An Intelligent Learning Support System

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Abstract: Fast-growing technologies are shaping many aspects of societies. Educational systems, in general, are still rather traditional: learner applies for school or university, chooses the subject, takes the courses, and finally graduates. The problem is that labor markets are constantly changing and the needed professional skills might not match with the curriculum of the educational program. It might be that it is not even possible to learn a combination of desired skills within one educational organization. For example, there are only a few universities that can provide high-quality teaching in several different areas. Therefore, learners may have to study specific modules and units somewhere else, for example, in massive open online courses. A person, who is learning some particular content from outside of the university, could have some knowledge gaps which should be recognized. We argue that it is possible to respond to these challenges with adaptive, intelligent, and personalized learning systems that utilize data analytics, machine learning, and Semantic Web technologies. In this paper, we propose a model for an Intelligent Learning Support System that guides learner during the whole lifecycle using semantic annotation methodology. Semantic annotation of learning materials is done not only on the course level but also at the content level to perform semantic reasoning about the possible learning gaps. Based on this reasoning, the system can recommend extensive learning material.

1 INTRODUCTION

Many young people face difficulties when trying to decide what kind of education to apply. Once the approval to the wanted education is achieved, many decisions must be made: which subjects to choose, what courses to put to the personal study plan, what courses are relevant in future job markets, or if the official curriculum should be supported with supplemental education from the private sector. These decisions might have life-long effects, but often the resources for making the right choices are limited. People should recognize their competitive advantages and put them in the perspective of global trends, technological development, and labor markets. Not only young people have such need, but many graduates and experienced workers also face the situation of economic change, and suddenly they have to adjust their competence by improving and extending their skills.

In welfare countries, flexible education system offers quite a many options to choose. The possibilities are so widespread that it is not easy to make the right choice without a comprehensive analysis of person's capabilities, ambitions, and values against the future labor markets. However, only a small amount of people have an actual freedom to choose their future profession. Usually, people have to be competitive enough to survive, especially in the times of crisis, and those who have the possibility, are changing their location to get a better education for themselves. On the contrary, it has become possible to get the education from another side of the world, especially in higher education. Massive open online courses and learning platforms like Udemy, Khan Academy, and Coursera are helping people to get desired skills (e.g., programming, developer skills, and data analytics) without leaving home. However, some courses have pre-requirements, so that it would be quite difficult to attend courses without filling the existing knowledge gaps by studying an additional learning material.

Educational systems are structured around curricula that aim to supply people with the defined competencies. The problem is that employers are more and more finding people with various skills and backgrounds, which may not be in line with the curriculum. Therefore, people should be able to create specific curriculum and be educated following personal learning trajectory. To meet this demand, topics around different learning support systems have become popular. For example, the Open University of Hong Kong has developed a system that instantly responds to inquiries about career development, pro-

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gram and course choices, study plans, and graduation checks (Leung et al., 2010). While these systems have potential, the problem is that they should be connected with various educational and career planning services. We can already verify this issue by looking how many different job portals there exists, both nationally and globally.

We argue that there is a need for an Intelligent Learning Support System (ILSS), which will be based on current research information about adaptive, personalized, and intelligent tools. We begin by reviewing the current body of knowledge about these topics. Next, we explain the whole ecosystem of ILSS and the components it includes. Finally, we discuss implications that must be considered when implementing this kind of system. This proposition paper is current because the development of adaptive, personalized, and intelligent systems for education are still in the premature phase in Finland, where technological infrastructure is Finland under reconstruction: The government's aim is to standardize and integrate the social and health care systems, including the career and employment services. Students, job seekers, employment officials, and company headhunters would benefit from a centralized system that aims to make educational interests and employment supply meet.

2 LITERATURE REVIEW

Each person has different knowledge background, ability to memorize, learning speed, motivation, and preferences. Furthermore, people have different health conditions and habits when and how to learn. The problem with educational applications is that they are built for a specific group of learners and not individually. Therefore, development of learning environments with individualized learning mechanisms is an important research topic. Researchers are interested in developing learning environments, which could adaptively provide learning path (Chen, 2008), but the challenge is the development of advanced learning applications that include intelligence and adaptivity (Brusilovsky and Peylo, 2003).

Intelligent learning systems are related to adaptive learning systems and have an intersection (Brusilovsky and Peylo, 2003). Intelligent systems are "systems which use techniques from Artificial Intelligence to provide better support and feedback for learners" (Brusilovsky and Peylo, 2003) and adaptive systems are "systems which attempt to be different for each learner or group of learners" according to information about learners received during their actions (Brusilovsky and Peylo, 2003). Personalized systems present a specific type of general adaptive systems (García-Barrios et al., 2005) and they mean adaptation towards a specific learner.

Computer based training or computer aided learning does not use a model of the learner's knowledge and does not take into account personality of the learner, but it just uses traditional instructional methods (Phobun and Vicheanpanya, 2010). The combination of adaptation, intelligence and personalization could make this better. The interaction with the learner would not only report the correct or incorrect answers, but also explanations of the error cause, and recommendations for study material.

The development of adaptive, intelligent, and personalized learning systems is important, especially for children with disabilities, because they require more personalization during their learning process. These techniques should allow them to learn at their pace and help to keep their motivation (Gavriushenko et al., 2016).

2.1 Personalized Learning Systems

Many authors suggest in their work different tools for learning systems, which could assist in learning and make this process more personalized. For example, in the work (Bendakir and Aïmeur, 2006) authors presented a course recommendation system which analyzes past behavior of learners concerning their choices. Authors used data mining association rules (user ratings), and this classification makes possible to build a decision tree that classifies each learner profiles. The system recommends learning path by checking which courses are followed simultaneously. Unfortunately, proposed system does not consider learners' background and course availability. Also, researchers (Werghi and Kamoun, 2009) have presented a decision support system for learner advising which provides an automated program planning and scheduling service that fits best their profiles while meeting academic requirements. The system was based on decision tree algorithm. The work (Jeong et al., 2012) presented a personalized learning course planner with decision support using user profile. This system allows the learner to select the learning course they desire taking into account previous learning information of learner. Authors used organization algorithm containing the decision matrix. The proposed system improved learning effectiveness and especially learners' satisfactory according to the questionnaire. Also, in a paper (Jyothi et al., 2012) was presented a recommender system which assists the instructor in building learning path, more specifically in identifying the groups of learners who have similar learning styles and then providing recommendations to these learners. Authors used Felder-Silverman learning style model.

2.2 Intelligent and Adaptive Learning Systems

Some research papers were concentrated on developing intelligent and adaptive applications for learning which could fully or partially reduce the involvement of human advisers. For example, in the work (Henderson and Goodridge, 2015) authors proposed a system which gives accurate advice only to those pursuing ”special degrees” or programs which follow a clear cut path of courses. This system is an intelligent Web-based application for the handling of general advising cases. Authors used Semantic Web technologies for designing this system. Also, in the work (Wen and McGreal, 2007) system allows learners to add preferences of the specialization to their profile and then recommend courses based on their preferences. The proposed system uses a multiple intelligent agents approach and ontology-driven methodology to tackle a dynamic and complex individualized study planning problem. In other research, (Nurjanah, 2016) authors proposed recommender system in adaptive learning which recommends learning materials for learners. This system combines content-based filtering and collaborative filtering approach which is based on the similarity between learners and learners' competencies. The result of the proposed new technique of recommendation showed that it performs well. In paper (Myneni et al., 2013) authors presented an interactive and intelligent learning system for physics education. This environment helps learners master physics concepts in the context of pulleys. System guides learners in problem-solving. Authors used the Bayesian network for pulley setup. In the work (Dolenc and Aberšek, 2015) authors demonstrate the design and evaluation of intelligent tutoring system based on cognitive characteristics of the learner. This model is based on a system for collecting metadata and variables that are vital for the teaching process. The important thing in this research is that system can be adapted to the different level of learner's knowledge and understanding subject matters. Authors in paper (Canales et al., 2007) suggest an adaptive and intelligent Web-based education systems that take into account the individual learning requirements. They proposed three modules for that: an Authoring tool, a Semantic Web-based Evaluation, and Cognitive Maps-based Learner Model. Proposed approach is focused on reusability, accessibility, durability, and interoperability of the learning content.

There are many intelligent tools developed for learning systems which are effective and shows good results. However, there are not much tools or systems which could help learner during his whole lifecycle.

3 ARGUMENTATION FOR THE ILSS

This section proposes the ecosystem of the Intelligent Learning Support System (as presented in figure 1) and describes the main mechanisms that allow learners to get learning content recommendations. The model of the system based on semantic technology. At first, we discuss using Semantic Web in building ILSS. After, the main blocks of the system are presented in sub-chapters. The proposed system is now in the development stage and includes the necessary functionality description required.

3.1 Using Semantic Web in Building ILSS

Developing adaptive, intelligent, and personalized systems require comprehensive knowledge in the domain and flexible mechanism for further extension of it as well as the automated mechanism for contextual information retrieval. It will require representation of knowledge, which is widely distributed among different organizations, freely available, and presented in machine readable form. The system should adopt benefits of Semantic Web and linked data technologies, as well as, be facilitated by text mining and natural language processing techniques.

There has been many studies proposed for the intelligent study advising utilizing Semantic Web technologies (Henderson and Goodridge, 2015; Gavriushenko et al., 2015; Ranganathan and Brown, 2007; Nguyen et al., 2008; Jovanović et al., 2007). Authors in (Dicheva et al., 2009; Jovanovic et al., 2007) used ontologies and Semantic Web in curriculum development and in institutional support and adaptation. Semantic Web helps formalize learning object content, shows how to use semantic annotation to interrelate diverse learning artifacts (Jovanović et al., 2009).

Semantic Web aims at integrating various types of information into a single structure, where each semantic data element will meet special syntactic block. It provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries (Berners-Lee et al., 2001). Semantic Web achieving interoperabil-

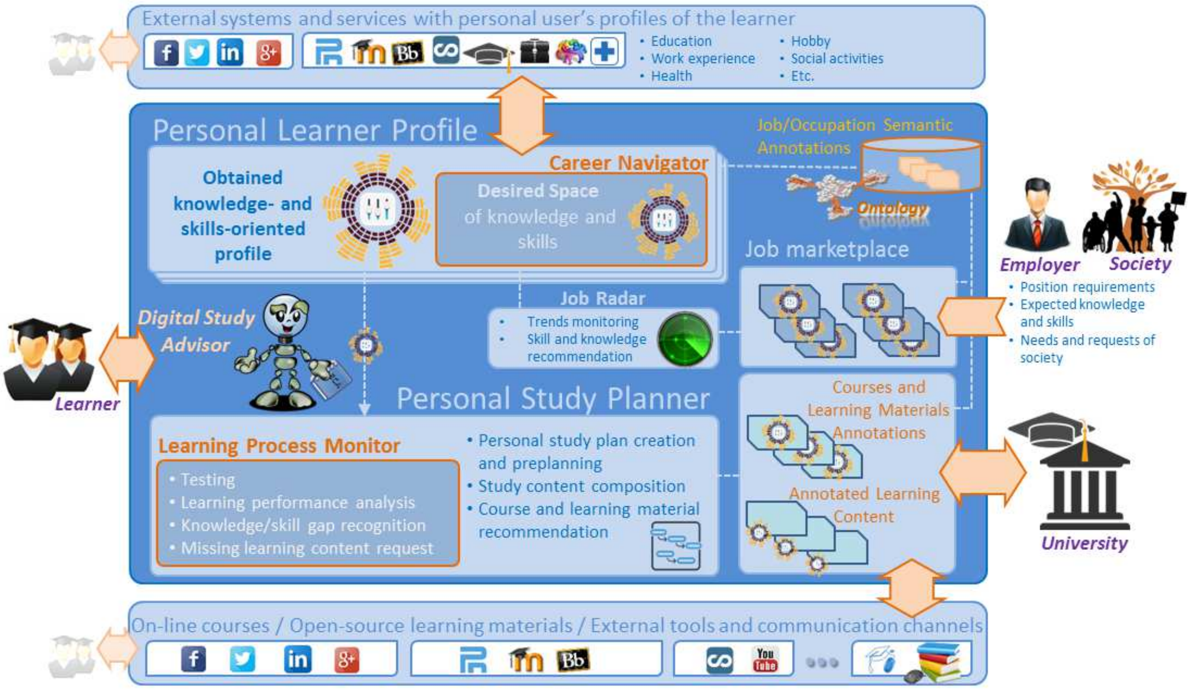

Figure 1: General ecosystem of an Intelligent Learning Support System.

ity among various educational systems and unified authoring support for the creation (Aroyo and Dicheva, 2004). The other branch of the Semantic Web associated with a direction close to the field of artificial intelligence, and it is called the ontological approach.

The ontological approach means a formal representations of a set of concepts within a domain and the relationships between those concepts (knowledge base). Under the knowledge base, we understand complex data structure that stores the knowledge domain. Typically, the knowledge base is represented as a graph in which the vertexes are one unit of learning, that is the simple essence of knowledge (training course, the term, the definition of the formula – depends on an agreement between system's makers that they will assume a basic understanding of the essence). The arcs are seeing as all kinds of links between training units.

Knowledge bases are used for solving problems like creation, transformation, and usage of content while learning. The engineering part includes the creation of the educational plans and their e-learning resources. Management part problems are solved directly during the learning process and are focused on operational adjustment training course depending on the results of the test control of learners' intermediate mastering of the material. Creation of the ontologies as knowledge bases are very useful for tests creation, automation of the evaluation, and management of the training paths based on the results of testing.

To be processed by intelligence (applications, services) and be consumed by end-user in a best optimal way, learning content should be adapted to the digital world of intelligent entities and must be supplied with correspondent semantic annotation. Semantic annotation provides a set of worldwide standards, which helps in operating with heterogeneous resources using common syntax and methods (Uren et al., 2006). Semantic annotation by the rules identifies concepts and their relationships, and it is meant for use by machines (Uren et al., 2006). Semantic annotation was presented and successfully applied in papers (Jovanović et al., 2009; Jovanović et al., 2007), where authors presented ontology-based approach to automate annotation of learning objects and tested it in integrated learning environment for domain of Intelligent Information Systems.

Providing the personalized point of view on content annotation, learner extends a pool of context dependent semantic annotations for the same content. Later, annotations might be transformed into a set of different annotations for the same content on the different clusters of the learners as well as to the wide variety of other contexts. Such clustered semantic annotations will enhance matchmaking for new content retrieving and personalized content recommendation processes.

3.2 Courses and Learning Material Annotation Module and Annotated Learning Content mModule

Usually, educational material and content are presented in the same way for everybody, without taking into account learner's existing knowledge, goals for browsing, preferences, and experience. This issue needs more attention, especially when it comes to e-learning because the learner is supposed to take responsibility for one's studies. The main factors that should be taken into account are learner's knowledge background, age, experience, motivations, professions and goals (Huang et al., 2007).

The common feature of learning support systems is that they have some grade range for learners of different learning levels. Usually, there is some pre-test which can determine learner knowledge and create simple learning path according to the particular level of the learner. A simple adaptation algorithm adds that if the learner makes lots of mistakes, the system returns the learner to the previous level. Otherwise, the system allows the learner to proceed. The threshold of right answers can be eighty percent. Unfortunately, twenty percent of wrong answers can mean that some critical knowledge may be missed, which can interrupt the process in future. It is important to keep track what learner does not exactly know and how this particular knowledge could be improved. The main idea is to find learning gaps which influence the learning process and recommend material to help the learner to fulfill those gaps. Same kind of learning gaps can also occur when the learner is searching for a specific skill and has to take some additional courses that are not included in the curriculum. The targeted courses might have prerequisites, which the person can not meet at the moment.

From the employer's point of view, it is not always possible to recognize the potential of a job seeker from a list of completed courses or degrees. The names of different courses do not always say much about actual content, or even opposite may bring wrong expectations about skillfulness of a person who passed them. Depending on the educational organization, there might be a huge difference between the content of courses with similar names.

It might be more reasonable to see an approximate level of particular skills of a person, to see an expectation of the potential to resolve the certain class of problems. Therefore, all the course descriptions or meta-information should include some explicit reference to skills and knowledge that it is aimed to lead or influence. Thus, having such skills and knowledge oriented annotation of courses and learning materials, it is possible to facilitate a better guidance for a learner.

If we make a straightforward assumption, that the aim of education is to develop certain knowledge and skills to be applied in different occupations, learner chooses education steps (university, program, course, lecture) for a certain goal (profession, career, occupation). Unfortunately, the learner may not be aware enough of the required skills or knowledge for this goal. Therefore, occupations and job descriptions should include skills- and knowledge-oriented annotation as well.

In this work we use semantic annotations with the use of ontologies (as presented in figure 2). Ontologies were used for storing and modeling information about learners, teachers, courses, specializations, universities, careers, job offers, among other things. With ontologies it is possible in future to apply methods of semantic alignment for matching the ontologies (Heath and Bizer, 2011; Berners-Lee, 2006; Henderson and Goodridge, 2015), if there will be some other existing ontologies which are related to our educational system. Nowadays, many tools exist for the creation and matching ontologies which have proven themselves well (Berners-Lee et al., 2001; Shvaiko and Euzenat, 2013). The implementation process was done by Protégé-tool which is the most widely used and offers a complete development environment.

3.3 Personal Learner Profile Module

The educational system produces a wide amount of data related to learning, performance, difficulties, and experiences. This information can be stored in a Personal Learner Profile (PLP), which always support changes and keeps the information up-to-date. Interfaces to profile give access to only authenticated learners and systems. The knowledge base would give anonymous data for pedagogical development purposes. Individual learners would be able to access the information related to themselves. Information stored in the personal profile would consist of: study history, work experience, personality, learning plans, learning difficulties, hobby, and social activities.

The PLP would be connected to the external system and services with learner's profiles that connects different systems, services, and databases, for example, the national social and health systems. The ILSS will be developed to analyze the information from systems connected with the digital service channel. The system is based on current research knowledge, and it will have various kind of pedagogical information related to learning theories, practices, environments, and special needs.

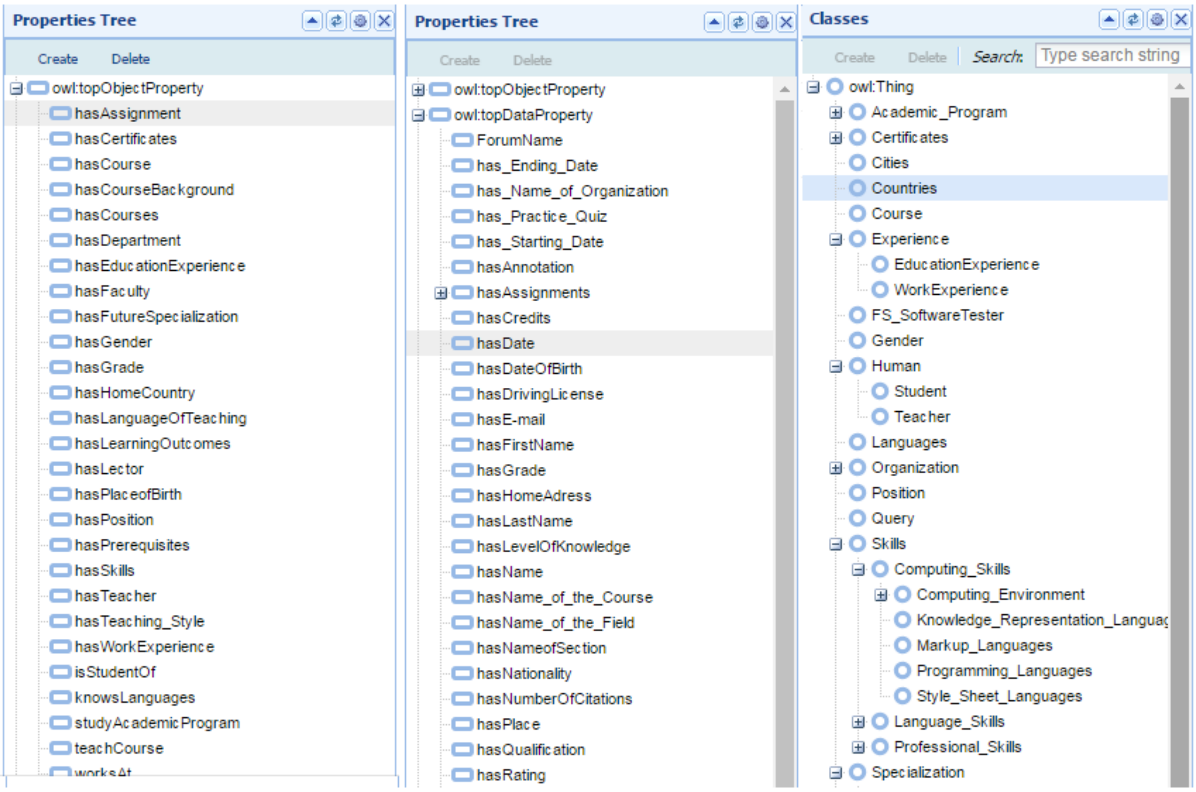

Figure 2: Proposed ontology for an Intelligent Learning Support System.

The PLP contains current skills- and knowledge-oriented profile of a learner in the form of a vector in multi-dimensional space of knowledge and skills. The *Career Navigator* module helps the learner to build a desired/aimed space of knowledge and skills, based on selected occupations/jobs the learner aims. The Career Navigator is connected to the *Job market place* that contains: job and occupation descriptions published by employers, national needs and requirements, and expectations of society. The Career Navigator is facilitated with proactive ”Job Radar” module that monitors/analyses changes in the Job marketplace and informs learner about latest trends. The Career Navigator tool should match curricula, various certificates, job history and other measured skills of a person with the description of profession and job position requirements. Depending on the set goal, the navigator may build a career path to the aimed point, highlight necessary steps and required missing skills for it, offer relevant study programs and online courses to extend personal skills and education. Furthermore, it can show the closest job offers from the labor market, taking into account latest trends in economics development on regional and governmental levels or even worldwide, and offer suitable new profession obtaining programs supported by the government for the temporally unemployed person.

This module should have a possibility to find the program that is more close to the learner’s goal of finding the desired job. Learner profile, career, and study content should be described with the same annotation type.

3.4 Personal Study Planner Module

The PLP module works as an input for a Digital Study Advisor (DSA), which uses a Personal Study Planner (PSP) to build corresponding study plan and compose the most suitable study content for a learner, depending on the available learning materials. *Learning Materials Space Manager* is connected to various online learning platforms and courses, has access to an open source learning materials, and allows the learner to extend the space with courses provided by any university or education organization learner is enrolled. The DSA analyses the gaps (missing parts) between the current skills-/knowledge-oriented profile of a learner and his/her desired knowledge/skills space and performs a semantic search among annotated courses and learning materials available in Learning Materials Space. Learning Materials Space will also be connected to external tools and communication channels, online courses, open-source learning materials. The PSA also uses the PSP to re-plan initially created study plan on the performance of a learner in the process of his/her studies. With the help of *Learning Process Monitor*, the PSA analyzes the performance of a learner based on real time tests and feedback, recognizes corresponding gaps in knowledge and requests for missing learning materials from the Learning Materials Space Manager.

For the ILSS there will be good to classify the each learning modules. The planning of the learning path will be on the content level, as well as on the content parts level. For the fulfilling knowledge gaps, we have to annotate the whole learning content (courses, study modules, assignments, etc.). Then the system will adapt the content according to learner's feedback.

The ILSS should take into account extracted not only knowledge background of the learner, but also his personal ability for learning new material. According to that, we have to minimize the time for studying and maximize the quality of the learning content. The system should improve the logic of the learning concepts' presentation, taking into account personal specifics of the learner via manipulation with the complexity level of the system. Also, system should analyze learning progress and see what is missing and try to fill missing knowledge by searching the connection between learning modules in the course. This connection search is needed because it will be easy to see on what step of the learning process learner starts to make mistakes and what parts of modules influenced that.

4 DISCUSSION

The best way to produce experts is to accentuate the learner's best abilities and skills, assess the learner's potential and develop it further. That is why we badly need revolutionary methods to facilitate intelligent personalization of study processes and approaches to make innovative education content more attractive and motivational for the learner (Khriyenko and Khriyenko, 2013).

To be able to provide appropriate recommendation or suggestion of relevant content, the system should be aware of learner preferences, experience and knowledge, and goals. Therefore, availability of recently updated learner profile is one of the crucial issues. The process of personal learner profile creation (extension, modification) should not be annoying for the learner, should not be time-consuming and should not demand significant efforts for him/her. The main questions remain the same: how to distinguish relevant parts of a profile to be modified, how to automate and simplify the process of profile management as an integral part of other processes/activities performed by the learner. Therefore, we are going to elaborate content-driven approach for personal learner profile management.

Having semantically annotated content and personalized knowledge/information spaces defined by correspondent semantic profiles of the learners, we may populate the spaces with relevant content. Semantic Web annotations enhance information retrieval and improve interoperability. Unfortunately, human annotators are prone to error, and non-trivial annotations usually require experts in the specific domain. Moreover, that is why annotations should be maintained. If annotations are done cost-effectively, then the future for the technology will not be limited.

The main idea behind proposed system is taking into account knowledge and skills of the person. That is why the whole learning content, courses, and learning materials should be annotated. For the annotation, we chose semantic annotation in the form of ontology. The majority of the universities have to follow the proposed ontology for it is better working and using. In consequence, we can have a full set of courses from different universities, available bachelor's and master's programs with specific requirements (i.e. with certain courses and backgrounds). Learner, using such system will be able to include his full transcript of records, then to find a university, link to courses that are interesting to him, as well as to find the shortest path for getting the higher education by the present knowledge background.

The proposed ILSS makes possible to review and reflect long-term information. One can produce a different kind of analyses related to individual strengths and weaknesses. With the system, one can get additional resources and individual recommendations about learning technologies, materials, courses and support.

A learner can use the system as a virtual career agent. One can get information about available careers and education possibilities, and review personal information against the prerequisites. One can easily produce an application, resume or curriculum vitae and decide what information to include. This will make the process of work applying more straightforward. The objective is that a learner can get complete information related to own educational history and up-to-date information related to work and career possibilities.

For a teacher, the system will provide information about the learner group. The teacher can get up-to-date and individual information about the person's learning, no matter where the learner is coming. This will help the teacher to guide learners and personalize teaching for individual needs. The teacher can produce different kind of analysis about the learners and get information about what methods, materials, and learning environments could be beneficial for them. The objective is that a teacher can get relevant and up-to-date information about learners, current research knowledge from the system, help with difficulties, support practices and methods related to learning.

This plan tries to fulfill the needs of modern digital and global society where learning and teaching are not necessarily bounded to single institutions. The concept of individual know-how will extend from degrees to a complete picture where formal education is only one part. Further study and experiments will consist of an extension of ontology for the University of Jyväskylä. This University has an in-house developed, integrated study information system *Korppi*[1], which already has some annotation about courses, and study modules. Because of that, it would be easy to transfer presented information in the well structured knowledge base. As well as at the University of Jyväskylä is possible to transfer courses and credits from other universities or online learning platforms.

5 CONCLUSIONS

Usually, computer based training or computer aided learning does not use the model of the learner's knowledge and does not take into account personality of the learner, but it just uses traditional instructional methods (Phobun and Vicheanpanya, 2010). The combination of adaptation, intelligence and personalization could improve the learning process.

In Web-based learning environments, it is an advantage to monitor the learner's knowledge level and automatically adjusts the content for each learner to improve the education process and make learning individual for each learner or group of learners. Since the Internet offers a vast amount of information, it is important to help the teacher in the creation of the materials most suitable for education; and as well help in finding the most relevant content and convert it to comprehensive information. Also, a big privilege of these Web-based learning environments is to help learners with selecting courses and study programs basing on their objectives, which will be beneficial in their further career development.

[1] https://www.jyu.fi/itp/en/korppi-guide

This paper describes the issues of the lifelong learning, and how to make it more personalized, supported by technology. Paper presents Intelligent Learning Support System and describes it is main modules.

An ontology to serve as the knowledge base of ILSS was developed. All semantically annotated information will be stored there for future SWRL-formulated rules which allow extraction of new facts from existing knowledge. The developed ontology is very flexible, and it is possible to modify data easily.

ILSS is connected to the different open-source learning materials, external tools and communication channels, and online courses. Also, external systems and services with personalized user profiles can provide better guidance for a learner in a personalized manner, as well as suggest new relevant content or events which could help to fill learner's knowledge gaps.

The proposed system might be very useful for universities and companies. It could also help in monitoring changes in labor market and modification of study paths according to the called-for competence, as well as to help in career planning.

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