



TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

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CERTIFIED LEARNING EXPERIENCES: FROM
HETEROGENEOUS LEARNING SPACES TO PORTABLE
EDUCATION PORTFOLIOS

Master of Science Thesis

Topic approved by Faculty Council of Computing and Electrical
Engineering on October 08, 2014

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ABSTRACT

VEERENDRA KUMAR DEVERASHETTY: Certified Learning Experiences:
From Heterogeneous Learning Spaces to Portable Education Portfolios
Tampere University of Technology
Master of Science Thesis, 56 pages, 4 Appendix pages
February 2015
Master's Degree Programme in Information Technology
Major: Pervasive computing
Examiner: Postdoctoral Researcher Dr. Terhi Kilamo (TUT), Adjunct Prof. Dr.
Imed Hammouda (TUT)

The digital era has accomplished new kinds of learning spaces, where learners engage in different kinds of learning activities. Thus different learners are gaining various learning experiences from heterogeneous learning spaces. A key challenge is how to systematically collect those heterogeneous learning activities into well-organized education portfolios. In existing Education Portfolio Systems (EPS) including LinkedIn, Mahara, and Open-Badges does not support importing learning activities from learning spaces. In these systems, it does not allow users to authenticate through OpenID, and also users cannot create multiple portfolio views. Thus to address these problems we propose our system named Portable Education Portfolios (PEPs) which imports certified users experiences from different learning spaces.

This thesis utilizes a Design Science Research Methodology (DSRM) for PEPs development, which intends to solve the key challenge. The proposed approach i.e. DSRM is modified to fit this research context. As a result, alike existing EPS, an innovative IT artifact called PEPs tool is created. PEPs collect certified experiences of users from different learning spaces and also create their portfolio. On the other hand, as an additional feature to existing EPS, the PEPs tool supports Life-Long Learning Process and Continuing Professional Development.

To address the research objectives PEPs system is experimented with three different learning spaces including TUT-Mantis, Moodle and OpenSE. These learning spaces follow informal, formal and non-formal learning patterns respectively. PEPs successfully collected various user experiences and created a single portable portfolio for the users. Hence, we conclude that the PEPs system is a complete tool to solve all the key issues raised in this research.

PREFACE

This thesis work was done in 2013-2014 in the Department of Pervasive Computing as a part of the OpenSE project - Open Educational Framework for Computer Science Software Engineering

I am pleased to express my gratitude and appreciation to my thesis supervisors, Postdoctoral Researcher Dr. Terhi Kilamo and Adjunct Prof. Dr. Imed Hammouda for their continuous support and guiding during the thesis work.

I would also like to express my gratitude to the Department of Pervasive Computing and my colleagues at the Department for providing the pleasant and joyful atmosphere which enabled the work on this thesis. I would also like to thank my friends who encouraged me to complete the thesis work.

Finally, I want to thank my family and friends for their support and motivation during my seemingly endless Master's degree.

Tampere, February 2015

Veerendra Kumar Deverashetty

CONTENTS

Abstract	ii
Preface	iii
Contents	iv
Lists of Figures and Tables	vi
List of Abbreviations	vii
1. Introduction.....	1
1.1 Motivation	2
1.2 Objective	3
1.3 Outline of thesis	4
2. Background Study.....	6
2.1 Learning spaces	6
2.2 Educational Portfolios.....	9
2.2.1 Need of the educational portfolio	10
2.2.2 Types of educational portfolios	11
2.2.3 Challenges in implementing education portfolios	12
3. Research Methodology and Approach	14
3.1 DSRM Methodology and Phases.....	14
3.2 Research Approach	16
4. Towards Portable Education Portfolios.....	20
4.1 Benefits	22
4.2 Existing Solutions.....	22
5. PEPs Environment	25
5.1 Architecture.....	25
5.2 Implementation.....	31
5.3 PEPs Features	32
5.3.1 Users registration and SSO service	33
5.3.2 PEPs GUI	34
5.3.3 Importing learning activities	35
5.3.4 Portfolio views	36
5.3.5 User settings interface.....	39
5.4 PEPs Viewer.....	40

6.	Integrating Informal, Formal, and Non-Formal Learning Activities	42
6.1	Integrating Informal Learning Activities	42
6.1.1	Setting up environment in TUT-Mantis learning space environment	43
6.1.2	Experiences and Results	44
6.2	Integrating Formal Learning Activities	45
6.2.1	Setting up environment in Moodle learning space environment.....	46
6.2.2	Experiences and Results	46
6.3	Integrating Non-formal Learning Activities	47
6.3.1	Setting up environment in OpenSE learning space environment.....	48
6.3.2	Experiences and Results	48
7.	Discussion.....	50
8.	Conclusions.....	52
	References	54
	Appendix A	57

LISTS OF FIGURES AND TABLES

<i>Figure 2-1 Framework of Life-Long Learning Process</i>	9
<i>Figure 3-1 Design Science Research Methodology (DSRM) for PEPs system</i>	17
<i>Figure 4-1 An overview of PEPs structure</i>	21
<i>Figure 5-1 PEPs Architecture</i>	26
<i>Figure 5-2 Code Snippet of Generic data model</i>	27
<i>Figure 5-3 Bootstrap elements</i>	31
<i>Figure 5-4 Registration page for PEP system</i>	33
<i>Figure 5-5 PEP graphical user interface</i>	34
<i>Figure 5-6 Import learning activities interface</i>	35
<i>Figure 5-7 Import learning activities modal interface</i>	35
<i>Figure 5-8 Create a portfolio view interface</i>	36
<i>Figure 5-9 Select learning activities interface for portfolio view</i>	37
<i>Figure 5-10 User credentials for portfolio view interface</i>	38
<i>Figure 5-11 Interface for selecting a portfolio view</i>	38
<i>Figure 5-12 Portfolio view credentials interface</i>	39
<i>Figure 5-13 User settings interface</i>	40
<i>Figure 5-14 PEPs viewer portfolio interface</i>	41
<i>Figure 6-1 Associate OpenID- Mantis interface</i>	43
<i>Figure 6-2 Interface to authenticate with OpenID- Mantis interface</i>	44
<i>Figure 6-3 Sample data collected from TUT-Mantis learning space</i>	45
<i>Figure 6-4 Sample data collected from Moodle learning space</i>	47
<i>Figure 6-5 Sample data collected from OpenSE learning space</i>	49
<i>Table 4-1 Issues related to existing portfolio systems</i>	24
<i>Table 5-1 pep_user_table</i>	28
<i>Table 5-2 pep_learning_details</i>	29
<i>Table 5-3 pep_portfolio_view</i>	29
<i>Table 5-4 pep_view_credentials</i>	30
<i>Table 5-5 Mapping PEPs Interfaces to the existing issues</i>	33

LIST OF ABBREVIATIONS

Abbreviations	Descriptions
CDP	Continuing Professional Development
cMOOCs	connectivist Massive Open Online Courses
DSRM	Design Science Research Methodology
EPS	Education Portfolio Systems
FLOSS	Free/Open Source Software Projects
GUI	Graphical User Interface
IS	Information Systems
IT	Information Technology
LLL	Life-Long Learning Process
MOOCs	Massive Open Online Courses
ODL	Open and Distance Learning
OER	Open Educational Resources
OpenID	Open-Identifier
OpenSE	Open Educational Framework for Computer Science Software Engineering
PEPs	Portable Education Portfolios
SSO	Single-Sign-On
TUT	Tampere University of Technology
UNESCO	United Nations Educational, Scientific, and Cultural Organization
URL	Universal Resource Locator
XML	Extensible Markup Language
xMOOCs	Extended Massive Open Online Courses

1. INTRODUCTION

An education portfolio is a tool to represent all the activities of learners [1]. These portfolios are a collection of artifacts, including demonstrations, resources, and accomplishments that represent an individual, group, or an institution. Education portfolios [1, 2]

- are driven by user
- are driven by personal philosophy and set of goals
- demonstrate key skills and accomplishments
- can be digitized and a web based collection
- act as a repository for collection of users work

Education portfolios are being used to support Life-Long Learning Process (LLLP) [1, 3] and Continuing Professional Development (CPD). LLLP is a process which defines all the learning activities involved throughout the lifetime of users. It deals with all the life experiences as the learner seeks to gain knowledge for professional or personal reasons. It includes educational activities after the formal education years from childhood (where learner is instructor driven) to learning driven individually. LLLP has become vitally important with the emergence of the new technologies that change the way we receive and gather information, communicate and collaborate with others. CPD [1, 4, 5] assists users to maintain their skills and knowledge of their professional lives. It consists of activities related to education which helps to develop or increase technical skills, knowledge and problem solving skills. The CPD [1, 4] has formal and self-directed activities. Thus the full potential of portfolios can be shown through LLLP and CPD.

1.1 Motivation

The importance of a portfolio is to gather learner outcomes. It provides communities and organizations with credible evidence of outcomes at every stage of the education system. There are different forms of portfolios such as employment, teaching, learning portfolios. A particular portfolio is chosen based on the purpose it is developed for [6]. Schools, Colleges, Universities, and Massive Open Online Courses (MOOCs) are providing different types of learning opportunities and educations, and therefore they have become the central of learning spaces [7]. These learning spaces (physical or virtual) bring the people together, which motivates collaboration, challenges and discussions among the learners. Different types of learning are emerged in these environments because of the change in learner's mindset and role of Information Technology (IT).

Learning spaces provide learners different styles of education. They involve learner's active and experimental learning, situations where they are not stuck to one type of learning style. All in all, IT has changed what we do and how we do it. IT has become a necessity factor in every discipline. Collecting, analyzing, displaying, and disseminating knowledge typically involves IT [8]. Learners prefer internet for searching results instead of libraries, i.e. both learners and teachers are collecting information from online databases. Because of these factors many online learning spaces are formed. This in turn provides both informal and non-formal type of educations. Informal education [9,10] is an education obtained outside of standard school setting and it has no set of objective in the terms of learning outcome. Non-formal [10] type of learning may or may not be intentional or arranged by an institution, but usually organized some way. There are no formal credit points granted for this type of education.

Open education has inspired by the success of open source software development model because of free access to the resources for everyone and from anywhere. Open education facilitates collaborative, flexible learning and the open sharing of teaching practices that empower educators to benefit from the best ideas of their colleagues. It may also grow to include new approaches to assessment, accreditation and collaborative learning [8]; in open education all the resources like learning material and teaching are freely available to everyone. Different communities are recognizing the benefits of open

education and providing different facilities to learners. Again learners are getting involved in different activities in heterogeneous learning spaces.

1.2 Objective

The main objective of this thesis work is to collect certified user experiences from heterogeneous learning spaces through proposed system Portable Education Portfolios (PEPs). The digital age has given rise to many learning spaces, thus it is important for users to keep track of their authentic work efforts in the form of single and secure portfolio, which includes all the informal and non-formal activities. However, the existing portfolio lacks to include all the essential information regarding the collection of certified users and their experiences in a single form. This is caused due to the fact that users are participating in many learning spaces.

The raise of learners and their interests lead to the open educational resources (OER) moment. In OER, teaching, learning and all the activities are openly accessible to everyone. Massive Open Online courses (MOOCs) are emerged from this OER moment. MOOCs provide quality distant education, which helps users to gain professional skills. In turn MOOCs has tight relationship with Free/Open Source Software Projects (FLOSS) [11]. In FLOSS, the learning process is informal. Thus users can start a project at any time and can participate from anywhere. As learners are actively participating in heterogeneous learning spaces, they create their own profile and recognition through their participation. The repository which represents and certifies the artifacts or learning activities of user is a portfolio. For users, it is hard to keep track of all records and also to remember details like credentials for each and every learning space. Another issue is that while users make their portfolios there is no guarantee that they specify their details correctly. Thus to address these problems, we designed and implemented the concept of PEPs, as a mechanism to collect different kinds of learning activities into one scalable and secure place, and allow users to create portfolio views.

This thesis defines building the environment that does not exist but solves the problem of existing portfolio environments. This kind of approach is called design science approach [12, 13]. In Design science approach, design means to invent or bring into being. Here design deals with artifacts that do not exist but the knowledge required for creating artifact already exists, hence it is an innovative artifact. The innovative design needs a design science research to fill knowledge gaps. The outcome is to produce a product using a state-of-practice application of state-of-practice techniques and readily available components.

In this research the PEPs environment is built through Design Science Research Methodology (DSRM) [13, 14]. The idea is evolved based on the existing EPS. An important question is how to keep track of different users in different learning spaces. The Single Sign On (SSO) [15] mechanism with OpenID is embedded with PEPs to identify the users in heterogeneous learning spaces, which makes users life easy to identify themselves in different learning spaces. Light-OpenID [16], an already existing tool is integrated with our environment to achieve SSO.

Within the scope of the thesis, the PEPs system can successfully import different user experiences from heterogeneous learning spaces. We designed and implemented the PEPs system. Towards the goal, we experimented this design to import informal and non-formal learning activities from three learning spaces. In this thesis, the environment is successfully experimented on TUT-Mantis learning space in Tampere university of Technology, with Moodle learning space and also OpenSE learning space.

1.3 Outline of thesis

The outline of this thesis is:

Chapter 1 presents what are educational portfolios and how they are emerged. It also presents the concepts of LLLP and CDP of the portfolios. We also discuss the motivation of the work followed by its objective. This chapter is concluded with information concerning the structure of the thesis.

Chapter 2 presents necessary background information i.e. detailed discussion on how various learning spaces and educational portfolios emerged. It also presents concepts of why many learners are participating in various learning spaces because of MOOCs and FLOSS. Next, challenges in implementing educational portfolios are defined and later discussed in the following chapters.

Chapter 3 presents a detailed overview of the research methodology, on which this research is carried out to address the challenges of education portfolios. Further, each stage of methodology is clearly stated how it relates to this research.

Chapter 4 presents the issues related to existing portfolio systems .We also present the solution towards those issues through our proposed system. Here benefits of the proposed system PEPs are also stated.

Chapter 5 presents design and development details of PEPs system and also architecture of PEPs system. Further we discuss regarding the PEPs features and also clear explanation of how the implemented PEPs features relate to research objectives is presented.

Chapter 6, the proposed system is experimented on three heterogeneous learning spaces including TUT-Mantis, Moodle and OpenSE. It also discusses how the significant results address the research problem.

Chapter 7, we discuss how the proposed system solves the key challenges of present education portfolios. Furthermore, we discuss how the artifact is developed through proposed methodology, and as also how well the final artifact able to addresses the research problems.

Chapter 8 reports on the conclusions that can be drawn from the results obtained through experimentation of PEPs system on various learning spaces, and also discusses about further ideas that could be used as future work.

2. BACKGROUND STUDY

In this chapter detailed discussion about what are learning spaces and education portfolios is presented. Furthermore, major perceptions on emergent of MOOCs are discussed. We also discuss about various types of educational portfolios, their needs and challenges in this chapter. This chapter will provide a basis to proceed further in understanding the work.

Before the digital age, the distant learning was given in different forms like correspondence, broadcast courses and also in beginning stages of e-learning [17]. In 1890's some correspondence courses with different forms were prompted. Emergence of various courses leads to rise in many learning spaces.

2.1 Learning spaces

The term "learning space" highlights the mutually supporting ways in which learning as an activity and space as an environment construct and modify each other [18]. As mentioned learning spaces are either physical or virtual but provide an environment to different users. So, these learning spaces play an important role in providing the things that motivate the user to participate in different activities.

With the right approach, the entire campus can become a learning space [18]. There are three trends that inspire this emerging reality: 1) design based on learning principles, 2) human-centered design, and 3) personal devices that enrich learning.

Our growing understanding of how people learn affects the configuration of learning spaces and the technologies supporting them. The learning supports knowledge transmission as the guide for learning spaces, encouraging more thoughtful space planning. It also necessitates a proactive process to ensure that these learning spaces deliver value.

Human-centered design helps us keep people—not the latest technology—in the forefront of design decisions. With access no longer driving technology deployments, a focus on the "why" rather than the "how" of learning space design becomes possible. One cannot effectively build learning spaces without a clear understanding of intended learning activities.

Our focus on enabling learning spaces has also shifted to a much more personal view. The technologies that students bring to campus are eclipsing the technologies colleges and universities can supply, broadening our concept of learning spaces to anywhere, anytime learning on residential, commuter, or virtual campuses. The shift from teaching to learning pervades the future design of learning spaces, with learning theory guiding technology implementation.

As mentioned, digital age has given rise to new kinds of learning spaces, where learners engage in different kinds of learning activities. The raise of different participants and their interests in various kinds of learning lead to Open Educational Resources (OER). The OER was first coined at UNESCO's 2002 Forum on Open Courseware [19]. It says that teaching, learning and all the activities related to OER are openly accessible in the public domain to everyone, which has open license that permits no costs, adaption, use and redistribution with no limits. Since OER is implemented for distant educational purposes, the organizations that use OER do not provide any certification or credits for their contribution. In open education, there is an emerging effort by some accredited institutions to offer free certifications, or achievement badges, to document and acknowledge the accomplishments of participants. The OER movement originated from developments in Open and Distance Learning (ODL) and in the wider context of a culture of open knowledge, open source, free sharing and peer collaboration, which emerged in the late 20th century [19, 20]. From this OER movement the Massive Open Online Courses (MOOCs) were emerged. The term MOOC was coined in 2008 by Dave Cormier of the University of Prince Edward Island in response to a course called Connectivism and Connective Knowledge.

MOOCs are online courses aimed for open education via the internet. The content of learning is open source, no costs, and redistributable. MOOCs are recent development in distant learning introduced in 2008, and even the New York Times stated that 2012 was the year of MOOC [11]. MOOCs provides a quality distant education which in-turn

provides learners to gain professional skills that meet requirements of dynamic market models that rigid universities cannot provide. There are two different types of MOOCs, xMOOCs and cMOOCs. xMOOCs abbreviated as Extended Massive Open Online Courses. These are most structured as they follow linear distribution of knowledge. xMOOCs are designed based on evaluation model, which are similar to traditional classes. They consist of set of videos, additional training materials, and test for accessing students' progress and learning. From point of view of the students, each student uses the contents in isolation, and homework and exams are done individually [21, 22]. cMOOCs are connectivist MOOCs. They emphasize the connectivist philosophy, provides a learning community which is more dynamic than xMOOCs [22]. Here the learning is focused on the discussions and contributions that are generated in the social learning network. cMOOCs provides minimum content to the participants during the course. With the comparison to traditional courses, in cMOOCs there is no clear difference between teachers and students. Teachers just assume a role of partial guide in this learning environment. Here there is limited number of participants because knowledge focuses on the participants and the connections established between them. cMOOCs are based on participatory and collaborative methodology. One example organization of MOOCs is Khan Academy [23]. Khan academy provides wide variety of online courses in which users can easily collaborate with other users to learn distant courses. Their motto is 'you have to know one thing: you can learn anything'. Khan Academy also offers practice exercises, instructional videos, and a personalized learning dashboard that empower learners to study at their own pace in and outside of the classroom [23].

MOOCs have a tight relationship with Free/Open Source Software Projects (FLOSS). In FLOSS projects learning process is informal and the learning goal is to create a software product which solves an implicit problem [11]. There is no particular start point of the project, and interaction of users takes place as community based learning.

As learners are the participants in these large MOOCs or FLOSS projects and contribute their ideas or solutions from anywhere, anytime, and get their recognition in different learning spaces. It is important to users to keep track of their authentic work efforts. The repository for collection and presentation of their work but also a mechanism for documenting growth and achievement of professional knowledge and skills is a portfolio. These portfolios help users to compile and reflect their work, efforts, and progress [2]. The following Section 2.2 gives a brief idea of how education portfolios

came into use, their benefits, and also gives an idea what challenges would be considered while implementing them.

2.2 Educational Portfolios

“Education is a social process; education is growth; education is not a preparation for life but is life itself.” - John Dewey.

In late 1980’s, the use of education portfolios was started. These education portfolios are a collection of learner activities [6]. It provides tangible evidences of learner achievements. The goal of education portfolios is to represent and certify different artifacts or learning activities achieved by learners. Disciplines such as history or science used portfolio techniques to promote critical thinking, thus making connections to assess learner progress. These portfolios support Life Long Learning Process (LLLP) and Continuing Professional Development (CPD). LLLP is a framework of formal, non-formal, and informal learning’s activities. Figure 2.1 shows the framework of LLLP [8].

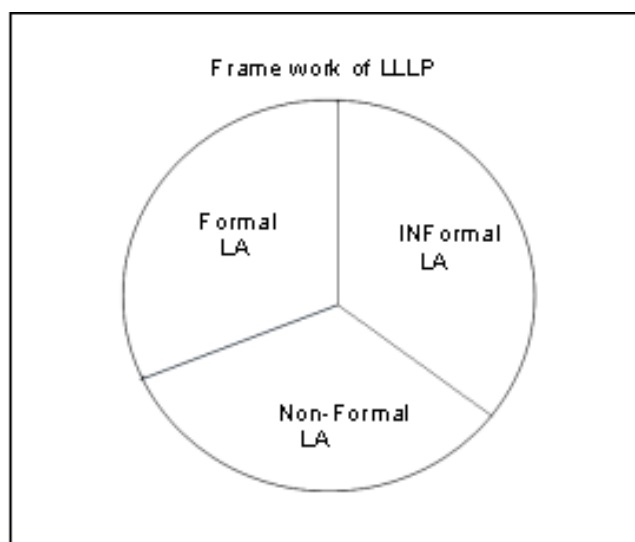


Figure 2-1 Framework of Life-Long Learning Process

Formal learning activities: Activities that belong to formal education are formal learning activities. These can be achieved through universities, colleges, schools and traditional learning.

Informal learning activities: Informal learning occurs in a variety of places, such as at home, work, and through daily interactions and shared relationships among members of society [10].

Non-formal learning activities: Learning that involves workshops, community courses, interest-based courses, short courses, or conference style seminars [9].

From a learner perspective, all the activities above complement each other and contribute to the overall learning experience, despite the fact that those activities are carried out within different kinds of learning spaces. Documenting and organizing those heterogeneous activities into proper education portfolios may be a good vehicle for recording recognition and showcase expertise. This is important for example in job searching. There are different types of education portfolios tailored to different purposes [24]. The main ones include documentation portfolios; process portfolios; showcase portfolios, an evaluation portfolio, and a composite portfolio.

Electronic portfolios, known as e-portfolios [2], have been one of the main digital tools to show evidence of learners' achievements in well-organized learning portfolios. E-portfolios, however, have been mostly applied to formal education settings. With the rise of open education resources such as open source communities and other online informal programmes, we argue that another generation of education portfolios, called Portable Education Portfolios (PEPs), is needed. The main difference to such earlier e-Portfolio works is perhaps that PEPs are well integrated within a well-defined approach towards open education. Two central questions emerge within PEPs: how to support as many learning spaces as possible in a smooth, highly interoperable way and how to ensure the credibility and soundness of recorded information.

2.2.1 Need of the educational portfolio

The purpose to design the portfolio is to escalate the passion in students to attain knowledge that will advantage them further in future. It broadens the view of what they have learned. It also provides with an approach to worth themselves as novices. It encourages them to increase their level of competence according to their educational needs [25]. It makes teachers and students more flexible and creative to demonstrate their competences and skills in their area of interest and keep it growing continuously in their education from one year to the next. It provides the opportunity for students to be

updated on recent market demands and technologies to look for the required skills needed. It provides the student an opportunity to assess their decision-making skills by visiting peer portfolios.

There are various advantages and disadvantages of portfolio. For example, Portfolio are a performance measurement based on genuine work samples done by students. It provides flexibility in judging how students completed their learning goals and enables teachers and students to share the responsibility for setting learning goals and for evaluating progress toward meeting those goals. It also facilitates cooperative learning activities, peer evaluation and cooperative learning groups. Portfolios also provide the opportunities for students and teachers to discuss learning goals. In structured and unstructured conferences it moreover shows progress toward those goals. It promotes self-evaluation, reflection, and critical thinking of student.

In contrary, Portfolio requires additional time to plan an evaluation system and conduct the evaluation. It gathers all of the necessary data and work samples .It can make portfolios massive and problematic to accomplish. Another disadvantage is that it is difficult to develop a systematic and deliberate management system, but this step is necessary in order to make portfolios more than a random collection of student work. Scoring portfolios involves the wide use of subjective evaluation procedures.

2.2.2 Types of educational portfolios

Different portfolios are needed to keep track of different activities that represent the work efforts of the user. There are three main types of educational portfolios [25, 26]. These portfolios only represent formal or informal experiences of the user, due to the reason that these portfolios were not designed for non-formal learning activities.

Documentation Portfolio:

Documentation portfolio is one of the very famous portfolios' also identified as the "working" portfolio [25]. This type of approach unambiguously comprises a gathering of work regarding how much work a student has gathered over time and their improvement in that time. It can comprise almost everything from brainstorming activities to drafts to completed goods, and this collection of work turned to be more significant when specific work is selected out to focus on specific educational

experiences or goals. This approach is the best way to track and know the bad and weakest parts of student work.

Process Portfolio:

This approach documents all phases of the learning process. They also provide a progressive record of student growth, particularly useful in documenting students' overall learning process [25]. This is the best way to judge a student track path when he has decided his specific knowledge or skills and how he progress towards both basic and progressive mastery. Additionally, it highlights students' reflection including the use of reflective journals, think logs, and related forms of meta-cognitive processing.

Showcase Portfolio:

This type of portfolio is best to include student's very best work. Learning experiences are selected by student and teacher so in this case just accomplished work will be involved. This type of portfolio is particularly compatible with audio-visual artifact development. It includes some other item like photographs, videotapes, and electronic records of students' completed work [25, 26].

Online or (e) portfolios:

These portfolios are, one of the famous portfolios used by students and teachers. In this type all the work records, skills are available online [25, 26]. Nowadays, it has the demand because some of the universities and academic schools need students to keep a virtual portfolio. It can comprise digital, video, or Web-based products and all the items related to students work. In this way accomplishments of students are tracked visually. This is the best way for a student to express their innovative progresses.

2.2.3 Challenges in implementing education portfolios

As mentioned Portfolios are collections of all of learner's learning evidence. The learners are participating in different learning activities in heterogeneous learning spaces, which are located in several places. So when users are preparing their portfolios, it is hard to remember all the details of learning activities. This leads to lack in some learning activities in portfolios. In such cases, the portfolio lacks support for the LLLP.

Every user can participate in open education and can achieve records in open education learning spaces. As learners can participate openly, they can provide wrong results of their learning outcomes in portfolio.

One of the challenges is to identify a user in different learning spaces. When a user deals with heterogeneous learning spaces he/she will be accessing them with different credentials for each space in order to access their environment. It's hard to remember or keep track heterogeneous learning space details in real time. This problem is handled by introducing the concept of Single Sign On (SSO), where users can associate and manage their learning space accounts with a single OpenID. In the future if they want to access their information from learning space then they can identify themselves with OpenID. This OpenID is developed by using an existing tool named LightOpenID [16]. Another important challenge is to deal with how the format of the data be coming from heterogeneous learning spaces where the data models will be changing.

3. RESEARCH METHODOLOGY AND APPROACH

This research approach is based on five phases of Design Science Research Methodology (DSRM). In this chapter, we present the DSRM methodology and its phases. Furthermore, we discuss how this methodology is applied to our research in order to achieve our objectives. We also revisit the purpose of this thesis in the research approach section of this chapter.

3.1 DSRM Methodology and Phases

Design Science Research Methodology (DSRM) is a process of sequence of expert activities that produces an innovative product [12]. In Design Science Research, design means to invent or build non-existing artifact. The outcome is to produce a product using a state-of-practice application of state-of-practice techniques and readily available components [12, 13]. But knowledge require to build this artifact is already exists or available. This methodology is an iterative process until the final design artifact is developed. In Design Science Research, the focus is on the so-called field-tested and grounded technological rule as a possible product of Mode 2 research with the potential to improve the relevance of academic research in management. Mode 1 knowledge production is purely academic and mono-disciplinary, while Mode 2 is multidisciplinary and aims at solving complex and relevant field problems [27]. According to Hevner, there are seven guidelines for DSRM process [13, 14, 28]:

Design as an Artifact: Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.

Problem Relevance: The objective of design-science research is to develop technology-based solutions to important and relevant business problems.

Design Evaluation: The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.

Research contributions: - Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.

Research rigor: Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.

Design as a Search Process: The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.

Communication of Research: Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

DSRM process includes six phases: problem identification and motivation, objectives for a solution, design and development, evaluation, and communication [13, 14].

Problem Identification and Motivation:

In this phase, we define the research problems and justify the value of the solution. This problem definition will be used to develop an effective artifactual solution. Justifying the value of solution accomplishes two things: it motivates the researcher and also the audience of the research to pursue the solution and also accept the results, and it also shows how well the researcher understood the problem. Resources required for this phase include knowledge of the state problem and the importance of the solution.

Objectives of the solution:

The objectives can be quantitative, e.g., terms in which a desirable solution would be better than current ones. For example, the new artifact is expected to support solutions to problems addressed. Resources required for this phase include knowledge of the state problems and current solutions and their efficacy.

Design and Development Phase:

In this phase, the activity includes determining the artifact's desired functionality and its architecture and then implementing the actual artifact. Resources required for this phase include knowledge of theory that can be brought to bear as a solution.

Demonstration Phase:

Here we demonstrate the efficacy of the artifact to solve the proposed problem. It can be done through experimentation, simulation, or through a case study. Resources required for the demonstration include effective knowledge of how to use the artifact to solve the problem.

Evaluation Phase:

We observe and measure how well the artifact supports to the problem. We compare the objectives of the solution to actual observed results. At the end of this activity researchers can decide whether to iterate back to phase 3 to improve the effectiveness of artifact.

Communication Phase:

The problem and importance of the artifact is communicated to researchers and relevant audiences. Communication phase requires knowledge of the disciplinary culture.

3.2 Research Approach

As mentioned earlier, this research follows a combination of the Design Science Research Methodology/guidelines (DSRM). The phases of DSRM are modified according to the research. They are Problem Identification in existing EPS, Objectives of a Solution, Design and Development of PEPs Environment, Integrating various learning activities, Evaluation and communication phases as shown in Figure 3-1.

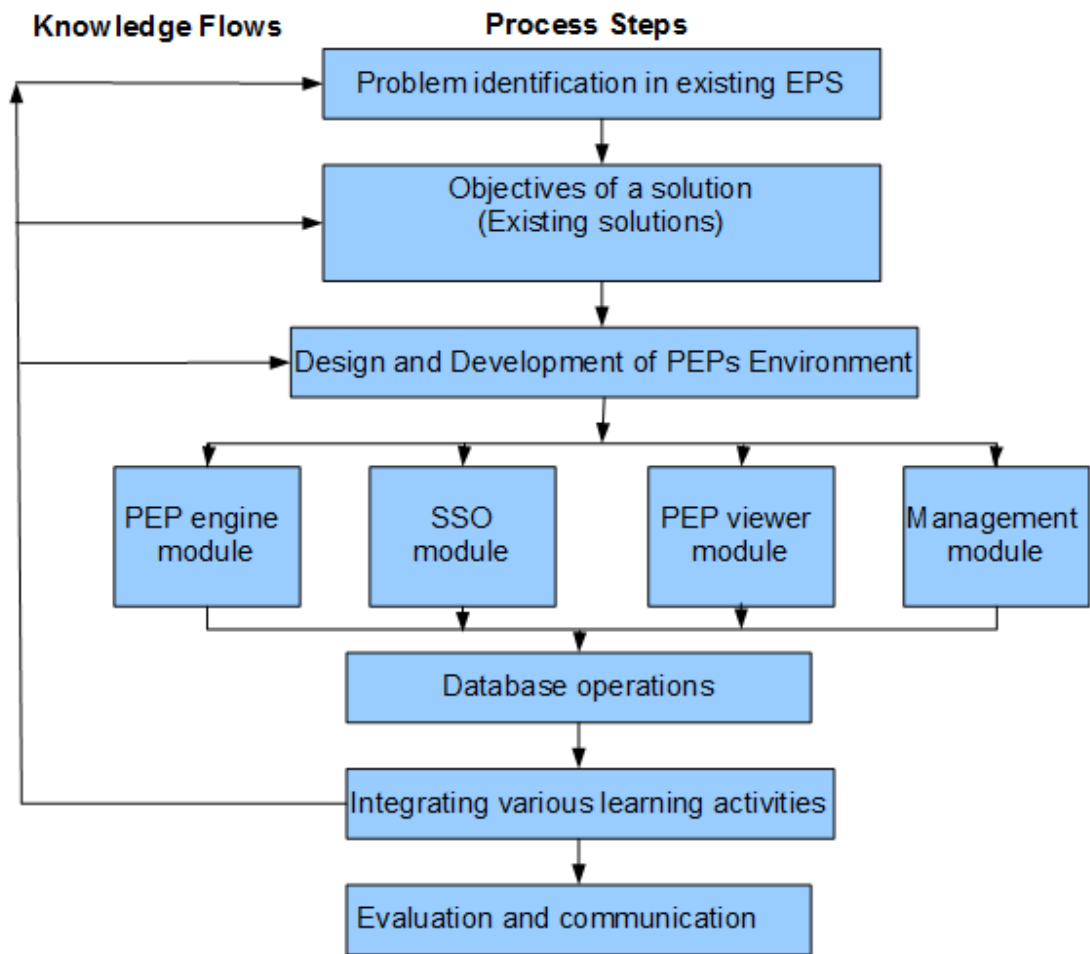


Figure 3-1 Design Science Research Methodology (DSRM) for PEPs system

Problem identification in existing EPS:

The first concern is to identify and define a problem. Since problem definition is used to develop an effective artifactual solution, it may be useful to atomize the problem conceptually so that the solution can capture the problem's complexity. This research is carried out to solve a particular problem which is to collect all these heterogeneous learning activities into well-organized education portfolios. Due to the fact of increase of various learning spaces in digital era, it is important for users to keep track of their authentic work efforts in the form of single and secure portfolio, which includes all the informal and non-formal activities. However, the existing portfolio lacks to include all the essential information regarding the collection of certified users and their experiences in a single form. This is caused due to the fact that users are participating in many learning spaces.

Objectives of a solution:

The objectives of a solution to a particular problem are to figure out “what would be the better artifact can accomplish?” i.e. to compare the proposed solution with existing solutions. The second phase of DSRM is to specify the objectives of the problem i.e. the existing solutions. For this research, the existing solutions are LinkedIn, Mahara, and Mozilla Open-badges. In this phase, we find the problems present in these existing portfolio system solutions.

Design and Development of PEPs Environment:

Here the artifacts are implemented based on the requirements and problem stated in previous phases. The third phase is about design and development of the proposed system. In order to solve the problems from the existing systems (phase 2), we designed and implemented a PEPs system which collects user certified experiences in to a single system. In addition, for the design of our solution system we added an additional feature called openID module, which helps users to connect to the learning spaces using same credentials called *open-identifier*. In PEPs system we implement four modules: PEPs engine, SSO, PEPs viewer, management modules. These all modules interact with backend database to retrieve or store user’s data.

Integrating various learning activities:

As a result from the design and development phase, we get PEPs system. This system is the input to the next phase, which is the Demonstration phase. Here, we demonstrate the artifact to solve the problem. In the fourth phase we demonstrate the PEPs system. To-do-so, we authenticated through SSO mechanism using OpenID and integrate user experiences from three heterogeneous learning spaces including TUT-Mantis, Moodle, and OpenSE and we obtained informal, formal and non-formal learning activities respectively.

Here we collect/import various user experience data including informal, formal and non-formal learning activities. We then create a single and secure portable educational portfolio to the PEPs user.

Evaluation and communication:

The results of the final PEPs system is communicated with OpenSE, and TUT open source members. The PEPs is developed through iterative process until the objectives are achieved. Finally we discuss how well the artifact supports a solution to the problem by comparing the objectives of a solution to actual observed results from the use of the artifact in the Demonstration. This phase is known as Evaluation phase. Based on the results from the fourth phase, an efficient solution to the asserted problem was discussed and verified as the evaluation phase of DSRM.

From this research approach, we obtain an effective artifact named PEPs and we experiment this system on various learning spaces to achieve the research goal. Finally based on results from phase five, the proposed system PEPs would be a better system to solve problems related to today's educational portfolios.

4. TOWARDS PORTABLE EDUCATION PORTFOLIOS

In this Chapter we provide a deeper insight on PEPs environment, with detail overview and its components. We also discuss its implementation in detail. In addition, benefits of PEPs and their comparison with the existing solutions are briefly discussed.

Portable Education Portfolio System (PEPs) is an application tool that is developed in order to solve the problems integrated with various tools of learning spaces. PEPs are portable education portfolios which are used to import learning activities from different learning spaces as shown in Figure 4-1. They provide an authenticated way to import the learning activities of learners from separate learning spaces. PEPs is also a system to provide authenticated or certified details of learners to their portfolio. PEPs system interacts with heterogeneous learning spaces and each learning space is developed with their own stack. Different learning spaces provide different types of learning activities as specified in Section 2.2. This challenge can be overcome by using a generic data model developed in XML [29]. The generic data model is designed in a way that can handle different forms of learning activities. Hence it is easy to extend the model and change it according to needs. But this should be done with mutual cooperation with PEPs administrator and learning space administrator. The learning spaces that we have experimented with our design solution are TUT-Mantis, Moodle and OpenSE learning spaces. The challenge is to understand how their database architecture is designed and find out how students grades, participation details are recorded in database. As all the learning spaces are developed in PHP it became easy to develop learning space interfaces.

PEPs can import all kinds of learning activities: formal, informal or non-formal learning, supporting LLLP. While importing the details from a learning space a PEPs system asks the learner to authenticate. Then PEPs imports learning activities from given learning space. Hence the details obtained are authenticated and thus authenticity

for evidences is provided. With the help of a PEPs system the users can create different views of their portfolio and can give access to others to view their portfolios.

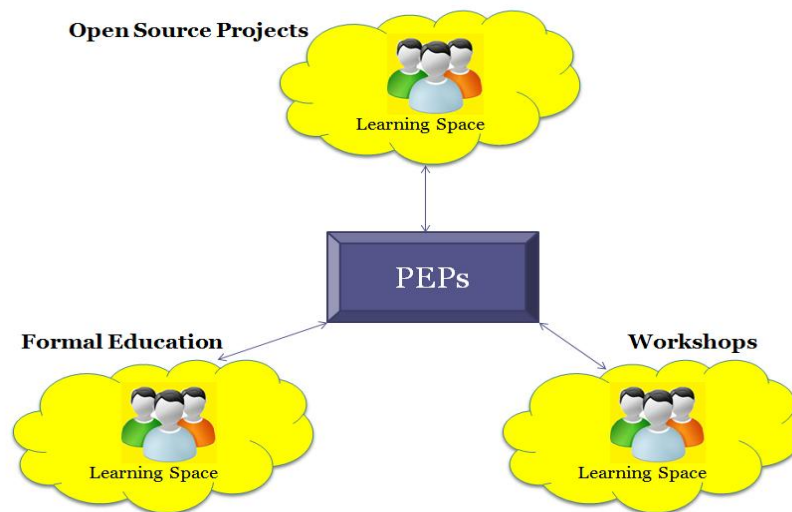


Figure 4-1 An overview of PEPs structure

Learners can participate in different learning spaces and can have different credentials for different spaces. It is hence problematic for the learners to remember all the credentials of different learning spaces. This problem is solved by introducing the OpenID authentication [15, 30]. OpenID is an URL, user-centered, open and decentralized standard for authenticating users. By the help of OpenID, users do not have to remember the multiple usernames and passwords. In order to login into a system, a new user always has to register to each site. The Single Sign On (SSO) concept means user logs into the system once and access to all the systems without giving login information again and again. As a solution to SSO, OpenID can simplify the user's operation process and reduce the resource provider overhead. i.e., OpenID has the single sign on procedure to reduce redundant, multiple accounts and passwords. Thus, the OpenID technology provides a secure and unified authentication mechanism to improve the anonymity of users [8].

PEPs support the interoperability of different learning spaces. They could show all types of artifacts that have been created by the learner, like for example assignments that they have completed and how educators or peers have assessed those, internships that they have completed, contributions to open source projects, certificates obtained, and other course interactions. In addition, PEPs could synchronize such information across the

technical solutions provided by the different learning spaces. Thus PEPs can be thought as an implementation of composite portfolios.

4.1 Benefits

The main benefit of PEPs system could be categorized in three significant parts.

Connecting courses and programs:

PEPs system connects to several courses and programs to learner-created artifacts as well as to the underlying discourses. It even synchronizes them across technical solutions therefore allowing re-usage and learning from what others have achieved.

Supporting non-formal learning experiences:

PEPs system allows non-formal ways of recognition of learning outcomes. It does the support within free/open learning by, for example clearly showing learning outcomes and how those have been evaluated by peers or educators. These educators provide a base for service providers who then offer individual assessment and formal certifications. Furthermore they also allow service providers to build up their reputations.

Supporting LLLP:

PEPs system allows the connection of numerous education spaces and takes all kinds of information across such spaces. PEPs therefore create a new model that allows learners and educators to carry education across institutions and other educational spaces. Hence it dovetails with life-long learning process framework.

4.2 Existing Solutions

Because of the digital age, many new things are implemented in learning spaces. Learners always try to seek new knowledge in different fields. They actively participate

in these learning spaces. Some of the best ways are known from online and open education. Users perform different activities and create their portfolio in different learning spaces. There are many portfolio systems that allow users to create their portfolios.

The Mahara open source e-portfolios [31] system is a fully featured platform to build your electronic portfolio. It is a web application and it is easy to access through a browser. It allows users to create their portfolio systems but here it does not provide user to import your activities from another learning space.

The most professional and well-known portfolio system is LinkedIn [32]. LinkedIn is a platform that allows users to create their own professional portfolios. It also allows users to apply for jobs based on their selected field of interest. It also allows other users to comment on your experiences, endorse other users, and also provides options to create and download curriculum vitae.

Mozilla open-badges [33] is another open source project, which allows users to collect badges for different activities from different learning spaces. The idea is user has to collect badges from multiple sources and then collect them to what is called a backpack [33]. With the backpack the learner can display skills, achievements on social network media.

From the above example portfolio systems, in Mahara and LinkedIn platforms users are allowed to fill their portfolios with their experiences. However, it shows inadequacy in fulfilling all the challenges in implementing education portfolios. With these systems users are always in need to keep track and update their portfolios manually.

The Open badges project is a good platform for displaying user's skills. But to use this platform the whole infrastructure has to be changed by the universities. Every course has to create badges, and add some authentication and user information to them. If a user has many badges it is hard to recognize for the interviewers to identify the skills by investigating what does each badge stand for. With existing solutions of portfolio systems there is no easy platform that successfully gets all learning activities and keeps track of them in one platform.

Table 4-1 shows issues related to existing portfolios systems including Mahara, LinkedIn and Mozilla open-badges. Users of these portfolio systems do not get/import

learning activities from learning spaces, but they provide their own details which lacks the evidence of authenticity. Thus these systems have issues regarding certified user experiences and import learning activities. In these portfolio systems every user has their own credentials, in which they have to remember credentials for every portfolio system. This raises an issue lack of OpenID. Multiple portfolio views helps users to group their experiences based on kind of learning activities. But these systems fail to provide multiple portfolio views to users. LinkedIn and Mahara are easily accessible and modified because they can be accessed through web browsers. But in open-badges it is hard for users to remember different badges and then modify according to their need.

These features are solved by our proposed system. PEPs support importing learning activities from any learning space. It has SSO mechanism to support OpenID through which imports certified user experiences.

Table 4-1 Issues related to existing portfolio systems

ISSUES	Mahara	LinkedIn	Mozilla Open-Badges
Certified Experiences	No	No	Yes
OpenID	No	No	No
Multiple portfolio views	No	No	No
Import learning activities	No	No	No
Ease of access and modify	Yes	Yes	Poor

5. PEPs ENVIRONMENT

In this chapter, the architecture of PEPs environment, the implementation details, and its features are provided. The aim of this chapter is to illustrate the technology how the PEPs are implemented and also familiarize the user how the PEPs environment can be used.

5.1 Architecture

Originally the architecture of PEPs is designed from scratch. Thus it is pretty simple and straightforward. From an architectural point of view the PEPs environment is divided into following modules

- OpenID module
- PEP Graphical User Interface (GUI)
- PEP Engine
- Learning space GUI
- User management module
- PEP viewer
- PEP database architecture

As mentioned in Chapter 3, the PEPs system uses SSO mechanism through OpenID. Here OpenID module handles registration and login mechanism for users. User can authenticate through Gmail, Yahoo, or OpenID services as shown in Figure 4-1. This SSO mechanism helps users only to remember same username and password for different systems.

PEP GUI is the welcoming interface to the user after login or registration where small introduction about PEPs is available. This PEP GUI provides users to interact with

different learning spaces and also users can view their own portfolios. This GUI also provides users to select or choose particular learning activities or study records to create portfolio view. The user has to give a name to every portfolio view. Hence these portfolio views can be accessed and edited through their names.

The user interacts with different learning spaces through PEP GUI. To interact with a learning space the user provides the address of learning space. Here address refers to a universal resource locator (URL). The URL is publicly available to users, provided by the administrator of each learning space. Then PEPs engine connects to the learning space based on the URL. Figure 4-1 shows the PEPs architecture.

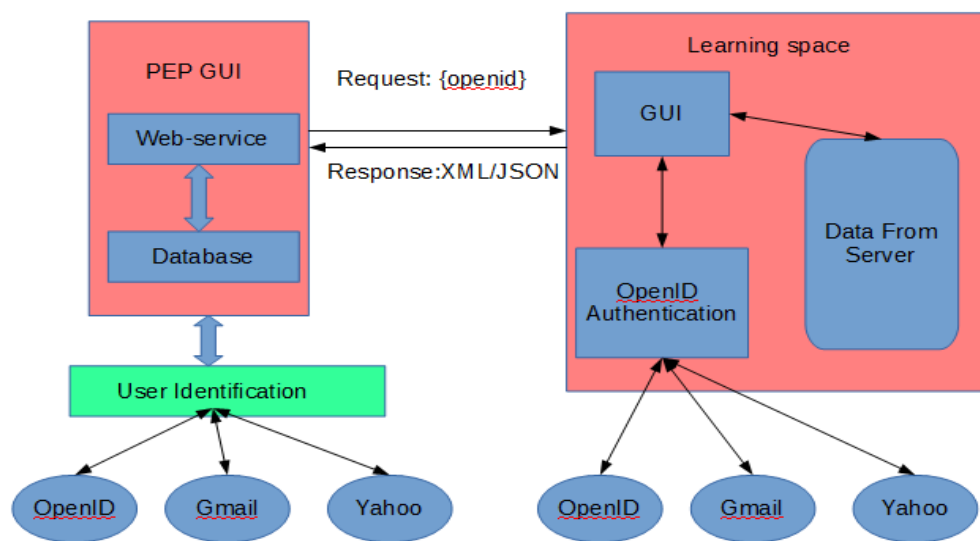


Figure 5-1 PEPs Architecture

The PEPs engine allows user to collect his activities from different learning spaces. The data collected is in the form of generic data model designed. This generic data model is designed based on the different portfolios mentioned in section 2.2. Generic data model can be easily extendable as it is in the form of XML [29]. It is easy for developers to use this model and extend it according to different learning spaces. Basically the collected data is in XML format. Therefore, the PEPs engine has an XML parser to parse data and save it in PEPs database. After this process, the system creates a portfolio with the information that is saved in database. The generic data model developed has the following format:

```

<learningproject>
  <lpid> </lpid>
  <lsname> </lsname>
  <name> </name>
  <email> </email>
  <projectname> </projectname>
  <projectdesc> </projectdesc>
  <participation> </participation>
  <recognition> </recognition>
  <grade> </grade>
  <certifiedby> </certifiedby>
</learningproject>

```

Figure 5-2 Code Snippet of Generic data model

As we know the main purpose of this thesis is also to import user experiences from heterogeneous learning spaces. Importing such experiences is a delicate task because all the learning spaces have their own stack. Therefore we designed a generic data model that fits to every stack of various learning spaces. Figure 5.2 shows the code snippet of generic data model in the form of XML tags.

The user information is placed between XML tags [29, 33]. XML is a markup standard language for defining the structured documents in a format of human readable and machine readable. It is defined by W3C's with open standards. XML format is simple, user defined, extendable and used across the internet. Thus the data format is chosen as XML.

Every study record or learning activity is placed in between <learningproject> and </learningproject> tags. From the data model, <lpid> and </lpid> tags are 'learning_project_ID' which is unique field to user records that is sent from the learning space. No two entries have same learning_project_ID's. <lsname> and </lsname> abbreviates as learning_space_name. Between these tags the name of the learning space is provided. It is the name of organization or institution who issues the learning records. <name> and <email> clearly indicates the username and email address of the particular user who requested their learning activities from the learning space. Here the <projectname> tag specifies the subject or course name that user actively participated and contributed something. <projdesc> is project description where learning space teacher or professor can describe about course content. <participation>, <recognition>

and <grade> tags are used to describe the participation level of user in that learning project. <grade> tag can be used for formal education learning spaces mostly. And <certifiedby> tag contains details on who actually issued these records to user. It can be professor names or project team name etc. As it is simple and straightforward it is easy for developers to create the above format. Also, it is platform independent.

From Figure 5-1, when user communicates to learning space it redirects to Learning space GUI. This learning space GUI also provides user to authenticate with OpenID. The authentication mechanism used is SSO through OpenID. User has to authenticate with OpenID that he has linked with his credentials in learning space. User can choose any services provided by the learning space to identify themselves. After successful identification user is auto redirected back to PEPs system with his learning activities.

The user management module is easy to maintain because of the SSO mechanism. All details of user are obtained like email, first name, last name, country, and language from the OpenID authentication. However, if user wants to remove his/her account one has to contact the administrator of the PEPs system.

The PEPs viewer is the place to view the portfolio views created from the PEPs GUI. To view a portfolio of a particular user, it requires username and password. These credentials can be obtained from the user.

Table 5-1 pep_user_table

Field Name	Type
id	Unique and auto generated
firstname	Varchar
lastname	Varchar
email	Varchar
country	Varchar
language	Varchar
datecreated	Datetime
last_visited	Datetime
access_level	Smallint

PEPs database is designed in a simple way. It consists of four tables: pep_user_table, pep_learning_details, pep_portfolio_view, and pep_view_credentials. The table pep_user_table has fields related to user information as shown in Table 5.1. When user logins with SSO service then registration details obtained from Gmail, Yahoo or OpenID are saved into this table.

The table pep_learning_details is used for saving the learning activities imported from different learning spaces. It has the following fields shown in Table 5.2. This table is designed based on the generic data model discussed above.

Table 5-2 pep_learning_details

Field Name	Type
Id	Unique and auto generated
Email	Varchar
learning_proj_id	Int
learningspace_name	varchar
Username	Varchar
learningspace_emailid	Varchar
Projectname	Varchar
Projectdesc	Text
Participation	Text
Recognition	Text
Grade	Text
Certifiedby	Text

Table 5-3 pep_portfolio_view

Field Name	Type
Id	Unique and auto generated
learning_proj_id	Int
learningspace_name	Int
Username	Int
learningspace_emailid	Int
Projectname	Int

Projectdesc	Int
Participation	Int
Recognition	Int
Grade	Int
Certifiedby	Int

When a user creates a portfolio view from imported learning activities, these view details are saved into pep_portfolio_view table as shown in Table 5.3.

For every portfolio view, user credentials are generated. These credentials are useful to access this view through PEP viewer. PEPs allow users to create multiple portfolios from the imported learning activities and these created portfolios are restricted to access by others. If the user wants to allow others to view the portfolio then he must provide these credentials to access them. Thus, these credentials are saved in Table 5.4.

Table 5-4 pep_view_credentials

Field Name	Type
Id	Unique and auto generated
View_id	Int
Userid	Varchar
Password	Varchar
Enabled	tinyInt
Login_count	Int
Date_created	Datetime
Last_visited	Datetime
View_name	varchar

5.2 Implementation

The tool is a web application, and the environment can be accessed through a web browser. The implementation should be platform independent and we have chosen PHP for development of the whole environment and MySQL as backend database since they are open source.

Login and Registration module uses SSO mechanism which is implemented by using LightOpenID tool. LightOpenID [16] is an open source library for easy OpenID authentication. This tool uses cURL feature of PHP or PHP streams otherwise. The cURL [34] allows transfer of data across websites including things like API interaction and OAuth. LightOpenID also supports both OpenID 1.1 and 2.0 versions. LightOpenID tool is configured according to our need. It supports Gmail, Yahoo, OpenID services for Login and registration mechanisms. This tool helps users to redirect to selected service and if authentication is successful then it redirects back to PEPs system with user details. Here LightOpenID is configured to get first name, last name, email, country and language of user at the time of registration. Same tool is used for login and registration services. If the user logs in for the first time into PEPs system through these services then user details obtained are saved into the PEPs database. Later on user can update their details from the interface provided as shown in Figure 5-13.

The PEPs GUI has simple options for users to collect learning activities. This GUI is implemented by PHP. It uses bootstrap elements [35] which gives a better look and feel for the interfaces. These bootstrap elements are imported in the front end development. These elements are chosen because bootstrap has user friendly and tested components.



Figure 5-3 Bootstrap elements

Figure 5-3 shows a clear color differentiation between two actions Success and Warning. The PEPs GUI provides an interface to user to enter the address of learning space.

The PEPs engine is implemented in PHP. When user specifies the address of a learning space PEPs engine initializes. After initialization it redirects to the learning space environment. The data is received according to the generic data model. This generic data model is developed in extensible markup language (XML) [29]. When users are redirected to PEPs system from the learning space environment with XML data, the PEPs engine parses that data and saves into PEPs database. Thus user needs following details to import his activities from different learning spaces:

Address of learning space: The administrator of a learning space has to provide an URL which locates the learning space. The user has to provide this URL to the PEP system for PEP to be able to locate the learning space.

Identify the user: The users have to associate OpenID with their learning space credentials. When the PEP system locates a learning space the user can authenticate with their OpenID. If the authentication process is successful then user gets recognized.

Type of web service: The PEP system provides a sample data web service model. The administrator of a learning space has to provide the learning activity details of users in the same format of the model.

As mentioned in Section 5.1, PEPs provides the necessary information to the learning spaces regarding the format of learning activities. Based on these details learning space administrator has to implement three things in order to successful interaction with PEP system. First implement the interface for SSO to identify the users who are requesting for learning activities. The SSO interface must provide the three services mentioned in Section 5.1. Secondly, write logic to send back the learning activities in the form generic data model as specified in Section 5.1. And third, provide address (URL) to the users to locate the learning space.

5.3 PEPs Features

In order to use the PEPs environment the users has to be familiar about the features and its usage in the environment. This section provides details about all the interfaces through which the users can interact with the system. Different use cases that learner

can do in the PEPs environment are directly mapped to the addressed challenges from the existing education portfolios systems. Table 5.1 presents the issues and different use case interfaces present in the PEPs environment.

Table 5-5 Mapping PEPs Interfaces to the existing issues

ISSUES	SOLUTION IN THE FORM OF PEPs FEATURES
Certified Experiences	Importing learning activities interface
OpenID	Login/Registration Interface
Multiple portfolio views	Create/Delete Enable/Disable Portfolio Interfaces
Import learning activities	Importing learning activities/ Modal Interfaces

5.3.1 Users registration and SSO service

Every user has to register or sign up to get access to the PEPs system. Here as mentioned in Section 5.2, registration process is done through LightOpenID tool. Users have to select any one service from GMail, Yahoo, or OpenID to register to the system. When user selects one of the services then he will be redirected to that service page to identify himself. After successful identification he will be redirected back to PEPs system with his email, first name, last name, language, and country details. So these details are registered into database. The users can select service to register shown in Figure 5-4. Users can select the service from carousel or login button shown on top right corner in Figure 5-4.

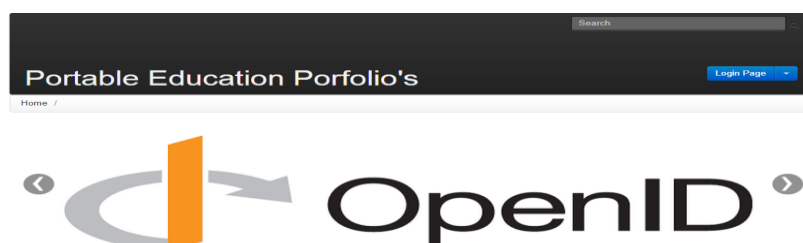


Figure 5-4 Registration page for PEP system

After registration, the user can login through the same interface by selecting any service shown in Appendix A.1. If the user is accessing the system for the first time then his details are saved into database. Otherwise users after identification will be redirected to PEP GUI.

For example if user selects Gmail service to login as shown in Appendix A.1. Then user is redirected to the following Gmail service page. Here user has to identify himself to login to PEP system as shown in Appendix A.2.

5.3.2 PEPs GUI

After successful registration or login user is redirected back to main page of PEPs system where user can select any service provided by PEPs system. A small introductory detail regarding PEPs system is shown in Figure 5-5. This GUI provides options import learning activities, create and updating portfolios. Also the user can edit his/her account information through user settings.

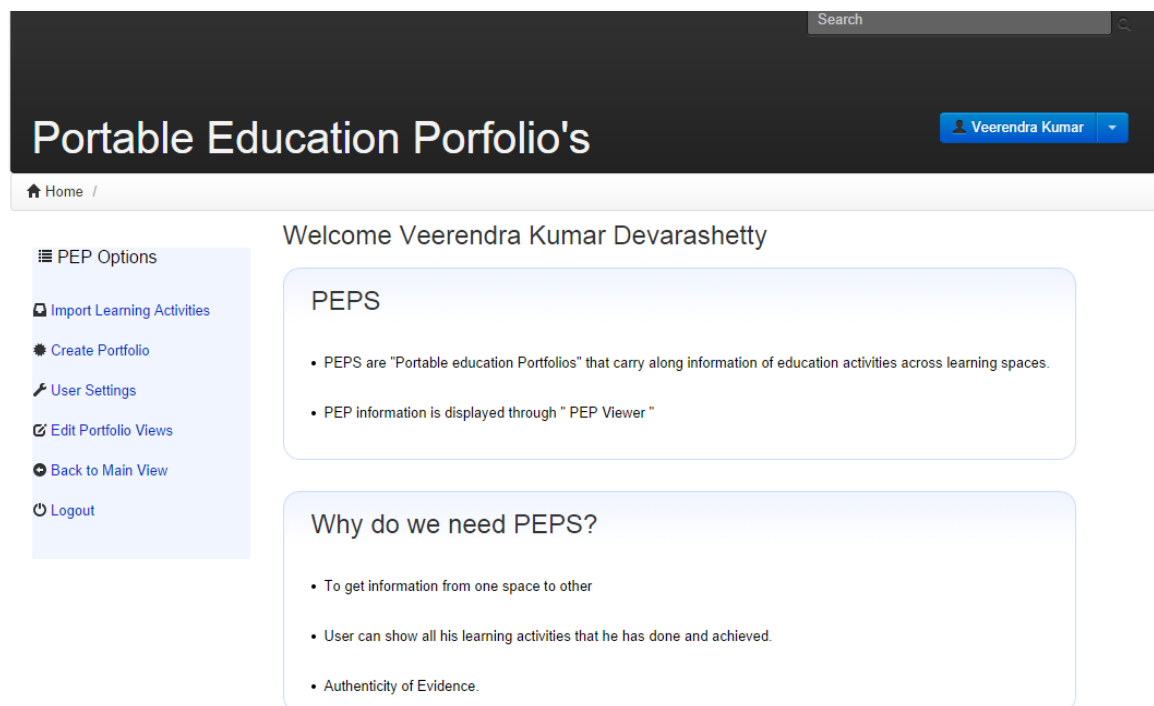


Figure 5-5 PEP graphical user interface

5.3.3 Importing learning activities

The most important service of PEPs system is to get learning activities from different learning spaces. So user can click "import" button as shown in Figure 5-6.

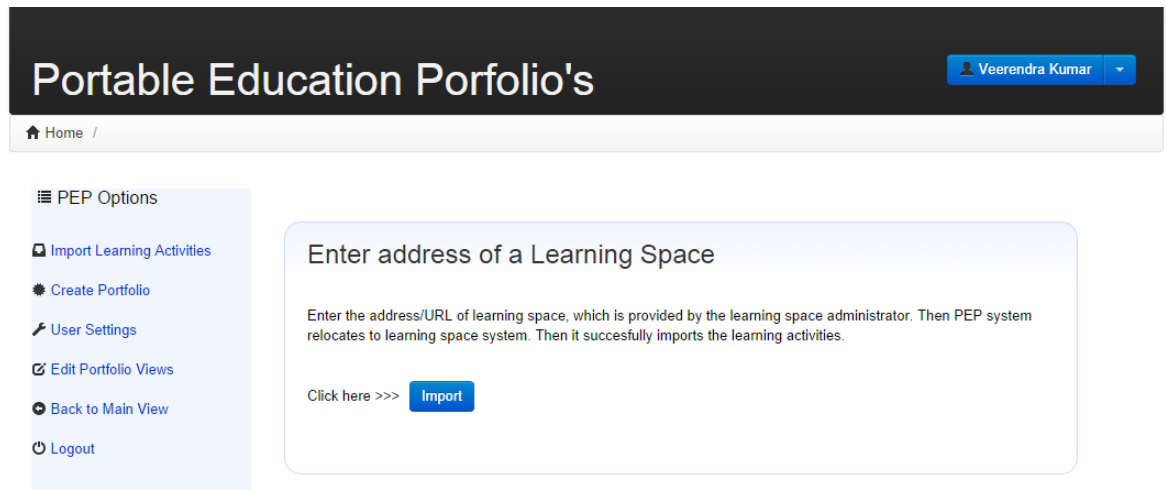


Figure 5-6 Import learning activities interface

When user clicks "import" button then a modal is displayed to user to enter the URL of learning space. Then after entering URL user has to click "Go!" button to redirect to learning space environment. Sometimes browser does not remove the previous URL from the textbox field. But the 'Reset' button helps to clear the previous or current input field 'Enter URL' as shown in Figure 5-8. When user choose 'Cancel' button then he will be redirected to interface shown in Figure 5-7.



Figure 5-7 Import learning activities modal interface

5.3.4 Portfolio views

After successful importing details from at least one learning space users can create portfolio views. But user has to give unique name to create every portfolio view as shown in Figure 5-8. The following GUI helps users to enter a name for portfolio and also validates whether it is unique or not. It warns user if one chooses the name already taken.

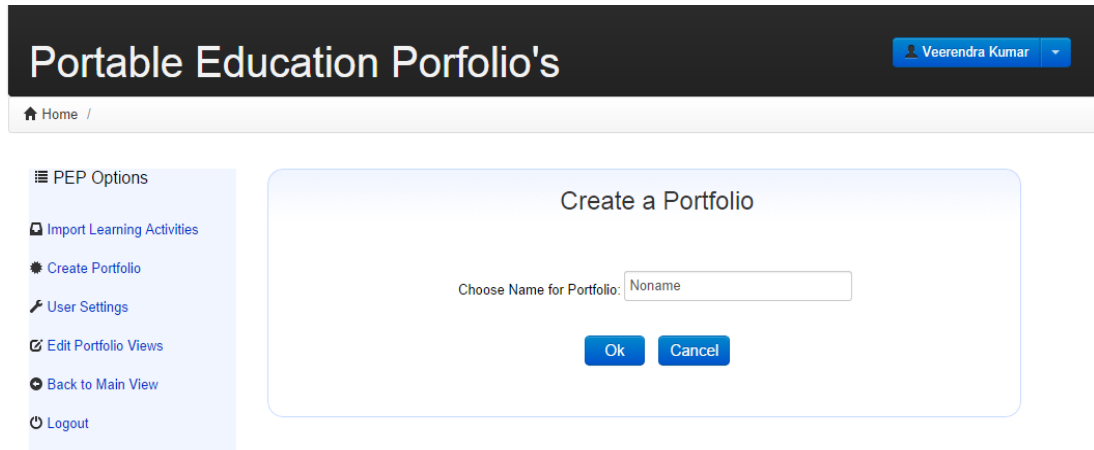


Figure 5-8 Create a portfolio view interface

After user gives a portfolio view name then clicks "ok" button. User will be shown to select the learning activities as shown in figure 5-9. From this GUI, user can check the selected details needed for their portfolio.

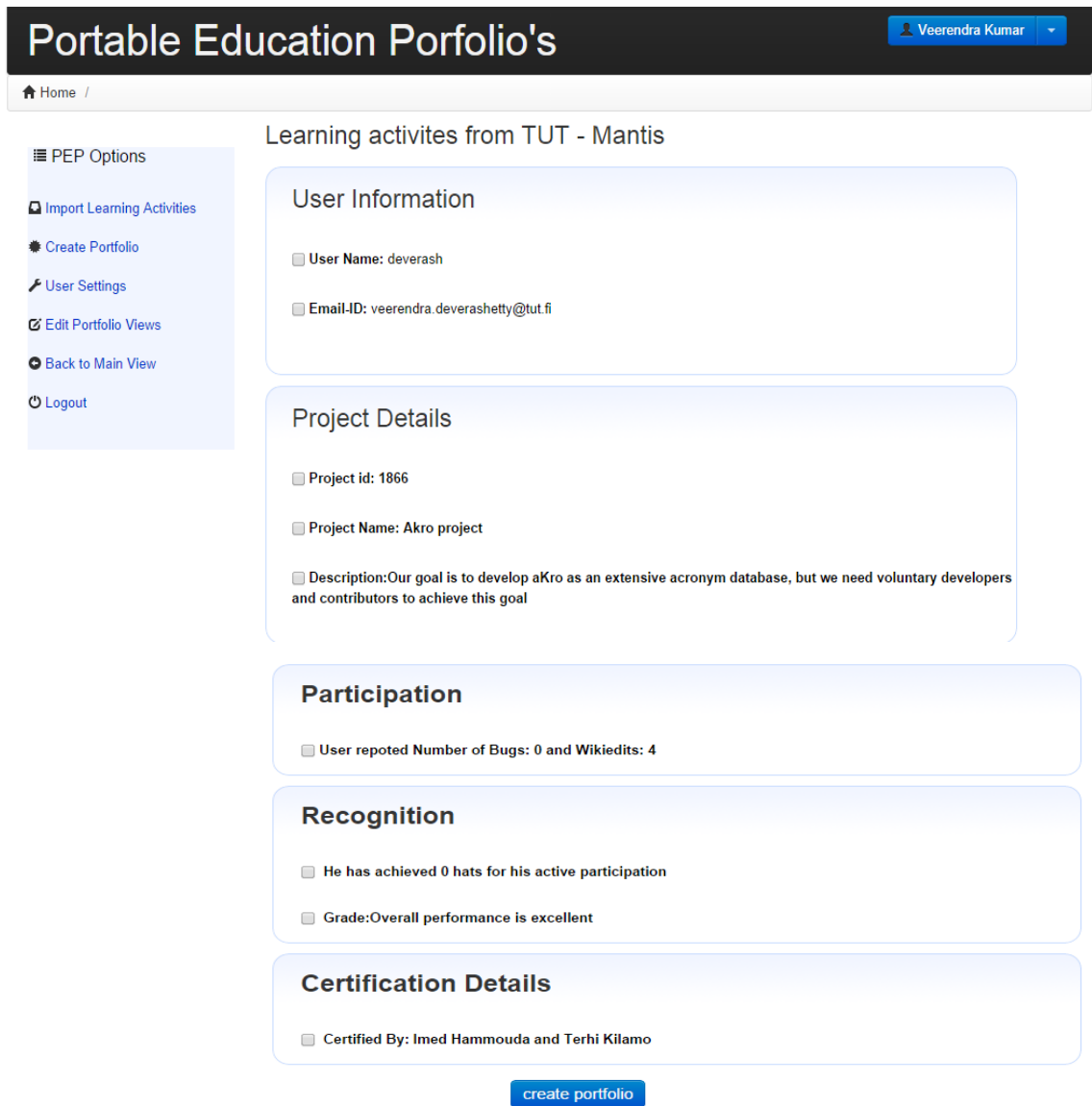


Figure 5-9 Select learning activities interface for portfolio view

After user selects learning activities, then clicks "create portfolio" button. Portfolio view is created with name, user id, password as shown in Figure 5-10. The created portfolio view default mode is 'enable'.

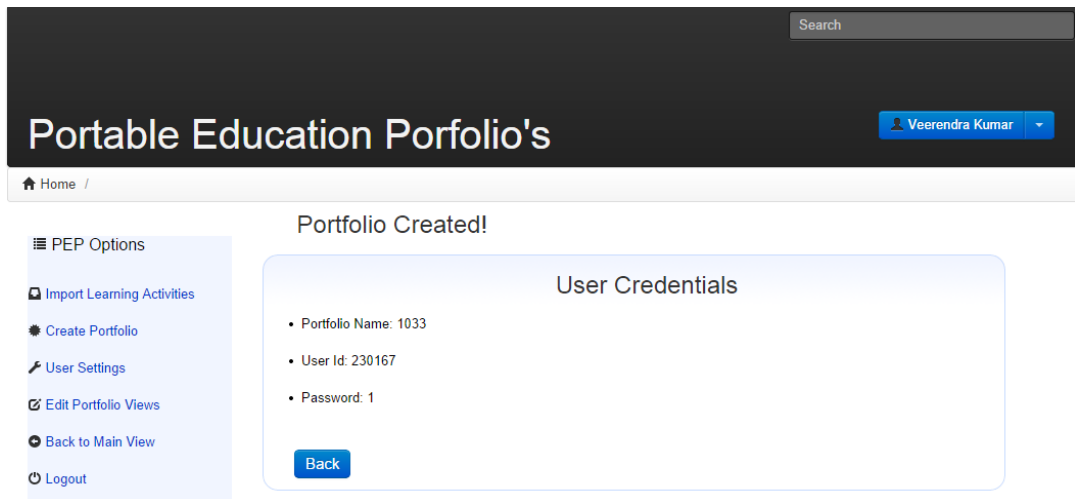


Figure 5-10 User credentials for portfolio view interface

When user clicks "edit portfolio views" from PEP options then Appendix A.3 is displayed. Where user can choose to view credentials, enable, disable or delete portfolio views.

Users can create multiple portfolio views. Every portfolio view has its own credentials. To see them user can select particular view and should click "Go!". Figure 5-11, GUI allows users to select a portfolio to view its credentials.

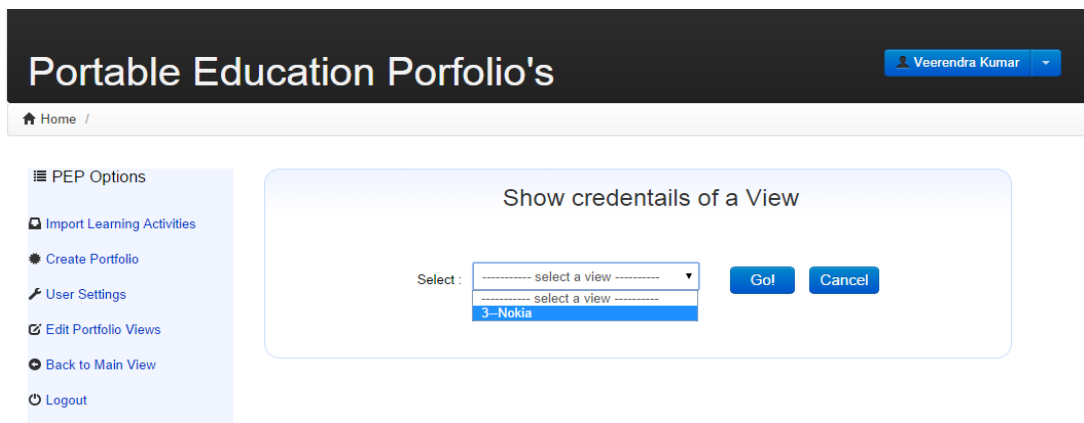


Figure 5-11 Interface for selecting a portfolio view

When user selects a particular portfolio view from Figure 5-11, then following details like userid and password of a view are shown in Figure 5-12. Every view name is unique for all portfolio views that are created.

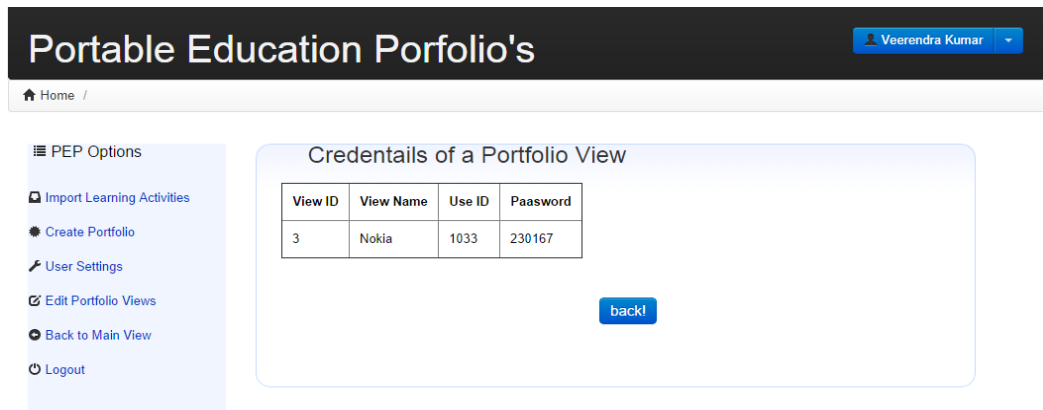


Figure 5-12 Portfolio view credentials interface

In the Appendix A.4, interface allows users to enable the portfolio view. If user enables the view then it can be viewed through PEP viewer by its credentials. This interface shows only disabled portfolios views in the drop-down list.

If user enables a view the following information is displayed through this interface to the user as shown in Appendix A.5. This is a simple interface that shows the information of the portfolio view which is enabled. The back button helps users to go back to the interface shown in Appendix A.4.

In Appendix A.6, interface allows users to disable the portfolio view. If user disables the view then it cannot be viewed through PEP viewer by its credentials. The idea behind disabling the view is if user wants to re-use the portfolio he can disable so that it cannot be viewed by PEPs viewer but later he can enable it.

If user disables a view the following information is displayed through this interface to the user as shown in Appendix A.7.

In Appendix A.8, interface allows users to delete the portfolio view. Deleted portfolios cannot be accessed through PEP viewer.

After successful deletion of selected portfolio view following information is shown in Appendix A.9. Once the portfolio is deleted it is completely removed from the PEPs database. Portfolio view cannot be retrieved back. So user must be careful before doing this action.

5.3.5 User settings interface

When user logs in for the first time then details are obtained from any one of the service i.e Gmail, Yahoo or OpenID. Those details are viewed in this interface. So user can edit

his own information and can update it as shown in figure 5-13. But user cannot edit his Email-ID field because with this email field user authenticate always with SSO service.

The screenshot shows the 'Edit Account Information' form in the 'Portable Education Porfolio's' application. The form fields are as follows:

Field	Value
Email-ID	veerudevarashetty@gmail.com
First Name	Veerendra
Last Name	Devarashetty
Country	IN
Language	en

Figure 5-13 User settings interface

5.4 PEPs Viewer

The main purpose of PEPs viewer is to show the portfolio view created by users. The scenario in which PEPs viewer is actually come into play is when user doesn't want to show his informal activities for a job interview then he can create a portfolio view by selecting which activities suites to the job requirements. Then user can send the credentials of the view created as shown in Figure 5-10 to interviewer or company. Then Interviewer at the company can check user's portfolio through PEPs viewer with the credentials provided by user as shown in Figure 5-14.

If the users want to block others to view the portfolio then he can disable it as shown in Appendix A.6.

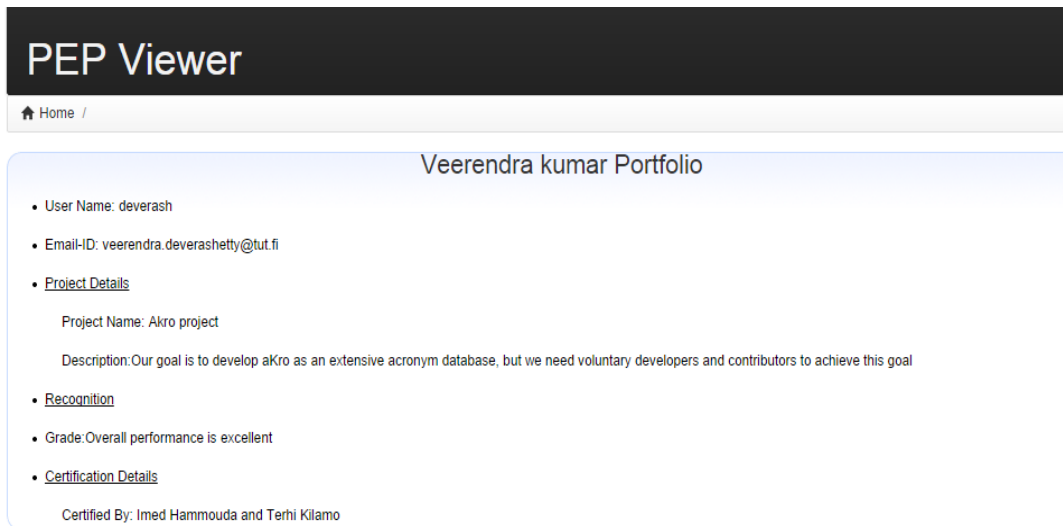


Figure 5-14 PEPs viewer portfolio interface

The PEPs allow users to create multiple portfolios views. This feature helps users to choose relevant learning details to create a portfolio view to a particular job or an interview. Every portfolio created has username and password generated. Unique name should be given to the portfolio created. The created portfolios can be viewed by PEP viewer and accessed through username, password. If user wants others to view his/her portfolio then user can forward username and password to others. The interviewer or an organization who received the credentials can log into the PEPs system and can view the portfolio as shown in Figure 5-14.

Users can go back to the system at any point of time to enable, disable or delete the portfolios views created. Once the portfolio view is deleted it cannot be retrieved back. But if user disables the portfolio then he can enable it back. They can import their learning activities from any system that adapts the architecture of data shown in Chapter 5 Section 5.1 and 5.2.

6. INTEGRATING INFORMAL, FORMAL, AND NON-FORMAL LEARNING ACTIVITIES

The purpose of this thesis is to solve various challenges from the existing portfolio systems. The challenges include LLLP and CPD compliances issues. In order to do so, we designed and developed a portable educational portfolio system (PEPs). In this chapter, we show how the PEPs environment validates itself (using OpenID) to heterogeneous learning spaces including TUT-Mantis, Moodle and OpenSE. We also show how the PEPs environment integrates with these learning spaces for informal, formal and non-formal learning activities. In addition, we import the certified user experiences from these learning spaces.

6.1 Integrating Informal Learning Activities

As mentioned in Section 2.2, informal learning activities takes place in wide variety of places like at home, work and daily interactions with colleagues or among the members of the society. Users involve by selecting a topic or area of study according to their will and contribute their work. Thus we have chosen TUT-Mantis as the informal learning space to integrate the activities of users of the PEPs system.

TUT-Mantis [36, 37] is a bug tracking system which calculates the user's contribution in a community based on this performance. It is used in a course in TUT to evaluate the user's contribution to the community project. An open source infrastructure was setup for the course and a reputation system was constructed. The main goal of the course was to give a practical experience of OSS development in an actual open source infrastructure which in turn should give students the ability to participate in real OSS projects. The activities carried out in the course are informal. As administrator of this course, the implemented features that mentioned in Section 5.2 are deployed in to

Mantis system. It helped us to successfully import learning activities of the users. Thus PEPs can import informal learning activities.

6.1.1 Setting up environment in TUT-Mantis learning space environment

For successful import of learning activities from TUT-Mantis to PEP system, administrator of TUT-Mantis has to provide three important resources to their users as mentioned in Section 5.2. It became easy to deploy the developed interfaces in TUT-mantis because of administration rights. Every user of TUT-Mantis has to do following actions.

Associate OpenID: The following interface as shown in Figure 6-1 is provided to user to associate OpenID. Here user logs to the learning space with his learning space credentials. After successful login to the learning space user has provided a link to associate his OpenID to learning space credentials. The following Figure 6-1 is an example of TUT-Mantis learning space interface illustrates to associate OpenID.

Main | [View Issues](#) | [Report Issue](#) | [FLOSSpedia](#) | [Project Wiki](#) | [Karma Ranks](#) | [Edit your notes](#) | [Manage](#) | [Edit News](#) | [My Account](#) | [Logout](#) | Issue #

Associate your openId to your Mantis account

Enter your OpenID:

Submit

Figure 6-1 Associate OpenID- Mantis interface

Mantis is a platform developed in PHP. Thus it became easy to understand its architecture and develop interfaces for it. When user enters his OpenID in this Associate OpenID interface and clicks "submit" then the OpenID entered is saved into database and associated with the user credentials table.

Interface to authenticate with OpenID: An interface is provided to user to authenticate with the OpenID that he has associated with learning space in Figure 6-1. This interface location is provided to PEPs user to import their learning activities. This address is specified by user in PEPs system in the interface as shown in Figure 5-7. Then PEP system redirects user to interface as shown in Figure 6-2.

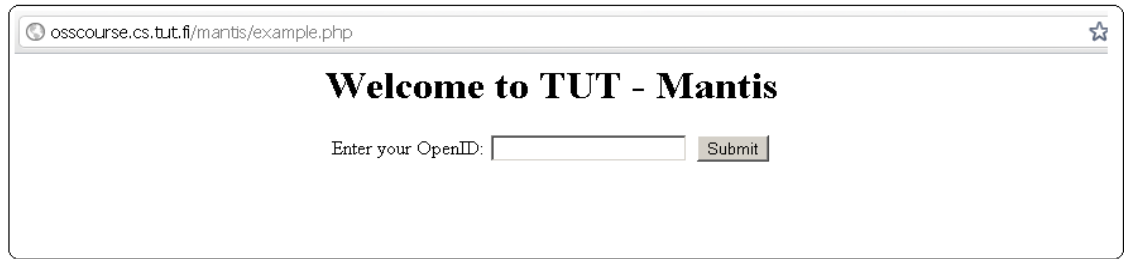


Figure 6-2 Interface to authenticate with OpenID- Mantis interface

When user is redirected to Mantis system, enters the OpenID and identifies through SSO mechanism as specified in Section 4.1. After successful identification users are redirected back to PEPs system with his learning activities. Here SSO mechanism is handled by LightOpenID tool.

6.1.2 Experiences and Results

As mentioned Mantis is a bug tracking system which is used in OSS course taught at TUT [37]. Users can contribute in different ways like wiki edits, reporting bug issues etc. And there is an Akro project which users can contribute to this project by adding the acronyms. These can kind of users actions are considered as their participation. There is Karma reporting interface in which it shows a graph of users participation. So based on their performance users are awarded through hats on weekly basis.

Here we considered wiki edits, bug reports as the users participation. Users recognized through hats in this learning space. Based on number of wiki edits and bug reports grade is decided at the end of the course. Based on these factors, a PHP script file named PEPs.php is implemented which reads the database of Mantis and get the user details based on the OpenID specified by the user. When PEP requests for learning activities the following data is returned from Mantis learning space.

```

<learningproject>
  <lpid>ohj-1866</lpid>
  <lsname>TUT-Mantis</lsname>
  <name>deverash</name>
  <email>veerendra.deverashetty@tut.fi</email>
  <projectname>Akro Project</projectname>
  <projectdesc>Our goal is to develop akro as
                an extensive acronym database,
                but we need voluntary developers
                and contributors to acheive this
                goal.
  </projectdesc>
  <participation>User Reported: Number of Bugs: 5
                and Wiki edits: 4
  </participation>
  <recognition>Number of Hats: 1</recognition>
  <grade>Good</grade>
  <certifiedby>Imed Hammouda and Terhi Kilamo</certifiedby>
</learningproject>

```

Figure 6-3 Sample data collected from TUT-Mantis learning space

Figure 6-3 shows sample data of user learning activities are collected by the PEPs system. In Figure 6-3, participation tag has information regarding user reported regarding bugs and wiki edits and user is recognized through one hat for his performance shown in recognition tag. From the Figure 6-3 successfully user learning activities are imported to PEPs system. Thus PEPs can successfully import informal learning activities.

6.2 Integrating Formal Learning Activities

Formal learning activities are achieved in an organized and structured environment. Here learning is intentional from the user's point of view. These activities can be achieved from universities, colleges, or schools. We have chosen Moodle learning space for collecting formal learning activities. Moodle is used in Tampere University of Technology for handling some courses like Finnish for beginners-1 [38]. The Moodle is

used to grade the assignments submitted by the students and also discuss regarding the course activities.

Moodle [39] is an Open Source Course Management System (CMS), also known as a Learning Management System (LMS), is designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalized learning environments. Many institutions use it as their platform to conduct courses fully online. Some typical features of Moodle are: assignment submission, discussion forum, grading, online calendar, online news, announcement (College and course level), and online quiz.

6.2.1 Setting up environment in Moodle learning space environment

As Moodle is an open source, Moodle 2.2 version is downloaded and installed in the local host successfully. Then created some courses programming-I and programming-II which mimics the courses that offered in TUT. These programming-I and programming-II courses contains the teachings of C++ programming language. A C++ quiz is created as part of the programming-I course and then played the quiz to get some test results.

As Moodle is developed in PHP, it became easy to develop script that creates learning activities for PEPs system. But its database architecture is a bit complex [40]. We deployed LightOpenID tool successfully with Moodle learning space. Then PEPs.php is modified according to Moodle stack that interacts with database tables and gets the learning activities, and creates XML file for PEPs system.

6.2.2 Experiences and Results

Setting up the environment of Moodle is quite easy. And there is good documentation of how to use Moodle environment is available online [39]. But Moodle's database is quite complex architecture [40]. So it took more time to understand and program for it. As Moodle is developed with PHP 5, it became easy to develop interfaces when PEPs makes a request call to it.

As mentioned the quiz for C++ course, we gave some grades based on the score of the quiz. Then a call is requested from PEPs to import my learning activities from Moodle learning space. The imported learning activities are shown in Figure 6-4.

```

<learningproject>
  <lpid>Project1</lpid>
  <lsname>Moodle</lsname>
  <name>deverash</name>
  <email>veerendra.deverashetty@tut.fi</email>
  <projectname>C++ Quiz</projectname>
  <projectdesc>This is an C++ Programming Quiz.
</projectdesc>
  <participation>Number of times quiz taken: 5
</participation>
  <recognition>Highest Score: 19 out of 20</recognition>
  <grade></grade>
  <certifiedby>Moodle Organization</certifiedby>
</learningproject>

```

Figure 6-4 Sample data collected from Moodle learning space

Figure 6-4 shows sample data of user learning activities are collected by the PEPs system from Moodle learning environment. In Figure 6-4, participation tag has information regarding number of times user participated in the quiz. And user is recognized through score, obtained based on number of questions were correct as shown in recognition tag. From the Figure 6-4 successfully user learning activities are imported to PEPs system. So PEPs can successfully import formal learning activities.

6.3 Integrating Non-formal Learning Activities

As we know, non-formal learning occurs when user involves some workshops, community courses, conference style seminars [9]. Here learning is part of the planned activities but not always and learning is intentional from the user's perspective. OpenSE platform is chosen as to collect non-formal learning activities.

OpenSE [41] is a learning space where users can contribute to different learning projects. It provides open source projects, mentored internships, and educational games to learners. It allows users to learn from what others learned and achieved. User can learn alone or with other learners in openSE. Users will not get any credits from their

contribution but they are recognized by badges. In the following sections we see how PEPs import those activities of the user.

6.3.1 Setting up environment in OpenSE learning space environment

OpenSE platform is a vast environment which provides online learners to submit their internship projects and get recognized. A study was done to figure out how the system architecture is implemented. Based on this study we created a temporary address to launch the interfaces required for other learning spaces.

As OpenSE is developed in PHP, it became easy to develop script that creates learning activities for PEPs system. But its database architecture and also the coding is complex. We deployed LightOpenID tool successfully with OpenSE learning space and created temporary tables with records. Then created a file named PEPs.php which interacts with database tables is deployed into the platform. With the help of the PEPs.php file we get the learning activities related to the user from database and then creates XML file for PEPs system.

6.3.2 Experiences and Results

The OpenSE is wide and huge environment for learners to exchange their ideas. There are many learners who always collaborate through OpenSE. The temporary records were created in the database which doesn't affect the live data. It took lot of time to understand the architecture of OpenSE because of its vastness. The coding is in PHP so it became easy to launch interfaces and communicate with back-end of OpenSE.

As mentioned earlier, we inserted some dummy records for test user account to test it. It actually replicates the live data of OpenSE. Then a call is requested from the PEPs to import my learning activities from OpenSE learning space and successfully imported learning activities as shown in Figure 6-5.

```

<learningproject>
  <lpid>ProjectCode-1866</lpid>
  <lsname>OpenSE</lsname>
  <name>deverash</name>
  <email>veerendra.deverashetty@tut.fi</email>
  <projectname>PEPS</projectname>
  <projectdesc>Import user experiences from
  heterogeneous learning spaces
</projectdesc>
  <participation>Projects Submitted: 5
</participation>
  <recognition>Badges: Qualified, Beginner</recognition>
  <grade></grade>
  <certifiedby>OpenSE Organization</certifiedby>
</learningproject>

```

Figure 6-5 Sample data collected from OpenSE learning space

Figure 6-5 shows sample data of user learning activities are collected by the PEPs system from OpenSE learning environment. In Figure 6-5, Number of projects submitted information is present in participation tag and user is recognized through badges, obtained based on user performance as shown in recognition tag. Figure 6-5 shows that successfully user learning activities are imported to PEPs system. So PEPs can successfully import non-formal learning activities.

From the case study, towards the goal of the MSc thesis the implemented system successfully imports three different activities from heterogeneous learning spaces, which completes the aim of LLLP.

7. DISCUSSION

The main aim of the thesis is to address and solve the key challenges of the widely used educational portfolio systems including LinkedIn, Mahara and Open-badges. The problem statement for this thesis is how to systematically collect those heterogeneous learning activities into well-organized education portfolios.

In other words, different learning environments have their own data formats and storage mechanisms. To obtain the user experiences from heterogeneous learning spaces we need a specified format to communicate the data between different systems. We have chosen XML as the data format because it is easy to understand, modify and extend. We proposed a generic data model which is implemented in an iterative process of DSRM. The proposed data model is designed by studying distant learning spaces, where each learning space has different form of activities. Thus, every learning space environment has to provide the requested user experiences in the format of generic data model.

Due to the nature of this research, it falls under information system (IS) research domain. The main goal of IS domain is to develop IT artifacts. The recent trend in IS domain shows that studies are increasingly adopting the DSRM that mixed with other methodologies [13]. Here DSRM is chosen to be utilized with PEPs tool to integrate with heterogeneous learning spaces. DSRM, which consists of 5 phases, phase 1 identifies the problem and phases 2, 3 and 4 anticipate addressing research objectives. Phase 2, specifies the problems in the existing systems. Phases 3 and 4, provides a robust prototype of PEPs system and also modules implemented in it. Phase 5 demonstrates the use of PEPs system and applied on three different learning spaces.

With the implemented PEPs system, we applied the PEPs tool with three learning spaces TUT-Mantis, Moodle, OpenSE to obtain Informal, Formal and Non-formal learning activities respectively. Chapter 6 discusses about the integration details like deploying the tool, challenges faced while implementing interfaces to the learning space

environment, and successful getting of certified user experiences. Thus we have shown that the PEPs system helps the education portfolios to handle complete LLLP and CDP. After obtaining the certified user experiences, we created some portfolio views through PEPs engine. These portfolio views are created to test whether they can be viewed through PEPs viewer or not. When we created the portfolio views PEPs engine provided user id and password associated for those portfolio views.

PEPs viewer is another module of stage 3 in DSRM. Here if any user like Interviewer or other stakeholder needs to watch others portfolio then they has to get the credentials for the portfolio from the PEPs user. If PEPs user provided those credentials, they can login to view a user portfolio through PEPs viewer. We created few portfolio views and with those credentials we successfully viewed the portfolio.

To obtain certified user experiences we introduced the authentication method using SSO mechanism, i.e. When PEPs user requests the data from any learning space before obtaining the details the requested user has to authenticate through SSO. Thus details obtained are authenticated and certified from that learning space. Not only authenticated details are obtained with SSO, it also reduces cumbersome of user to remember credentials for each and every learning space.

The output of this thesis is an IT artifact i.e. PEPs system which solves the current problem of education portfolios, thus this research comes under FLOSS project. Here our community is OpenSE, and TUT open source members. The research is carried out under the ideas of this community. The results of the research were shown and modifications were proposed based on the ideas of these members. The research is carried out as the top to bottom stages of DSRM. As a large number of growing participants in MOOCs like in Khan academy, user contributions is happening from anywhere and anytime. Thus the produced PEPs system can be modified and applied to MOOCs which helps learners to keep track of their work efforts in an easy way.

In greater context, the system holds a generalized model to get the certified learning experiences from heterogeneous learning spaces. However the model can be easily modified and adjustable to different learning environments.

8. CONCLUSIONS

The thesis studied the problems of present educational portfolios. The implemented PEPs environment aim is to handle the issues of education portfolios. The approach of PEPs tool allows learners to successfully collect all their learning activities from heterogeneous learning spaces.

The advancement in IT field given rise to new learning space platforms for learners, to actively participate and get some recognition. Hence different learners are gaining different learning experiences from heterogeneous learning spaces. A key challenge is how to systematically collect those heterogeneous learning activities into well-organized education portfolios. Education portfolios are collection of learner activities. The goal was to create environment which helps learners to collect their learning experiences from heterogeneous learning spaces through Portable Education Portfolios system. This system makes learners life easy to interact with heterogeneous learning spaces.

The approach of PEPs tool allows learners to collect all their learning activities from heterogeneous learning spaces. It uses a generic data model that handles different types of web service platforms. This model made PEPs to interact easy with different learning spaces. PEPs architecture is simple and straightforward. The environment also allows users to create multiple views of portfolio. So it helps users to show which learning experiences they are willing to show depending on the situation.

The current implementation of a PEPs system has been applied on three different learning spaces: TUT-Mantis, Moodle and OpenSE. It is able to import formal, informal and non-formal activities successfully and reached the goal of LLLP. The implementation of PEPs is based on the different types of learning activities in which user involve. So based on these activities a generic data model is designed that handles different types of web service platforms. The model can be easily extended and modified according to the needs.

The use of PEPs system is to keep track of users learning activities to achieve LLLP. PEPs easily interact with different learning spaces. But learning space administrators has to implement some features in their learning environment and the set up required for learning spaces are pretty simple to implement as shown from Chapter 5. With the help of OpenID, authentication of evidences is successfully solved. Here evidence relates to learning activities of user. From the case studies in Chapter 5 shows PEPs tool can handle formal, informal, non-formal educational activities.

The current system of PEPs is developed to handle all learning experiences related to learners. In future, PEPs system can be extended to support learner activities for practitioners. Practitioners PEPs extends the features of existing PEPs system. They include the supervising activities of practitioners, and also practitioners can rank and comment on the learner's experiences.

Finally, based on these experiences and results from different learning spaces PEPs system would be a better system to solve problems related to today's educational portfolios.

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APPENDIX A

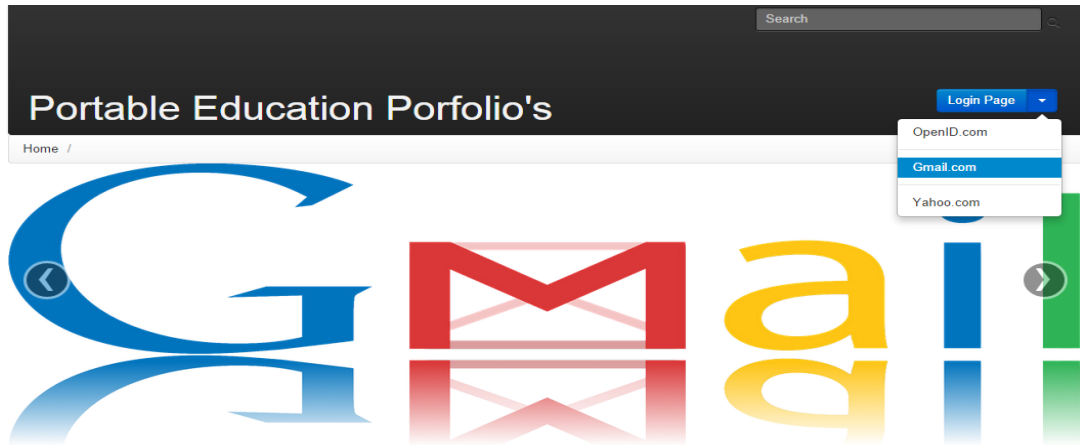


Figure A.1 Login page for PEP system

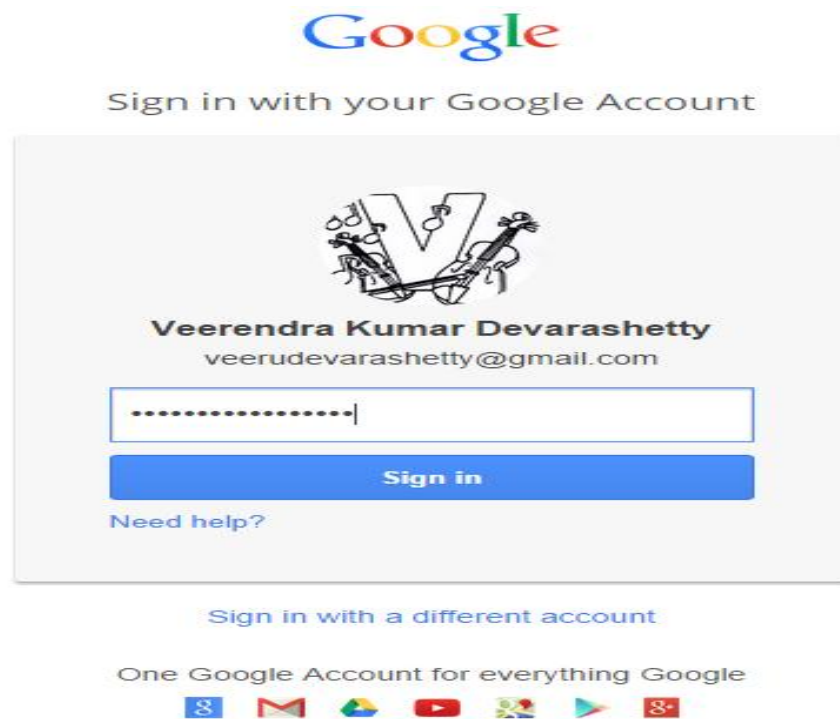


Figure A.2 Gmail Login page for PEP system

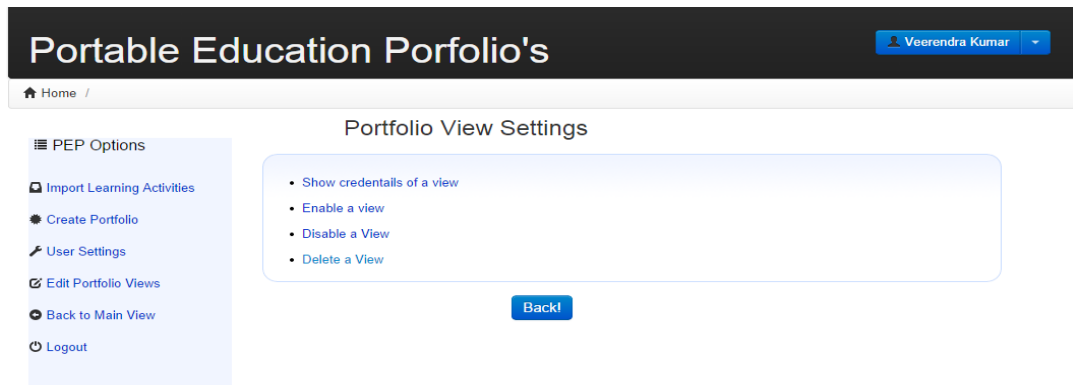


Figure A.3 Interface for portfolio view settings

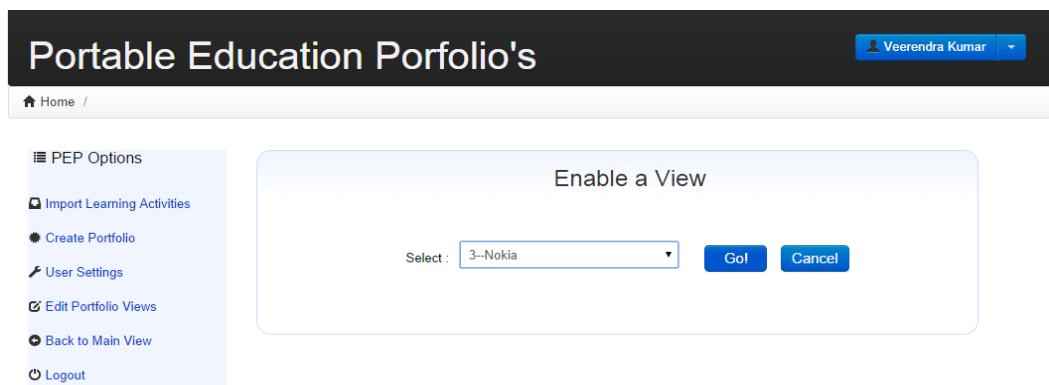


Figure A.4 Enable portfolio view interface

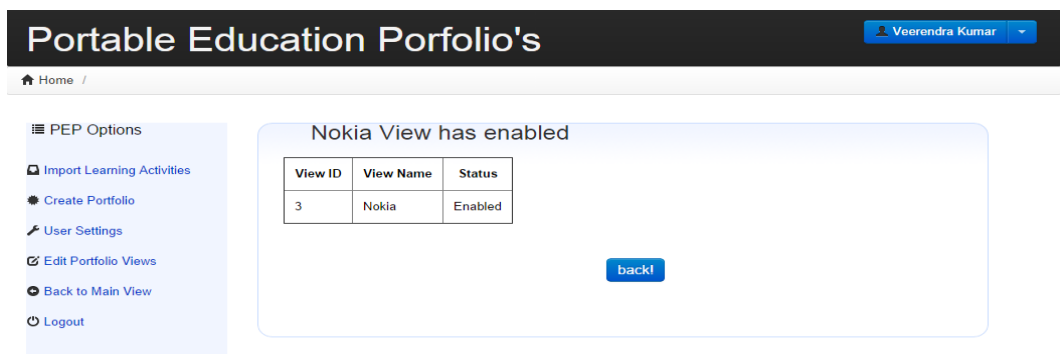


Figure A.5 Enable portfolio success interface

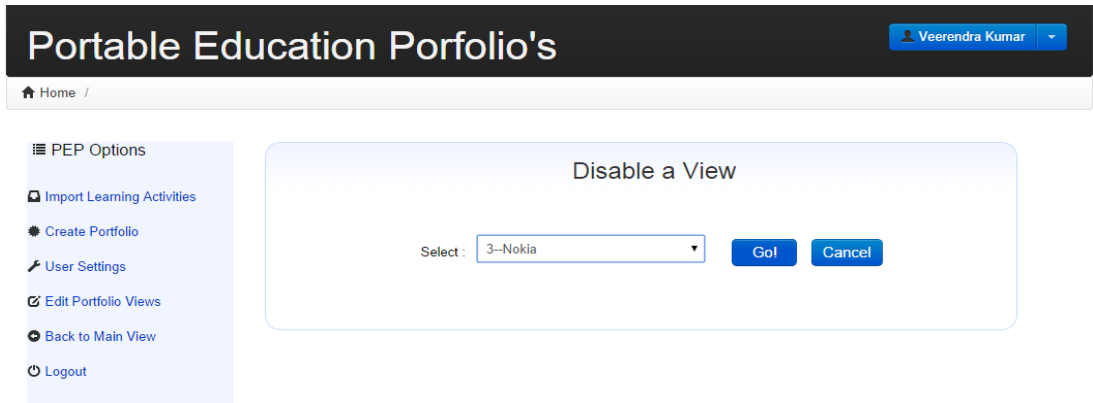


Figure A.6 Disable portfolio interface

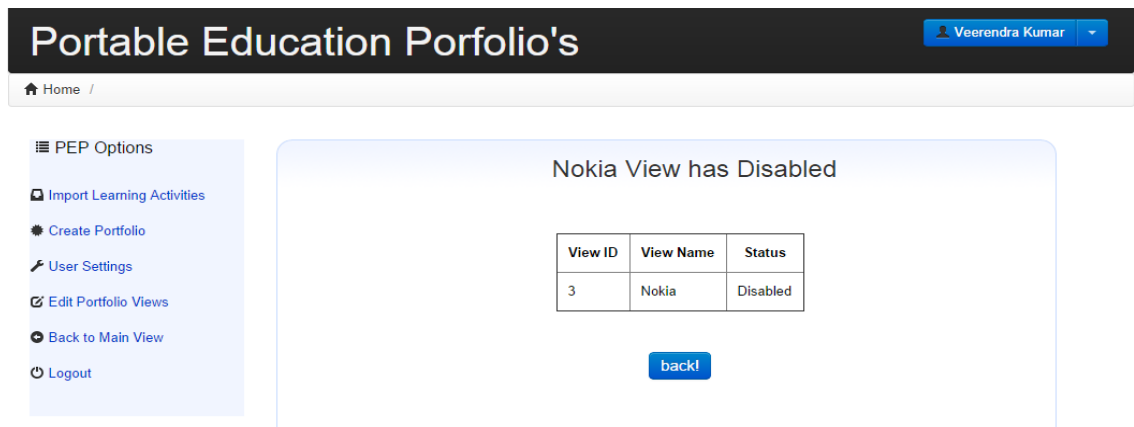


Figure A.7 Disable portfolio success interface

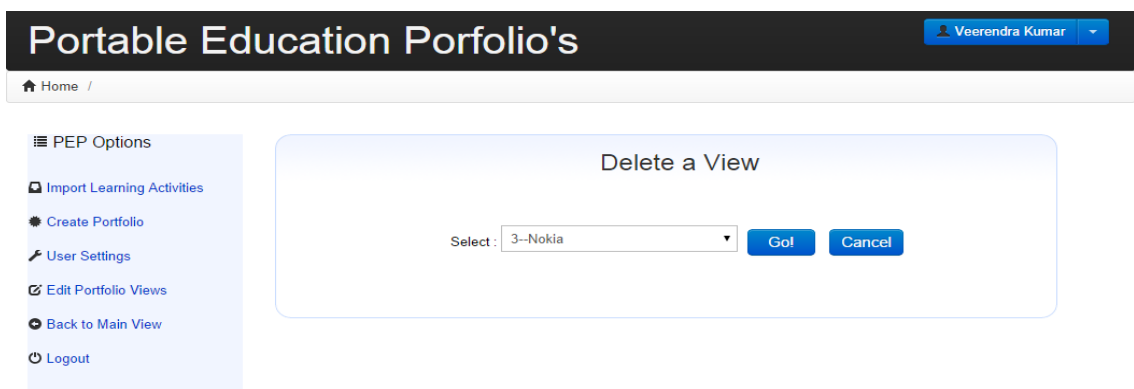


Figure A.8 Delete portfolio view interface

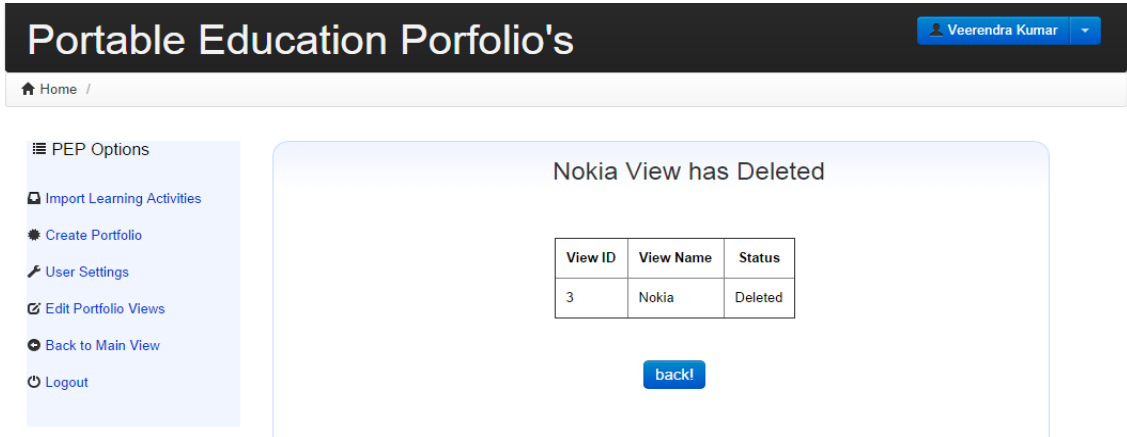


Figure A.9 Delete portfolio success interface