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Enhancing Professional Skills through Literature Reviews in Automotive Engineering

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Abstract

As the automotive industry embraces electrification, autonomy, and AI-enabled diagnostics, engineering education must evolve accordingly. It is especially important to develop not only technical skills but also professional capacities known as the 4C's (critical thinking, communication, collaboration, and creativity). This work-in-progress describes a senior elective, Introduction to Automotive Engineering, designed for mechanical engineering undergraduates, which combines modules on traditional subsystems, vehicle electrification, and AI in the automotive industry. One of the most important aspects of the course is a team-based literature review project. In this project, students progress through stages of topic selection, source evaluation, critical analysis, synthesis, peer review, and final reporting. The assignment is constructed in a way that explicitly targets each of the 4C's. Students are required to assess the credibility of the research, present their findings clearly, collaborate effectively in teams, and creatively apply new technologies to vehicle systems. Early feedback and evaluation of draft work indicate that many teams are able to produce well-structured reports (communication) and occasionally propose novel ideas (creativity). However, they tend to merely summarize rather than critique, highlighting a weakness in their critical thinking skills. They also experience difficulties with equitable division of labor; thus, their collaboration skills require further development. Future work will explore approaches, such as structured critique prompts and enhanced peer review, to promote students' balanced growth across the 4C's. These insights are intended to guide educators who seek to integrate emerging automotive topics and professional skills in a coherent curricular experience.

Introduction

With powertrain technologies evolving and new mobility solutions emerging, the automotive industry now demands a new kind of engineering graduate. This rapid shift, driven by stricter emissions laws, electrification, automation, and the integration of Artificial Intelligence (AI), requires engineers to possess more than just foundational technical knowledge. Today's professionals must be resilient and capable of designing, analyzing, and improving vehicles within a constantly changing global context. Preparing such professionals is essential for society to address contemporary challenges in transportation, environmental sustainability, and safety.

Modern engineering practice necessitates a broader pedagogical approach that expands beyond traditional topics such as thermodynamics and vehicle dynamics. While these foundational subjects remain indispensable, engineering education must now prioritize real-world applications and active learning. Equipping engineers for the modern workforce requires the development of 21st-century competencies, commonly referred to as the 4C's: critical thinking, communication, collaboration, and creativity. Integrating these skills into curricula is essential for cultivating the capacity to analyze emerging technologies, communicate complex ideas, collaborate effectively in diverse teams, and generate creative solutions to open-ended problems.

Research in modern Science, Technology, Engineering, and Mathematics (STEM) education highlights the importance of non-technical (soft) skills for graduates. These skills are strongly connected to employability, career success, and the ability to adapt to real-world professional demands [1,2]. This focus aligns directly with the student outcomes mandated by ABET (Accreditation Board for Engineering and Technology), which require graduates to demonstrate broad professional competencies. Studies show that, beyond technical expertise, engineers require a wide range of professional skills. These include problem-solving and critical thinking abilities [3-5], communication skills (oral, written, active listening, and reading) [6], and teamwork competencies such as multicultural collaboration and networking [7]. Additional skills include ethical perspective (ethics, professionalism, social responsibility) [1], emotional intelligence (emotion control, motivation, lifelong learning, self-direction) [8], and creative thinking and innovation [9].

To address this educational gap in automotive engineering, a senior elective titled "Introduction to Automotive Engineering" has been developed. The course features a semester-long, team-based literature review project anchored in the 4C's. Through this project, students practice several professional skills. They develop critical thinking by analyzing and synthesizing technical literature and strengthen communication through written reports and oral presentations. Students also build collaboration skills by working in teams and apply creativity by connecting automotive engineering fundamentals with emerging technologies such as AI.

This paper demonstrates how a literature-review-based project can simultaneously reinforce technical knowledge and cultivate essential professional competencies, offering a scalable model for integrating impactful learning practices into engineering education. Early student feedback, instructor observation, and implementation challenges are discussed to provide insight into the project's effectiveness. While this study focuses on automotive engineering, the structured literature review approach can be adapted to other engineering disciplines by adjusting the technical content while maintaining the same 4C's.

Course Design and Implementation

Course Architecture

The Introduction to Automotive Engineering course is a 3-credit senior elective designed to provide mechanical engineering students with foundational knowledge of automotive systems while systematically developing professional competencies. The course met twice per week for 75-minute lectures and enrolled 54 students in fall 2025. As described in detail in previous work [10], the technical content was organized into three modules: (1) fundamentals of vehicle design and dynamics, (2) propulsion systems and energy efficiency, and (3) emerging technologies, including autonomous driving and intelligent vehicle systems.

This sequence allows students to first understand conventional vehicle systems and then explore how emerging technologies are reshaping the automotive sector. Core principles were supported by widely used references such as Gillespie [11], Heywood [12], and Ehsani [13], along with ignition and combustion research studies [14–16]. Rapidly evolving topics are supplemented with current peer-reviewed journal articles, Society of Automotive Engineers (SAE) technical papers, government publications, and industry reports. This combination enables students to connect established engineering theory with modern developments in automotive engineering.

Assessment Strategy

The course followed a constructive alignment framework to evaluate students' technical understanding as well as their soft skill development. Table 1 outlines the grading structure, which was intentionally designed to provide a balanced assessment across technical mastery, communication, collaboration, and research skills.

Table 1. Course assessments

Assessment Component	Focus	Weight (%)
Participation and In-class Discussions	Engagement and articulation of ideas.	10
Midterm and Final Exams	Evaluating theoretical and applied understanding of the course material.	30
Individual Homework Assignments (3)	Analytical problem-solving of foundational topics.	30
Literature Review Project	Developing research literacy and 4C's.	30

The Integrated Literature Review Project

To simulate real-world engineering R&D environments, the course featured a semester-long, team-based literature review project. This project served as the primary pedagogical intervention for cultivating the 4C's. It was structured into four distinct phases to allow for iterative feedback and continuous improvement.

Phase I: Team Formation and Topic Selection: Phase I was introduced early in the semester to give students sufficient time to explore potential topics. During this phase, students communicated with the instructor for feedback and began developing familiarity with scholarly sources. Students were provided with a list of suggested topics aligned with modern automotive engineering. However, they were also encouraged to propose their own ideas, giving them full freedom to pursue areas that genuinely interested them.

Using a discussion forum on the course Learning Management System (LMS), Moodle, students connected with peers who shared similar interests and formed into teams of three. Then, each team submitted a one-paragraph proposal explaining their chosen topic, why it interested them, its relevance to the modern automotive industry, and five keywords to guide their initial research.

Proposals were reviewed by the instructor, and teams revised and resubmitted as needed until instructor approval was granted. This phase is worth 5% of the project grade.

4C's Focus: This phase emphasized critical thinking (evaluating the importance and relevance of the topic), collaboration (coordinating team formation and choosing the topic), and creativity (proposing or shaping new ideas).

Table 2 lists the selected topics. The literature review covered several propulsion technologies, including internal combustion engine (ICE) vehicles, battery electric vehicles (BEV), and hybrid electric vehicles (HEV). Most teams chose topics related to AI or electrification, reflecting current industry trends and students' interest in innovative technologies.

Table 2. Topics for the literature review project

Team	Topic	Application
1	Active Safety Systems (emergency braking, lane keeping, collision avoidance)	Safety
2	AI-Enhanced Route Optimization for Energy Efficiency and Travel Time	BEV and AI
3	AI in Automated Vehicle Perception, Decision-making, and Control	AI and autonomous
4	AI in Maintenance Assistance and Preventive Diagnostics	AI and maintenance
5	AI-Powered Simulation and Virtual Testing for Vehicle Performance	AI and simulation
6	AI Use in Generative Design for Optimized Suspension Components in Motorsports	Motorsports
7	Analysis of Modern Aerodynamic Improvements and their Effect on Truck Efficiency	Aerodynamics
8	Crashworthiness and Occupant Protection Design	Safety
9	Lap Time Simulator Modeling the Battery Pack Discharge of an Electric Car	BEV
10	Military Ground Vehicle Technologies and Modernization	Defense
11	Optimization of Regenerative Braking Strategies in Hybrid and Electric Vehicles	BEV/HEV
12	Racing Chassis Design and Optimization	Performance
13	Solid-state Battery Development and Integration in EVs	BEV
14	Solutions to Improve Low-speed Regenerative Braking Energy Recovery	BEV/HEV
15	The Impact of AI on Manual and Autonomous Driving Features	Autonomous
16	Thermal Management Systems for Electric Vehicle Battery Packs	BEV
17	Vehicle-to-everything (V2X) Communication Systems	Connectivity
18	Waste Heat Recovery in ICE Systems	ICE

Phase II: Abstract Development: After receiving the instructor's approval on the project topic, teams developed an abstract using the SAE technical paper template. Phase II is worth 15% of the project grade.

4C's Focus: This phase strengthened critical thinking (identifying main ideas, key findings, and gaps in the literature, and narrowing the topic to a clear focus) and communication (summarizing technical information in a short, clear abstract). In addition, this phase emphasized collaboration through coordinating the division of readings and integrating team insights into a unified abstract. It also encouraged creativity by allowing teams to shape the research direction and determine how to frame the topic in a meaningful way. Instructor feedback at this stage helped refine the scope and clarity before moving on to the full paper.

Phase III: Full Literature Review Paper: In this phase, teams submitted a 6–10 page literature review manuscript following the SAE technical paper template. They were required to include at least three peer-reviewed sources. Phase III accounts for 35% of the project grade.

4C's Focus: This phase helped students practice critical thinking by evaluating sources and distinguishing high-quality research from general web content. It also strengthened communication skills through formal technical writing, proper citations, and logical argument development. In addition, teams practiced collaboration by coordinating writing tasks, editing drafts, and managing citations together. Creativity was encouraged through original figures, technology comparisons, and thoughtful discussion of future trends and projections.

Phase IV: Oral Presentation: In the final phase, each team delivered a 15-minute presentation using an SAE PowerPoint template, followed by a Q&A session.

4C's Focus: In phase 4, teams delivered engaging presentations (communication), demonstrated creativity by projecting future industry implications, using visual aids, case examples, or design comparisons, and defended their analysis during the Q&A session (critical thinking), and coordinated speaking roles and slide design (collaboration). This phase is worth 45% of the project grade.

The Q&A sessions were particularly valuable in developing students' ability to think on their feet and reason through complex issues under time pressure.

Table 3 maps specific project activities to the targeted 4C's, demonstrating how the project served as a comprehensive tool for professional development.

Table 3. Integration of 4C's across project phases

Project Milestone	Critical Thinking	Communication	Collaboration	Creativity
Topic Proposal	Evaluate scope and relevance	—	Team decision-making	Topic choice or design
Abstract	Frame research narrative	Concise writing	Shared synthesis of findings	Structure and framing
Full Paper	Analyze, evaluate, and compare literature	Technical writing	Joint drafting and editing	Figures, models, projections
Oral Presentation	Defend conclusions and respond to questions in Q&A	Oral and visual communication	Coordinated delivery	Slide design

Accountability and Team Dynamics

To promote accountability in teamwork, teams submitted a contribution table for each submission to indicate individual roles and workload percentages. Students contributing less than

25% of the team's work were required to meet with the instructor, and individual grades were adjusted accordingly. Regular check-ins encouraged teams to address collaboration issues early. This approach ensured that the collaboration component reflected active and fair participation rather than passive involvement.

Academic Integrity

To uphold academic integrity, all submissions were processed through Turnitin via the Moodle submission page. This tool served to check for plagiarism and flag potential AI-generated content, reinforcing the importance of original work. However, it is important to note that while Turnitin is reliable for plagiarism detection, its ability to accurately identify AI-generated material is still considered limited. Therefore, it was used as an advisory tool rather than a definitive measure of academic misconduct.

Results and Discussion

Early evaluation of team submissions, instructor observations, and student feedback suggests that the literature review project supported the intended 4C's learning outcomes. As this is a work-in-progress, the results are preliminary and primarily descriptive, indicating a mixed but promising performance with distinct strengths and areas for development.

Communication and Research Skills: Key Strengths

Communication emerged as the most developed competency. Full paper submissions were well-organized, followed a logical structure, and used appropriate technical terminology. A significant improvement in writing quality was observed between the abstract phase and the final paper. Student reflections corroborated this finding. One student noted, "*Writing the report helped me organize my thoughts more clearly and present technical information logically.*" In parallel, an ancillary outcome was the development of research skills. Many students reported using academic databases such as Google Scholar and SAE Mobilus for the first time to locate and evaluate peer-reviewed sources. Together, these outcomes demonstrate the project's effectiveness in reinforcing both technical communication and research literacy.

Critical Thinking and Creativity: Areas Requiring Support

In contrast, critical thinking and creativity posed a significant challenge for most teams. The struggle with critical thinking appeared to come from students' unfamiliarity with academic literature, as many had not engaged with technical papers beyond textbooks. Consequently, they struggled to evaluate methodologies, assumptions, or limitations, which resulted in a tendency to summarize sources rather than critically evaluate or synthesize them. This difficulty was echoed in student feedback, as several students stated that analyzing sources was considerably harder than summarizing them. Similarly, creativity was present but inconsistent. While some teams demonstrated originality through novel ideas or diagrams, this was not widespread. This indicates that analytical and creative skills need more explicit scaffolding to foster consistent development across all teams.

Collaboration: Challenges in Equitable Participation

Collaboration was another area with challenges. Despite meeting deadlines, teams struggled with equitable task distribution. In several instances, one or two team members were responsible for the majority of the research, writing, and editing. Some teams also appeared to report inflated contribution percentages to avoid grade penalties, suggesting potential issues with accountability. A student's comment, "*It was sometimes hard to make sure everyone contributed equally*." captures this common struggle and highlights the need for improved coordination mechanisms.

This was particularly apparent during oral presentations. Instructor observations revealed a common pattern in several teams where a single member presented the core technical analysis, while teammates were limited to reading the introduction and conclusion passively from the screen. This suggested an uneven involvement in the project's most demanding aspects and indicated that some students were not fully engaged with the technical content, despite clear expectations for balanced teamwork. These observations align with prior work on structured in-class collaborative problem-solving [17]. Such approaches can enhance accountability and reduce passive participation compared with traditional homework models.

Future Work

As a work-in-progress, this study has several limitations. The findings are based on instructor observations and early student reflections. Therefore, the results are preliminary and descriptive. The study lacks post-project data, which would provide valuable quantitative insights into students' perceived growth across the 4C's. Without this data, conclusions rely on student performance artifacts and instructor interpretation.

Future work will address these limitations through the following instructional changes. To enhance critical thinking and creativity, structured critique prompts will be introduced early in the project through in-class discussions or online forums. Specifically, these prompts will include questions such as "*What are the methodological limitations of this study?*" and "*How might this technology evolve in the next 5-10 years?*" To improve collaboration, periodic progress check-ins will be implemented with a standardized rubric to evaluate team dynamics. In addition, the presentation rubric will be revised to require all team members to participate in presenting technical content. This change will promote accountability and deeper engagement. Furthermore, to support foundational research skills, tutorials on exploring academic databases and possible partnerships with librarians will be included through workshop sessions in the first month of the course to reduce early barriers and build confidence.

Frequent instructor feedback and clear rubrics for each phase of the project will be maintained to support communication and overall skill development. Finally, future work will include a stronger assessment framework. Specifically, a mixed-methods approach will be employed, combining pre- and post-project surveys with rubric-based quantitative scoring to measure changes in students' confidence and perceived abilities across the 4C's. Combining survey results with performance data will lead to a more rigorous evaluation of the project's impact and support refinement of the instructional model for broader use in engineering education.

Transferability to Other Disciplines

Although this project was implemented in an automotive engineering course, the structure of the literature review assignment is not limited to automotive topics. The core process – selecting a focused topic, evaluating credible sources, synthesizing findings, writing a structured technical paper, and presenting conclusions – develops skills that are essential in any engineering or STEM discipline. For example, in mechanical engineering, students could review emerging technologies in renewable energy or advanced manufacturing. In electrical and computer engineering, the focus might shift to semiconductor devices, embedded systems, or AI applications. Civil engineering courses could examine sustainable infrastructure or resilient design, while biomedical engineering students could analyze medical device innovations. The technical content would change, but the learning process and emphasis on critical thinking, communication, collaboration, and creativity would remain the same.

Because the framework emphasizes how students analyze and communicate knowledge rather than what specific topic they study, it can be adapted easily across disciplines while maintaining its professional skill-building goals.

Conclusion

This work-in-progress paper presented the early implementation of a literature-review–based project designed to strengthen students' technical knowledge and the 4C's in an undergraduate automotive engineering course. Preliminary results suggest progress in communication and research literacy, with challenges remaining in critical thinking and collaboration. These descriptive findings, although limited, underscore the need for continued instructional scaffolding. The planned enhancements for future iterations, detailed in the future work section, will address these challenges. The skills developed through this approach are transferable, preparing students not only for advanced automotive coursework but also for other engineering disciplines and professional contexts. These ongoing efforts aim to provide engineering educators with a flexible, scalable model for embedding high-impact, literature-driven learning experiences that effectively integrate technical content with essential professional skill-building.

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