Can We Leverage Replication Studies to Instill Ethical Practices in Future Software Engineers?

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***Abstract*—Plagiarism activities such as copying code, algorithms, or documentation without consent and attribution are rising in industry and academia. While this can be attributed to the rise of generative AI, a lack of awareness about plagiarism and its implications among soon-to-be Software Engineers and practitioners raises serious concerns about academic integrity and adds another dimension to this challenge. This research proposes exploring "replicating a study" as a teaching mode to impart ethical considerations to Software Engineering undergraduate students. Replicating a study involves recreating and validating existing research findings utilizing datasets from the original study, contributing to a deeper understanding of engineering concepts. Thus, while working on a replication study, students can be prompted to explore and understand professional ethics such as obtaining informed consent, permission to reuse data, and giving credit to original authors. Using preliminary results from such an experiment with an undergraduate student group, we explore and solicit input to modify the methodology for a more extensive study.**

***Index Terms*—Replication study, Plagiarism, Professional Ethics, Software Engineering, Academic integrity**

I. Introduction

Recent technological advancements such as generative AI and rising plagiarism are serious concerns in academia and industry [1] [2]. Teaching ethical considerations such as data privacy, obtaining informed consent, and giving appropriate credit to the original authors when using their work while maintaining academic integrity are essential tools for life-long learning as the next generation of professionals/technologists face challenges never seen before [3]. Software Engineering (SE) has emerged as perhaps the most dynamic engineering discipline in the recent past. Software engineers of the twenty-first century face new challenges, and their roles are constantly redefined [4].

Replicating a study allows researchers to recreate and validate existing research findings, contributing to a deeper understanding of engineering concepts [5] [6]. Replication studies are held as a gold standard for ensuring the reliability of published scientific literature in various domains, including SE [7]. Several guidelines have been formulated that emphasize the importance of accurately and appropriately crediting the authorship, and obtaining consent and permission to reuse data in their publication (replication of the original study) [8]. Much research has been done to establish the methods and impact of replication studies in graduate studies. However, utilizing the process of replicating a study as a mode to impart ethical considerations such as data privacy, obtaining informed consent, giving credit (avoiding plagiarism), maintaining data privacy and security (anonymizing data when working with sensitive data or personal information), obtaining permissions when using copyrighted materials, transparency, and reproducibility of the work while contributing to open science fundamentals remains unexplored (more details in Section III). To our knowledge, **this study** is the first to explore this aspect further and to provide a nuanced perspective on the use of replicating study and their utility in undergraduate education in the SE domain.

To inculcate professional ethics and integrity in undergraduate SE students, we explore the following research questions (RQs) in this study.

- RQ1: How helpful is a lecture in improving students' awareness and understanding of ethics? How useful is an interactive scenario-based quiz for the same?

- RQ2: How effective is leveraging "replicating a study" as a mode to enhance and integrate undergraduate students' professional ethics and integrity, comprehension of theoretical knowledge, and problem solving skills?

Our findings will provide valuable information on the role of replication studies backed with scenario-based quizzes in inspiring intrinsic motivation and active participation in the engineering field, thus enhancing the overall quality of undergraduate engineering education.

II. Motivation

A. Need for teaching software ethics

Programming (also called coding) is an essential aspect of the software development life cycle. Sojer et al. [2] explains that programming is riddled with ethical issues. Various platforms such as GitHub and StackOverflow make source code legally available for gratis download from the Internet, mainly through open source software (OSS), which has further increased potential benefits. Such practice has become "standard practice for many programmers." which is a cause for concern. For example, Mlouki et al. [9] shows how software developers blindly copy the code from a popular code-sharing platform called Stack Overflow while violating the usage and site policies. Although all Stack Overflow posts are free to access, code examples on Stack Overflow are

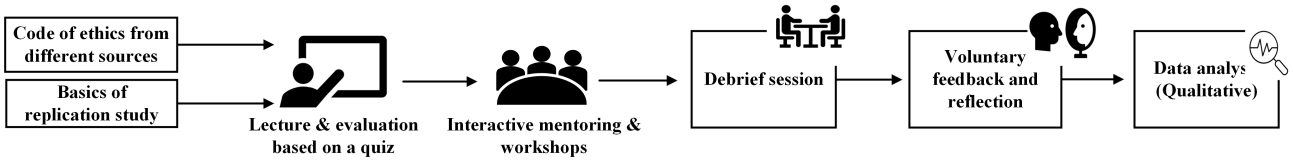

Fig. 1. Teaching design used in our study

governed by the Creative Commons Attribute-ShareAlike 4.0 Unported license that developers should obey when reusing code from Stack Overflow or when posting code to Stack Overflow. Emphasizing potential unethical code reuse from Stack Overflow when sharing code to a website, Mlouki et al. [9] recommends that developers mention the license of the original project from which the code was borrowed and provide a reference to this initial project. The reference can also help future developers (who reuse the code) to choose the right software license. With the rise of ChatGPT and Bard (Google's Large Language Model), such unethical practices have only increased, causing more harm than good to students, as highlighted by [4].

Students may also not be aware of licensing requirements, and are quick to copy the first adequate solution from their search engine. Perhaps, instead of trying to avoid or restrict the use of such generative AI in practice, educators may focus on developing pedagogical techniques and practices to teach ethical behaviour through training.

B. Need for a novel method to teach ethics

Traditional classroom methods, vignettes, role-play games, and quizzes have been employed over the years to teach SE students about software ethics [10]. However, lectures on SE ethics can quickly become a boring list of do's and don'ts, reducing their effectiveness or frequently requiring more engagement techniques to hold students' attention [11].

A few studies have also shown that there needs to be more than education of awareness through guidelines and rules. Life-long learning skills, ethical engineering practice, and the ability to follow regulations and policies within engineering design are common graduate attributes assessed by engineering accreditation boards such as the Canadian Engineering Accreditation Board (CEAB), ABET, and other international signatories of the Washington Accord [12]. Despite the importance that industry employers place on these skills, there remains a gap within engineering education to help students bridge between technical course outcomes and practical application of professional skills [13]. As put by B.Boehm et al. [14], we need to be anticipating future trends, helping students learn how to learn, preparing students for future challenges, participating in leading-edge SE research and practice, and incorporating the results into the curriculum. Therefore, our study aims to work towards this vision at the undergraduate level.

III. Related work

Replication studies are held as the gold standard for ensuring the reliability of published scientific literature in various domains, including SE. With much emphasis on open science in the recent past, data sets, source code and experimental setup information are made publicly available for other researchers and the scientific community to reuse and modify, therefore enabling a transparent research approach. As explained by Schmidt [15], "replication experiment demonstrates that the same findings can be obtained in any other place by any other researcher, proving that the experiment reflects the knowledge that can be separated from the specific circumstances (such as time, place, or persons) under which it was gained". [6] and [7] established the importance of replication studies in the domain of SE. Carver et al. [8] proposed guidelines for experimental replications. It emphasized declaring the original author's involvement and ascertained the importance of crediting their work in the replication study publication. [16] and [17] then followed these guidelines to further establish a methodical way to perform replication studies in the domain of SE. As such, replication studies have been explored as an alternative to rote learning in education by [18].

In the most recent study, [5] showed how replication studies can improve doctoral students' education, making it meaningful and allowing budding researchers to practice in a safe zone. However, none of these studies explore replicating a study as a method to inculcate academic integrity at the undergraduate level.

IV. Methodology

A. Intended course context

SE students at [institution redacted] have the option of completing a technical elective course in advanced software engineering requirements. This course goes beyond foundational concepts around software requirements and expands on the elicitation, modelling, expression and validation of requirements while considering the software development lifecycle. The nature of the course content allows students to consider not only technical applications, but also the importance of ethical and professional practice.

B. Participants

The participants in this pilot study were Winter 2023 undergraduate SE students from the [institution redacted]. With obtained ethics permission, all participation was voluntary. Participation in this study was offered as an alternative to

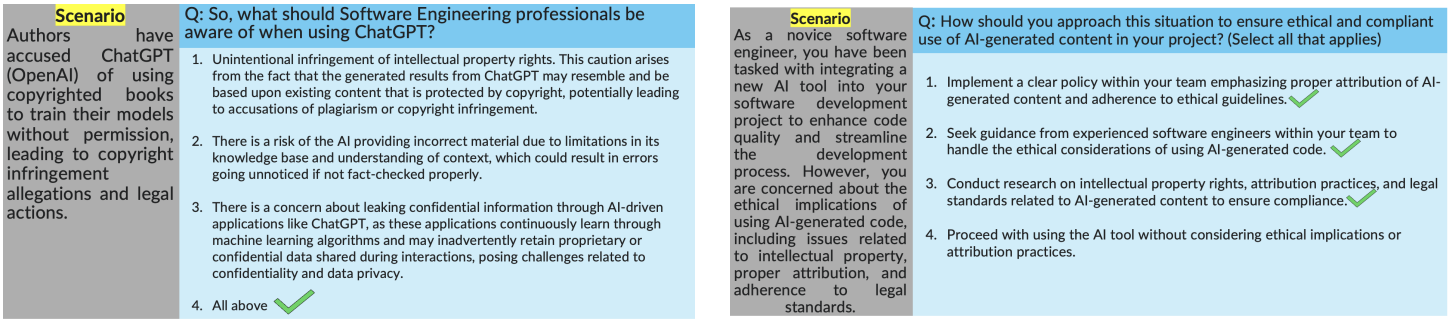

Fig. 2. Multiple choice example questions asked in the quiz

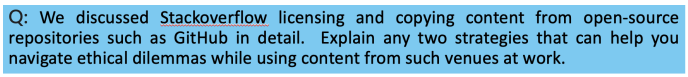

Fig. 3. Open-ended questions from the quiz used to bring out effectiveness of the content taught priory

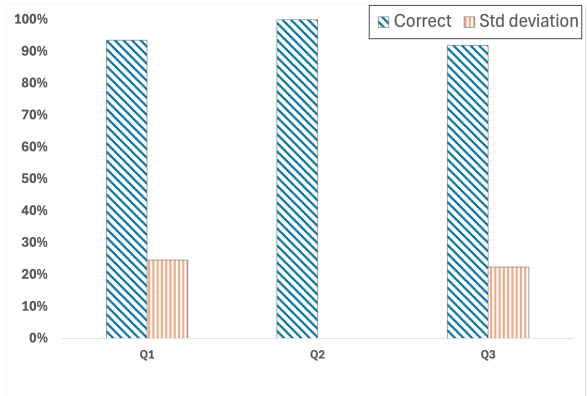

Fig. 4. 30 students took the quiz and the results of correct answers and standard deviation is as shown

an equally weighted component of the course, and informed consent was obtained from all participants prior to their inclusion.

C. Study design

Figure 1 shows the overall design of this study. Using code of ethics guidelines from different sources such as The ACM/IEEE Software Code of Ethics [19], IEEE code of ethics [20], and general country codes of ethics [**?**], we designed a module to teach data privacy, differentiating between appropriate and inappropriate reuse of the internet-accessible code [2], taking informed consent, plagiarism, and giving credit to original investigators related topics. We used an already published study (scholarly paper) in the domain of Software Requirements Engineering for replication to allow students to practically implement and use the guidelines outlined in the teaching phase through interactive mentoring and workshops. For example, in the initial phase of exploration of the replication study, we asked students to evaluate the availability of the source code and data sets to begin the project work. Based on the findings, students contacted the original authors to obtain the information formally and inform them about their replication study agenda.

The students were also provided with instructions and guidelines to clearly articulate their contributions in the replication research work and differentiate them with that of the original authors of the paper in the intermediate and final reports. Students eventually expanded the original scholarly research further to publish at the AI for Requirements Engineering workshop co-hosted with IEEE International Conference on Requirements Engineering conference [redacted for double blind review].

Finally, reflection on the complete activity were solicited as part of their final project reports, which were then qualitatively analyzed to draw conclusions.

D. Interactive assessment design

The pilot study included the creation of a quiz-based assessment focused on the concepts of plagiarism and ethical considerations while using ChatGPT for work with scenario-based and open ended questions. The learning objectives of the quiz were to help students understand a) Codes of ethics from professional organizations (e.g., IEEE, ACM), and the balance between business goals and ethical considerations. b) Ethical decision-making in software design and deployment, code-reuse c) Data privacy, informed consent and anonymization d) Continuous ethical reflection, lifelong learning in professional ethics, staying informed about ethical trends and developments in the era of Generative AI and other similar tools.

The quiz was designed with varied question formats, including multiple choice, scenario-based questions, and open-ended responses, to evaluate student understanding across different contexts. Quizzes are a valuable tool for encouraging motivation and learning while also assessing student knowledge and implicitly supporting self-regulated learning [21]. This assessment allowed students to understanding potential gaps in their knowledge while practising application skills.

Figures 2 and 3 show examples of these questions.

E. Proposed qualitative evaluation

Based on the success of initial pilot results, further analysis techniques will be integrated for the expansion stage of the study in the next teaching cycle. A mixed-methods approach, combining quantitative and qualitative methods, will allow

us to comprehensively investigate the impact of replication studies on undergraduate student learning and career outcomes in Software Requirements Engineering (RE).

Curriculum Integration: Building on the pilot implementation, we will develop a comprehensive module on replicating studies and ethical considerations in SE and integrate this module into the existing undergraduate software requirements course. Additionally, we will identify papers suitable for replication and validation studies, ensuring diverse topics and methodologies.

Data Collection Instruments: Data collection will begin with the distribution of anonymous surveys to the identified participants. Participants will be provided with all the necessary information regarding what a replication study entails. Interested students will be asked to contact us through via an email confirmation. Informed consent will be obtained from all participants before data collection.

- Surveys: Quantitative data will be collected through structured surveys administered to the participants. The surveys will anonymously assess students' perceptions of replication studies, their engagement in research activities, and the impact of replication studies on their learning experiences and career aspirations.
- Interviews: Qualitative data will be gathered through semi-structured interviews with a subset of participants. The interviews will delve deeper into students' experiences with replication studies, their challenges, and the perceived benefits of engaging in research-oriented activities.

V. Preliminary Results

This section discusses the answers to the two research questions and elaborates on our findings.

A. Professional ethics related awareness through lecture (RQ1)

Figure 4 shows the overall performance of the 30 students who took the quiz. Results show that the students demonstrated a fair understanding of the concepts for the ethics-related questions (3 and IV) posed in the quiz. However, teaching SE students about these codes of ethics in a way that is both engaging and effective is a non-trivial pursuit for SE [11]; thus, we explored replicating a study as an alternative method in this study.

B. "Replicating a study" as a mode to teach ethics (RQ2)

In the Winter 2023 semester, three undergraduate students in their third year of study took up a replication study of the aresearch paper in Software Requirements Engineering as an equally weighted alternative to the midterm exam. This student group successfully replicated the study with mentoring and generated compelling results. This pilot is used as a research-informed basis for further pedagogical development within this study, and the preliminary results are described below.

The excerpt of the reflection component from the students' replication study's final report is as follows. The students' work was accepted at a software engineering conference and was subsequently published as a top conference workshop. Artificial Intelligence in Requirements Engineering 2023.

> Excerpt from student feedback: We successfully replicated Henao et al.'s study using the same methodology, dataset, code, and hyperparameters, including validating their results and determining their reproducibility for transfer learning models. By thoroughly citing the original paper, we have given credit to the original author and underscored our commitment to ethical research practices, ensuring a transparent and respectful research community.

VI. Discussion

Based on preliminary reflections and feedback from student groups, it was evident that asking students to replicate studies highlighted the importance of transparency and reproducibility in research and software development while supporting the practical development of ethics and professionalism. In software engineering, this directly relates to producing transparent, understandable, and accountable code. Some key lessons undergraduate students may learn include:

- Documentation and Reproducibility: Through replication, students understand the importance of thorough documentation, as incomplete or unclear methodologies can make it challenging to replicate a study. This lesson translates to software engineering, where proper documentation ensures others can understand, use, and maintain code, making projects sustainable and ethically sound.

- Another Important Aspect that students can learn from replicating studies is the role of negative results in honest scientific practice. Not all studies yield positive or expected results, and this is a crucial part of transparent reporting. This aspect is often overlooked in software engineering, where only successful projects are sometimes highlighted.

- Open Data and Open Science Principles: Replicating research often involves using publicly available datasets or tools. This encourages students to contribute to the community by making their work transparent and accessible, fostering collaboration and ethical behavior in academic and professional environments.

Replicating Research also teaches students the importance of accountability. They learn to hold themselves responsible for their findings, a lesson that is equally important in software development. Software engineers must be accountable for the consequences of their work, whether it's security vulnerabilities, biased outputs, or system failures. By encountering these challenges and learning the value of transparency, students are better equipped to make ethical decisions in their future careers as software engineers.

VII. Conclusion and Future work

The outcomes from running this pilot study have yielded promising results for a future expanded research study. In this instance, the students' work led to scholarly publications in conferences and journals. The outcomes of this study are

fourfold. It will a) enhance professional ethics and integrity, b) provide an in-depth understanding of the subject, c) enhance problem– solving and critical thinking, and d) inculcating shared vision and team-working skills. However, due to the low participation level, the study must still be evaluated within a larger pool of students to determine the generalizability of the results obtained, which is part of our future work.

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