skills of activities if they have.
	Adding new skills to activity if it is needed and allowed.
	Viewing completed and cancelled activities with their all attached documents, scores and notes.
	Being notified about expired or nearing activities.
	Viewing power for each skill.

Table 4.6 The roles of management staff in the proposed e-Worter portal application

The Internal Participants	**Roles**
Management (~ Secretaria)	Defining and managing course workflows and other workflows if they have necessary rights.
	Managing the organization members using Organization Schema Builders.
	Managing and deploying the documents flowing through academic processes.
	Viewing the location, time and necessary material information for the activities if they are defined.
	Preparing / requesting necessary reports according to the requirements of accredidation committee, MÜDEK and/or faculty.

Table 4.7 The roles of faculty members in the proposed e-Worter portal application

The Internal Participants	**Roles**
Faculty Members	Defining and managing course workflows and other workflows if they have necessary rights.
	Maintaining the skill catalogue according to the rights they have.
	Listing their pending activities via web portal.
	Completing, approving, rejecting or canceling their assigned activities.
	Giving scores to the required activities according to the policies of the department.
	Changing metadata of activities such as definition, location, time and material information.
	Managing, storing, viewing or deleting all documents stored in the workflow database.
	Getting any lists / reports about the students and courses that the management requires.
	Tracking the expired activities.
	Comparing the estimated or planned and realized processes for every academic year.

4.4.2.2 Workflows

4.4.2.2.1 Templates. Each workflow has a template. Templates behave as classes in the object oriented programming. A template includes all necessary definition, steps and components of a business process. In academic area, the templates are the lectures as it is mentioned in the equivalent table. Figure 4.16 shows the templates belonging to the Spring term of 2008 – 2009.

2008 - 2009 (Spring)

Workflow Code	Workflow Name	Type	Owner	Class
CSE102	Algorithms and Programming II	M	Yrd.Doç.Dr. Gökhan Dalkılıç	1
CSE120	Discrete Computational Structures	M	Öğr. Gör. Dr. Canan Eren ATAY	1
CSE122	Introduction To Comp.Sci II	M	Doç. Dr. Yalçın ÇEBİ	1
CSE202	Probability & Statistics	M	Yrd.Doç.Dr. Esin FİRÜZAN	2
CSE222	Theory of Computer Science	M	Öğr. Gör. Dr. Emine EKİN	2
CSE224	Programming Languages	M	Yrd.Doç.Dr. Gökhan Dalkılıç	2
CSE226	Computer Organization & Architecture	M	Öğr.Gör.Dr. Özlem ÖZTÜRK	2
CSE302	Systems Programming	M	Yard. Doç. Dr. Adil ALPKOÇAK	3
CSE304	Software Engineering	M	Öğr. Gör. Dr. Kökten Ulaş BİRANT	3
CSE306	Database Management Systems	M	Öğr. Gör. Dr. Canan Eren ATAY	3
CSE402	Introduction To Artificial Intelligence	M	Prof.Dr. Efendi NASİBOV	4
CSE404	System Simulation & Modeling	M	Yard. Doç. Dr. Şen ÇAKIR	4
CSE405	Parallel Computing	O	Yard. Doç. Dr. Adil ALPKOÇAK	4
CSE420	Quality of Service Advancements in IP Networks	O	Öğr. Gör. Dr. Malik Kemal ŞİŞ	4
CSE427	Network Administration And Management	O	Doç. Dr. Yalçın ÇEBİ	4
CSE434	Introduction To Digital Image Processing	O	Öğr.Gör.Dr. Özlem ÖZTÜRK	4
CSE442	Principles of Embedded Systems	O	Öğr. Gör. M. Hilal ÖZCANHAN	4
CSE444	Visual Programming Applications with Databases	O	Prof. Dr. Alp KUT	4
CSE470	Project Proposal	P	Prof. Dr. Alp KUT	4
CSE472	Introduction To Data Mining	O	Öğr. Gör. Dr. Derya BİRANT	4

Figure 4.16 Academic Workflows

4.4.2.2.2 Terms. The definition of workflow templates can be changed at any time. So the versioning of templates is important to keep the historical data consistently. Workflow templates are copied for each period which they can belong to. For example there exists two different CSE102 course definition in the database because of different academic time units.

Educational institutes usually have two main term period in a year especially called Autumn and Spring periods. Figure 4.17 shows how term selection page appears in the suggested portal application.

2008 - 2009 (Spring)

Figure 4.17 Workflow Term Selection

4.4.2.2.3 Details. Figure 4.18 gives details of a Workflow Template in Participant Portal.

Figure 4.18 All Details of a Workflow Template in Participant Portal.

4.4.2.2.4 Definition. This is the workflow template description. It gives the general objective of the lecture in free text. Figure 4.19 shows the definition of CSE224 lecture.

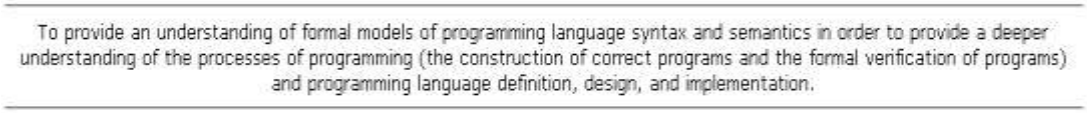

Figure 4.19 Workflow Description of CSE224

4.4.2.2.5 Users. It is possible to define more than one user for workflows. It is recommended that only one supervisor should be defined for a workflow, the other workflow users can be defined as assistant or normal user. Figure 4.20 shows the owners part of workflow detail screen.

Figure 4.20 Workflow Owners (Initiators)

Some workflows are instantinated every time by every supervisor for every participant of the system, but some workflows are specific to a user group / range. According to the privileges, only a set of user can start, process, watch, cancel and / or end these type of workflows.

Workflows may have a supervisor managing them from the begining to the end.

4.4.2.2.6 References / Sources. The procedures, process definitions, books, magazines or internet sites can be attached to the whole workflow so that during the process, workflow users can benefit from these resources. Figure 4.21 shows the references part of workflow detail screen.

Figure 4.21 Workflow Resources: Text books and reference books

4.4.2.2.7 Outline (Activities). Once a workflow is defined, each related activities are also included in it. In the workflow details page, only the course activities (C) are listed with the activity date information as it is shown in the following picture. Figure 4.22 draws the outline of CSE224 course.

Date	Subject
26.02.2009	Pointers
05.03.2009	Linked Lists
12.03.2009	Programming Language Concepts
19.03.2009	Describing Syntax and Semantics
26.03.2009	Names, Binding, Type Checking
02.04.2009	Data Types
09.04.2009	Review for Midterm
23.04.2009	C# Generics / C# Exceptions
30.04.2009	Expressions and Assignment Statements
07.05.2009	C# Regex; Introduction To C++ / Classes / Objects
14.05.2009	Subprograms
21.05.2009	Abstract Data Types and Encapsulation
28.05.2009	Support for OOP

Figure 4.22 Workflow Activities (Outline): The datetime of lectures.

4.4.2.2.8 Activity Summary . Activity Summary table shows the number of activities grouped by activity type as it is shown in Figure 4.23.

Type	Count
Course	13
Lab	10
Exam	2
Homework	2

Figure 4.23 Activity Summary: The numbers of different types of activities.

4.4.2.2.9 Objective (Skills). After a workflow ends, the participants have just gained experiences on some technical keys (skills). The skills are retrieved from Skill Catalogue and have some rules within e-Worter system. Figure 4.24 shows the objective skills CSE224 exposes for the defined term period.

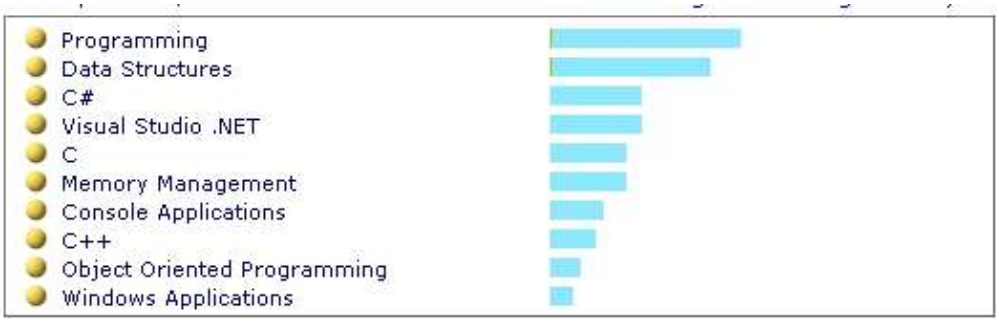

Figure 4.24 Objective skills of CSE224

These are the most densitied technical keys exposed from the activities during the processing of CSE224 workflow. Once the supervisor defined the workflow with the activities, the he / she also attaches the exposed skills to them. The width of bars in the figure depends on the planned execution time of activities. This information is beneficial for guests, candidates and the students who will choose these courses in their academic life.

4.4.2.3 Activities

Pending activities mean non-completed assigned tasks indeed. Even the activities are from different workflows, participant portal combines all activities into a single list. This is the online activity list for the user. Figure 4.25 lists some activity instances for a user some of which are pending and some of which are in approval.

Activity	Workflow	Due Date	Due Hour	Status
H C++ To C# Converter *Programming Languages*	CSE224	30.03.2011	15:00	Pending
E Final Exam *Computer Organization & Architecture*	CSE226	28.01.2011	18:00	Pending
E Final Exam *Programming Languages*	CSE224	27.01.2011	12:30	Pending
L Simple Matrix Implementation *Programming Languages*	CSE224	13.01.2011	12:00	In Approval
L Template Queue Class *Programming Languages*	CSE224	27.12.2010	10:30	In Approval
L Regex and Collections Usage *Programming Languages*	CSE224	12.12.2010	12:00	In Approval
L PL Class Model *Programming Languages*	CSE224	01.12.2010	12:00	In Approval
L Student Class Implementation *Programming Languages*	CSE224	24.11.2010	12:00	In Approval

Figure 4.25 Pending Activity List

Activity list includes the fields of type, name and description, belonging workflow, planned due date and hour and status information. When the user clicks on the name of the activity, the details screen appear.

In details screen, the definition, due date, documents, references, exposed skills, notes and the status of an activity appear. The user can save the activity without changing the status, completes the activity or if he /she has the necessary rights delegate the activity to other users. Figure 4.26 shows a simple detail screen of an exam activity that is in Pending status.

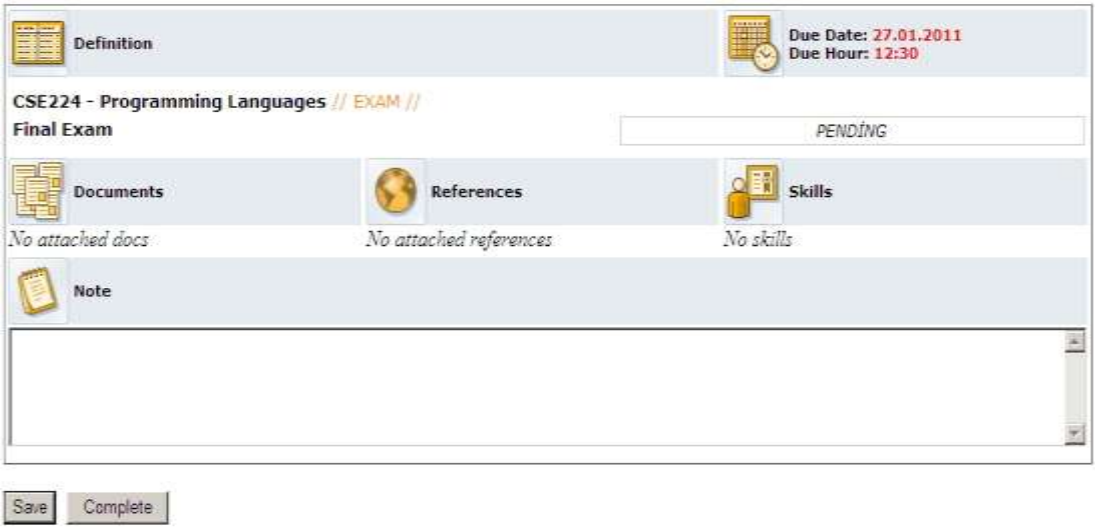

Figure 4.26 Detail screen of an exam activity.

Figure 4.27 shows that some activities may be in approval status.

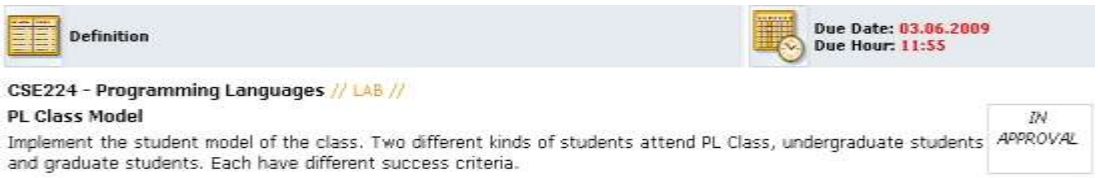

Figure 4.27 The activity of lab study waiting in approval status.

4.4.2.3.1 Owner. Pending activities mean non-completed assigned tasks indeed. Even the activities are from different workflows, participant portal combines all activities into a single list. This is the online activity list for the user.

4.4.2.3.2 Status. If the status is Completed, Canceled or Missing, the activity does not appear in the “Pending Activities” list. Instead, they can be watched by the Activity History search. The activity which is hold In approval, Waiting, Delegated or Pending status appears in the “Pending Activities” section.

4.4.2.3.3 Dates. Each activity has a deadline (date / hour combination). It is expected from the activity owners to finish / complete the activities till the defined deadline. If the deadline expires, list processor displays the activity with a different color.

4.4.2.3.4 Definition. Workflow code, name, type, activity name and activity description information are displayed in that part.Figure 4.28 shows this part.

Figure 4.28 Activity definition

The due date and due hour also appear at the right top side of the activity detail screen.

4.4.2.3.5 Documents. There exists two type of activity documents: The documents attached by supervisor during the design phase and the documents attached by activity owner during the process. The following figures show the documents part in an activity detail screen. Attaching new documents to activities is based on the types of activities. Only the homework, lab and project activities allow users to attach new documents. Figure 4.29 and 4.30 show the documents part of detail screen.

Figure 4.29 Documents part in activity detail screen

Figure 4.30 Attaching documents in activity detail screen

4.4.2.3.6 References. There exists two type of activity references: The references attached by supervisor during the design phase and the references attached by activity owner during the process. Attaching new references to activities is based on the types of activities. Only the homework, lab and project activities allow users to attach new references. Figure 4.31 and 4.32 show the references part of detail screen.

Figure 4.31 References part in activity detail screen

Figure 4.32 Attaching new references in activity detail screen

4.4.2.3.7 Skills. The exposed set of skills is listed in the details screen of the activity. The users can view the rank of interest for each skill.

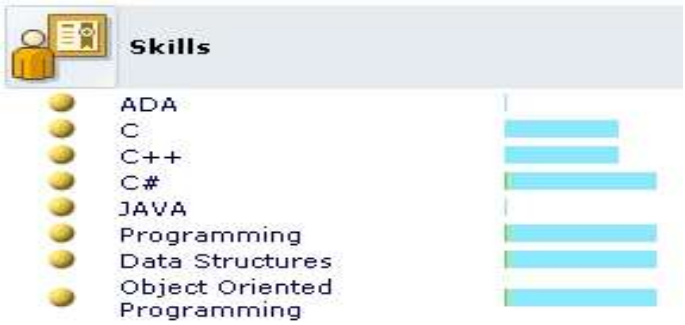

Figure 4.33 Pending Activity List

4.4.2.4 Activity History

4.4.2.4.1 Activity List. Old Activity list includes the activities which are not in pending status. Even the activities are from different workflows, participant portal combines all activities into a single list. Figure 4.34 lists some activity instances for a user some of which may be completed, canceled or missing and some of which are in approval.

Activity	Workflow	Due Date	Due Hour	Status
C Support for OOP *Programming Languages*	CSE224	28.05.2010	10:00	Completed
C Abstract Data Types and Encapsulation *Programming Languages*	CSE224	21.05.2010	12:00	Completed
C Subprograms *Programming Languages*	CSE224	14.05.2010	10:00	Completed
C C# Regex; Introduction To C++ / Classes / Objects *Programming Languages*	CSE224	07.05.2010	10:00	Completed
L Mathematical Operations *Programming Languages*	CSE224	01.05.2010	12:00	Completed
C Expressions and Assignment Statements *Programming Languages*	CSE224	30.04.2010	10:00	Completed
C C# Generics / C# Exceptions *Programming Languages*	CSE224	23.04.2010	10:00	Completed
C Review for Midterm *Programming Languages*	CSE224	09.04.2010	10:00	Completed
C Data Types *Programming Languages*	CSE224	02.04.2010	10:00	Completed
L Generic Queue Class *Programming Languages*	CSE224	27.03.2010	12:00	Completed
C Names, Binding, Type Checking *Programming Languages*	CSE224	26.03.2010	10:00	Missing
H Building A Simple Parser *Programming Languages*	CSE224	21.03.2010	12:00	Completed
L Binary Search Tree Parser *Programming Languages*	CSE224	20.03.2010	12:00	Completed
C Describing Syntax and Semantics *Programming Languages*	CSE224	19.03.2010	10:00	Completed

Figure 4.34 Activity History List

Activity History page is similar to Pending Activity page except the differences listed in the table below:

- Only Completed, Canceled and Missing activities are listed.
- Editing / Delegating or Approving is not possible.
- Adding /removing documents or references is still possible.

4.4.2.4.2 Details. The details screen of Activity Histroy pages is similar to the activity details'. For completed activities, the score is also displayed as it is shown in the figure below.

Figure 4.35 Activity History List

4.5 SRS in the Department

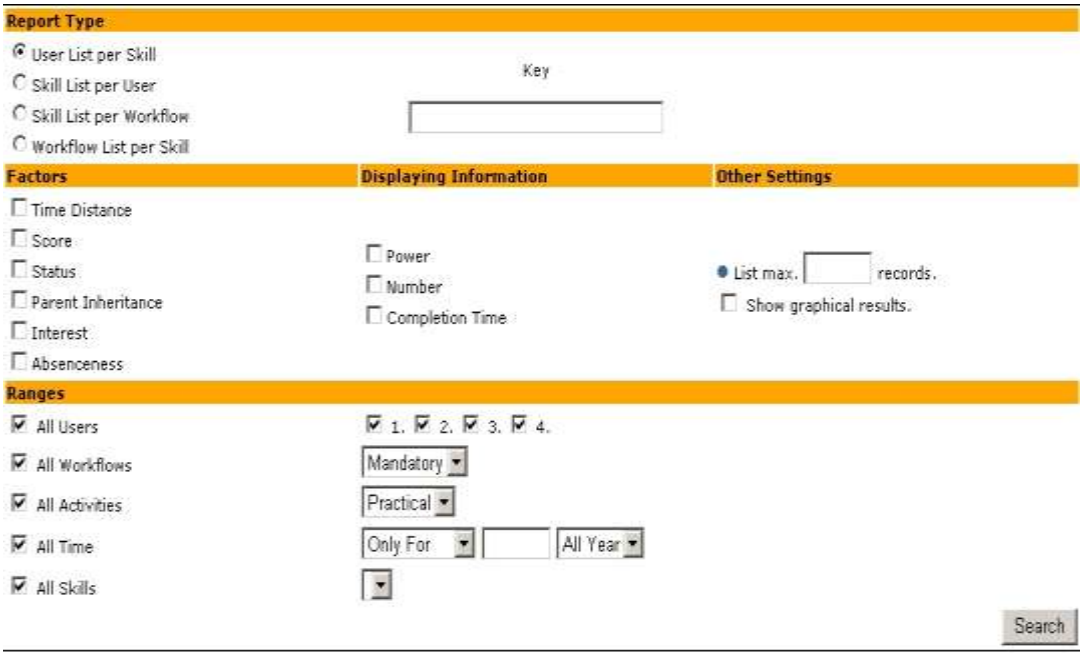

Figure 4.36 Skill Research Service – Input Criteria

As Figure 4.36 shows the proposed SRS includes all input factors regarding report types, SPCP factors and ranges. “Show Graphical results” lists the powers in bars. The results may be viewed in different outputs.

4.6 SPCP in the Department

e-Worter suggests interactive and visual tools with work, time and business management capabilities in order to produce the optimal use for a range of different users in an academic department. As a pilot, 19 courses many of which is about software engineering and programming disciplines were chosen from different academic years and simulated using e-Worter approach. Table 4.8 shows summarized data stored in both skill catalogue and workflow database, gathered during the pilot phase.

Table 4.8 The Pilot research data

Course Research
19 academic courses, 37 text books / references (Early-bound), 240 lectures, 74 lab studies, 26 Midterms, 17 Final Exams, 12 Term Projects, 52 Assignments, 191 Documents (Late-bound)
(194 unique skills) are determined as exposed skills of all the activities of which belonging courses are those 19 courses. Skills are evaluated under ETA Competency Model

Table 4.9 shows the courses with number of activities and exposed skills for last 3 years. Table 4.10 shows the skill power factors and the result of 5 students regarding the skill of XML. Those tables show that tracking all activities with their exposed skills provide drawing of skill maps for each students

Table 4.9 The courses with number of activities and exposed skills for last 3 years

Workflows	**2006 – 2007**				**2007 – 2008**				**2008 - 2009**			
	s(T)	**s(P)**	**s(S)**	**$\Delta t_{(P)}$**	**s(T)**	**s(P)**	**s(S)**	**$\Delta t_{(P)}$**	**s(T)**	**s(P)**	**s(S)**	**$\Delta t_{(P)}$**
CME1001	12	12	12	106	11	12	12	99	11	12	14	99
CME1002	13	12	15	99	13	10	10	86	12	11	15	89
CME2001	12	6	18	60	10	8	17	64	11	8	17	73
CME2004	11	5	24	70	10	5	17	66	11	5	18	66
CME3001	8	12	25	120	11	10	18	83	10	9	19	76
CME3002	7	6	22	90	10	6	22	69	9	6	23	120
CME4415	5	5	21	90	6	6	25	60	7	6	29	110
CME4444	11	4	19	80	10	5	20	60	10	10	21	86

*** s(T) …** Number of theoretical activities (Courses, Seminars): A term includes 14 weeks, because of holidays, some activities seem to be absent.

*** s(P) …** Number of practical activities (Labs, Homeworks, Projects)

*** s(S) …** Number of skills

*** $\Delta t_{(P)}$ …** Total completion time (hours) for practical activities

CME1001: Algorithms and Programming I, CSE102: Algorithms and Programming II

CME2001: Data Structures And Algorithms, CME2004: Concepts of Programming Languages

CME3001: Database Management Systems, CME3002: Systems Programming

CME4415: Distributed Databases, CME4444: Visual Programming Languages

Table 4.10 5 students in the skill of XML with all results from SPCP

Students	**SP results for the skill: XML**							
	s(T)	**s(P)**	**$\Delta d_{(P)}$**	**I**	**$\Delta t_{(T)}$**	**$\Delta t_{(P)}$**	**S**	Skill Power
S1	6	4	2	5	13	60	255	255
S2	7	4	2	3	15	60	174	174
S3	1	0	-	-	3	-	-	-
S4	3	1	8	2	7	10	8	8
S5	5	4	3	4	11	60	180	180

As Table 4.10 shows, 5 different students from 3rd year classes have different level of experiences, the distinction is clear. The factor of number of activities is not included into the calculation. Only the practicial activities are evaluated and most of them have an attached score.

4.7 Discussions

The success factors, advantages and challenges are discussed during the periodic meetings prepared by the Chair of Computer Engineering Department. The attendees of those meetings are the chair and the vice chair of the department, three other faculty members (two of from the same department, one of from the Textile Engineering deparment), three research assistants and the secretary of the department. The following three tables include the opinions exposed during those meetings for SCPP, SAAP and SPCP processes.

Table 4.11 The issues exposed from the meetings about SCPP

Process	**Issues**
SCPP	The Competency Model of ETA seems completely applicable for the academic processes of the department. It will be easier to adapt the model to the department according to the needs of management.
	Only hard skills (Professional skills such as programming languages, operating systems, development tools, etc. and methodological skills such as presentation, documentation, design, etc.) should be handled. But some social skills such as Teamwork can also be tracked because some projects or homeworks are accomplished by teams, not always individually.
	The academic staffs attend to meetings at the beginning of each semester to discuss about the plannings of the closer academic term and also the content of courses. The maintenance of catalogue can be done via those discussions.
	Self population of skills can be done via both students and academicians while the SAAP continues.

Table 4.12 The issues exposed from the meetings about SAAP

Process	**Issues**
SAAP	In the periodic meetings just mentioned, the academicians also determine what kind of activities would be performed during the semester and which tools should be used to complete them. The assignment part of SAAP can be done in that time.
	Instead of defining different workflows each time, a copy-change option and/or document integration process (transferring the data from a Microsoft Office Excel form to the target databases) seem more efficient and applicable.
	The students may be allowed to define their external studies by the system. However, the reliability of data is important, therefore the subjective opinions should be approved when the saving operation is attempting. The experiences gained during summer training or part-time employment are such examples here.
	The department still uses an application customized from a template produced by Moodle (n.d.), which is *an Open Source Course Management System (CMS), also known as a Learning Management System (LMS) or a Virtual Learning Environment (VLE).* That system provides the participating of ongoing students; it displays the courses, activities; it has forum and discussions parts. Because it is a platform for the academic processes to be processed, the integration of skill mechanism with Moodle is suggested instead of developing and maintaining a new huge application.

Table 4.13 The issues exposed from the meetings about SPCP

SPCP	Defining optionality for each SPCP factor seems important for the flexibility and effectiveness of results because of the different point of views using SRS. For example, absenceness of a student may be extremely important for an academician, but not for another one. Similarly, some people highlight the scores, but for some people their interests are more important rather than experience. This is noticed by almost all members of meeting.
	SPCP is so important to produce any putput that MÜDEK required in the periodic meetings.

As a result, some beneficiaries using such a system are extracted as they are following:

- Flexible and usable skill modeling with a standardized competency model.
- Execution and tracking of academic processes in terms of workflows.
- Workflow based population and assessment of skills with minimal effort.
- Reduced maintenance of surveys about the experiences and interests of students.
- Comparing current academic processes with the historical ones.
- The performance evaluation of all system participants.
- Online access to technical background map of each student.
- Better planning of academic programs and realization of future targets.
- Better document access and management.

CHAPTER FIVE
E-WORTER WITHIN AN ERP (ENTERPRISE RESOURCE PLANNING) APPLICATION

5.1 SAP as an ERP Application

The previous studies introduced an approach of e-Worter combining both Workflow and Skill Management disciplines. Its own workflow model which is integrated with a skill model was shown and the methods about the definition, assignment and calculation of skills were also formulized and described. The focus area for previous study is an academic department. Because it is a generic approach optimizing the human resources (HR) processes, the Enterprise Resource Planning (ERP) applications having HR modules can also use it to improve skill management. Therefore, e-Worter approach is applied to SAP, an ERP application used over the world, to show how skill management is handled by such ERP applications, what the advantages, opportunities and open issues they are extracting and how they are matching the requirements what e-Worter demands.

As an ERP application, SAP (n.d.) provides several applicable Human Resources applications to improve the quality and speed of related processes. It also has a lot of management and application screens for business experts and reports for top managers. Most of them are categorized and used under HR modules.

This chapter also summarizes the opinions of personnel still working in the Human Resources, Quality Control and Software Engineering departments of an IT company.

5.1.1 SCPP via SAP HR Module Applications

Before the population process, the first step is the determination of competency model. Because industry-wide technical competencies are still focused, the 4th tier of competency model suggested by ETA can completely be used again. All the categories have been applied via SAP HR module Qualifications Catalog (SAP, n.d.b) screens as it follows. Notice that SAP installation is in the language of Turkish.

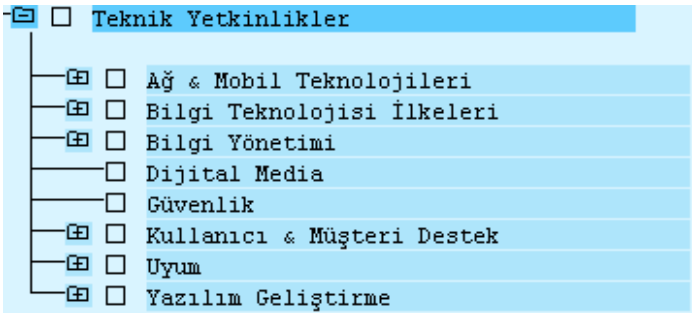

Figure 5.1 Skill Catalogue view in SAP HR OOQA transaction
8 categories (in Turkish) of 4th tier of ETA Competency Model

Based on the structure of skill trees, all top skill groups can have sub groups and at the leaf level, the unique skill names arise. For example, the first top group, Ağ & Mobil Teknolojileri (in English: Web & Mobiling Technologies) have 9 sub groups and 7th sub group, Protokoller (in English: Protocols) have 3 leaf skills as it is represented in Figure 5.2:

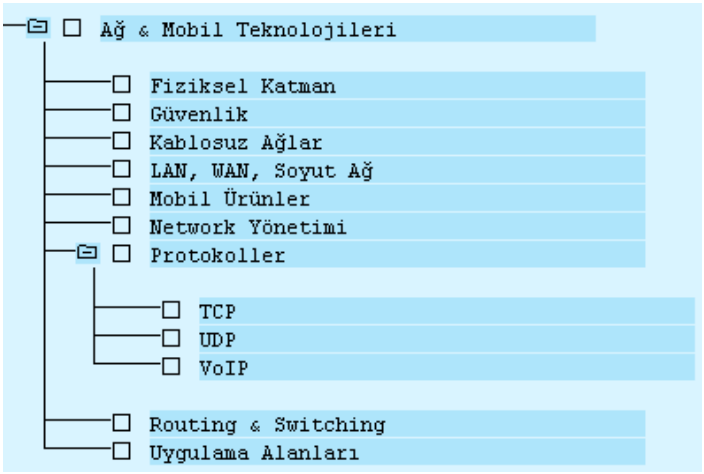

Figure 5.2 Skill Catalogue view in SAP HR OOQA transaction
First category (in Turkish) of 4th tier of ETA Competency Model
with child categories and leaf skills

Figure 5.3 shows another branch, Yazılım Geliştirme (in English: Software Development), the last category of 4th tier of ETA. It is important to remember that determination of which leaf skills should be included in the whole catalogue is an important process to which many members should join to decide as it is detailed in Chapter 4: SCPP.

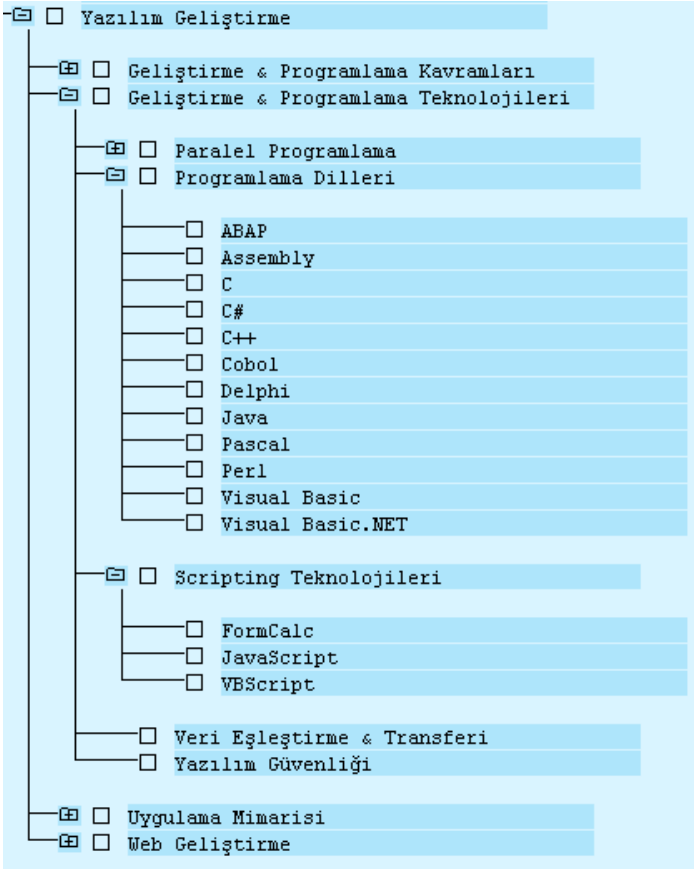

Figure 5.3 Skill Catalogue view in SAP HR OOQA transaction Last category (in Turkish) of 4th tier of ETA Competency Model with child categories and leaf skills

5.1.2 SAAP via SAP HR Module Applications

SAP HR module provides some application screens to attach and rank skills for each personnel. This is the default behavior of the system.

In SAP, skill management is performed by the Human Resources experts via PA30 – Personnel Maintenance screens. As it can be seen from Figure 5.4, all human resource related information for a personnel can be defined via the main maintenance screen. Commonly manipulated parts for each personnel are master data, education and training, communication, family, addresses, organizational roles, positions and salaries. Each operation has its own information type being symboled with a transaction number. The information type number for personnel skill management is

24 (Qualifications Info Type). After the user selects it, the main page of Skills information type appears. The figure below shows the first tab, Skills, of that information type.

In the figure below, the main maintenance page of a personnel with the 31001341 personnel number is shown.

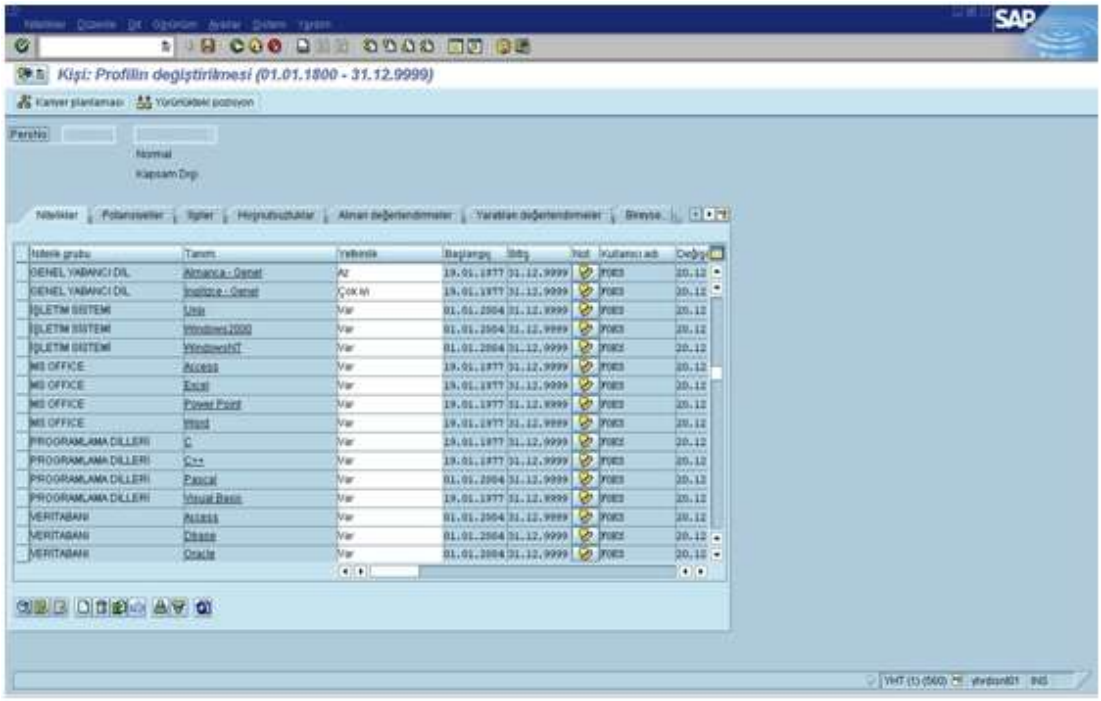

Figure 5.4 SAP Profile Maintenance – Skills tab

The figure above shows the list of defined skills with their proficiency levels for the personnel whose number is 31001341. Each skill row of a personnel includes

- Skill group
- Skill name
- Proficiency (skill rate)
- Skill Validity Start Date
- Skill Validity End Date

The scale of proficiency for a skill depends on its group. In current system, the 3-scale is used for “General Foreign Language”: AZ (Little), İYİ (Good), ÇOK İYİ

(very good). On the other hand for ERP skill group the used scale has 2 items: VAR (Yes) or YOK (No).

All the skills with their proficiency levels for each personnel are manually defined row by row by the experts of Human Resources department.

This maintenance screen includes some other tabs related with skill management.

In Interests (Satisfactions) tab, the skills being interested in, their groups, validity start and end date are listed. On the other hand, the Dissatisfactions tab includes the skills that the personnel is not interested in, in fact, dissatisfied. The data listed is the same as in satisfactions. In SAP, the evaluation of both satisfactions and dissatisfactions is not based on any different scales. That means a person is interested in a skill or not (YES | NO). And this information depends on the time. For example, an IT employee could be interested in C++ programming for 2005-2006 period but now he/she may not be interested in it any more.

In Evaluations tab, the results of evaluations (exams, interviews, satisfaction forms, etc) are listed. Each evaluation row of a personnel includes

- Evaluation name
- Exact result
- Result definition
- Creation Date

5.1.3 SAAP via CRM Service Order Modules

The Service order modules of SAP (n.d.c) CRM works as the participant portals of workflow systems. A user support center, as a web application, provides the tracking and updating the processes of any error detection and fixing processes, new report and dialog program developments, projects, research studies and routine (other) works. Every processes are running on created service orders (SO) in which

the documentation, issues, spent time, used products are defined and several approval mechanisms arise.

Here is a life cycle example of support request from ama customer for an IT organization that uses SAP CRM.

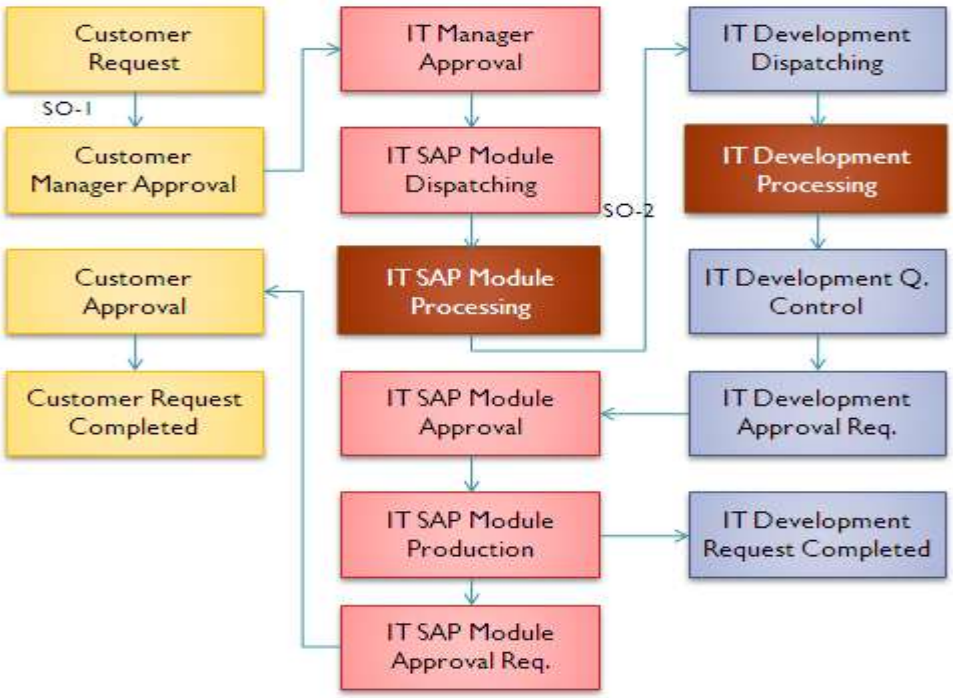

Figure 5.5 SAP CRM Service Order Modules: An example of a customer request

Figure 5.5 shows a serial workflow including 3 sub workflows. First workflow starts with customer request and ends when the customer approved the solution. Second workflow starts when the second step of first workflow completes (the manager approves the request). If responsible SAP module expert requires a development, creates the third workflow for the software development department. That workflow includes dispatching, development, quality control and approval steps. By looking through all 3 workflows, 2 of them seem to expose a set of skills to their owners because they need a technical background, SAP module experience and / or development experience. The other activities are approval, distribution and control activities which do not exactl deal with skills development. A SO is like an activity or a sub workflow of a workflow. It includes all the required properties that a workflow activity includes. Table 5.1 shows the features of orders.

Table 5.1 The main features of service orders in SAP CRM

SO	**Definition**
Flow	SO is created somewhere in a whole workflow that has been initiated by the customer. It can fire new workflows automatically or manually according to the documentation of business processes.
First Date	It is the date in which the order is assigned to its owner.
Owner	The owners are determined by the superusers (dispatchers) who are defined for each department in the organization. There is no "find-best-user" mechanism that is able to find the users automatically, the experience on skills that the order requires are evaluated by the superusers.
Status	The status of a SO can be changed by owner, dispatcher or requester. The order status can be • Pending (Still working) • Canceling requested • Canceled • Waiting an information • Approval requested • Approved • Quality control requested • Quality control approved • Production requested • Production completed
Approval Mechanisms	Many approvals arise anywhere. The dispatcher approves the order and directs it to the programmer, the assigner approves the solution, the quality controller approves the order by evaluating it with the quality control check list, the major approves the due date change requests.
Documents & Notes	A SO can include many pre-attached documents. The owner can also attach notes and documents to the service order.
Logging	Every automatic or manual step can be tracked.

Figure 5.6 shows the main page of a service order.

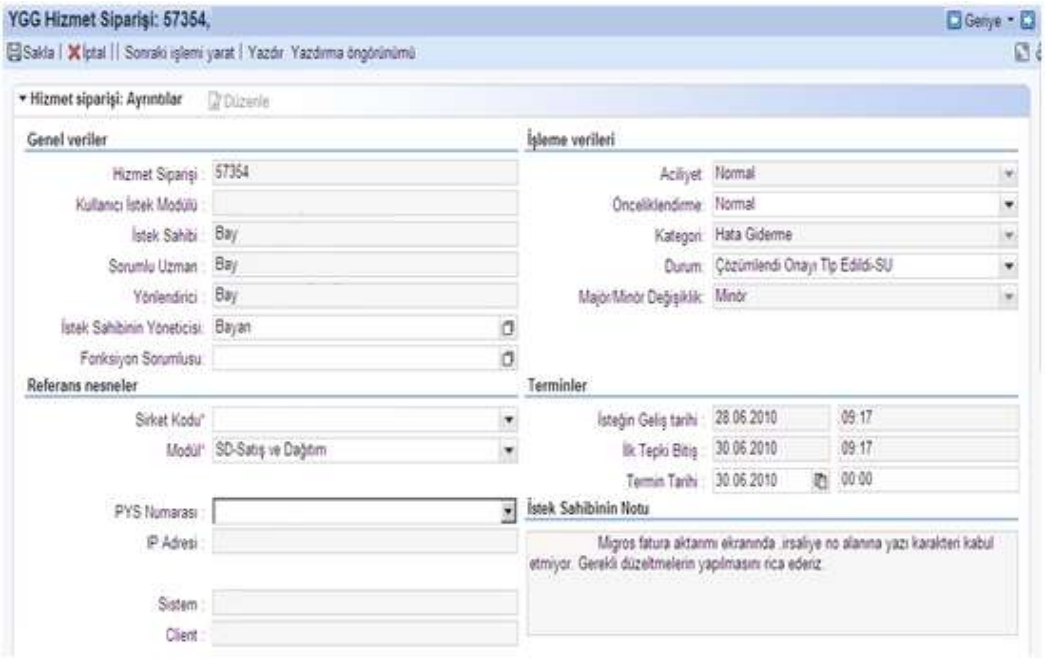

Figure 5.6 SAP Service Order Main Page: The attributes and content of the order are displayed.

The owner can define the time he/she spent on that service order. The figure below shows how the owner defines the time duration via screens.

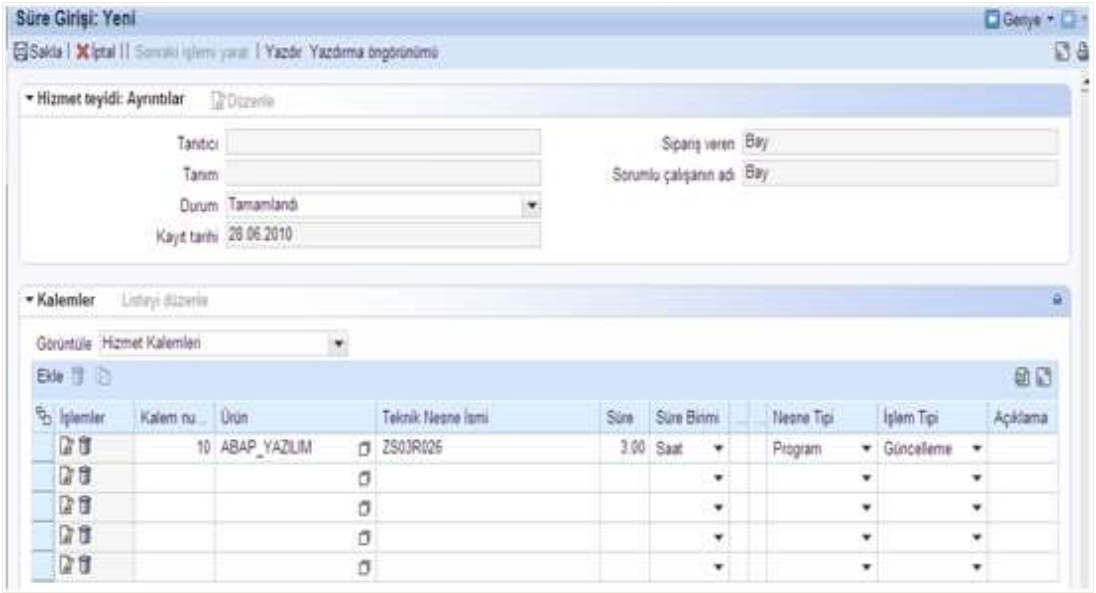

Figure 5.7 SAP Service Duration Entry Page: Object-based duration definition.

Table 5.2 The main issues about duration entry of service orders in SAP CRM

Issues
Each duration should be assigned to an object. In the figure above, there is an object called ZS03R026 of which • Duration is "3 hr(s)". • Type is "Program". • Operation Type is: "Modification" • Product is "ABAP_PROGRAMMING"
Product of duration object of a service order can refer to skills and skill groups. This is the critical point for applying the approach of e-Worter. The communication among CRM Service Order products and the skills stored in the Skill Catalogue of SAP HR system should be built up.
A service order can include more than one duration item of which objects, operation types, types and products may be different. For example, an owner of an order can spend 60 percent of the time for an ABAP program, 25 percent for a .NET program, and 15 percent for SQL Server database maintenance. For that situation, three different objects should be defined in the Duration Entry screen.
The duration entries are only allowed when the status of belonging order is "Pending".
The owner is allowed to define durations for the current day and the day before.

5.1.4 SPCP via SAP HR Module Applications

Skill power calculation requires many factors as listed in previous chapters. But skill maintenance screens of SAP HR modules support restricted numbers of them. Therefore appraisal forms are defined including list of any factors for any skills and having calculation formulas.

An appraisal form is defined via OOAM t-code of SAP HR modules (n.d.). Appraisal forms have the required skills under their groups with their proficiency levels. As an example, for Technical Skills group, all defined skills (Java, C#, …) have those scale types for proficiency (skill power) calculation:

- Number of skill-related works,
- Total working date,
- Last work date,
- Exam Result,
- Interest rank and
- Manager's opinion

On the other hand, the group of Personal Skills has a skill of "Team evaluation and relationships" and its scale types differ from the technical one:

- Manager's opinion
- Partner's opinion

Figure 5.8 shows an example of appraisal form. It includes all skills with their defined factors.

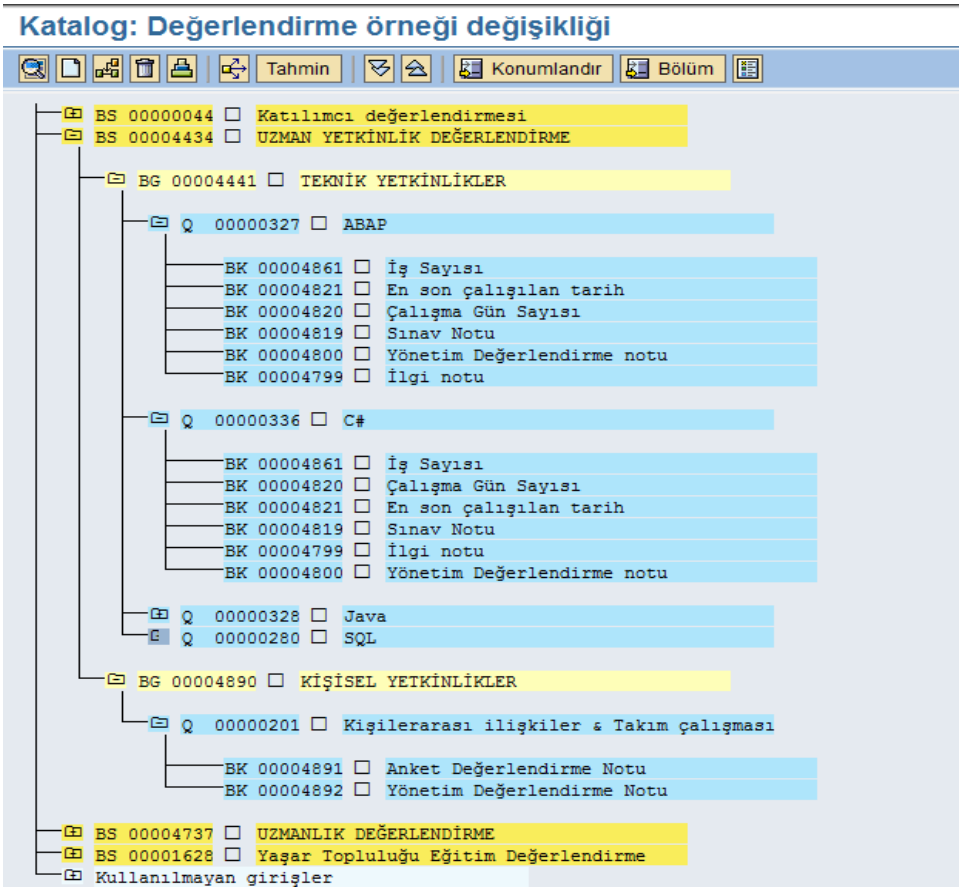

Figure 5.8 An Appraisal Form Example (In Turkish): ABAP and C# have 6 defined Factors, while Teamwork has only 2 factors for efficency calculation process.

The factors can be sorted and weighted as it is shown in Figure 5.9

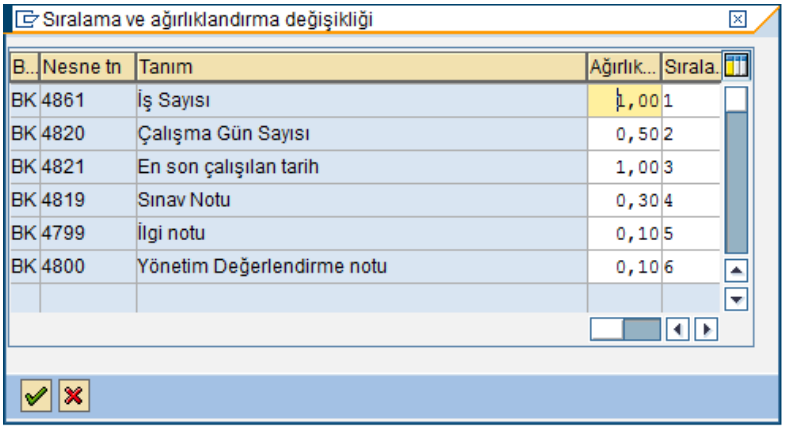

Figure 5.9 Sorting and weighthing of factors are possible in SAP HR. (In Turkish)

Figure 5.10 shows the summarized skill set of an SAP user with their calculated levels.

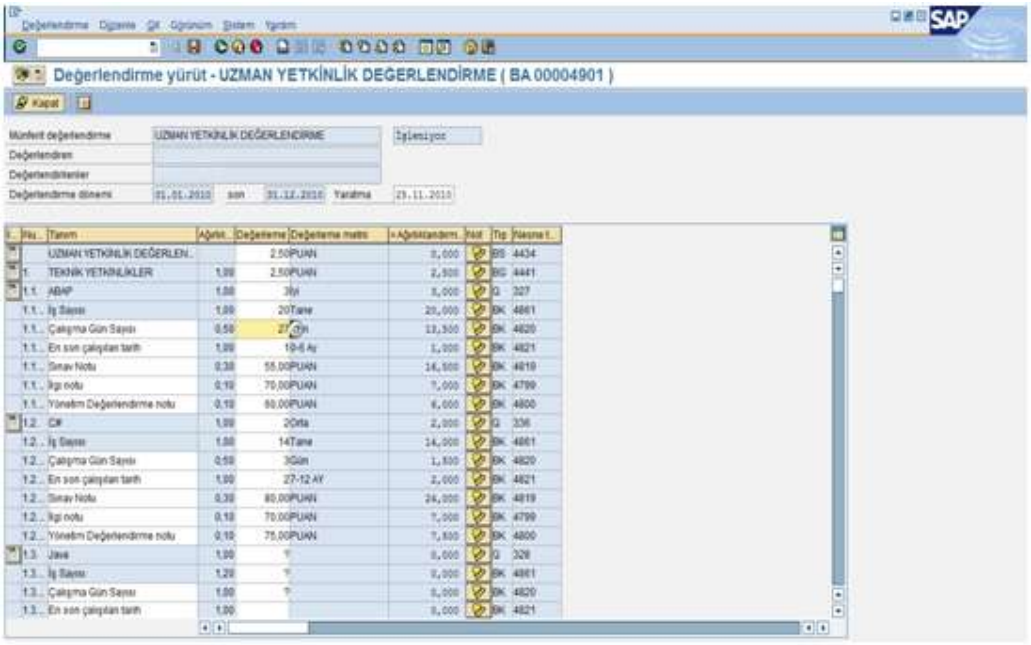

Figure 5.10 Appraisal Results of a User (in Turkish).

5.2 Discussions

The model was presented to a group including general manager of an Information Technologies company, the manager of Quality Control, the manager of Software

Development and System Support department, a software engineer and 4 experts belonging to Human Resources department.

After a presentation and brief discussion, the benefits, challenges and suggestions are determined alltogether and the approach was planned for using for a department in a pilot phase.

The benefits of using e-Worter approach integrated with SAP systems are listed here:

- It can be easily tracked that for which skills the personnel improve themselves.

- The effect of rotations or unexpected position changes is so important. The gaps are immediately determined and decision would be made as soon as possible if such a system is successfully implemented.

- Human resources operations such as employment, career planning are successfully performed if a robust and business process-related skill management framework is used.

- Skill catalogues will be built according to the standards, skills will be up-to-date. The recruitment forms including old-versions of technologies and tools which are used to measure the experience of candidates can be dynamically updated.

- The skill and experience data are hold in the Human Resources databases, where it really should be.

That study also improves those qualifications of the personnel who would be involved in the integration project in addition to the enterprise benefits:

- The concept of Skill Management will be learnt.

- The Skill Management capabilities of SAP ERP HR modules are experienced by the experts of Human Resources department.

- The service ordering capabilities of SAP CRM service order modules are used in detail.

- By the periodic meetings required by the phases of e-Worter, the innovations and development from the technological and business areas are tracked therefore quality of departments in terms of operational excellence and capability of working will improve.

Here are some suggestions to set up more comperehensive and efficient skill management mechanism by including business processes:

- At first, small working teams should be organized. Teams should design the catalogue, (including the classification, branching, naming, prioritizing and elimination operations according to their related working area)

- Which skills of catalogue are demanded for power calculations should be chosen by the managers and Human Resources department according to the requirements and neccessities.

- The scale types, scales, the weights, priorities and necessities of skills should ve determined by the managers and Human Resources department together.

- The defined products of service orders should be matched with the skills defined in the HR Skill catalogue.

- The products of CRM Order service orders that are corresponding to the skills can be self-populated after a modification to the skill catalogue and vice

versa. That means both databases should be reflected by a unique new|update|delete operation.

- The spent time and what is done on all routine jobs and research studies should be tracked by user support center.

- The time duration spent on large or small projects should be defined by the end users via CRM service order screens.

- The gained skills during training and educational processes should be gathered via CRM Service Order screens.

- Some of the calculated and valuable results gathered from service order processes such as total work duration, deviations on the plans and customer satisfaction ranks are used for KPI operations (balanced scorecard systems) because of the current performance rewarding processing. Those data can also evaluated by skill management to determine the ranks of matching personal skills such as Operational Entirety, Work Performance, Customer Satisfaction, etc.

- The results of non-SAP Human Resources and top-management applications such as Team Study questionairre, Quality Control processes and the exams about principles and procedures of the organization should be transferred to SAP HR Skills Management information types.

- A survey should be applied to the members of organization at least twice in a year to see what their interests to the skills they experienced. The data should be integrated with HR and CRM modules.

- The exam results and the opinions of the managers should be integrated with the appraisal system.

- The staff should easily view their skill map via readable user interfaces.

The following figure shows the main components of all systems that e-Worter approach needs for a company using ERP applications.

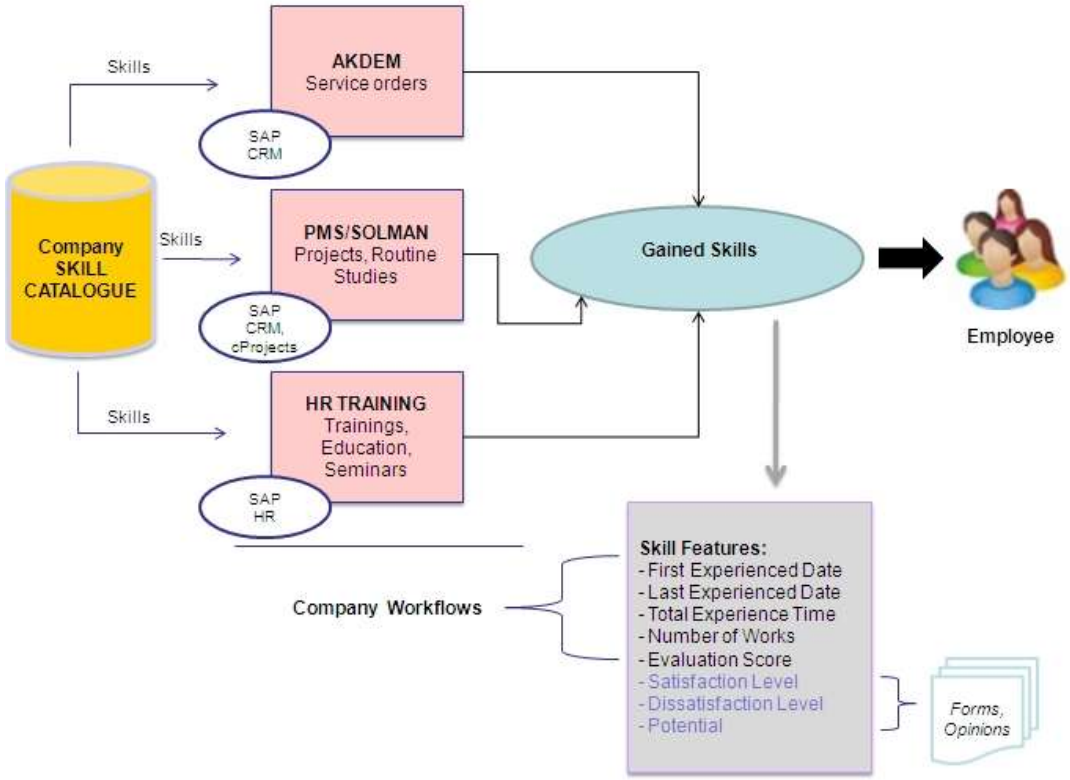

Figure 5.11 General Schema of Skill Management in a company using ERP

CHAPTER SIX
CONCLUSIONS

Both Workflow Management and Skill Management Systems are preferred to improve human resource operations of any organization. The ability to find the right human for the right job is commonly accepted by any enterprise as a crucial success factor. But a complete cognition process should be the first step to see what the resources have been qualified for and what they would like to do in the future.

In this thesis, we contextualize the need of using skill based workflow systems. The integration of skills with workflows improve further resource allocation, team building, human selection, training and development processes. With such integration, the enterprise starts to cognize its members and also itself in terms of owned knowledge and abilities. That continious cognition process exactly improves the quality of decision making and future planning operations. On the other hand, the fundamental problems of existing skill management systems especially appearing in catalogue maintenance and skill assessment phases are overcome by the workflow systems in which those problems are handled using the primal features of workflows. We state that workflow and skill management systems can be both executed as complementary systems to have the ability of drawing detailed knowledge map of organizations.

e-Worter, an electronic work, resource and time manager defines a platform for any type of users to achieve the combination of workflow and skill management disciplines. In e-Worter approach, skills are tracked, populated and maintained by existing resources without any extra effort. Once the skills are introduced, they would be ready to be attached to the workflow activities during design-time manipulations. Then, they can be owned by the owners of those activities during the run-time execution of workflows. Skills are then ready for the power calculation process and skill research services.

The model improves both the reliability and usability of Skill Management discipline in various areas of business. Instead of applying time-consuming surveys, the automated business processes to which skills are attached positively affects the decision making processes regarding Human Resources. The opinions of users or managers are not completely excluded, they are still the key points in the model; however the actual data flowing through knowledge-based workflow processes also gives other important factors such as the completion time, last date and interest rank to find experience level of users on any skills. Computing the data coming from a lot of number of different processes and calculation of skill power are handled by automatic jobs. Using such automation improves the reliability of results.

The model proposed in this thesis has been applied within both an academic department and an IT company to show how knowledge-intensied processes can be integrated with a skill framework and how they result to efficient store, assign and search mechanisms about being developed and targeted skills. In Computer Engineering Department of Dokuz Eylul University, it is shown that using skill based processes improves the quality of academic operations and meets some of the requirements of accreditation committee, MÜDEK, because of its open framework providing development any reports. e-Worter offers a powerful product serving as both process and resource manager which improves the quality of business processes according to the needs. The model can be developed with any custom code in any other workflow-based systems because it is designed as a platform and technology independent approach to enpower the management of skills by minimizing its difficulties and challanges.

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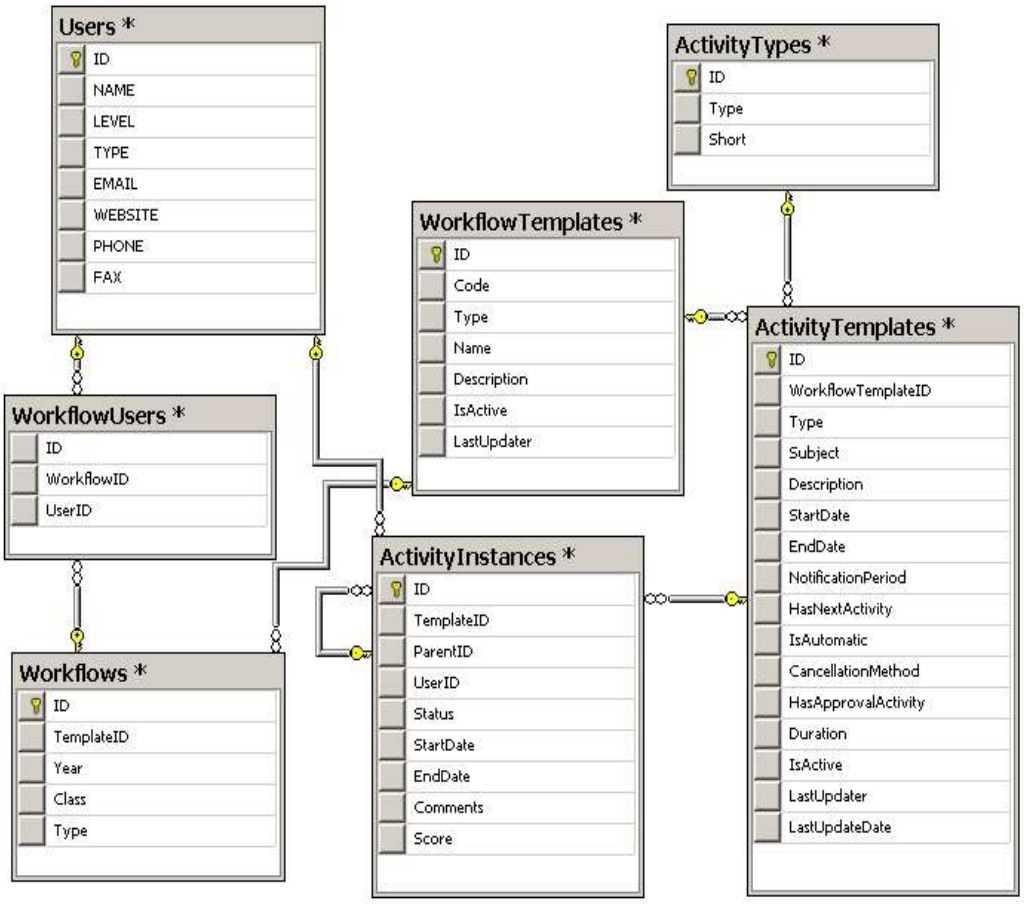
APPENDICES

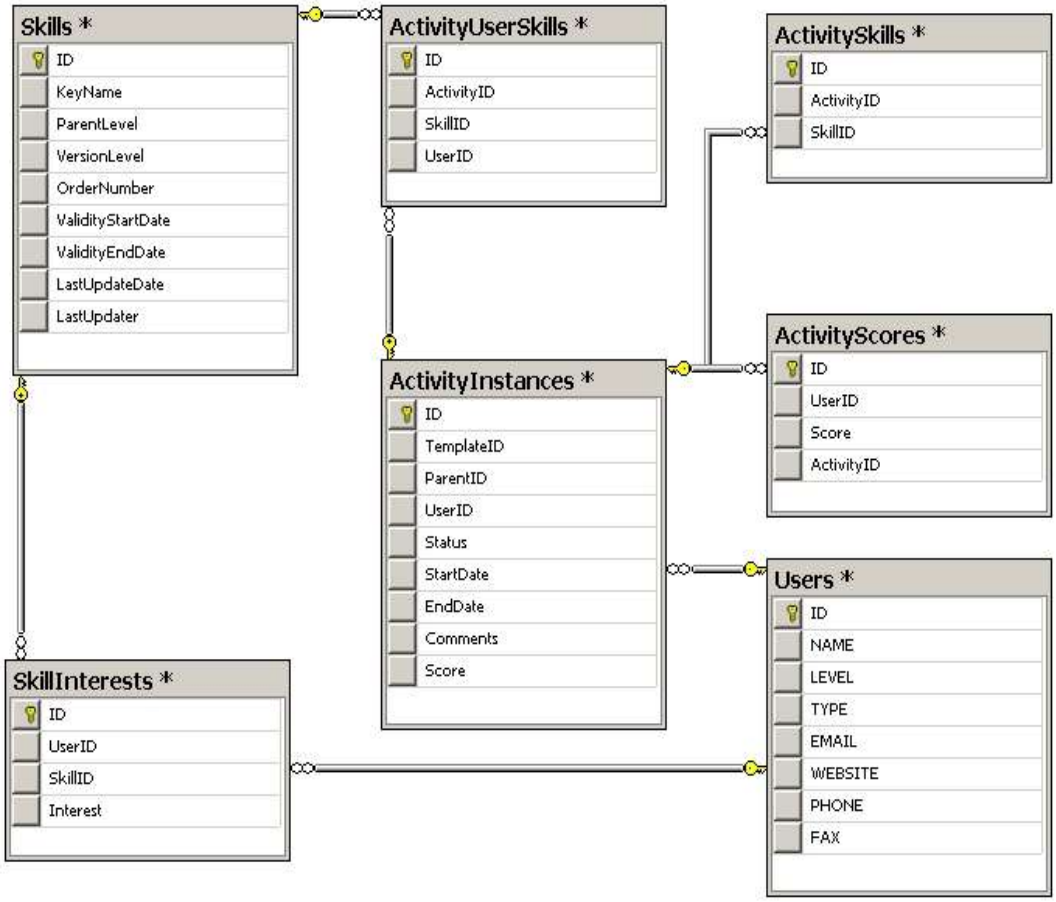
A. e-Worter Workflow – Activity Diagram



Included Tables:

* Users
* WorkflowUsers
* Workflows
* WorkfowTemplates
* ActivityInstances
* ActivityTemplates
* ActivityTypes

B. e-Worter Workflow – Skills Diagram



Included Tables:

* Skills
* SkillInterests
* ActivityUserSkills
* ActivityInstances
* ActivitySkills
* ActivityScores
* Users

C. Workflow Templates – Master Data

Header Information

Description	The header information for the workflow templates
# of columns	7
# of up-to-date rows	52
Matching Terminology	Workflow Templates, Workflow List

Columns (with an example record)

Field Name	**Field Description**	**Field Example**
ID	Unique ID for the template.	18
Code	Unique, business-based specific code for the template.	CSE306
Name	The name of the template.	Database Management Systems
Subject	The most appropriate skill group that the template is belonging to.	Database (Reference to TB_SKILLGROUPS)
Group	The main group information.	Courses (Reference to TB_TEMPLATEGROUP)
Description	The description of the template.	This course acquaints students with the techniques involved in determining database requirements, designing databases, components and architecture of databases, and database management systems.
IsActive	Sets whether the workflow is activated or not. Disactivated workflows cannot be started, viewed and managed.	True

List of Academic Workflows (Courses) – Accessed in 01.06.2008

ID	CODE	NAME
1	CSE100	Introduction to Computers
2	CSE101	Algorithms and Programming
3	CSE102	Algorithms and Programming II
4	CSE120	Discrete Computational Structures
5	CSE122	Introduction To Comp.Sci II
6	CSE220	Data Structures
7	CSE221	Digital Logic Fundamentals
8	CSE222	Theory Of Computation
9	CSE223	Assembly Language Programming
10	CSE224	Programming Languages
11	CSE226	Computer Organization & Architecture
12	CSE300	Probability & Statistics
13	CSE301	Data & File Structures
14	CSE302	Systems Programming
15	CSE303	Operating Systems
16	CSE304	Software Engineering
17	CSE305	Automata and Formal Languages
18	CSE306	Database Management Systems
19	CSE307	Introduction To Digital Electronics
20	CSE401	Information Systems Analysis and Design
21	CSE402	Introduction To Artificial Intelligence
22	CSE403	Computer Networks
23	CSE404	System Simulation & Modeling
24	CSE408	Int.to Cryptography
25	CSE409	Introduction To Machine Learning
26	CSE410	Int.to Software Verification
27	CSE419	Natural Language Processing
28	CSE420	Quality of Service Advancements in IP Networks
29	CSE424	Microprocessors
30	CSE425	Network Services and Applications

List of Academic Workflows (Courses) – Accessed in 01.06.2008 (cont…)

ID	CODE	NAME
31	CSE426	Network Programming
32	CSE430	Data Communication
33	CSE431	Int.to Pattern Recognition
34	CSE433	Software Project Management
35	CSE434	Introduction To Digital Image Processing
36	CSE435	Topics in Databases
37	CSE442	Principles of Embedded Systems
38	CSE444	Visual Programming Applications with Databases
39	CSE450	Distributed Databases
40	CSE470	Project Proposal
41	CSE472	Introduction To Data Mining
42	CSE531	Advanced Software Engineering
43	CSE605	Constraint Programming
44	FBE681	Innovation, Invention and Creativity
45	FBE684	Araştırmaların Yazılı ve Sözlü Sunum Teknikleri
46	FBE688	Doğa Bilimleri Tarihi
47	MATH201	Linear Algebra and Differential Equations
48	MATH101	Calculus I
49	MATH102	Calculus II
50	MTS305	Methods of Artificial Intelligence
51	PHYS101	Physics
52	PHYS102	Physics II

D. Workflow Template Groups – Master Data

Header Information

Description	The group information for the workflow templates.
# of columns	5
# of up-to-date rows	9
Matching Terminology	Workflow Groups

Columns (with an example record)

Field Name	Field Description	Field Example
ID	Unique ID for the template.	18
Name	The name of the template group.	Courses
Description	The description of the template group.	This template group includes the academic courses.
ParentId	The parent group id for the subject.	Default: 0 (No parent)
IsActive	Sets whether the workflow group is activated or not. Deactivated groups' workflows cannot be started, and managed.	True

List of Workflow Template Groups – Accessed in 01.06.2008

ID	Template Group Name
1	Courses
2	Events
3	Meetings
4	Projects
5	Academic
6	Personal
7	Other

E. Survey: Technical experience and İnterests of 3rd years students

Definition

Range	3rd Year Students
Target	Determining the technical experience and interests of the students.
Date	12.04.2008
# of participants	24
Method	Requesting a free text from the participants

Name-Surname: _____
E-Mail: _____

Please fill the form.

Please list the technical subjects / tools / products / concepts from the programming area that you have experienced / interested in? And rank your interest for each subject.
(The example means that I used C# in 3 projects, took 2 seminars about it and my interest to C# programming language can be ranked as 4)

Subject	**Interested In**					**Experienced before**	
	1	2	3	4	5	Y/N	Reference
Example: C#				*X*		*Y*	*3 projects, 2 seminars*
Example: Visual Studio .NET			*X*			Y	*2 web application design*

F. Survey: Interests of 3rd year students – Pair comparison

Definition

Range	3rd Year Students
Target	Determining the interests of the students.
Date	12.04.2008
# of participants	24
Method	Requesting a selection of two related technical skills

Choose one of two for each line:

( ) .NET	( ) Java
( ) Structured Programming	( ) Object Oriented Programming
( ) Web Design	( ) Application Development
( ) Analyse	( ) Development
( ) Database Management	( ) File System Management
( ) C#	( ) C++
( ) Windows	( ) Linux
( ) E-Commerce	( ) Work Management
( ) Academic	( ) Industrial
( ) Internet Explorer	( ) Firefox
( ) Software	( ) Hardware
( ) Desktop Programming	( ) Network Programming
( ) Computer Graphics	( ) Artifical Intelligence
( ) Financial Processes	( ) Import / Export processes
( ) ASP	( ) PHP
( ) Team Study	( ) Free Lance Study
( ) SQL Server	( ) MySql
( ) Google	( ) Microsoft
( ) Private sector	( ) Public sector
( ) Top Down Hierarchy in Organizations	( ) Horizontal Hierarchy in Organizations
( ) Reading Books	( ) Reading from Internet
( ) Assembly	( ) C

G. Survey: Exposed skills of a Data Mining Applications homework

Definition

Range	4th Year Students
Target	Determining what skills are exposed by a homework activity to the participants of the course.
Date	18.03.2008 – 27.03.2008
# of participants	18
Method	After a small project about Data Mining Applications, a survey form sent to the participants of the course.
Output	Graphs, Comparison Tables

Please fill the form about the activity you completed.

Study Type

( ) Homework ( ) Research ( ) Project

( ) Seminar ( ) Education ( ) Other

Duration: (_____) Day(s)

What subjects have you experienced during the study?

Subject	**Interested In**					**Experienced before**	
----------	1	2	3	4	5	Y/N	Reference

What tools / books & references have you used during this study?

Tools	**Books / References**

- *Any tools or references should be added even they are from internet.*

Which roles have you played during the study?

( ) Researcher	( ) Designer
( ) Analyser	( ) Developer
( ) Documenter	( ) Tester
( ) Deployer	( ) Trainer
( ) Trainee	( ) Team Player
( ) Other _____	

H. Research: Curriculum Vitaes of recently graduated students

Definition

Range	Graduated Students
Target	Determining the power of Curriculum Vitaes which are based on people's subjective opinions by comparison of project experience and interests on technical skills of different graduates.
Date	16.06.2008
# of participants	27
Method	The evaluation of Curriculum Vitaes (CVs) catalogue of students that was published in 2008 by The Department of Computer Science.
Output	Graphs, Comparison Tables

I. ETA Tier 4 Industry-Wide Technical Competencies

1. Principles of Information Technology: Knowledge of the Information Technology industry, its systems, platforms, tools, and technologies.
Business Process Management Business activity management, Change management, Content management, Document management, Process improvement (Lean/Six-Sigma), Process modeling, System process integration **Platform Technologies** Architecture and organization, Computing infrastructures, Enterprise deployment software, Global standards, Hardware, Open source, Operating systems **Systems Administration and Maintenance** Administrative activities, Administrative domains, Applications **Systems Integration and Architecture** Acquisition and sourcing, Architecture, Integration and deployment, Organizational context, Requirements, Testing and quality assurance **Web Management** Analytics, Optimization, Utilization

2. <u>Information Management</u>: The use of technology to control and safeguard the collection, organization, structure, processing and delivery of information.
Business Intelligence Competitive intelligence, Data analytics, Data mining, Predictive data modeling **Data Administration** Concepts and fundamentals of data management, Content management, Data integration, Data modeling **Database Management** Data architecture, recovery, search, storage, query languages, the database environment, Metadata, Semantic Web, Special-purpose databases

3. <u>Networks & Mobility</u>: The processes, hardware, and software employed to facilitate communication between computer systems and devices.
Application areas, Foundations of networking, LANS, WANS, virtual networks, Mobile media, Network management, Physical layer, Protocols, Routing and switching Security, Wireless

4. <u>Software Development</u>: The process of writing, testing, debugging/troubleshooting, and maintaining the source code of computer programs.

Application Architecture

Configuration and adaptation, Deployment, Global standards, Patterns, Risk management, Scalability, Standards, Strategies

Development/Programming Fundamentals

Data structures (list, vector, array, stack, queue, tree, graph), Algorithms (sorting, searching), Basic programming constructs (assignment, arithmetic expressions, loops, conditions, input/output, error handling), Event-driven programming, Object oriented programming, Programming concurrent processes, User interface/user experience (UIUX)

Development/Programming Technologies

Data mapping and exchange, Familiarity with multiple programming languages, Integrative coding, Inter-systems communications, Parallel systems development/programming, Scripting techniques, Software security practices

Social Networking Services

Business/educational/personal networks, Internal/external services, Privacy/security , Social capital

Web Development

Quality assurance, Technical content, Web site design, Web site, development/programming and maintenance**,** Web site/Internet security

5. <u>User & Customer Support</u>: The range of services providing assistance and technical support to help users implement and solve problems related to computer technology.

Engagement

Communicating with the user, Community architecture, Content development and categorization, Engagement success metrics, Gadgets, Inventory and audit of content assets

Helpdesk Functions

Administrative activities, Application support, Asset management, Computing infrastructures and networks, Configuration management, Incident and problem management, Operating systems, Release management, Systems administration, monitoring, and maintenance, Strategies for engaging the community, User participation guidelines/ground rules

6. <u>Digital Media</u>: Conveyance of ideas and information in forms such as presentation of audio, text, pictures, diagrams, photos, et cetera.

Digital media application test and implementation, Digital media design, Digital media production and acquisition, Gaming, Graphics, Multi-media technology, Multi-user applications, Streaming technologies, Utilization and optimization, Videos and dialogues, Visual and functional design

7. <u>Compliance</u>: The standards, processes, and procedures in place to ensure that products comply with regulatory requirements.

Compliance Standards

Global standards, Internet standards

Important Topics

Intellectual property, Professional ethics, Safeguarding confidential data

Public Policy

Client program management operations (PMO) , Code of Federal Regulations (CFR), ISO requirements, State and local laws

8. <u>Security & Data Integrity</u>: The standards, issues, and applications used to protect information and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction.

Data Accessibility

Fundamentals of data security, Operational issues, Policy development, User and customer support

Data Integrity

Business continuity, Disaster recovery, Encryption, ID management, Information states, Redundancy

Threats

Attacks, Forensics, Security domains, Security mechanisms, Security services, Security tools, Threat analysis model, Vulnerabilities