Enhancing Quality of Computer Science Bachelor Theses by Preparing Students via a Prior Research Methodology Course Including AI Tools

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Abstract

For future higher education, it is paramount to ensure computer science students successfully complete their bachelor's theses on time which is a growing challenge due to increased complexity in both scientific approaches, engineering skills and the AI tools palette entering the stage. Problem solving skills are fundamental for students to be able to navigate through these information flows to be able to express and formulate their own set up criteria following a logical order to be able to reflect and state outcomes from this process. The process includes a reverse engineering assessment approach at the same time as the formal requirements demand a sequential writing order including both natural and programming languages described and motivated. We require parallel processes where we need to support students in how they base a problem, how to gain insights from previous industrial and academic attempts by others, formulate research questions from a scientific perspective and at the same time as hardware and/or software implementation is based on this approach. Many students struggle with understanding scientific prerequisites, their role in relation to this often due to a lack of comprehension of what this means when to formulate, prepare and motivate themselves in an academic context. It is paramount to highlight joint necessities for scientific and engineering problem formulations to reach higher quality and timely aspects. Incorporating AI-driven tools can be a way to increase and support curiosity around searching for information and answers to problems or concepts being unfamiliar. Iterative feedback loops can significantly improve students' ability to formulate research questions, conduct systematic investigations, and manage their time effectively. Important though, it is not to reduce one's own problem-solving capacity by only copying-paste actions solely without understanding its meaning(s). The findings suggest that early engagement through a course in research methodology not only improves the quality of bachelor theses but also enhances students' confidence and readiness for future professional and academic challenges. The quality for the students is to explain the unexplainable and/or its complexity even when using AI tools for reaching enhancements. Student throughput and the course evaluations indicate the quality improvement of the theses.

Keywords: "Computer Science Education", "Research Methodology", "Computer Science Bachelor Thesis Quality", "Problem Solving skills", "Scientific and Engineering Approaches", "AI Tools in Education"

Introduction

In the name of ACM/IEEE Computer Science Curricula 2023 [1] it has happened a whole lot on the AI stage since the curricula was published 2024. The Swedish Higher Education Authority (UKÄ) and its Swedish Higher Education Act (1992:1434) [2] is updated regularly on a yearly basis with later amendments added. This said, teaching staff needs formal support and updates on a regular basis both nationally and internationally to know how to navigate these AI additions and sources for teaching and learning tools. ACM/IEEE is a good source and supports an ever-changing discipline and its computer science sub subjects.

"A substantial section on artificial intelligence (AI) and the role computer scientists and engineers will play in its continued evolution. CS2023 also introduces a chapter on ways Generative AI could propel further innovation in computer science education." [3]

The three-year Computer Science Bachelor programs at Kristianstad University (HKR), Sweden, have undergone significant changes and improvements in recent years. These revisions were aimed at aligning the programs with both the Swedish national requirements for a Bachelor's degree [4] and the ACM/IEEE curriculum guidelines [1]. While substantial subject-specific knowledge has been

successfully integrated into the core courses, this shift has also revealed gaps particularly in students' academic writing abilities and their understanding of research fundamentals.
Different approaches have been tested over time, such as implementing an academic track in the program by integrating general competencies and skills throughout the curriculum [5] or combining the thesis course, which is the final course in the program, with another course running in parallel [6], but students still faced significant challenges; particularly in formulating a clear research question, connecting empirical study to a relevant literature review, or even presenting a well-structured, logical line of reasoning in their Bachelor theses.
To reverse-engineer the thesis process, the end goal must be clearly defined - specifying the requirements and expectations from both scientific and engineering perspectives for computer science students. This end goal can be understood through three key dimensions: (1) achieving the learning outcomes specified in the course syllabus, (2) producing a high-quality thesis, and (3) applying appropriate assessment and grading criteria to the thesis work.
Clearly outlining the grading requirements - including what is expected for different grade levels and to what extent - provides students with a structured framework. This matrix-like approach not only helps students navigate the thesis process more effectively but also serves as a shared foundation for constructive dialogue between students and educators.
Integrating AI tools into education [7], along with our evolving roles as educators in response to these changes [8], is crucial in fostering curiosity, supporting independent inquiry, and addressing knowledge gaps as they arise.
To better prepare students for the thesis process, a 7.5 HEC Research Methodology course was introduced three years ago. Delivered at half pace, the course is designed to build research competence ahead of the final thesis work. This article outlines the structure of the Research Methodology course, the Thesis course and an example of how AI tools can assist in clarifying grade levels and their corresponding expectations in terms of required content (see Table 1).

Method for Enhancing Quality in Education

The educators in the computer science courses at the Kristianstad University computer science department employ an iterative reflection process, grounded in action research (as illustrated in Figure 1 [9]). This ongoing approach involves regular meetings where staff collaboratively discuss and refine the courses to support continuous improvement.

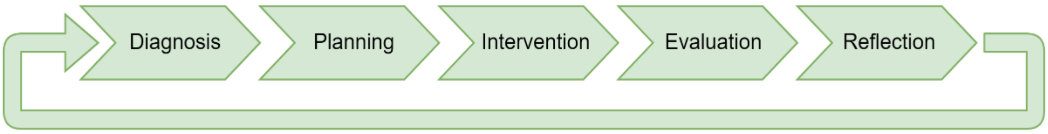

Fig 1. The cycle of five stages in action research.
Course evaluations serve as one source of feedback, while real-time teaching reflections conducted with students actively involved offer another valuable perspective. The continuous, cyclical reflection process illustrated in Figure 1 can also be described through the sequence: reflect, plan, act, observe, and then reflect again; forming an ongoing cycle [8]. This represents a continuous process of research and learning, grounded in the teaching staff's long-term engagement with a particular problem area.
As noted in [8], both action research and traditional scientific methods share the overarching goal of generating knowledge. However, their approaches differ: action research typically begins with limited knowledge of a specific context and involves collaborative efforts to observe, understand, and ultimately improve the situation - while also reflecting on one's own actions throughout the process. In contrast, traditional science usually starts from a foundation of established theoretical knowledge and seeks to discover new facts, verify existing ones, and analyse causal relationships with a strong emphasis on precision and measurable cause-and-effect outcomes.

Research Methodology Course, DA311A

In this reverse-engineered approach, the Research Methodology (RM) course (DA311A, 2022) [10] plays a central role by anchoring key elements of the grade matrix. It functions as a scaffold, a palette of components designed to help students recognize and understand the individual elements of the thesis process and how these contribute, with varying weight, to the overall outcome. This structure can be conceptualized as a network or web that supports the development of deeper comprehension,

enabling students to build greater self-confidence in both understanding the research process and articulating their ideas through academic writing.
The primary course literature was Research Methodology 2.0 by Säfsten and Gustavsson [11], which provided a solid foundation of factual knowledge. However, to extend beyond theoretical understanding, the course also incorporated scientific articles and engineering specifications. These additional resources helped demonstrating how scientific and engineering processes are applied in practice -illustrating how knowledge is not only acquired but also structured, problematized, analyzed, and communicated in a scholarly context. Changing main literature to Wohlin et al. [12] the authors present essential principles for conducting empirical studies in software and hardware engineering, effectively linking research questions and their variables through implementation to achieve meaningful results. This approach helps students better understand how the various components of a research process are interconnected, from the initial question to the final outcome. By gaining clarity on how the end result is constructed, students are better equipped to comprehend where and how to begin their own research journey. To include feedback loops jointly informing theory and practice [13] are crucial so guidance can occur.
When reading peer-reviewed articles and engineering specifications, the writing is typically presented in a linear, start-to-finish format, making the iterative and exploratory nature of the actual engineering process largely invisible. To strengthen students' problem-solving abilities, the RM course has, for the past three years, required students to write a thesis project plan intended to serve as a preliminary draft for the subsequent thesis course. While this approach has shown some positive effects, challenges remain, particularly in effectively utilizing these project plans during the early stages of the thesis course. The core issue lies in the fact that students have no prior experience writing a thesis. As a result, asking them to draft a project plan for something they have never created or written before can lead to disconnects in purpose and execution. This process, therefore, requires a different foundation - one that better supports first-time thesis writers in bridging the gap between planning a scientific study and actual writing.
The latest revision of the RM course places greater emphasis on having students write a so-called mini thesis in the form of an empirical study, followed by a short project plan. This approach is intended to help students understand the relationship between these two distinct documents and what aspects will be further developed and emphasized in the thesis course. The aim is to clarify that a project plan serves as the starting point for addressing a problem, specifically, a research question - and is not merely a generic document without purpose or direction.
It is important to note that if a problem area is defined but no clear research question is formulated, it becomes difficult to demonstrate meaningful results. A thesis cannot rely solely on being a process-oriented activity; it must also have a clearly defined objective to guide the research and lead to a tangible outcome.
As students' progress in their academic writing, it is important to understand that a literature study is not merely a chapter in the thesis (sometimes incorporated in main body text). Rather, it is a continuous tool informing, equipping, and supporting the research process from beginning to end.

Bachelor Thesis Course, DA399E and DT339F

The Bachelor Thesis course spans an entire semester and is designed to deepen students' knowledge and skills within a defined area of Computer Science. It is offered with a focus on Software Development (DA399E, 2024) [14] and on Computer Science and Engineering with a specialization in the Internet of Things (DT339F, 2024) [15]. Through the completion of a scientific study, students produce a bachelor thesis. The chosen topic must be relevant to the student's educational program.
The course includes a midterm seminar, during which students present the aim of their study, the selected scientific method, and a review of relevant prior research. While participation in the seminar is not mandatory, it is strongly encouraged, as it provides an early opportunity for supervisors and examiners to identify potential issues. Addressing such challenges at an early stage supports students' progress and informs them of the need for any additional guidance.
Students are encouraged to work in pairs, unless there are valid reasons for completing the project individually. Each thesis is supervised by a faculty member and assessed by an appointed examiner. In cases where the project is carried out in collaboration with an external organization, an additional external supervisor is also assigned.
The overall aim of the course is to enable students to independently plan, conduct, and present a scientific study, both in written and oral form. This includes developing the ability to:

- Apply scientific methods within the field of computer science or computer engineering.

- Demonstrate a deep understanding of relevant theoretical foundations and current research.
- Clearly and effectively communicate technical and scientific knowledge at an advanced level.

To support both the learning process and assessment, a self-evaluation form aligned with the program's intended learning outcomes is used throughout the course. This form serves as a structured tool to help students understand the expectations and requirements of the thesis, while also assisting supervisors and examiners in ensuring that the final work meets the academic and professional standards of the degree program. Again, feedback loops by supervisors and examiners [13] are crucial in evolving the theses to their completion.

AI Tool Case Study: Support via Large Language Model Tools

In just the last years' advancements of Natural Language Processing (NLP) and the many Large Language Models (LLMs) entering everyone's computer we need from instructors/teachers' perspectives think how we form our student tasks and how students benefit from this, to not unhook themselves from the problem-solving capability and ability. One can without problem stipulate prompts generating theses, here a mini thesis, and get a draft made within 10-15 minutes. With this in mind, we need to emphasize the steps and make clear that the students understand their own capabilities and what is solvable within a certain timeframe.
As a thought-provoking example, perhaps instead of asking students to produce a flawless, LLM-generated thesis draft, we could ask them to generate ten mini-theses and critically evaluate what is lacking or incorrect in each. While slightly tongue-in-cheek, this suggestion highlights the need to reconsider how we approach content creation and how we evaluate the academic integrity and educational value of student work.
To directly explore how LLMs can support student comprehension and enhance understanding, a couple of examples are provided below. These examples illustrate how LLM-generated content can serve as a basis for developing grading rubrics and self-evaluation tools (as mentioned earlier). Specifically, the examples demonstrate how individual sub-tasks within an empirical computer science or computer engineering thesis can be structured and evaluated. Table 1 presents a response generated by OpenAI's ChatGPT, based on a prompt requesting a grading scheme categorized into Pass, Good, and Very Good, displayed in a clear table format. This type of AI-generated material can serve as a helpful reference for students, offering guidance on what criteria are expected and how their work will be assessed from the outset.
Table 1. An Open AI ChatGPT-4 2025 generated reply by prompt "Show a grading scheme with grade 3, 4 or 5 on a 5-grade scale for an empirical computer science thesis in Computer Science with a focus on software development (DA399E) and Computer Science and Engineering with a focus of Internet of Things (DT339F) at Kristianstad University. What should be included for the different grades?".

Grading Scheme for Empirical Thesis in Computer Science / Computer Science and Engineering

Criterion	Grade 3 (Pass)	Grade 4 (Good)	Grade 5 (Very Good)
Problem Formulation	Clear but basic problem; aligned with course scope	Clearly defined and justified; some depth or originality	Well-defined, clearly motivated, and shows originality or innovation
Literature Review	Sufficient to support understanding; sources are relevant	Comprehensive with relevant comparisons and some analysis	Critical, analytical, well-structured; integrates sources to form arguments
Methodology	Appropriate method chosen; basic understanding shown	Method well-chosen, explained, and adapted to the context	Strong methodological rigor, justified choices, and critical understanding demonstrated
Implementa-tion /	Functionally	Effective implementation, shows problem-solving	High-quality, innovative, or technically complex solution;

Experimenta-tion	correct; limited complexity	and software engineering skills	strong engineering practices
Evaluation / Results	Basic evaluation; limited but valid conclusions	Clear evaluation using relevant metrics; thoughtful interpretation	In-depth, critical evaluation; data well-analyzed; limitations discussed
Academic Writing	Mostly correct language and structure; citations mostly used correctly	Well-structured, good language use, formal tone; references follow academic standards	Excellent academic writing; coherent, well-structured, precise; citations and formatting consistently correct
Reflection & Contribution	Basic reflection on work and learning	Good self-awareness and understanding of results' significance	Deep reflection; clear articulation of contributions and broader impact
Independence & Project Management	Completed with some supervision; basic planning shown	Shows initiative; manages time and tasks with limited supervision	Highly independent; excellent planning, problem-solving, and communication with supervisor
Relevance to Field (SW Dev / IoT)	Relevant to the field; meets minimal expectations	Adds some value or insight to the chosen area	Strong relevance; demonstrates contribution or innovation within Software Dev or IoT

This method allows us to clearly demonstrate the steps necessary to enhance student understanding of grading criteria, as well as the specific requirements at various stages of the writing process and their corresponding content.

Another example is provided below, illustrating how to develop a research question, including an additional column in Figure 2 indicating the expected grade level. This serves to clarify what is required at each stage. Students can use LLMs such as ChatGPT, Gemini, or similar tools by crafting targeted prompts to support their own knowledge development in parallel with meeting formal academic requirements.

Research Question Improvement With Grade Scale

	Stage	Research Question	Clarity	Specificity	Feasibility	Novelty	Grade Scale
1	Low Quality	How is software implemented using computer science theory?	Too broad and lacks focus	Covers a vast area with many interpretations	Difficult to answer due to wide scope	General topic with extensive prior research	Fail or Needs Major Improvement
2	Medium Quality	How can algorithmic principles improve software performance?	More specific but still general	Narrowed down to algorithmic principles	More feasible but still needs refinement	Somewhat original but could be explored further	Pass
3	High Quality	How can graph theory-based algorithms optimize large-scale software system performance?	Clearly defined with a precise scope	Focused on a well-defined theoretical and practical aspect	Achievable with clear methodologies and data	Addresses a specific research gap with innovation	Pass with Distinction

Fig 2. Prompt: "Show a research question improvement in how implementation of software based in computer science theory", ChatGPT, 2025.

The integration of advanced tools such as ChatGPT and Gemini has the potential to significantly enrich academic experience by providing instant, in-depth responses supporting both students and instructors. These models can swiftly generate relevant content, aiding students in refining their research questions and developing well-structured project plans. By leveraging the capabilities of AI, students can cultivate a deeper understanding of their subject area and advance their academic work with increased clarity and precision.

However, to fully benefit from these tools, it is essential to ensure, nurture and maintain logical consistency and coherence throughout the research and writing process. Given the vast amount of

content LLMs can generate, adopting a structured approach guided by a clear and focused line of reasoning is crucial.
Results
The students´ evaluations from courses arranged in EvaSys confirm that connecting the RM course prior to the thesis benefits the learning, it is easier for the students to understand the connections to research question(s), it is easier to write with support of AI-tools (to know when to use it and not), etc. Students´ comments also confirm how valuable the engagement of the teachers is.
Some comments from students´ evaluations in the RM course include:
"Good to have time to come up with an idea for thesis."
"The course provided a solid foundation in the subject matter, fostering critical thinking and practical skills. Additionally, the engaging lectures and collaborative assignments enhanced the overall learning experience."
"When we were given independent time to focus on our projects and the instructors would meet us individually we were able to make some progress on our specific projects."
"[…] is a great teacher and carries a positive attitude throughout the course, keeping the students motivated. Correspondence with her is easy and she is very engaged in the course."
Some comments from students in the Thesis course:
"I love the organization of the course. […] did great! We were introduced to the course a bit in advance to be able to plan well. We were given all the information needed and remined for any important event. I am extremely happy with my supervisor who was always there for us with his great knowledge and wisdom to guide us.
I liked how everything was handled, the midways, and the presentations... everyone was friendly and understanding. I did not feel pressured or judged.
I also appreciate […]'s commitment to […] carefully planned schedule. I had some requests for a change in the schedule, and although they were rejected, I appreciate that […] is strict with important matters while being flexible and understanding with other aspects to ensure the organization remains balanced and not too stressful.
Talking to people from previous years I could clearly see that this course has improved a lot and I am happy to see that HKR is using the feedback for improvement and I am event happier I could be part of this course."
"Learning outcomes were more than rewarding."
Still, even when students express satisfaction with the course, we as teachers must remain prepared for the challenges and opportunities that come e.g. with new technologies. It is also important to note that much of the students' feedback is shared orally—during supervision sessions or in seminar discussions—rather than through formal evaluations. This highlights the ongoing need for active listening and adaptability in our teaching practices.
In response to student feedback and the evolving educational landscape, new changes have been implemented in the thesis course. Students are now required to submit a declaration outlining both their own contributions and the use of AI tools. The statement reads:
"I/We hereby confirm that this thesis is my/our own original work. AI tools were utilized solely for grammar checking and language refinement, without contributing to the thesis, analysis, or conceptual development of the content."
It is important to recognize that AI tools can support students beyond writing, particularly in engineering problem-solving scenarios where students encounter gaps in their own knowledge. In computer science we deal with both natural and programming languages, so the AI tools extend for software and hardware development, analytics, ... The challenge for a student is to weave together these various parts via text to a logical thread making sense.

Summary

In summary, the Research Methodology (RM) course is designed to establish the empirical foundations that students will draw upon in the subsequent thesis course. Genuine understanding and academic integrity remain non-negotiable cornerstones in the light of AI tooling accompanying us in what core knowledge we need to build and how to prepare our students and staff for AI generated content. In the near future, we can expect the emergence of additional language models, including Digital Twins, which will further increase the complexity of language-based systems. These models will increasingly be integrated with and extended into 3D environments [16].

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