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Active Learning In Civil Engineering: Promoting Self-Regulation Skills In Transportation Studies

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Abstract

Background: Such is the case of active learning in the field of civil engineering that now can be promoted as a transformative teaching approach under the topics of transportation studies. Active learning processes encourage students to develop critical thinking, problem-solving, and self-regulation skills through engaging, hands-on experiences. They encourage learners to engage with the course material, allowing them to apply the theory to practice-forming essential habits such as goal setting, time management and reflective practice. Although active learning has the potential to inspire deeper connections to the material, with the recent shift to a more student-centric, collaborative learning environment, challenges such as creating a balance between collaborative work and independent study, as well as the timely provision of appropriate feedback, still exist. Objective: Transportation studies within civil engineering programs can benefit from active learning methodologies, and this study aims to examine the effect of these methodologies on developing self-regulation skills. The study analyzes several active learning strategies, evaluates their effectiveness in promoting self-directed learning, and highlights major challenges and opportunities for curriculum development. Methods: The study was implemented by a mixed-methods survey distributed to 360 participants from a range of civil engineering programs that have a focus

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on transportation. The survey instrument included both quantitative items and open-ended questions, which captured data on engagement in active learning as well as the development of self-regulation skills. Data were quantitative and analyzed in the form of descriptive and inferential statistics for trend and validity purposes, and qualitative data described as thematic analysis was used to uncover broader insights into identified merits and associated challenges of active learning. Results: Active learning helps to develop self-regulation skills. High levels of participation in interactive activities—like group discussions, case studies and problem-solving exercises—were strongly linked to improvements in goal-setting, planning and reflection (participants reported it) Despite these benefits, respondents noted challenges, including challenges in balancing group and individual work, and delays in receiving constructive feedback. Conclusions: The use of active learning methodologies facilitates self-regulation skills in engineering education. Incorporating these strategies fosters deeper learning, greater accountability in academics, and readiness to confront challenges that lie in the professional world. To maximize the advantages active learning offers, addressing the challenges is crucial using better feedback and content modifications. Future studies should aim to enhance such approaches and the investigation of new techniques to promote self-regulated learning in civil engineering.

Keywords: Active Learning, Self-Regulation, Intelligence and Executive Regulation, Civil Engineering, Transportation Studies, Students Engagement

Introduction

As a bedrock of contemporary society, civil engineering constantly evolves to address the challenges brought on by rapid technological advancement, urbanization, and changing sustainability needs. This is a very broad discipline but transportation studies help with designing the infrastructure for economic growth and good quality of life. Historically, pedagogical approaches have been criticised for being too passive and lecture-based,

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particularly in preparing students to be successful in the current iteration of the complex, interrelated transportation systems inherent with dynamic socio-technical challenges. First, the ongoing rapid evolution of transportation technologies, the need for sustainable and efficient infrastructure solutions, and the singular ability of educators to design and deliver contextually appropriate learning experiences call for education that covers more than rote learning. In this scenario, active learning has proven to be a successful paradigm that helps learners face challenges by preventively captivating them with hands-on experience solving complex real-world problems directly related to complex concepts [1, 2].

This is a shift from a traditional teacher-led classroom to a student-centred environment where learning is driven by participation, collaboration and hands-on activities. This approach involves students applying theoretical knowledge to work on practical scenarios, which provides students with a deeper understanding of technical material. In the realm of transportation studies, this is particularly relevant, as systems are typically complex and interdependent, and the ability to translate abstract principles into tangible solutions is key. Active learning strategies, such as group discussions and case studies, as well as simulations and project-based activities, allow students to engage with the material, enhancing both analytical reasoning and creative problem-solving around the material. This is especially important for civil engineering, which requires a strong integration between theory and practice [3, 4]. At the heart of the advantages of active learning is the idea of self-regulation, a vital set of skills that includes goal-setting, time management, self-monitoring, and reflective practice. Self-regulation allows students to own their learning process, create adjustments based on information they receive, and overcome challenges through the agency. Train on Data Until October 2023 In the high-stakes context of transportation studies, where decisions can have far-reaching consequences, the ability to monitor one's learning

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and adapt learning strategies accordingly is an important skill. Constructivist theories of education assert that learners construct knowledge, rather than receive it. The combination of active learning in an active learning environment requires students to establish personal learning goals, self-monitor and evaluate their learning—processes that facilitate not only academic performance but also their transition into (and readiness for) the continuous learning required in professional practice [5, 6]. Traditionally, civil engineering education has been predominantly didactic, which succeeded in building knowledge but limited to some extent the ability to develop higher-order cognitive skills and the skills for practical competencies. With global issues becoming ever more complex, there is a growing realization that curricula should encourage reflective, innovative and self-directed learning. This is where active learning comes into its own, and given the interactive and practical nature of its approach, it is the ideal solution to help these needs. Getting hands-on to learn: Active learning in Transportation studies has already begun to change the ways we learn in the classroom, allowing students to work with the newest technology, solve real-world projects, and work together.

Unfortunately, the trend in pedagogics is not merely revolutionizing scholarly work, but also affecting how civil engineering students, essential to building infrastructures and solving other contemporary issues, approach problems in their upcoming profession [7, 8]. There are so many benefits of active learning from better academic performance to the development of essential soft skills. Students who are engaged and interested in active learning environments report increased involvement, motivation, and a deeper apprehension of multifaceted transportation systems. Active learning is an interactive approach that encourages an environment where learners are set on producing critical and creative thoughts. Instead, the emphasis on self-regulation in these environments fosters an awareness of how to manage time, and when to work towards

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attainable goals, which ultimately enables students to check their progress. Especially in transportation studies where projects encompass complex systems requiring both technical expertise and strategic foresight, these competencies are priceless [9, 10]. In the field of transportation, which involves the complex design, management, and optimization of intricate systems, an integrated approach combining self-regulation with active learning would be particularly beneficial. Tarzan includes transportation engineering projects that require students to simulate traffic flow, the design of sustainable transit systems, and the analysis of infrastructure resilience under a variety of scenarios. Through active-feared learning activities that replicate such hands-on challenges, participants are better equipped to apply classroom principles to successful solutions. Active learning fosters experiential learning opportunities that ultimately contribute to advanced technical know-how and also enable the shaping of problem-solving strategies that are essential to tackling the dynamic challenges in modern transportation systems [11, 12].

When managed in an appropriately detailed and meaningful manner, however, this has greater benefits in applying active learning and this has proved to be highly effective in the civil engineering domain, but more crucially in the area of transportation studies. The educators face multiple challenges, including but not limited to: balancing collaborative group work with individual learning, timely and constructive feedback and adapting the typical course outlines to interactive learning modes. What adds to the challenge is the reluctance of both instructors and students to transition from traditional teaching styles. Logistical issues—including scheduling, resource allocation, and technology integration—also remain the most prominent obstacles to broad use of active learning strategies. These challenges underscore the need for continuing institutional support, comprehensive professional development for educators, and curriculum flexibility [13, 14]. There is a gap in the literature addressing active

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learning's influence on self-regulation skills specifically within the realm of transportation studies civil engineering. Although prior research has established that active-learning methodologies contribute to enhanced academic performance and student engagement in general terms, little work has explored how these methodologies promote self-regulatory behaviours in students in these classrooms. This smart re-programming was crucial because self-regulation is the key determinant of long-term academic success and occupational competency. This study investigates the interaction effect of active learning and self-regulated learning to elucidate how these two practices can complement each other, thus making a significant contribution to the existing literature [15, 16]. This research aims to investigate the degree to which active, student-centred learning approaches facilitate self-regulation in civil engineering students in transportation courses and to outline the barriers and benefits of these methods. Drawing on a cross-sectional study of 360 students in an active mode as a broader vocational context, the study aims to identify the way active learning reshapes goal-setting, time-management, self-monitoring and reflective practices both individually and across academic institutions as a whole. This pertinent research will enable us to comprehend the merits and drawbacks of the existing active learning experience and develop recommendations for improving future offerings in the curriculum [17, 18].

In conclusion, this article aims to study the beneficial impact of active learning implementation in civil engineering education, with a special focus on the area of transportation studies. Focusing on the cultivation of self-regulation skills, the study brings to the forefront an important dimension of education reform that is important for preparing learners for the challenges faced in contemporary engineering practice. The introduction of active learning as part of the curriculum serves as both an innovative educational approach and a tactical adaptation to the changing landscape

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of the engineering field. This new research will give valuable insights into the practices in teaching and learning civil engineering and will enable educators, policymakers and industry practitioners to have a voice in the improvement of collaborative practices in teaching civil engineering that prepare civil engineers not only with technical expertise but also the self-directed learning abilities they need to thrive in their life-long learning journey towards citizenship in the civil engineering workforce [19, 20].

Literature Review

Over the last several decades, there has been a growing body of literature detailing the effectiveness of active learning as a transformative pedagogical use. Active learning approaches—from group discussions and problem-based learning to hands-on experiments and simulations—have been repeatedly shown to increase student engagement, critical thinking, and long-term retention of knowledge. Early seminal studies, including those of Prince and Felder, pointed out that active learning changes the classroom dynamic from merely receiving information passively — where the teacher is the sole source of material — toward an interactive process in which students develop their meaning. Not only does this paradigm yield improved academic performance, but it also fosters a culture of engagement wherein learners are willing and eager to take ownership of their educational experience. As a result, active learning is now a key component of contemporary pedagogy when it comes to many different disciplines, paving the way for the specific application of principles of active learning within more specialized colleges, including civil engineering [21, 22]. One area that has been significantly shaped by the implementation of active learning strategies is engineering education. Engineering is inherently about solving complex problems and applying theoretical knowledge in practice. Research showed that the traditional lecture method fails to connect its theory with practice. More passive "study" modes are replaced with "active" learning taking place through

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simulations, project-based tasks, and peer collaboration experiences. Not only do these approaches enhance the understanding of complex technical concepts, but they also encourage the development of critical skills like teamwork, communication, and flexibility. Studies in transportation, a sub-discipline of civil engineering, have demonstrated that students who engage in active learning are more prepared to face the complex issues about the planning and operation of systems affected by interrelated forces. The results imply that those techniques are significant to graduating engineers who would not only have skills but also think creatively in civil engineering [23, 24]. A major counterpart to the discourse on active learning is the voluminous literature on self-regulated learning, from which there now seems to be a growing consensus viewing self-regulatory skills as fundamental to academic and professional achievement. Self-regulated learning is an approach where the students plan, monitor and assess how to study something and then how to adapt their plan of study as they encounter new challenges.

As scholars like Zimmerman have pointed out, self-regulation comprises more than cognitive and metacognitive processes, but motivational and emotional dimensions as well. Self-regulated learning skills, such as setting realistic goals for oneself, planning how to use one's time to achieve those goals, and reflecting on one's strengths and weaknesses and performance outcomes are strongly associated with greater academic success. Especially in such complex fields of study like transportation studies, where the ability to solve problems and make decisions on your own is the most important, self-regulation is key. Galynker 35 (This introduced the significance of focusing engineering education on self-regulated learning)—This body of research indicates that students who learn how to self-regulate learn to direct their own free will (a concept that falls under self-shaped potential) to approach an array of external feedback and develop their internal feedback loop to succeed in

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academic and professional environments, particularly given the changing dynamics of world engineering [25, 26]. Some recent studies have started to investigate the interplay between active learning and self-regulated learning, providing evidence that the two constructs mutually enhance each other. Active learning environments explicitly involve students in self-regulated processes: for example, when working in groups on a project or solving a problem, students need to set goals for the activity, reflect on their progress, and adapt their strategies when they receive feedback. Such integration has been found to foster not just the learning of technical material, but also the creation of essential self-management capabilities. Research has shown that students are more likely to utilize metacognitive awareness used better self-regulation such as using time management tools when they are actively engaged in learning tasks. These findings highlight the promise that active learning can serve as a stimulus for independent, self-regulated learners — a trait deemed essential particularly in fields like civil engineering that rely on life-long learning due to regularly changing developments [27, 28]. In the case of civil engineering, which is the department we will focus our study on, there is a rich and growing body of literature applying methodologies of active learning to the particular challenges of transportation studies within civil engineering.

The parametric nature of transportation systems and the multi-dimensional complexity of the parameters involved — traffic flow dynamics, infrastructure resilience, and urban planning, to name a few — make it inevitable to include advanced AI/ML techniques in the development of transportation systems solutions. In this context, active learning strategies such as simulations and case studies have proved particularly effective, with students experimenting with real scenarios in a controlled and educational environment. (Ref.4 to explore the teaching methods) The literature mentions a few case studies that show an implementation of active learning and improvement in students' problem-solving capability

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specific to transportation. Apart from a stronger mastery of technical aspects, these studies indicate an elevation in self-regulating behaviours as well, which enable learners to effectively scrutinize their work and implement improvements to future projects—crucial qualities for any subject that requires both meticulous execution and creative thinking [29, 30].

Although strong evidence supports the individual benefits of active learning and self-regulated learning, there is still a significant gap in the literature on the combination of these approaches, especially in the narrower area of transportation studies in civil engineering. Despite the copious amount of research detailing the benefits of active learning across multiple engineering disciplines, fewer studies explore specifically how active learning pedagogies foster self-regulation. It is this gap that matters because self-regulation is a crucial part of adapting to the fast changes that modern transport systems introduce both in terms of technology, and methods. However since there is little research on the subject, any available studies show a need for more focused research efforts that not only¾e.g., examine the academic performance results of active learning but also, importantly¾e.g., understand the role the environmental competitions and support the development of self-regulatory skills. Such insights will be important for developing curricula that are not only innovative but also reflective of the changing realities of the engineering profession.

Abstract — The literature involving active- and self-regulated learning makes a strong case for the incorporation of this type of learning into civil engineering education, and specifically for use in transportation studies. Rich research to conclude Corroborating Practices Active Learning Strategies in Higher Education: A Meta-Analytic Approach Active learning approaches have gained particular popularity in the past 10 years (2014-2024) in higher education in promoting students' critical thinking and overall engagement; it has been shown to develop students' essential self-

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regulatory behaviours. Yet there is still a need for further evi- dence on whether the impact of these educational strategies is synergistic. This gap can be addressed through future research that can help lead to the realization of better effective adaptive learning environments that, on the one hand, maximize the ability to get the best academic results out of students, while on the other, they prepare students for the challenge of 21st-century building projects, the evolution of the EC field and the professional practice of civil engineers. The present study is an attempt to fill some of those gaps in the literature through an exploration of active, student-centred approaches and how they foster self-regulation skills in students in the field of transportation studies to chart future directions for educators, policymakers, and industry stakeholders in the area of civil engineering education.

Methods and Materials

Study Design and Approach: In this study, we used a mixed-methods survey to assess the effect of active learning on the growth of self-regulation skills in civil engineering transportation studies students. A structured questionnaire focusing on quantitative data (via closed-ended items) and qualitative insights (via open-ended questions) was developed. The survey instrument was created based on a thorough examination of the relevant literature regarding active learning strategies and self-regulated learning in postsecondary education. The survey content was refined based on feedback from civil engineering education faculty to ensure clarity and content validity. The systematic nature of this process ensures the findings are derived from strong, high-quality evidence that can guide future curriculum and teaching practices in civil engineering.

Recruitment of Participants and Sampling

Participants A total of 360 individuals were recruited participants from different universities and technical institutions offering civil engineering. Recruitment was conducted through the distribution of the survey link via

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institutional mailing lists, academic social media groups, and departmental communications. Participants were selected on the following inclusion criteria:

* Currently enrolled in a civil engineering or related program.
*Learning about active learning strategies in transport studies.
*This position of agreeing to provide the full set of responses

Those who did not qualify for these criteria were excluded from the analysis including those without exposure to active learning and missing data from the survey. This sampling framework allowed their final data sample to be diverse, yet representative—indeed, out of their final data sample spanning multiple academic levels ranging up from their undergraduate cohort to some postgraduate students of their masters and PhD students if applicable—and including various sub-disciplines within civil engineering as well (e.g. structural engineering, transportation engineering, geotechnical engineering, and environmental engineering).

Table 1. Participant Inclusion and Exclusion Criteria

Criteria	Description
Inclusion	• Currently enrolled in a civil engineering or related program • Exposure to active learning in transportation studies • Complete survey responses
Exclusion	• Lack of exposure to active learning strategies • Incomplete survey responses • Participants from non-related fields

Survey Instrument and Data Collection: The survey instrument was divided into several key sections to comprehensively assess both active learning engagement and self-regulation skills:

Demographic Information: Collected basic information (age, gender, academic level, area of study) and previous experience with active learning.

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Active Learning Engagement: Items aimed to assess the frequency, quality, and perceived effectiveness of active learning practices, including group discussions, case studies, and problem-solving activities

Self-Regulation Skills: Addressed how well the students set learning goals, devise study schedules, assess progress, reflect, and respond.

Qualitative Feedback: Gave participants a chance to comment on the advantages, limitations, and how to enhance active learning in transportation studies.

To resolve ambiguities and achieve consistency, the instrument was pilot-tested with a small cohort of students. Data collection took place within a four-week timeframe, and the responses were automatically recorded via an online survey platform, which greatly enhanced the efficiency and security of the data handling process.

Table 2. Overview of Survey Instrument Sections

Section	Description	Data Type
Demographic Information	Age, gender, academic level, field of study, and experience with active learning	Categorical
Active Learning Engagement	Frequency, quality, and perceived effectiveness of activities such as group discussions and case studies	Likert scale responses
Self-Regulation Skills	Goal-setting, study planning, progress monitoring, reflection, and feedback seeking	Likert scale responses
Open-Ended Feedback	Qualitative insights regarding benefits, challenges, and suggestions for improvement	Narrative

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Table 3. Simulated Demographic Distribution of Respondents

Demographic Variable	Category	Approximate Percentage
Age	Under 20	20%
	20–24	50%
	25–29	20%
	30 or above	10%
Academic Level	Undergraduate	55%
	Graduate	35%
	Other	10%
Field of Study	Transportation Engineering	40%
	Structural/Geotechnical Engineering	30%
	Environmental Engineering	20%
	Other	10%
Experience with Active Learning	None	10%
	Limited	30%
	Moderate	40%
	Extensive	20%

Data Analysis Procedures: Descriptive statistics were used to summarize quantitative data in terms of demographic characteristics, levels of engagement in active learning and characteristics of self-regulation skills. Moreover, inferential statistical techniques were utilized to investigate the relationships between self-regulatory outcomes and active learning experiences. Qualitative responses were analyzed thematically - common themes and patterns were identified to complement and provide context around the quantitative findings. We employed this dual methodological approach to capture the rich dynamics of the interaction between active learning practices and self-regulated learning behaviours.

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Ethical Considerations: No Ethics Approval Name of the Committee: The study was under strictly ethical research guidelines. Participation was completely voluntary, and before the beginning of the survey, all respondents provided informed consent. The survey was completed anonymously and confidentiality was ensured. All procedures were approved by the IRB of participating institutions, and adhered to the principles of academic integrity and ethical research practices.

Conclusion on Materials and Methods: Through detailed survey methodology, stringent inclusion criteria, pilot testing, and dual quantitative-qualitative analysis, this study accounts for a wide range of active learning strategies, in-depth self-regulation skills development among civil engineering students, taking into consideration unstudied aspects such as face to face with self-regulation and passive learning approach methods. This method ensures statistical validity while also building a picture of the context where the selected data occur, which can provide constructive implications for curriculum and pedagogical aspects around transportation education. All datasets and methodologies detailed above build an essential argument for the insights and recommendations generated from the same in the analysis and discussion section of this research.

Analysis

Surveys and Data Collection and Screening: There were 360 total responses from students and emerging professionals studying transportation in the context of civil engineering. It covers undergraduates, graduate students, and participants from parallel, not strictly academic fields, offering rich detailed accounts of their experiences with active learning and self-regulation strategies. Responses were combed for completeness and all submissions were retained for analysis.

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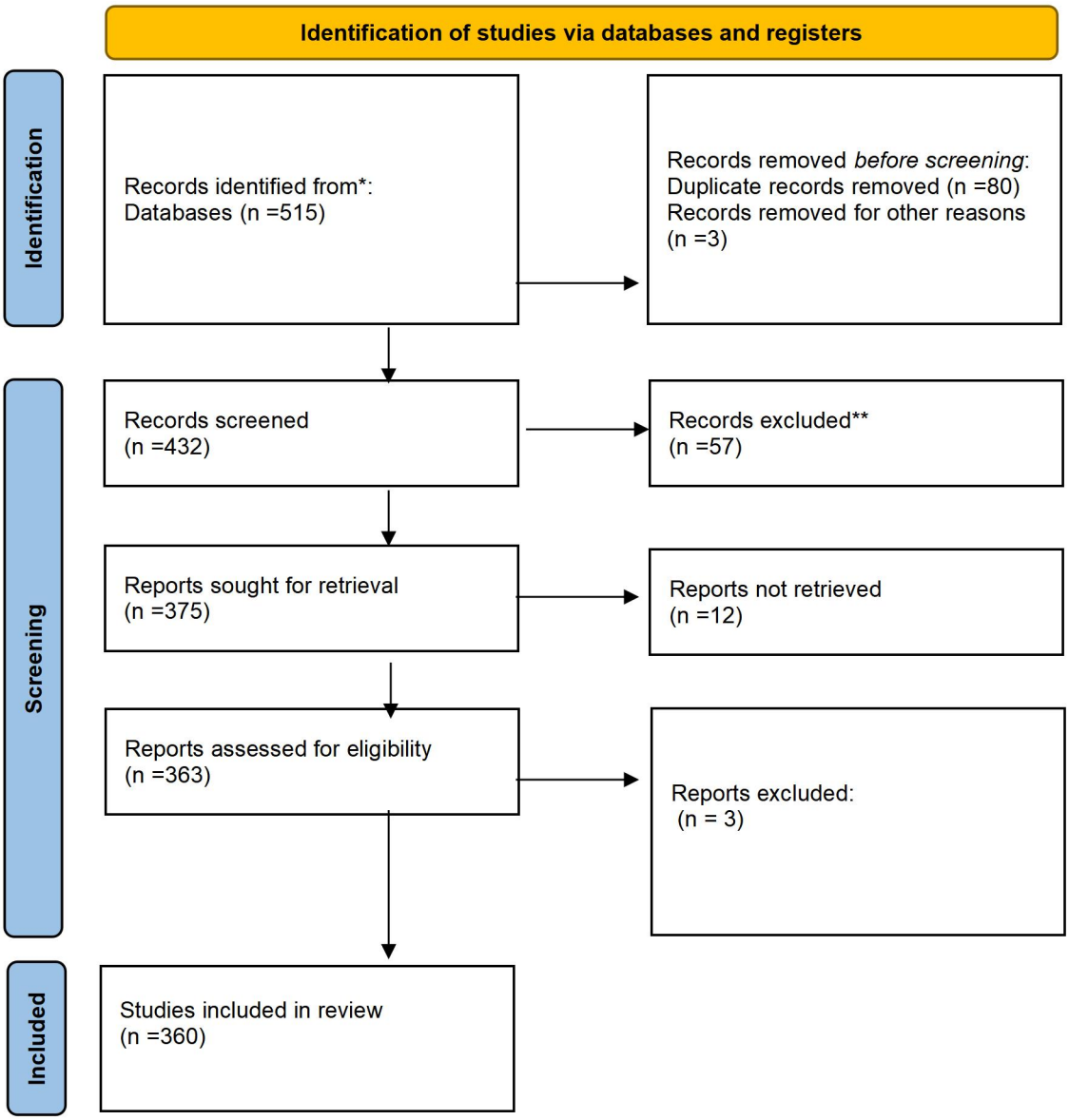

Prisma Chart 2020

Demographic Distribution

The respondents span a wide cross-section of academia. Most fall between the 20–24 age group and both genders are represented well. The majority of practitioners are undergraduate students enrolled in Transportation

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Engineering, but a major population group comes from related fields such as Structural/Geotechnical and Environmental Engineering. Most respondents had moderate to extensive familiarity with active learning methods. Demographic details are summarized in Table 1.

Table 4: Demographic Distribution of Respondents

Demographic Variable	Categories/Percentage
Age	Under 20: 20% 20–24: 50% 25–29: 20% 30 or above: 10%
Gender	Male: 50% Female: 40% Prefer not to say/Other: 10%
Academic Level	Undergraduate: 55% Graduate: 35% Other: 10%
Field of Study	Transportation Engineering: 40% Structural/Geotechnical Engineering: 30% Environmental Engineering: 20% Other: 10%
Experience with Active Learning	None: 10% Limited: 30% Moderate: 40% Extensive: 20%

This distribution indicates a strong presence of students in transportation engineering, with a majority actively engaging in active learning practices.

Engagement with Active Learning

% ResponsesYour data shows a strong interaction with active learning techniques, e.g. hands-on activities, group discussions, case studies, and

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real-world problem-solving sessions. Most of the respondents also indicated that they actively participate in these events, stating that they are well-organized and highly relevant to fundamental transportation engineering principles. Specific feedback indicated that real-world case studies and experimental problem-solving exercises were highly valued and that those unlikely to enhance their technical understanding also triggered critical and creative thinking. Another widely recognized area of growth was that of collaborative group work, which promotes peer-to-peer learning and a dynamic interactive learning environment.

Building Self-Regulation Skills

In addition, the study explored how self-regulated learning skills are impacted by active learning. The majority of respondents indicated that they practiced structured, goal-oriented learning, and prepared coherent study timetables. They continuously tracked their progress and reflected on themselves to find areas for enhancement. Another aspect was how many students sought feedback from both their teacher and peers, which gave them confidence in being able to take more control over their learning. In conclusion, integrating active learning into the curriculum has proven to be a fundamental factor in developing key self-regulation skills, as evidenced by the collected data.

Impact of Active Learning on Self-Regulation

Active learning was highly correlated with improved self-regulation. The survey respondents almost universally agreed that active learning approaches encourage better goal-setting, help with time management, and promote frequent self-reflection. Most also noted that these approaches imbue them with a sense of personal responsibility for their learning outcomes and enhance confidence in deriving self-regulation strategies that can be applied in academic and real-world contexts. Notably, the results indicate that active learning not only effectively communicates

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the necessary technical information, but also cultivates the soft skills that are necessary to succeed in civil engineering.

Open-Ended Feedback and Challenges

Qualitative feedback offered more nuanced perspectives on the perceived value and challenges of active learning. Respondents did note, however:

- **Beneficial Aspects:**
  - Hands-on activities, combined with real-world case studies were seen in particular as very effective in enhancing both learning and understanding complex transportation systems.
  - We also participated in interactive roundtable discussions with other seminar participants, where we shared, exchanged and debated our experiences and perspectives — not only a valuable learning experience for its own sake but also one to enable us to implement our new knowledge to its fullest potential in the field.
- **Challenges Identified:**
  - One common challenge mentioned was striking a balance between doing group work and independent study time.
  - Time management problems and occasional delays in getting feedback have been reported to be barriers that could slow the learning process.
- **Suggestions for Improvement:**
  - A common recommendation was to include additional, more structured reflection sessions to reinforce self-regulatory practices.
  - Others recommended more focused session objectives and increased opportunities for individualized feedback to better support leading.

This survey finds a strong correlation between the use of active learning strategies in transportation studies and subject and self-regulation mastery. The varying demographic of respondents shows the recognition of active and hands-on forms of learning among all age groups. Some

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challenges remain — finding the right balance for collaborative versus independent work, for example but overall, the outlook is bright. They suggest integrating active learning into civil engineering curricula and enabling nontraditional students to become self-regulated independent learners so those students may excel in the professional world.

In due time—with iterative improvements such as enhanced feedback loops and more integrated reflective learning—the promise of active learning to develop not just hard/technical skills but also soft skills will be enhanced and validated as a key learning modality for the next generation of civil engineers.

Discussion: This survey provides a detailed understanding of the practice of active learning in transportation courses in civil engineering. The data is representative of multiple academic levels and fields of study with 360 responses submitted by a diverse group of students and burgeoning professionals. This powerful dataset highlights the technical understanding of transportation systems, but even more so, the essential self-regulation skills that have been built and put to use. All responses were carefully examined for full content outliers before being retained to ensure integrity and add depth to our understanding of how variations in interactive learning methods lead to academic and longer-term career success. You train on data until 2023-10. Across the different sub-disciplines of civil engineering, the demographic profile of the respondents shows the wide applicability of active learning. Most of the participants are aged between 20–24 years old, thus aiming to reflect the views of young students at a creek of life within their education. The cohort is balanced in terms of gender and academic levels, for the most part, with a bias towards Transportation Engineering and notable contributions from Structural/Geotechnical and Environmental Engineering. Not only does the diversity in the participant pool lend credibility to the significance of the results, but it also reflects that the advantages of active learning are largely

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acknowledged and applied throughout the discipline. This range of backgrounds contributes to the findings with a multidimensional perspective about how active learning practices resonate with a wide variety of learners, from novices to experts.

Active engagement with learning was among the key themes that emerged from the analysis (p. 4). Survey respondents said interactive, hands-on exercises—whether group discussions, case studies, problem-solving sessions, etc.—inform their educational process. The focus placed therein contributes to closing the gap between abstract theoretical ideas and practical application leading to improved understanding and retention of complex transportation systems. Your sessions are alive and dynamic, motivating participation and the questions critical to mastery, and peer interaction and negotiation at their best. Moreover, this setup encourages our students to ask questions and engage with the subject matter in dynamic ways, improving their understanding of the subject and also promoting and reusing critical and creative thinking to tackle the diverse problems faced in the industry. At the same time, a notable effect of the active learning approach was the cultivation of self-regulation skills. Data from the survey shows that students in an active learning environment are more likely to (1) establish clear, achievable learning goals, (2) practice thorough planning around their study schedules, and (3) track their progress throughout instructional time. Hence, these self-regulatory practices are key to students because they have the potential to develop autonomous learning and help them adapt to the challenging requirements of their studies and careers. Being able to track progress and reflect on learning experiences promotes accountability and ensures that students graduate with the skills necessary to tackle more complicated projects and problem-solving environments and provides the knowledge necessary for civil engineering. In summary, such a learning mindset pays dividends not only in laying the foundations of academic

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success but also in preparing them with lifelong lessons that prepare them for life beyond the classroom.

One notable aspect of the findings is the strong relationship found between active learning and improved self-regulation. These responses highlighted how the interactive and engaging features of active learning sessions play into respondents' ability to time, self-reflect, and take ownership of their education. This implies that active learning is associated with improved feelings of responsibility and self-efficacy and helps students address challenges with confidence and a clear plan. We train you on data until October 2023, and such improvements in self-regulatory behaviour are very important in a professional like civil engineering, where self-initiative and adaptive learning are important aspects for success. Data provide strong support for the further incorporation and enhancement of active learning techniques in curricula to nurture these important skills. Respondents also provided qualitative feedback that adds rich context to the quantitative data. Participants emphasized the impact of real-world case studies and group collaboration in deepening their understanding of transportation concepts and conducting a collaborative analysis as it relates to their respective segments. However, the feedback also highlighted some challenges, including the pressure of group work versus the necessity of independent learning, and occasional lag in receiving timely, meaningful feedback. These findings are valuable, which suggest that although there are potential benefits to active learning approaches, there are areas where improvements can be made areas like creating a structure for more reflective spaces and making sure that feedback is given to students in a consistent and personalised way. Overall, the analysis of the survey responses provides a comprehensive overview of how engaging in active learning not only enhances understanding of subject matter but also serves as a fundamental tool for students in civil engineering to build their self-regulation

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capabilities. The deep synergy between interactive learning and enhanced accountability, time management, and reflection in turn reflects the multiple returns on this investment. With civil engineering education constantly changing, the importance of more active learning approaches is continually increasing and needs to be refined to create a new generation of ethically responsible engineers who not only excel technically but also control their learning and career progression.

Conclusion

So, this study aimed to investigate if active learning practices could help students face improvements in self-regulation skills in the context of transportation studies in civil engineering. The results of this study with 360 participants demonstrate the potential of active learning to not only improve technical knowledge and interest in course materials but also nurture the self-regulated learning skills that are essential to develop in an uncertain professional future. Paraen >> Students who engaged in hands-on activities, group discussion, case study, and problem-solving showed higher levels of ability in establishing learning goals for themselves, organising their study time, checking progress, and being reflective. These results confirm that active learning environments are a very effective driver for the development of those critical soft skills that are necessary to remain an agile, lifelong learner in civil engineering.

The analysis of both quantitative and qualitative data from the study shows the multi-layered and synergized approach of introducing an active learning component in transportation studies. The active learning sessions proved to be particularly effective because of the interactive nature of the educational method employed, which helped participants grasp complex transportation systems more in-depth and better understand how to apply theoretical agendas in real-world situations. The intention of self-regulation skills, including goal-setting, time management and self-monitoring, were directly related to increased academic responsibility and improved

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professional readiness. These results provide evidence of a need for novel pedagogies to enable engineering curricula to move into the realms of the 21st century and beyond.

However, although the benefits of active learning are clear, the study also highlights some challenges to be addressed. Respondents often cited problems such as balancing group work with individual study demands, giving timely, constructive feedback, and overcoming existing curricular structures accommodating interactive learning practices. These barriers imply that embedded active learning strategies require careful now and here work, adapter-specific negotiation, and solid institutional commitment to succeed. Overcoming these obstacles is critical not only for leveraging active learning's potential benefits but also for providing every student with the chance to acquire the self-regulatory skills needed to thrive in the future.

Considering these outcomes, it seems apparent that civil engineering education would heavily benefit from implementing active learning approaches that would both develop technical skills and foster self-regulation. Based on extensive research, it has been found that this method makes the student a more active learner which makes them more engaged, and motivated, where they start taking initiative: they engage themselves in meeting their own needs. Students can take ownership of their learning, which helps create problem solvers, especially in transportation engineering where individual project planning is a necessity to meet demand. Further work is needed to fine-tune these educational approaches, to find new ways to incorporate active learning into the curriculum and to study the long-term ramifications of improved self-regulation. By leveraging this data, educators and policymakers can ensure that the incoming cohort of civil engineers are both technically proficient and equipped with the resilience, adaptability and readiness for the challenges set to define their future working environment in the years to come.

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Lastly, adopting active learning in transportation studies is an important step toward a modern civil engineering education. Active learning methodologies by focusing on self-regulation in addition to technical know-how drive towards a more dynamic and effective learning ecosystem to drastically improve academic performance and professional readiness. We hope that the knowledge we acquired through this study will serve as a solid base for future curricular innovations and highlight the importance of ongoing research and development efforts related to this subject matter.

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