Investigating the Benefits of Applying Artificial Intelligence Techniques to Enhance Learning Experiences in Capstone Courses

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ABSTRACT

This research seeks to improve the learning experiences in Software Engineering Programs using Virtual Assistants based on Artificial Intelligence (AI) models. Students of Software Engineering Capstone Courses face real world situations and challenges that grant them valuable experiences for their professional preparation. However, since this knowledge is acquired through real-life exposure projects, it is difficult to transmit it among different generations of students. In consequence, all the gained knowledge, experiences, and computer codes developed are lost and cannot be reused outside the project context when they finish their assignment at the end of the semester. To address this challenge, this thesis considers the development of AI based virtual assistants applied in higher education, in a form of a lesson learned system, a recommender system integrated with a chatbot, to help students , solve problems similar to those they face in the different stages of their software project development by recommending previous lessons learned. The innovative contribution lies in the implementation of the described techniques from the state-of-art artificial intelligence field in an educational platform with the goal to leverage the experience gained during years of the teaching a Capstone Course in Software Engineering to new student generations who might benefit from this universal knowledge gained previously, in order to assist software engineering students to enhance their learning experience.

CCS CONCEPTS

• **Artificial Intelligence**; • **Machine learning algorithms**; • **Natural language processing**;

KEYWORDS

Software Engineering teaching, recommender systems, collective knowledge, lessons learned

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1 MOTIVATION

In order to provide the best, authentic learning experience possible for students, many software engineering degrees incorporate team-based capstone projects courses in the final year of study, following the recommendations of the ABET accreditation program [1]. However, designing capstone projects to solve real world problems is not a trivial undertaking, and a number of constraints needs to be considered, especially when it comes to defining learning outcomes, choosing clients and projects, providing guidance to students, creating an effective "educational support infrastructure" for the project, and measuring student outcomes [2]. In this thesis work, I am exploring how to improve learning experiences through the application of automated intelligent systems to the formation of software engineering students and the transmission of the acquired knowledge among the generations of students of a Capstone Course in Software Engineering (CCSE). To address this challenge, this thesis considers the development of virtual assistants based in AI applied in higher education, in the forms of a lesson learned system, a recommender system integrated with a chatbot, to help students solve problems similar to those they face in the different stages of their software project development, by recommending lessons learned from the previous projects. The integration is made in a system that supports concretely the activities of the project and the interaction among the student's team, the client, and the academic staff, with the capability of giving recommendations to students about their inquiries. Furthermore, according to Bonnin and Boyer [2] there is a lack of research in recommendations systems in higher education, probably explained by the fact that recommendations are particularly difficult in the context of education, where unsuitable recommendations can be harmful. The nature of textual contents makes its processing difficult [3], so it constitutes a research topic in the search for computational tools for its processing. Deep learning methods are used as representation of learning techniques, directly with raw data, allowing to discover the necessary representations for classification [4]. The expected contribution of my thesis is the increase in the knowledge on how to enhance the learning experiences in a software engineering capstone course, while providing new methodologies and AI based tools to improve it. The importance of reusing the gained knowledge in an assertive way is one of the benefits that these systems could report to students, giving them answers which had been probed to solve problems they face. My dissertation will contribute to the software engineering educational community with new tools to improve students' learning process.

2 LITERATURE REVIEW OF KEY WORKS

Bellow, I mention some of the most relevant work regarding collective knowledge systems, recommendation systems, chatbots and their potential use in teaching software engineering.

2.1 Collective Knowledge Systems in Software Engineering

Systems such as Stack Overflow, GitHub and Slack, to mention a few, are collective knowledge systems and have become popular platforms for information interchange in various areas of software engineering, especially in education, since they are frequently used by students. For example, [5] proposes a system called DevRec that recommends developers for open-source projects, combining the contributions they make in social coding in systems like GitHub, as well as their contributions in question-and-answer communities like Stack Overflow.

2.2 Recommendation systems based on Collective Knowledge

Researchers have proposed the use of deep learning algorithms in recommendation systems since they are capable of capturing complex relationships in the semantic information in the relation between user and item [6]. The use of multi-criteria collaborative filtering, based on deep learning, has been successfully applied in recommendation systems. Nasaar et al. [7] describe its application using a two-branch model: one for predicting the criteria ratings and the other for predicting the overall rating. Azcona [8] has reported algorithms, based on Machine Learning and Deep Learning as teaching support tools in programming courses, for recommending programs' source code to students, based on code2vec and Collaborative Filtering.

2.3 Chatbots in Higher Education

Emerging technologies, such as artificial intelligence or virtual assistants, have brought as a benefit greater flexibility, personalization, commitment and motivation of students [9]. The use of virtual assistants increases the feeling of loyalty to the University [10], and helps the acquisition of new students [11]. It also helps to optimize the teachers' time, allowing for a distribution of their time on activities of greater academic value [12, 13]. The University of Warwick is researching, for improve the use of AI chatbots in the areas of learning and teaching, educational application training, and helpdesk support [14]. On the other hand, Paikari and van der Hoek [15] introduce general guidelines to develop chatbots with certain characteristics to support software development process. Another application of a recommending system based on chatbot has been reported by Holotescu [16] which developed a chatbot for recommending Massive Open Online Courses.

2.4 Deep Learning techniques

I will explore Deep Learning techniques in natural language processing (NLP) for analysis classification of textual information, among other kinds of objects. I will study the fundamental building blocks of Deep learning in NLP as feed-forward or fully-connected neural networks (FNN), recurrent neural networks (RNNs), and convolutional neural networks (CNNs). I am going to explore advances in the application of libraries as Keras, Numpy, and Tensorflow. These models could also be used together, using the synergies of each one.

3 HYPOTHESIS, THESIS, AND KEY IDEAS

I proceed this investigation with the following hypothesis in mind: The corpus of knowledge for teaching software engineering can be implemented using artificial intelligence techniques to enhance the learning process among students. To contrast this hypothesis, I consider the following research:

Q1: How to effectively leverage the knowledge acquired by students and pass it on to future generations?

Q2: How significant is the application of tools based in AI and learning lessons for improvement of the learning experience in software engineering?

Q3: What kind of AI-based techniques can be used to augment a body of knowledge?

4 RESEARCH APPROACH AND METHODS

This thesis follows the Design-Based Research (DBR) approach [17]. This methodology combines empirical research in education with theories geared towards the design of learning environments. This methodological approach was selected for three main reasons: 1) to propose a technological solution driven by educational considerations; 2) to understand the impact of analytical frameworks and solutions in real environments; 3) for its interactive nature, to adapt to the changing field of research which this project encompasses. This approach consists of three phases: phase 1: analysis; phase 2: design and implementation; and phase 3: evaluation.

To apply the DBR approach, we followed the interactive learning design (ILD) framework [18]. This framework organizes the research process into four phases: 1) Informed exploration, which studies the needs, available theories and audience; 2) Enactment, which consists of the design of the technology; 3) Evaluation of local impact, which analyzes the impact of the technological intervention at the local level; and 4) Evaluation of broader impact, which considers the dissemination and discussion of findings and the adoption of the technological intervention by a wider audience. In the informed exploration phase, we conducted literature reviews which focused on analyzing current tools and solutions to the concerns that are shown in section 2 of this document. In the enactment phase we developed a recommender system based on content (text) embedded in a Kanban system used for project control in the course. In terms of natural language processing, the BERT [19] algorithm was used for the extraction of feature vectors, because the dataset is in Spanish with terms in English. We also developed a virtual chat to use with these systems. Now, the proposal is in the evaluation of local impact phase, in which several quasi-experiments are planned. For instance, since I have been teaching a section of this capstone course since 2020, I have conducted the first quasi-experiment that included the students of the CCSE, which aims to answer the given research questions. This study was applied during 2020 with a universe of 98 students and voluntary participation, the repository of

lessons learned has 1900 records. It is planned to repeat these quasi-experiments that will be framed within the following phases of the methodology used for the validation of this research proposal.

5 PROGRESS ON THE RESEARCH

The progress includes building a collective knowledge system with the lesson learned system, GitHub code repositories of previous software projects, the interactive chatbot and the implementation of the recommender system. The results, although not conclusive, show that the first and most important conclusion to obtain from the experiment is the fact that AI Virtual Assistant combined with recommender systems can be a very useful and viable tool in capstone courses. Regarding the research questions Q1 and Q2 the current results show the effectiveness of the collective knowledge system which includes lessons learned system and the recommender system.

A new way of research that has emerged this semester is to automate the weekly Stand Up Report that students do, based on the agile software development practices of Scrum [20], appropriate for supporting software engineering education courses. Students report their work, weekly, through answers to several typical questions, in particular we have incorporated the questions: i) what was the main problem that you had last week? And ii) what was the way to solve it? This is done in standard instant messaging platform, the students' answers are captured by a bot, and incorporated as new knowledge into the lessons learned base, to provide a new source of input to the AI-based agent that delivers the recommendations for future questions on similar topics.

The next stage is to explore the deep learning techniques to apply NLP to texts to test new ways of improving the recommendations. Other important source of innovation is the exploration of ways to reuse a great amount of source codes from previous projects that we have stored in GitHub, to incorporate them into the recommendation tools, to achieve an additional goal: Solving a typical problem in the software industry, which is to recommend and reuse already built programs that solve typical tasks of the information systems to develop.

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