Innovation Requirement for Practicum Projects

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Like many computing and engineering programs, final practicum projects or capstone projects have been recognized to be essential in the Bachelor of Technology program in Computer Systems at the British Columbia Institute of Technology to provide students with relevant and practical skills before graduation. In order to make further distinctions between regular course projects and capstone projects, students in the program are required to include an innovation component in the latter. The objective is for students to explore some areas of computing that they have not been formally taught in their courses, to develop deep thinking and cognitive skills, and to become independent learners as they enter into the computing profession. This is particular crucial as changes in computing / IT technologies are especially fast and successful IT workers need to have an aptitude to embrace such rapid changes and be able to integrate their current knowledge with new developments, and to take advantage of them as needs arise. This paper describes the overall practicum projects, with special focus on the innovation requirement, how these are evaluated, and examples of how this requirement can be fulfilled in different areas of computing. The benefits of the practicum projects with the innovative requirement to student learning are also investigated based on pedagogical theories.

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Introduction

In order to ensure that students in the Bachelor of Technology in Computer Systems program at the British Columbia Institute of Technology (BCIT) are well prepared to work with new technologies that they have not been formally taught in class, the practicum component of the program, which is equivalent to the capstone project in many other programs, requires the students to work on a project, usually industry sponsored, with an innovative component. The exact (or even approximate) level for innovation in the Bloom taxonomy[1] is not clear. However, it is commonly understood that to be innovative, one needs to go beyond careful analysis of a problem to be solved, synthesize relevant data and possible existing solutions to formulate a plan, and to experiment with ideas that may not be conventionally applied to the problem at hand. This places the level of expectations to be at least at the higher levels of Bloom taxonomy. In this paper, we provide a working definition of what is expected in the innovative component of the final practicum project from our graduating students.

The paper is organized as follows: the next section provides a general background of the Bachelor program. Section II describes the practicum component and section III focuses on the innovative requirement of the practicum. Section IV relates the pedagogical theories that support the innovation requirement of the practicum project. Finally section V is a discussion on student experiences of the practicum project and the innovation requirement, and how faculty can assist the students in fulfilling this requirement.

Section I. Background

The Bachelor of Technology in Computer Systems program at the British Columbia Institute of Technology is a practitioner oriented program which focuses on job ready skills development and advanced use of computing technologies. It is a two-year top-up program for diploma graduates who have completed at least two years of computing education. Graduates from the Bachelor of Technology program attain similar computing education as defined by ACM Computer Science curriculum guidelines[7], but with a more practical, hands-on focus.

The program consists of two mandatory courses on software development, one course on applied research, three courses that allow the students to specialize in one area of computing (such as network security, games development, database, HCI, etc.), and two technical elective courses. Since this Bachelor program is a top up final two year Baccalaureate program, students are also required to take two business courses, and four liberal education courses. One of these liberal education courses is on critical reading and writing, and is a prerequisite course before students can take on the practicum project. The reason is that there are significant writing and formal documentation of the project (e.g. project proposal and final report), and students need to acquire the necessary writing skills to successfully fulfill these requirements.

Section II. Practicum

The practicum component of the degree program comprises 18 credits of the total 60 credits in the Bachelor program (readers should keep in mind that the program is basically the upper two years of a traditional Baccalaureate program). This constitutes 30% of the program and further indicates the importance placed on the practical knowledge and skills expected from the graduates. But what does it mean by 18 credits? In a normal degree level course, a credit is equivalent to 15 hours of lecture time. Each lecture hour usually implies at least two more hours of self-study. Using the same formula, each credit of the practicum is estimated to involve three hours of work. A practicum of 18 credits should therefore require about 800 hours of work.

Students can either find their own projects, projects initiated from the faculty, or projects from a pool of industry sponsored projects. Each student works on her project individually. Some of the more common projects required by the local industries include database applications with web front end, consolidation of multiple databases, migration of applications from one platform to another, embedded systems programming, mobile applications, network design, and network auditing and testing.

Almost all practicum projects are real life applications rather than "toy" programs. Also no two students work on the same project. One of the advantages of this arrangement is that the students can select a project they like rather than having a standard project for every student. This also reduces cheating and the overhead for instructors to come up with a new project every year. The students also make vital connections with the industry, as some of them continue to find full time employment with their industry sponsors upon graduation. One main disadvantage of some industry projects is that there is not sufficient depth to challenge the students. In those cases, either the projects will be dropped, or deferred to the diploma students who work on smaller and more trivial projects, or students can supplement the project with other more challenging tasks to satisfy the innovation requirement. This will be explained in more details later.

Once the students have decided on a project, their first task is to prepare a practicum proposal after consultation with the project sponsor to determine the scope and details of the project. The proposal is then reviewed by a Practicum Review Committee which is made up of a number of senior instructors. The primary task of the committee at this stage is to ensure that the project is suitable and of sufficient depth, especially in satisfying the innovation requirement. If the proposal is not acceptable, the student will be asked to revise and resubmit. Upon approval, the committee will assign a Subject Expert, who is one of the regular faculty members in the department, to supervise the project. The student will then work on the project and develop a final detailed document in consultation with the Subject Expert. When the project and the document are completed, the Subject Expert will first approve the final report before it is submitted to the Practicum Review Committee for final evaluation. The students are also required to provide a signed letter from their sponsors so they may provide feedback on their experience with the students, their development skills, and their overall performance on the project. A number of these letters have been used for program accreditation to testify to the quality of work the students have demonstrated, resulting in tremendous support of the practicum and the Bachelor program. Many industry sponsors also continue to provide new as well as follow up projects for other students.

In reviewing the final report, the Practicum Review Committee may schedule a meeting with the student for an interview and demonstration of the project if necessary. The final report is evaluated based on the following criteria:

- contribution to employer, client or others,
- adherence to time and cost budgets,
- adherence to deliverables in initial proposal,
- clarity of written communication in final report.

Section III. Innovation Requirement

The innovation requirement of the practicum project is stated in the project description as follows: "The practicum should contain some elements, which are deemed to be innovative, experimental or exploratory in nature. …. Since the practicum should contain some elements, which are deemed to be innovative, experimental or exploratory in nature, it is strongly recommended new leading edge technologies, even experimental, be considered for the practicum. Even if these technologies are not required by your client, or practically feasible, research on these areas should be included as part of the proposal, and a chapter or two detailing how they can be used for this project should be included in the final report."[8]

The innovation requirement is specific for the academic program requirement and may not be required by the industry sponsors. Projects initiated by faculty are usually quite challenging since most of them are based on their research areas and these projects usually involve complex computations. However, for industry projects, while some clients may want just a simple application, these projects often do not satisfy the innovative component. Hence, students are advised to treat their industry sponsor requirements distinctively from their academic requirements. They can think of completing a first version of the project to satisfy their client's needs, and a second version of the project to satisfy the requirement for their academic program.

The most common ways to satisfy the innovation requirement are as follows:

- Apply the latest or emerging technologies to a problem which may include the use of new programming languages, new development frameworks, new databases, new open source development tools, etc.
- Develop the solution of a problem on a new platform. This may include the use of new hardware platforms, mobile or embedded devices, new operating systems, etc.
- Applied research on a related topic of the student's specialty area. Usually this is driven by faculty research areas, or through the institute's research lab. Students can engage in the implementation of proof of concepts, redesign of existing protocols or toolkits for specific needs, or comparative study and analysis of competing applications / supporting tools / platforms, etc.

Since innovation takes on different forms for different areas of computing, the following subsections provide additional examples of the types of projects our students have worked on. Special attention is given to computing areas where little or no programming is required, as students and faculty often find it difficult to satisfy the innovation requirement in these areas.

Network Design / Administration

Under this category, students may take on a project to design and implement a local network, secure or audit an existing network, extend an existing network for efficient monitoring and management, etc. Innovation extensions of these projects may include the following:

1. performance tuning and enhancement of networks backed up by careful statistical analysis,
2. extension of security protocols on embedded system boards for wireless networks,
3. perform risk analysis of a network and assess network security through methodological penetration testing.

Human Computer Interface

A number of projects involve students to redesign an application with a "better" interface. This can be nebulous on what "better" means. Innovation extensions to these types of projects include:

1. analyze usability based on a more scientific approach such as: number of user keystrokes, number of pages to be viewed, time spent on task, user satisfaction, etc.
2. apply HCI design principles on special devices, such as portable devices, mobile devices, etc., or for special needs.

Research Literature Review

In cases where the students have demonstrated some extensions of their project to fulfill the innovation requirement, but not as much as expected by the Practicum Review Committee, they may supplement their practicum with a survey of recent research literature related to the project. The students may then be asked to summarize their findings, implement a small extension of their project based on their findings, and / or provide additional documentation on how to extend their projects in the future. Students are expected to review research literature from ACM or IEEE digital libraries and not just from trade magazines.

Section IV. Pedagogical Foundations

The practicum project is a form of Problem Based Learning[2] (PBL) which is a well-defined, structured instructional method that students work through in seven steps with appropriate scaffolding support, learning resources, instructional support, tutor support, and group discussions. In these seven steps, students:

1. clarify any terms and concepts in the problem,
2. generate a definition of the problem to be solved,
3. brainstorm ideas, hypothesize, question about the problem,
4. systematize and scrutinize the ideas,
5. produce a list of issues behind the problem,
6. study the available resources,
7. share findings, review and discuss literature, solve other problems, and synthesize what is learned.

In the practicum project, the process of clarifying the project objectives with the sponsors, writing up of the proposal, experimenting with possible solutions, implementation of the solution, and final report write-up parallels these seven steps quite closely. Although the students work individually, they collaborate with the industry sponsors and other team members on the project. Hence, even though it seems the practicum project affords the students minimal guided learning, which has been shown to be of little value to student learning[3], such is not the case.

The practicum projects provide job ready training for the students, and the innovative requirement promotes far transfer[4,5] of knowledge from courses to a problem the students have never seen before. Research has shown that such learning, referred to as cognitive apprenticeship[6], results in deep thinking and cognitive skills. The process begins with problems and practice *in situ*, and moves the students beyond the traditional practices by emphasizing that practices are not absolute, and students are encouraged to generate their own solutions with "a community of practice". The practicum project, in conjunction with the innovative requirement, thus seems to have profound effect on student deep thinking and cognitive skills.

Section V. Discussion

Students often find it difficult to come up with sufficient work for the innovative component despite the coaching support and the preparatory proposal writing seminar provided by the faculty. It is not surprising that some students do not include the section on innovation even though this has been emphasized repeatedly that it is mandatory before proposals are to be approved. At other times, students may be involved in a project that is already quite challenging but they fail to see the complexity and innovative components in the project.

There have also been projects that neither the students, project sponsors, nor the faculty can accurately estimate what, if any, innovation is involved. Such is especially the case when the project sponsor may have a vague idea of a project but not the detailed specifications. Although there is some potential for innovation in the project, it is not clear what this entails. In such cases, the Practicum Review Committee may allow the student to defer the submission of a full proposal, and start working on the project. The proposal and the final report will be evaluated and approved when there is sufficient evidence of the innovation component in the project.

Lastly, some students cannot finish the Bachelor program because of the practicum project. The time commitment can be significant especially if the students have already secured employment after they have completed all the courses but not the practicum project. However, the innovation requirement is not usually the main obstacle that the students face.

Section VI. Conclusion

The innovation component of the Bachelor of Technology program in Computer Systems at BCIT was included to encourage student deep thinking and far transfer skills, and to become independent learner. Having learned the fundamental concepts of computer systems in their courses, the students need to assess what they have learned, what is required in a project, and include an innovation component that involves a far transfer of their knowledge. This paper has provided a number of examples of what can be considered as innovation in the practicum projects. Research has also shown that such a combination of situated learning with innovation extension can result in significant student learning.

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