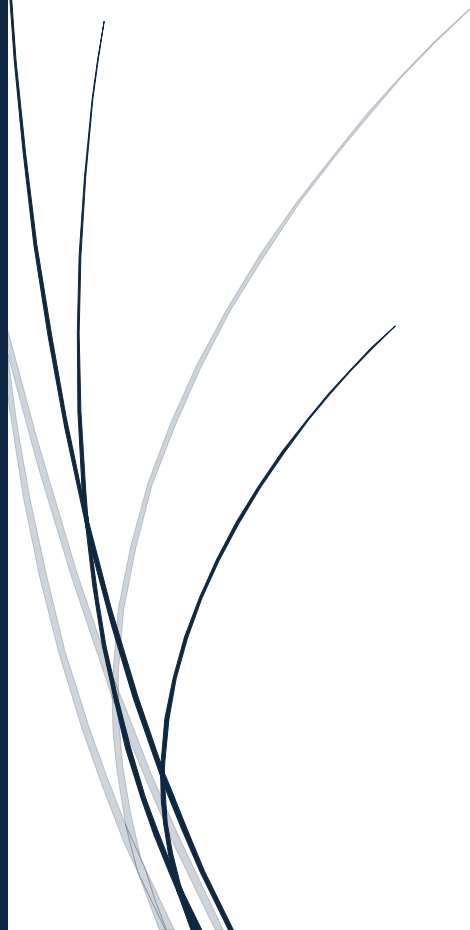


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Research Proposal, ACFA7004-

Evaluating the Effectiveness of
Structured AI-Assisted Feedback
in Secondary School Computing
Education.



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1. Introduction.

1.1. Context and background.

Artificial Intelligence (AI) is becoming increasingly common in education and is starting to change how students learn and interact with technology. AI-based tools such as intelligent tutoring systems, automated feedback systems, and adaptive learning platforms are designed to support learning by providing personalised guidance and improving student engagement [1].

In computing education, programming is widely recognised as a challenging subject, particularly for beginners. Students often struggle to understand key concepts, debug errors, and interpret compiler feedback. This is largely due to the abstract nature of programming and the technical language used in error messages, which are not designed for novice learners [2].

Feedback plays a critical role in learning, as it enables students to identify mistakes, improve their understanding, and develop problem-solving skills [3]. However, in many programming environments, feedback is often unclear, overly technical, and difficult to apply effectively.

Recent developments in AI provide an opportunity to improve this. AI systems can analyse student input and generate clearer explanations, hints, and step-by-step guidance, making feedback more accessible and aligned with how students learn. However, much of the existing research still focuses on higher education or general AI applications, with limited attention given to structured AI feedback in secondary school computing [1].

1.2. Research Problem.

Despite the increasing use of Artificial Intelligence (AI) in education, there is still limited research evaluating how effective structured AI-assisted feedback is in secondary school computing. While many studies highlight the potential of AI to support learning, most focus on higher education or general applications, rather than targeted use within classroom environments for younger learners [1], [2].

A key challenge in computing education is that beginner students often struggle with debugging and interpreting feedback. Error messages are typically technical, abstract, and designed for experienced users, making them difficult for novices to understand. This can lead to confusion, frustration, and reduced confidence, which negatively affects engagement and learning [3].

Although feedback is widely recognised as an important part of the learning process current programming environments rarely provide feedback that is clear, structured, and easy to apply. While AI offers a potential solution, there is still limited evidence showing how it can be used to deliver structured feedback that aligns with effective teaching practices, particularly in secondary education [4].

In addition, existing research tends to focus on performance measures, such as accuracy, with less attention given to student experience. Factors such as confidence and usability are also important, as they influence engagement and long-term learning.

Therefore, the central research problem addressed in this study is:

“There is limited empirical evidence on whether structured AI-assisted feedback can effectively improve both understanding and confidence in secondary school computing students compared to standard technical feedback.”

Addressing this problem is important, as it allows AI to be explored not just as a tool, but as structured support that better meets the needs of beginner learners.

1.3. Research Aim and Objectives.

1.3.1. Research Aim.

The aim of this research is:

“To design and evaluate a structured AI-assisted feedback system and examine its impact on understanding and confidence in secondary school computing students.”

1.3.2. Research Objectives.

To achieve this aim, the study will:

- Conduct a structured review of existing literature on Artificial Intelligence in education, programming education, and feedback theory
- Identify common challenges faced by secondary school computing students when debugging and interpreting feedback
- Design and develop a prototype system that provides structured AI-assisted feedback based on educational principles
- Implement and test the prototype with secondary school computing students in a controlled setting
- Collect and analyse both quantitative and qualitative data, including measures of understanding, confidence, and system usability
- Evaluate the effectiveness of structured AI-assisted feedback compared to standard technical feedback

1.4. Significance of the research.

1.4.1 Importance of the Research

This research responds to a gap in the use of Artificial Intelligence (AI) within secondary school computing education. Although AI tools are increasingly used in learning, there is limited empirical evidence evaluating their effectiveness when applied to structured feedback for beginner programming students [1]. This study contributes to both AI in education and computing education by focusing on how feedback can be improved for novice learners.

This research focuses on the challenge of interpreting programming feedback, which is widely recognised as difficult for beginners [2]. Feedback plays a key role in learning by helping students identify mistakes and improve their understanding [3]. By designing and evaluating a structured AI-assisted feedback system, this study aims to support both understanding and confidence, which are essential for successful learning and continued engagement in computing.

1.4.2. Potential Applications

The findings of this research may have practical value in both education and technology development. In educational settings, the results may inform how AI tools are integrated into computing classrooms to support learning rather than replace traditional teaching. Structured feedback systems could help teachers provide clearer guidance and better support students with different ability levels.

From a technical perspective, this research may contribute to the development of AI-based feedback systems that align more closely with educational principles. The approach could also be adapted to other subjects where students struggle to interpret complex feedback.

In addition, the study may support future research by demonstrating how AI can improve both understanding and confidence. These outcomes are important for learning, as they influence engagement and long-term skill development.

2. Literature review.

2.1 Introduction to the Literature Review

The purpose of this literature review is to examine existing research related to Artificial Intelligence (AI) in education, programming education, and the role of feedback in learning. It aims to identify key themes, approaches, and gaps relevant to this study.

The review focuses on studies from the last two decades, with particular attention to recent developments in AI-supported learning systems and feedback methods. It includes research from both higher education and school settings, while placing greater emphasis on secondary school computing where possible.

The literature is organised into four key themes:

- The use of AI in education
- Challenges in programming education
- The role of feedback in learning
- AI-assisted feedback systems

These themes provide a structured overview of the research area, highlighting key contributions while identifying gaps. In particular, they show that although AI and feedback are well-established areas, there is limited research combining them in a structured and empirically evaluated way within secondary school computing

2.2 Artificial Intelligence in Education.

Artificial Intelligence (AI) has become a key area of research in education, particularly in its ability to support teaching and learning. AI technologies are widely used to personalise learning, automate processes, and provide feedback to students. Early work in this field focused on intelligent tutoring systems, which adapted content and guidance based on student performance [5].

More recent research highlights the development of AI-driven learning environments that use techniques such as machine learning and natural language processing to provide tailored support. These systems can analyse large amounts of student data and respond dynamically, making them particularly useful in subjects such as programming, where learning involves problem-solving and repeated practice [6].

AI systems also enable scalable support in educational settings. In situations where teachers cannot provide detailed feedback to every student, AI can deliver immediate responses, allowing learners to refine their understanding in real time [7]. This has increased interest in using AI not only for content delivery but also as a tool for supporting learning through feedback.

However, there are still several limitations. Many AI systems focus primarily on performance outcomes, such as correctness, rather than supporting deeper understanding or building student confidence [6]. In addition, much of the research has been conducted in higher education, with less focus on secondary school contexts where learners may require more structured guidance.

Another limitation is the lack of alignment between AI systems and established pedagogical principles. Although AI can generate feedback, it is not always presented in a way that supports effective learning. In many cases, feedback highlights errors without providing sufficient explanation or guidance on how to improve [7].

Overall, while AI has strong potential to support education, there remains a gap in its application for structured feedback in secondary school computing. This highlights the need for research that integrates AI capabilities with effective teaching approaches to improve both learning outcomes and student experience.

2.3. Challenges in Programming Education.

Programming education is widely recognised as challenging for beginner learners, particularly in the early stages. Students often struggle with understanding abstract concepts, applying logical thinking, and interpreting system-generated feedback, which can lead to frustration and reduced confidence [2].

One of the main difficulties is debugging, which requires students to identify, understand, and correct errors in their code. Research shows that novice learners often lack the experience needed to interpret error messages effectively, as these are typically technical and not designed for beginners [8]. As a result, students may attempt to fix errors without fully understanding the underlying problem.

Programming also presents significant cognitive challenges. Learners must manage multiple elements simultaneously, including syntax, logic, and problem-solving strategies. This can create cognitive overload, making it harder to develop a clear understanding of programming concepts [9]. Without sufficient support, students may rely on trial-and-error approaches rather than structured problem-solving.

Another issue is the limited effectiveness of traditional feedback in programming environments. Compiler error messages often indicate that an error has occurred but provide little explanation or guidance on how to resolve it. This restricts students' ability to learn from mistakes and improve their skills over time [2].

In addition to these technical challenges, affective factors such as confidence and motivation play an important role. Students who repeatedly encounter difficulties without clear guidance may experience reduced self-efficacy, which can negatively

impact engagement and progression. Research suggests that feedback should be clear and supportive to maintain both performance and motivation [3].

Overall, programming education presents both cognitive and technical challenges for novice learners. These challenges are closely linked to the limitations of existing feedback systems, reinforcing the need for more structured and accessible approaches. This provides a useful basis for exploring AI-assisted feedback for exploring AI-assisted feedback in secondary school computing.

2.4. The Role of Feedback in Learning.

Feedback is widely recognised as a key factor in effective learning, particularly in skill-based subjects like programming. It helps students identify mistakes, improve understanding, and develop problem-solving skills. Research shows that feedback is most effective when it is clear, timely, and structured, as this supports both understanding and academic performance [3].

Effective feedback goes beyond indicating whether an answer is correct. It should explain errors, provide guidance for improvement, and support the development of better problem-solving strategies. Hattie and Timperley emphasise that feedback is most useful when it addresses three questions: “Where am I going?”, “How am I doing?”, and “What should I do next?” [3].

In programming education, feedback is particularly important during debugging. However, most programming environments provide feedback in the form of technical error messages, which are not designed for beginner learners. These messages often lack clear explanations and do not guide students towards understanding the cause of errors, limiting their ability to learn effectively [8]. Feedback also influences affective factors such as confidence and motivation. Clear and supportive feedback can increase confidence and encourage continued engagement, while unclear or overly technical feedback may lead to frustration and reduced self-efficacy [9].

Despite its importance, delivering effective feedback can be challenging in practice. Teachers often have limited time, making it difficult to provide detailed and personalised feedback to every student. This has led to increasing interest in the use of AI to support feedback delivery.

Overall, while feedback is essential for learning, current approaches in programming education are often not suitable for beginner learners. This highlights the need for feedback that is more structured, accessible, and aligned with how students learn.

2.5. AI-Assisted Feedback Systems

The use of Artificial Intelligence (AI) in feedback systems has gained increasing attention, particularly in subjects such as programming where students often require additional support. AI-assisted feedback systems analyse student input and provide automated responses, ranging from error identification to explanations and guided support. These systems aim to provide immediate and scalable feedback, addressing limitations of traditional approaches [7].

Advances in AI, including natural language processing and machine learning, have enabled the development of more context-aware feedback. Unlike standard programming environments that provide fixed error messages, AI systems can generate explanations, hints, and step-by-step guidance tailored to the learner's input. This has the potential to improve understanding and engagement, especially for novice learners [6]. However, several limitations remain. Many systems focus primarily on correctness rather than supporting deeper understanding. In some cases, feedback may still be too complex or insufficiently structured for beginners, highlighting a gap between technological capability and educational effectiveness [6].

In addition, much of the existing research has been conducted in higher education or controlled environments, with limited focus on secondary school classrooms [4]. There is also a lack of empirical studies directly comparing AI-assisted feedback with traditional feedback methods, particularly in relation to both cognitive outcomes, such as understanding, and affective outcomes, such as confidence.

Overall, while AI-assisted feedback systems show strong potential, there is a clear gap in the development and evaluation of structured, pedagogically aligned feedback for secondary school computing. This research aims to address this gap by designing and empirically evaluating a structured AI-assisted feedback system.

2.6 Literature Summary and Relation to the Study

This literature review has examined key areas relevant to this research, including Artificial Intelligence (AI) in education, challenges in programming education, the role of feedback in learning, and AI-assisted feedback systems. Across these areas, the literature highlights both the potential of AI to support learning and the limitations of current approaches in educational contexts.

Research on AI in education demonstrates its ability to provide personalised and scalable support. However, much of this work focuses on higher education or general applications, with limited attention to structured use within secondary school computing [1], [4]. This indicates a gap in understanding how AI can be effectively integrated into classroom settings for younger learners.

Studies on programming education show that beginner learners face significant challenges, particularly in debugging and interpreting technical feedback. These difficulties are closely linked to the limitations of traditional feedback systems, which often lack clarity and guidance [2], [8]. The literature on feedback emphasises that effective feedback should be clear, structured, and actionable in order to support learning [3]. However, in programming environments, feedback does not consistently follow these principles, especially for novice learners.

Research into AI-assisted feedback systems suggests strong potential for improving learning through immediate and automated support. However, many systems are not aligned with educational principles and are rarely evaluated in secondary school contexts. There is also limited empirical evidence comparing AI-assisted feedback with traditional approaches, particularly in relation to both understanding and confidence.

Based on these findings, this study focuses on the following research gap:

“There is a lack of empirically evaluated, structured AI-assisted feedback systems designed specifically for secondary school computing education that address both understanding and confidence.”

This research aims to address this gap by designing, implementing, and evaluating a structured AI-assisted feedback system, contributing both practical and theoretical insights to the field.

3. Research Design and Methodology

3.1 Research Design

This study uses a Design Science Research (DSR) approach, commonly used in computing and information systems to develop and evaluate solutions to real-world problems. The focus of this approach is on creating an artefact and assessing how effectively it addresses a specific issue. In this study, the artefact is a structured AI-assisted feedback system designed to support secondary school computing students [10]. This approach is appropriate as the research aims not only to understand a problem but also to develop and evaluate a practical solution. The study begins by identifying challenges students face when interpreting programming feedback, followed by the design and development of a prototype system that provides structured AI-assisted feedback. The system is then evaluated to examine its impact on student understanding and confidence.

The Design Science Research process follows established stages, including problem identification, objective definition, design and development, demonstration, evaluation, and communication of results [10]. This helps provide a structured framework for conducting the research and ensures methodological consistency.

By adopting this approach, the study contributes to both theory and practice, offering insight into the use of AI for educational feedback while also producing a practical system that could be applied in real classroom settings.

3.2. Research Methods and Materials

This study adopts a mixed-methods approach, combining both quantitative and qualitative data to evaluate the structured AI-assisted feedback system. This approach enables the measurement of learning outcomes while also capturing participant experiences, providing a more comprehensive evaluation of system effectiveness.

The research is conducted as an experiment within a controlled case study setting, allowing the system to be tested in a structured environment that reflects a realistic classroom context. This enables a direct comparison between different feedback approaches while ensuring that external variables are controlled.

The experiment compares two types of feedback provided during programming tasks: standard technical feedback and structured AI-assisted feedback. The independent variable is the type of feedback, while the dependent variables include student confidence, perceived understanding, and system usability. These measures allow the study to evaluate both cognitive and affective outcomes.

The study is based on the hypothesis that structured AI-assisted feedback will lead to higher levels of understanding and confidence compared to standard technical feedback

3.2.1. Experimental Design

To ensure the credibility of the experiment, several factors are considered. Reliability is maintained by ensuring all participants complete the same tasks under consistent conditions, allowing the study to be replicated. Validity is addressed by using appropriate measures of understanding and confidence, ensuring the research accurately assesses its intended outcomes. Generalisability is also considered; while the study focuses on a specific group, the findings may apply to similar educational settings, although this may be limited by sample size and experimental conditions.

3.2.2. Data Collection and Analysis.

The study will involve secondary school computing students aged between 11 and 16, recruited through local schools. Schools will be contacted directly to obtain permission to conduct the study, and appropriate consent will be obtained prior to data collection.

Data will be collected using both quantitative and qualitative methods. Quantitative data will include confidence rating scales, perceived understanding scores, and system usability ratings, allowing direct comparison between feedback conditions. Qualitative data will be gathered through short written reflections, providing insight into student experiences and perceptions.

The data will be analysed using appropriate methods. Quantitative data will be processed using descriptive statistics and comparison tests to identify differences between conditions. Qualitative data will be analysed using thematic analysis to identify recurring patterns and themes. This combined approach provides a more comprehensive understanding of both effectiveness and usability.

3.2.3. Materials.

A range of tools and technologies will be used to support system development, data collection, and analysis. The structured AI-assisted feedback system will be developed using HTML, CSS, and JavaScript for the frontend, and Node.js for backend functionality. GitHub will be used for version control and project management.

Data collection will involve short programming and debugging tasks representative of beginner-level activities. Questionnaires will be used to collect participant responses, with tools such as Google Forms capturing quantitative data, including confidence ratings, perceived understanding, and usability feedback. These responses will typically

use simple rating scales, ensuring consistency across participants. Observation notes may also be recorded to capture real-time interaction with the system.

Data analysis will be conducted using Microsoft Excel and Python via Jupyter Notebook to perform statistical analysis and visualisation. Qualitative data will be analysed using thematic analysis to identify common themes in participant responses.

The study requires only standard computing equipment, such as laptops or desktop computers, allowing it to be conducted in a typical classroom environment.

Ethical considerations will be addressed throughout the study. Participants will provide informed consent, and all data will be anonymised and stored securely in accordance with GDPR and institutional guidelines.

3.2.4. Research Onion Framework.

As shown in Figure 1, this study is guided by the Research Onion framework, which provides a structured approach to research design. The study adopts a positivist philosophy, focusing on objective measurement and analysis of observable outcomes. A deductive approach is used, beginning with a hypothesis that is tested through experimental investigation.

The research follows an experimental case study strategy, allowing the system to be evaluated in a controlled but realistic educational setting. A mixed-methods approach is used to collect both quantitative and qualitative data, providing a comprehensive evaluation of system effectiveness. The study adopts a cross-sectional time horizon, as data is collected at a single point in time.

This structured framework ensures that all elements of the research design are aligned and clearly justified.

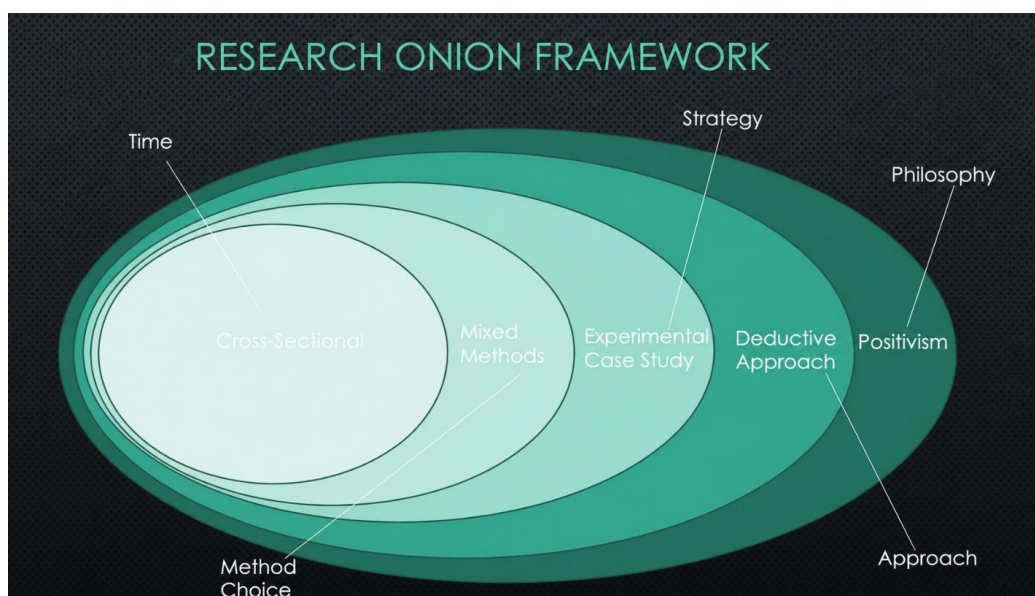


Figure 1 Research Onion Framework

4. Expected Outcomes.

The outcomes of this study are expected to show that structured AI-assisted feedback improves students' understanding of programming concepts. By providing clearer explanations and guided support, the system should help students interpret errors more effectively and develop more structured approaches to problem-solving compared to standard technical feedback.

Structured feedback is also likely to have a positive impact on student confidence. When feedback is easier to understand and more supportive, students may feel less frustrated and more capable of completing tasks. This is particularly important for beginner learners, as confidence often plays a key role in engagement and progression.

The system is expected to be perceived as more usable and helpful than standard technical feedback. Feedback that is clear and actionable is more likely to support learning in practice, especially in classroom settings where students benefit from immediate guidance.

The findings of this research are expected to contribute to both theory and practice. Theoretically, the study may provide insight into how AI can be used to deliver structured feedback in educational contexts. Practically, it may inform the design of AI-supported learning tools that better meet the needs of secondary school students.

4.1. Limitations.

Several limitations should be considered. The study will involve a relatively small sample size, which may limit the generalisability of the findings. Data will be collected over a short period, meaning long-term learning effects may not be fully captured. In addition, the use of self-reported measures, such as confidence and perceived understanding, may introduce some subjectivity.

In addition, differences in teaching style or prior student experience may also influence the results.

Despite these limitations, the study aims to provide valuable insight into the role of structured AI-assisted feedback in supporting learning in secondary school computing.

5. Timeline.

The project will be conducted over a six-month period, from March to September 2026, and is structured into key stages to ensure a clear and manageable progression.

The literature review and ethics preparation will run throughout the project. During the early stages, ethical approval will be prepared and submitted, and contact will be made with local secondary schools to obtain permission for participation.

The system design and development phase will take place between May and June. During this stage, the structured AI-assisted feedback system will be developed, tested, and refined to ensure it meets the required functionality.

Data collection will be carried out in July. Participants will be recruited from the schools contacted earlier, and controlled experimental sessions will be conducted. Both quantitative and qualitative data will be collected.

Data analysis will take place in August. Quantitative data will be analysed using statistical methods, while qualitative data will be examined to identify key patterns and themes.

The final stage in September will focus on writing the dissertation, making final revisions, and preparing the project for submission.

The Gantt chart in Figure. 2 provides a visual overview of the project timeline and key stages.

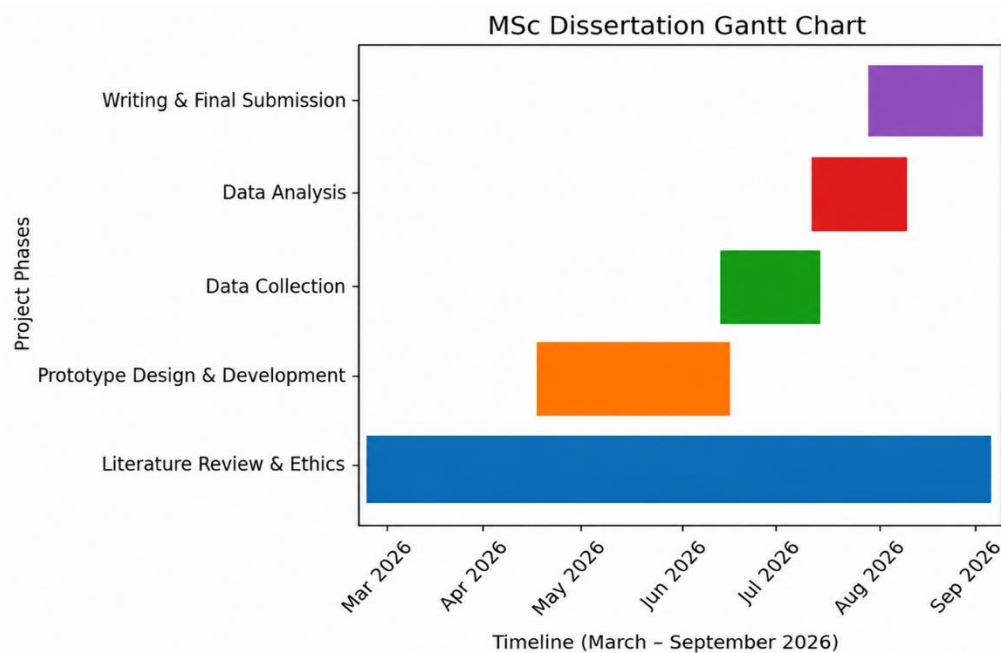


Figure 2 Gantt chart of the project timeline (March – September 2026)

Bibliography

- [1] O. Zawacki-Richter, V. I. Marín, M. Bond, and F. Gouverneur, “Systematic review of research on artificial intelligence applications in higher education – Where are the educators?,” *International Journal of Educational Technology in Higher Education*, vol. 16, no. 1, p. 39, 2019. doi: 10.1186/s41239-019-0171-0.
- [2] A. Robins, J. Rountree, and N. Rountree, “Learning and teaching programming: A review and discussion,” *Computer Science Education*, vol. 13, no. 2, pp. 137–172, 2003. doi: 10.1076/csed.13.2.137.14200.
- [3] J. Hattie and H. Timperley, “The power of feedback,” *Review of Educational Research*, vol. 77, no. 1, pp. 81–112, 2007. doi: 10.3102/003465430298487.
- [4] S. J. Lee and K. Kwon, “A systematic review of AI education in K-12 classrooms from 2018 to 2023: Topics, strategies, and learning outcomes,” *Computers and Education: Artificial Intelligence*, vol. 6, p. 100211, 2024. doi: 10.1016/j.caeai.2024.100211.
- [5] K. R. Koedinger and V. Aleven, “Exploring the assistance dilemma in experiments with cognitive tutors,” *Educational Psychology Review*, vol. 19, no. 3, pp. 239–264, 2007. doi: 10.1007/s10648-007-9049-0.
- [6] R. Luckin, W. Holmes, M. Griffiths, and L. B. Forcier, *Intelligence Unleashed: An Argument for AI in Education*. London, U.K.: Pearson Education, 2016. [Online]. Available: <http://oro.open.ac.uk/50104/>
- [7] R. S. J. d. Baker and K. Yacef, “The state of educational data mining in 2009: A review and future visions,” *Journal of Educational Data Mining*, vol. 1, no. 1, pp. 3–17, 2009. doi: 10.5281/zenodo.3554657.
- [8] E. Lahtinen, K. Ala-Mutka, and H.-M. Järvinen, “A study of the difficulties of novice programmers,” *ACM SIGCSE Bulletin*, vol. 37, no. 3, pp. 14–18, 2005. doi: 10.1145/1151954.1067453.
- [9] J. Sweller, “Cognitive load during problem solving: Effects on learning,” *Cognitive Science*, vol. 12, no. 2, pp. 257–285, 1988. doi: 10.1207/s15516709cog1202_4.
- [10] K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee, “A design science research methodology for information systems research,” *Journal of Management Information Systems*, vol. 24, no. 3, pp. 45–77, 2007. doi: 10.2753/MIS0742-1222240302.