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Creating communities of practice for teaching electrical power systems

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ABSTRACT: Many students do not see much relevance in the theory they are taught, so their focus is often limited to passing a course rather than actively engaging in learning activities, even when a course involves laboratory experimentation. The question is how to promote and foster students' hands-on activities, especially, when their access to laboratory equipment is limited and the use of equipment requires highly specialised skills like in a modern electrical power engineering laboratory. In this article, the use of a communities of practice model is suggested as a way to address this problem. This model reinforces learning and promotes better understanding through teaching, and also provides a friendly learning environment for students. An additional benefit is better networking and collaboration among students from the same class, but also among students from different levels of studies, which is expected to benefit their future career.

INTRODUCTION

Nowadays, universities pay particular attention to students' learning outcomes and their readiness for work in relevant industries. Thus, engineering programmes regularly engage students in various learning activities and very important ones are laboratory hands-on activities. Teaching the laboratory component of modern electrical power systems requires high financial investments, and universities usually cannot afford more than one set of equipment. On the other hand, modern power substation automation equipment requires learning of new software and the development of many other new skills, which necessitates students spending extensive time in the laboratory, if they are to learn how to configure the system for a particular experiment.

However, supervised laboratory sessions are limited usually to 1-2 hours per week per course. In this article, a project that proposes the use of communities of practice to address the above issue is described. The use of communities of practice is a very effective model for engaging students in learning by involving them also in teaching. This project proposes a model where students at different levels of their studies, including postgraduates (both Master's and PhD) and undergraduates, are involved in laboratory activities in small groups, which overlap providing students with the opportunity to teach students in one group what they learned in another group.

This model reinforces the learning and promotes better understanding through teaching and also provides friendly learning environment for students. An additional benefit is better networking and collaboration among students from the same class, but also among students from different years of studies, which hopefully benefit their professional careers.

COMMUNITIES OF PRACTICE

The concept of the community of practice (CoP) was introduced by Lave and Wenger as part of a more general social theory of learning [1]. Unlike majority of theories that treat learning as an individual process in which one acquires knowledge of objects or abstract categories, Lave and Wenger argue that learning is a social phenomenon as it occurs in a community through interactions of the members and for the benefits of the members as social entities of the community. In fact, there are many aspects of learning and as many theories of learning. However, in this project, the focus is on social aspects of learning as students acquire knowledge, while involved in professional activities, through interactions with other students in initially small groups, which are envisaged to grow over the time and possibly merge into bigger groups through interactions.

These initial small groupings that are identified as CoPs are defined by Wenger as …*groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly* [2]. The authors of this article believe that there are so many different CoPs that even this broad definition may not include every type of CoP.

For example, CoPs may include the international and intercultural collaboration as illustrated by the authors, where CoPs were formed between several countries (Singapore, Australia and Sweden) and several campuses of the University of South Australia (UniSA) [3]. The students worked on the same experiment at the same time in the NetLab remote laboratory situated physically at the Mason Lakes Campus of UniSA, Internet connected by all the participating students. As a matter of fact, the NetLab laboratory is accessible by anybody in the world with Internet access.

The students may interact regularly, but only for a limited time, while involved in activities set by the teacher. However, the concept of the CoP has been adopted as a form of situated learning where community members learn through interactions within a group by participating in common activities. In the case of this project, the common activities are assignments to be completed in the new power system laboratory at UniSA.

It is important to note that a CoP is not just a group of friends or a social network. It differs from other communities by its specific characteristics. The structural model of a CoP is based on three fundamental elements: *domain, community* and *practice* [4].

The domain is normally defined as domain of knowledge or more specifically, a topic or a set of issues that community members are concerned with or a set of problems they are trying to solve. However, here the domain is not seen as a static knowledge area with clear boundaries. It is a structural element, which …*creates common ground and a sense of common identity. A well-defined domain legitimizes the community by affirming its purpose and value to members and other stakeholders. The domain inspires members to contribute and participate, guides their learning, and gives meaning to their actions* [4].

In this project, students have both well-defined tasks, as well as design projects. The well-defined tasks are in the form of laboratory experiments on which students work collaboratively in small groups of two-three students. This usually involves solving problems, discussing issues related to the background theory, performing experiments and writing a joint report. During the experiments students acquire basic skills in setting up equipment, performing experiments and collecting data for analysis. Then, there are open ended projects where students are required to solve certain design tasks and, therefore, need to develop a deeper understanding of the power engineering topics to complete these assignments.

The laboratory will also have a remote on-line access through the Internet, which will provide students with the opportunity to collaborate and communicate in on-line environment and form the on-line CoPs. Consequently, students will also develop certain technology, communication and on-line collaboration skills. In other words, their knowledge domain is multifaceted and boundaries are not clearly drawn. As such, it is a fertile ground for learning various skills some of which often have a form of tacit knowledge.

The community is a group of people who care about the domain that a particular CoP is based on. They are important as they …*create the social fabric of learning. A strong community fosters interactions and relationships based on mutual respect and trust. It encourages a willingness to share ideas, expose one's ignorance, ask difficult questions, and listen carefully. Community is an important element because learning is a matter of belonging as well as an intellectual process, involving the heart as well as the head* [4].

In this project, each team of two-three students works together as one CoP. Although they work on the same experiment and are expected to have similar discipline knowledge, the personality of each will vary, as well as their attitudes and cultural backgrounds. This will influence the behaviour of each member and, consequently, the dynamics of their participation. It is believed that there is no simple way in which students can become successful members of these CoPs. Particularly, in circumstances that the grouping may be imposed on them and that the lecturer may not have control over how students interact with each other. Students will receive guidance in a form of teaching them fundamental principles of what a community of practice is and basic principles of creating and nurturing a successful community of practice. This also includes motivating them to become active participants of their community of practice by teaching them the importance of wanting to become a member of a community of practice and benefits they can expect from their participation.

It is also planned to involve postgraduate students in teaching, which will give students the opportunity to meet and interact not only with students from the same year and the same course, but also those from different years and different courses and programmes. This will provide the CoP fabric with both horizontal and vertical structure that will strengthen and grow over the time.

Wenger et al state that …*The practice is a set of frameworks, ideas, tools, information, styles, language, stories, and documents that community members share. Whereas the domain denotes the topic the community focuses on, the practice is the specific knowledge the community develops, shares, and maintains* [4].

In this project, students are given documents that provide the theoretical background and instructions on how to exercise the set of experiments to perform in the new modern power automation laboratory either through the remote or proximal access. The students are given instructions and the initial steps on how to organise their collaborative work on experiments and which tools they can use to accomplish their tasks. This means that the students are equipped with enough discipline knowledge and technical skills to successfully complete their assignment in both proximal and on-line collaborative setting, and to produce a joint report which will be assessed.

Depending on its composition, to some extent, each group will develop different practices and tools. However, interacting with members of the wider community, they will enrich their knowledge and skills, especially, in configuring modern digital protection relays, remote terminal units (RTU) and human machine interface (HMI) of a supervisory control and data acquisition (SCADA) system. Working with these modern instruments and software requires highly specialised skills, and help from other students within the CoP will be fundamental.

MODERN POWER ENGINEERING LABORATORY AT UNISA

It is proposed that the teaching of power systems courses be structured around the modern power system laboratory shown in Figure 1 that is in the process of the development at UniSA through the framework of CoP.

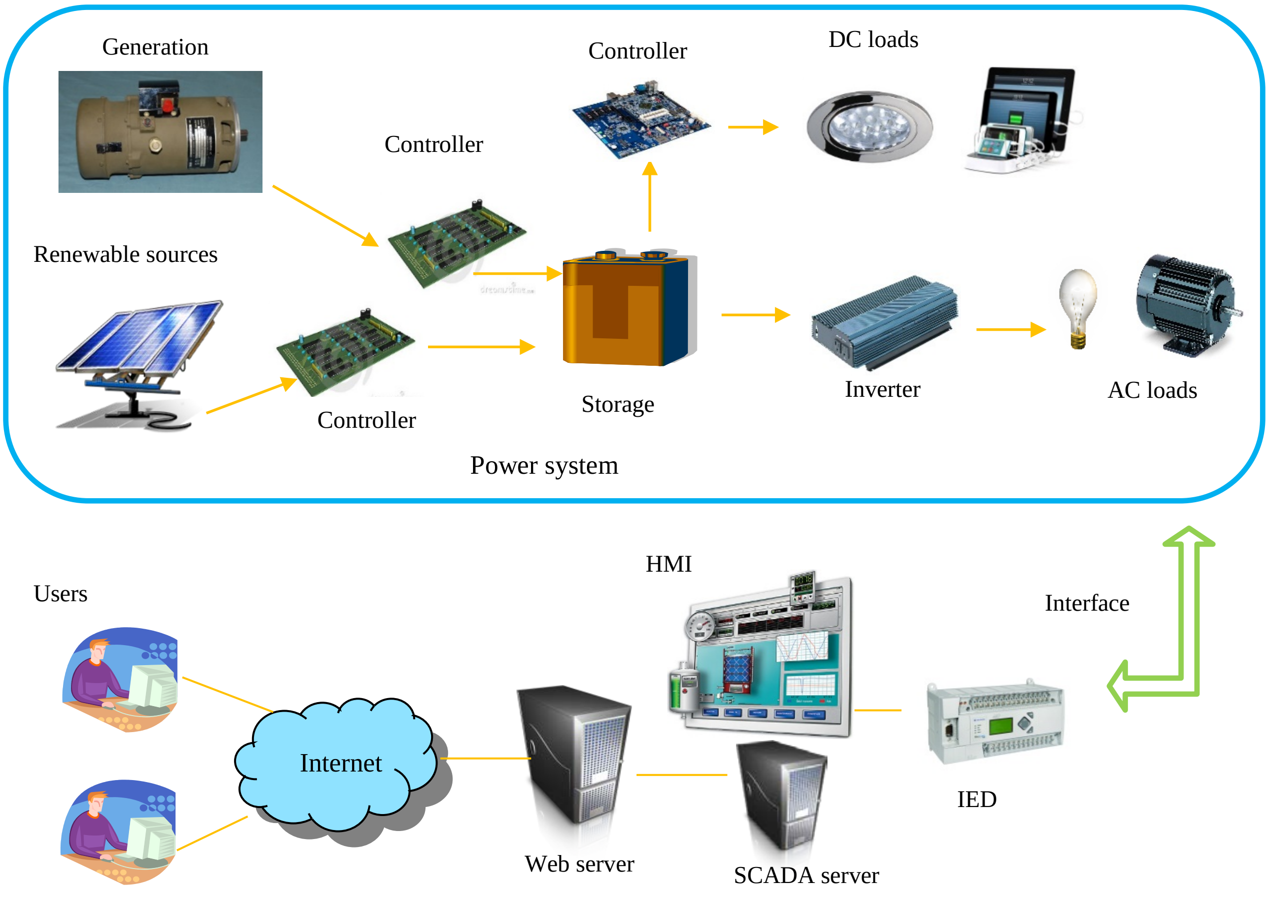

Figure 1: Laboratory's basic architecture.

The laboratory will include renewable power generation (wind and solar), energy storage (batteries), a hardware simulated distribution network and distributed loads integrated into a SCADA system that also provides the HMI, which enables users to interact with the system. Interface with the physical layer of the power system is accomplished through RTUs and other intelligent electronic devices (IEDs).

The system is designed with the aim to be expanded over the time, including addition of different types of renewable sources generation (e.g. fuel cells) as new technologies develop and become available and affordable. The same applies to loads. It is envisaged that the new loads will be added over time. In particular, more efficient loads will be used to replace old loads, with a final goal to make the laboratory self-powered (green), so no power from the external power grid will be used.

A number of companies offer their educational systems for teaching electrical power systems [5-8]. However, it has been decided to develop one in collaboration with local industry because of the previous good experience in such collaboration [9] and because of the University's strong interest in developing new collaborative projects and strengthening the links with industry in both teaching and research activities.

The laboratory will be used as an integrated learning environment for running traditional experiments on electrical machines and power systems operation and control, but also for new experiments on renewable energy generation, energy storage, SCADA implementation, design of a protection system utilising digital protection relays (e.g. SEL311C-1 that is already owned by the University) and implementing concepts of the smart grid, which opens up limitless educational opportunities for teaching and research at various levels and in various fields.

This development gives a platform for a number of projects both at undergraduate (e.g. final year research projects) and postgraduate levels (e.g. Master's and PhDs). Because of its complexity, it gives students from different disciplines numerous opportunities to collaborate and to develop their knowledge and skills and, at the same time, to develop a system that showcases the capability of the students to industries that employ UniSA graduates. In addition, it provides opportunities for growth of CoPs and exchange of knowledge and skills with students from other disciplines (e.g. computer science students).

CONCLUSIONS

In this article, an initiative to teach power systems courses through the development of the CoPs around the creation of a modern power system laboratory has been presented. As it is in the initial stage, success of the project cannot yet be claimed, but based on the previous successful experiences, international and intercultural, it is envisaged that this model will enhance the students' learning outcomes, improve their communication and collaboration skills and their career prospects. The outcomes of this development will be presented in future publications.

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