The Learning Activity Management System (LAMS) in Vocational Laboratory Education

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1. Introduction

1.1 Importance of Structured Laboratory Learning in Vocational Education

Laboratory-based learning constitutes a core component of vocational education and training (VET), as it enables learners to acquire practical skills, professional competencies, and procedural knowledge directly related to occupational practice. Unlike general education, vocational education places strong emphasis on the integration of theoretical understanding with hands-on experience in authentic or simulated work environments (Billett, 2011). However, research consistently indicates that practical experience alone is insufficient to ensure meaningful learning outcomes unless it is supported by a structured pedagogical framework.

Structured laboratory learning refers to the systematic organization of learning activities, including clearly defined objectives, sequenced tasks, guided practice, and opportunities for reflection. According to Billett (2014), effective vocational learning emerges from the intentional alignment of instructional guidance and learner participation, rather than from unstructured exposure to practical tasks. In laboratory settings, particularly in technical domains, the absence of structure may lead to fragmented skill acquisition and superficial procedural knowledge (Rauner & Maclean, 2008).

Several studies emphasize that structured learning environments enhance learners' ability to connect theoretical concepts with practical applications. Tynjälä (2008) highlights that guided laboratory activities promote deeper cognitive processing by supporting learners in understanding not only how tasks are performed, but also why specific procedures are followed. This integration of conceptual and procedural knowledge is essential for the development of transferable vocational skills.

Moreover, structured laboratory learning has been associated with increased learner engagement and collaboration. Schaap et al. (2012) argue that clearly designed learning sequences foster purposeful interaction among learners and facilitate the development of problem-solving and decision-making skills. In vocational laboratories, where safety, accuracy, and procedural compliance are critical, structured instructional approaches contribute to both effective learning and risk reduction.

From a broader perspective, international organizations such as the OECD (2018, 2021) stress the importance of instructional design in vocational education, noting that well-structured laboratory learning environments support skill mastery, learner autonomy, and employability. The increasing complexity of modern vocational fields, including vehicle engineering, further amplifies the need for pedagogically grounded laboratory instruction that guides learners through progressively complex tasks.

In this context, digital learning design systems offer promising opportunities to enhance the structure and coherence of laboratory-based instruction. Platforms that support the design, sequencing, and monitoring of learning activities can assist vocational educators in organizing laboratory work in a way that aligns instructional goals with practical skill development.

1.2 Challenges in Vehicle Engineering Workshops

Vehicle engineering workshops constitute complex learning environments that pose multiple pedagogical, technical, and organizational challenges within vocational education and training (VET). These workshops require learners to develop not only procedural skills, but also diagnostic reasoning, safety awareness, and the ability to integrate theoretical knowledge with practical application. Research in vocational education highlights that such complexity often exceeds the instructional capacity of traditional, unstructured laboratory teaching approaches (Billett, 2011).

One of the primary challenges in vehicle engineering workshops is the increasing technological complexity of modern vehicles. Rapid advancements in automotive systems, including electronic control units, diagnostic technologies, and hybrid or electric powertrains, demand continuous adaptation of instructional practices and learning content (CEDEFOP, 2017). As a result, learners are frequently exposed to cognitively demanding tasks that require systematic guidance and scaffolded learning sequences in order to avoid superficial skill acquisition.

Safety constitutes another critical challenge in vehicle engineering laboratories. Workshop activities often involve hazardous equipment, high temperatures, electrical systems, and heavy mechanical components. Rauner and Maclean (2008) emphasize that insufficient instructional structure in vocational laboratories can increase the risk of unsafe practices, particularly among novice learners. Clear procedural guidance and structured task sequencing are therefore essential to ensure both effective learning and safe working conditions.

Furthermore, vehicle engineering workshops often struggle with the challenge of connecting theoretical instruction to hands-on practice. According to Tynjälä (2008), learners in vocational contexts may experience difficulties in transferring classroom-based knowledge to practical tasks when instructional activities lack coherence and pedagogical alignment. In poorly structured workshops, students may focus on task completion rather than on understanding underlying principles, resulting in fragmented learning outcomes.

Learner heterogeneity also presents a significant challenge in vocational laboratories. Students enter vehicle engineering programs with varying levels of prior knowledge, technical experience, and learning readiness. Schaap et al. (2012) argue that without structured instructional frameworks, such diversity can lead to unequal participation and learning opportunities. Well-designed laboratory activities are therefore necessary to support differentiated learning paths while maintaining common learning objectives.

Finally, time constraints and curriculum pressures further complicate instructional practices in vehicle engineering workshops. Vocational educators are often required to cover extensive content within limited instructional time, making it difficult to provide individualized guidance and reflective learning opportunities (OECD, 2021). These constraints highlight the need for pedagogical tools and instructional models that can support efficient yet meaningful laboratory learning.

Collectively, these challenges underscore the importance of structured and pedagogically grounded approaches to laboratory instruction in vehicle engineering education. Addressing issues related to complexity, safety, theory–practice integration, learner diversity, and time limitations requires instructional frameworks that support systematic learning design and guided laboratory practice.

1.3 Role of Learning Design Systems in Vocational and Laboratory Education

Learning design systems play a critical role in contemporary educational practice by supporting the systematic planning, implementation, and evaluation of learning activities. Learning design is grounded in the assumption that effective learning does not emerge spontaneously but rather results from intentional pedagogical planning that aligns learning objectives, activities, resources, and assessment (Conole, 2013). In vocational and laboratory-based education, where learning outcomes are closely tied to procedural accuracy, safety, and professional competence, the role of learning design systems becomes particularly significant.

One of the primary contributions of learning design systems is their ability to structure complex learning environments. Vocational laboratories often involve multiple phases of instruction, including preparation, demonstration, hands-on practice, collaboration, and reflection. Learning design systems enable educators to organize these phases into coherent learning sequences, ensuring pedagogical continuity and transparency for learners (Dalziel, 2003). This structured approach supports learners in understanding not only what tasks they are expected to perform, but also the pedagogical rationale underlying each activity.

Furthermore, learning design systems promote the explicit representation of pedagogical intentions. By visualizing learning sequences and activity flows, these systems make teaching strategies more explicit and reusable, allowing educators to reflect on and refine their instructional designs (Dalziel et al., 2016). This feature is particularly valuable in vocational education, where instructional practices are often shaped by tacit professional knowledge rather than formal pedagogical models.

Another important role of learning design systems lies in their support for collaborative and learner-centered approaches. Research indicates that systems designed around learning activities rather than content delivery facilitate interaction, peer learning, and reflective practice (Mor et al., 2013). In laboratory settings, collaboration and reflection are essential for developing diagnostic reasoning and problem-solving skills. Learning design systems provide integrated tools that enable learners to share experiences, discuss procedures, and reflect on outcomes, thereby enhancing deeper learning.

Learning design systems also contribute to pedagogical consistency and quality assurance in vocational education. Given the diversity of learners and the variability of instructional contexts, maintaining consistent learning experiences across laboratory sessions can be challenging. Structured learning designs help ensure that all learners are exposed to essential learning elements, regardless of individual pace or prior experience (Masterman & Vogel, 2007). This consistency is particularly important in safety-critical environments such as vehicle engineering workshops.

Finally, learning design systems supports innovation and adaptability in vocational education. As technological advancements continually reshape professional practice, vocational curricula must evolve accordingly. Learning design systems allow educators to update, adapt, and extend learning sequences in response to emerging technologies and industry requirements (Persico & Pozzi, 2015). This flexibility enables vocational education institutions to respond effectively to changing workforce demands while maintaining pedagogical coherence.

Overall, the literature highlights learning design systems as powerful pedagogical tools that enhance structure, transparency, collaboration, and adaptability in vocational and laboratory education. Their role is especially prominent in technical domains, where structured learning environments are essential for supporting complex skill development and professional competence.

1.4 Aim and Research Questions of the Review

1.4.1 Aim

The aim of this literature review is to systematically examine and synthesize existing international research on the use of learning design systems, with particular emphasis on the Learning Activity

Management System (LAMS), in vocational and laboratory-based education. The review seeks to explore the pedagogical role of structured learning design in addressing the challenges of vehicle engineering workshops and to identify the potential of LAMS in supporting effective, safe, and coherent laboratory learning in vocational education and training (VET).

1.4.2 Research Questions

To achieve this aim, the review is guided by the following research questions:
RQ1: How are learning design systems conceptualized and applied in vocational and laboratory-based education according to the international literature?
RQ2: What pedagogical benefits and limitations of the Learning Activity Management System (LAMS) are reported in existing studies?
RQ3: What challenges of vehicle engineering workshops are identified in the literature, and how can structured learning design approaches address these challenges?
RQ4: What gaps in the existing literature can be identified regarding the use of LAMS in vehicle engineering and vocational laboratory contexts?

1.4.3 Structure of the Paper

This paper aims to review and synthesize the existing international literature on learning design systems, with particular emphasis on the Learning Activity Management System (LAMS), in the context of vocational and laboratory-based education. Special attention is given to vehicle engineering workshops, which represent complex and safety-critical learning environments requiring structured pedagogical approaches. By examining studies on structured laboratory learning, the challenges inherent in vehicle engineering education, and the pedagogical affordances of learning design frameworks, this review seeks to explore how LAMS can support effective, coherent, and pedagogically grounded laboratory instruction in vocational education and training. The paper is organized as follows: the next section describes the methodology adopted for the literature review, followed by a thematic synthesis of relevant studies. The final sections discuss the main findings, identify gaps in the existing literature—particularly in relation to vehicle engineering contexts—and propose directions for future research and educational practice.

2. Methodology of the Literature Review

The methodology of this review adopts a systematic approach to identify, evaluate, and synthesize existing international research on the application of learning design and LAMS in vocational settings. To ensure transparency and replicability, the review process followed the stages of identification, screening, and inclusion.

2.1 Search Strategy and Databases

A comprehensive search was conducted across major academic databases, including Scopus, Web of Science, ERIC, and Google Scholar. The search strategy employed combinations of the following keywords: "Learning Activity Management System", "LAMS", "learning design", "vocational education", "laboratory learning", and "TVET". Boolean operators (AND/OR) were used to refine the results.

2.2 Selection Criteria

The studies were selected based on the following criteria.

2.2.1 Inclusion Criteria

Peer-reviewed journal articles and conference papers.Publications written in the English language. Published between 2003 (the introduction of LAMS) and 2024. Focus on structured learning, learning design frameworks, or empirical applications of LAMS in technical/vocational contexts.

2.2.2 Exclusion Criteria

Non-academic sources (blogs, trade magazines). Unpublished theses and dissertations. Studies focusing solely on general K-12 education without vocational or laboratory relevance.

2.3 Data Synthesis and Analysis

Initial search results yielded 142 records. After the removal of duplicates and a preliminary title/abstract screening, 45 full-text articles were assessed for eligibility. The final synthesis includes 28 key sources that directly address the research questions. A thematic synthesis approach was used to categorize findings into four areas: (a) conceptual frameworks of LAMS, (b) collaborative learning affordances, (c) experiential/laboratory applications, and (d) pedagogical implications for vehicle engineering.

3. Results of the Literature Review

The thematic synthesis of the selected literature reveals four primary dimensions regarding the use of learning design and LAMS in vocational and laboratory contexts.

3.1 LAMS as a Learning Design Framework

The foundational work of Dalziel (2003, 2006) establishes LAMS as a pivotal tool for operationalizing the "Larnaca Declaration on Learning Design" (Dalziel et al., 2016). Unlike traditional Learning Management Systems (LMS) that focus on content delivery, LAMS is conceptualized as an activity-centric platform. In technical education, this shift is crucial; it allows educators to move beyond providing manuals to designing "sequences of doing." The literature emphasizes that the visual representation of these sequences enables instructors to model complex procedural logic, which is essential for mastering automotive diagnostics and repair workflows.

3.2 LAMS and Collaborative Learning

Research by Campbell and Cameron (2009) and Dennis (2007) highlights LAMS as a "cognitive tool" that fosters social constructivism. In vocational laboratory settings, learning is rarely an isolated activity. The literature demonstrates that LAMS tools (such as chat, forums, and Q&A) facilitate peer-to-peer knowledge transfer. For vehicle engineering, this affordance supports the development of "diagnostic communities" where students collaborate to troubleshoot heavy mechanical or electronic faults, mirroring the collaborative environment of a professional modern garage.

3.3 Applications of LAMS in Laboratory and Experiential Learning

Badilescu-Buga (2012) provides evidence that LAMS supports large-scale adoption of innovation by providing a synchronous and structured bridge between theory and practice. The synthesis indicates that LAMS's "Gateway" and "Branching" features are particularly valuable for laboratory education. These tools allow for scaffolded learning, where a student must demonstrate theoretical understanding (e.g., of electrical safety) before the system "unlocks" the practical laboratory task. This integration of experiential learning (Kolb, 2015) within a digital sequence ensures that hands-on practice is never unguided.

3.4 Implications for Vehicle Engineering Workshops: A Proposed Synthesis

While empirical data specifically for automotive labs is sparse, a theoretical synthesis of the literature (Billett, 2011; Tynjälä, 2008) suggests that LAMS can directly address the "complexity-safety-time" triad in vehicle engineering. Based on the pedagogical affordances identified, a structured LAMS sequence for a vehicle workshop would logically include: Safety Scaffolding: Using "Gateway" tools to ensure 100% compliance with high-voltage or mechanical safety protocols before physical contact with vehicles. Procedural Visualization: Breaking down complex diagnostic tasks (e.g., CAN-bus troubleshooting) into manageable, sequenced digital steps that guide the student's physical actions.
Theory-Practice Integration: Embedding reflective prompts immediately after a practical task to ensure that students connect the "how" (procedural skill) with the "why" (theoretical physics of automotive systems). Resource Efficiency: Leveraging LAMS to manage learner heterogeneity, allowing advanced students to move through diagnostic branches faster while providing extra instructional scaffolding to novices.

4. Discussion

4.1 Convergence of Findings

The synthesis of the international literature reviewed in this study reveals a strong convergence of findings regarding the importance of structured pedagogical approaches in vocational and laboratory-based education. Across diverse theoretical frameworks and educational contexts, researchers consistently emphasize that effective vocational learning depends on the systematic organization of learning activities rather than on unstructured exposure to practical tasks (Billett, 2011; Rauner & Maclean, 2008).

A central point of convergence concerns the critical role of structure in laboratory learning environments. Studies focusing on vocational education highlight that structured learning sequences—characterized by clear objectives, guided practice, and reflective activities—support deeper learning and the integration of theoretical and practical knowledge (Tynjälä, 2008; Schaap et al., 2012). This finding is particularly relevant for complex and safety-critical settings such as vehicle engineering workshops, where procedural accuracy and conceptual understanding are equally essential.

Another area of agreement across the literature relates to the challenges posed by increasing technological complexity in vocational fields. Reports from international organizations and empirical studies indicate that modern vocational workshops require instructional approaches capable of managing cognitive load, ensuring safety, and supporting learners with diverse prior knowledge (CEDEFOP, 2017; OECD, 2021). The literature converges on the view that traditional, instructor-centered laboratory teaching models are often insufficient to address these demands without the support of structured pedagogical frameworks.

The reviewed studies also demonstrate strong consensus regarding the pedagogical value of learning design systems. Research on learning design consistently underscores the importance of explicitly representing pedagogical intentions and sequencing learning activities to promote coherence and transparency in instruction (Conole, 2013; Dalziel, 2003). Learning design systems are widely recognized as tools that enable educators to align learning objectives, activities, and assessment in a systematic manner, thereby enhancing instructional quality and consistency (Dalziel et al., 2016; Masterman & Vogel, 2007).

With specific regard to the Learning Activity Management System (LAMS), the literature converges on its suitability for experiential and collaborative learning environments. Empirical and conceptual studies indicate that LAMS supports structured activity sequencing, collaboration, and reflection, which are essential components of effective laboratory learning (Campbell & Cameron, 2009; Dennis, 2007). Although most existing studies do not focus explicitly on vehicle engineering workshops, their findings suggest that the pedagogical affordances of LAMS align closely with the instructional needs of vocational laboratory education.

Finally, a notable convergence emerges in relation to identified gaps in the literature. While learning design systems and LAMS have been examined in various educational contexts, there is broad agreement that their application in vocational laboratory settings—particularly in vehicle engineering education—remains underexplored (Dalziel et al., 2016; OECD, 2018). This convergence highlights both the relevance of learning design systems for vocational education and the need for further focused research in this domain.

Overall, the convergence of findings across the reviewed literature supports the view that structured learning design, facilitated by systems such as LAMS, constitutes a promising pedagogical approach for addressing the complexity, safety requirements, and instructional challenges of vehicle engineering workshops in vocational education and training.

4.2 Relevance for Vocational and Technical Education (TVET)

The findings synthesized in this literature review underscore the strong relevance of structured learning design approaches for vocational and technical education and training (TVET). Vocational education is inherently practice-oriented and aims to develop occupational competence through the integration of theoretical knowledge and hands-on experience. However, the literature consistently highlights that effective skill development in TVET requires pedagogically structured learning environments that guide learners through progressively complex tasks (Billett, 2011; Rauner & Maclean, 2008).

One of the key implications for TVET concerns the alignment of instructional practices with workplace demands. International research emphasizes that vocational learning is most effective when educational activities mirror authentic professional practices while remaining pedagogically scaffolded (Tynjälä, 2008). Structured laboratory learning supports this alignment by enabling learners to understand not only how vocational tasks are performed, but also why specific procedures and standards are applied. This pedagogical coherence is particularly important in technical domains characterized by rapid technological change, such as vehicle engineering (CEDEFOP, 2017).

The relevance of learning design systems for TVET is further reinforced by the need to address learner diversity. Vocational classrooms and laboratories often include students with heterogeneous prior knowledge, learning styles, and professional aspirations. Research indicates that structured instructional frameworks help mitigate these challenges by providing clear learning pathways and differentiated learning opportunities (Schaap et al., 2012). Learning design systems facilitate such frameworks by enabling educators to organize learning activities in a transparent and adaptable manner (Conole, 2013).

Moreover, TVET is increasingly expected to meet international quality standards related to safety, employability, and competency-based education. Reports by international organizations stress that vocational education must adopt instructional models that ensure consistency, accountability, and relevance to labor market needs (OECD, 2018, 2021). Learning design systems contribute to these objectives by supporting the systematic planning and documentation of learning activities, which can enhance quality assurance processes in vocational institutions (Dalziel et al., 2016).

In the context of vocational laboratories, particularly vehicle engineering workshops, the pedagogical affordances of learning design systems are especially relevant. These environments require structured instructional approaches that balance practical skill development with safety considerations and reflective learning. The literature suggests that systems such as the Learning Activity Management System (LAMS) can support these requirements by enabling the design and implementation of coherent learning sequences that align instructional goals with laboratory practice (Dalziel, 2003; Campbell & Cameron, 2009).

Overall, the reviewed literature converges on the view that learning design systems represent a valuable pedagogical resource for TVET. By supporting structured, transparent, and adaptable laboratory instruction, such systems can enhance the quality and effectiveness of vocational education and better prepare learners for the demands of contemporary technical professions.

4.3 Pedagogical Affordances of the Learning Activity Management System (LAMS)

The literature reviewed in this study highlights several pedagogical affordances of the Learning Activity Management System (LAMS) that are particularly relevant to vocational and laboratory-based education. LAMS was explicitly designed to support learning design by enabling educators to create, visualize, and implement structured sequences of learning activities that align pedagogical intentions with instructional practice (Dalziel, 2003). This focus on activity sequencing constitutes one of the system’s most significant pedagogical contributions.

A key affordance of LAMS lies in its ability to structure learning processes in a transparent and coherent manner. By representing learning activities as interconnected sequences, LAMS supports learners in understanding the progression of tasks and the relationships between theoretical preparation, practical execution, and reflective activities (Dalziel, 2006). This structured representation is particularly valuable in vocational laboratories, where learners must follow precise procedures and develop a clear understanding of process logic.

Another important pedagogical affordance of LAMS is its support for guided and scaffolded learning. Research indicates that LAMS enables educators to design learning sequences that gradually increase in complexity, thereby supporting learners’ cognitive development and reducing the risk of cognitive overload (Campbell & Cameron, 2009). Such scaffolded approaches are essential in technical domains, including vehicle engineering, where learners are often required to master complex systems and safety-critical procedures.

LAMS also facilitates collaborative learning, which is widely recognized as a core component of effective vocational education. Through integrated tools such as discussion forums, shared tasks, and collaborative activities, the system promotes peer interaction and collective problem-solving (Dennis, 2007). These features support the development of professional communication skills and diagnostic reasoning, which are essential competencies in vocational and technical fields.

Reflection constitutes another central pedagogical affordance of LAMS. The platform allows educators to embed reflective prompts and activities at specific points within a learning sequence, encouraging learners to critically evaluate their actions and outcomes (Dalziel et al., 2016). Reflective practice is particularly important in laboratory-based learning, as it enables learners to connect practical experiences with underlying theoretical concepts and professional standards.

Furthermore, LAMS supports pedagogical consistency and reusability. Learning sequences designed within the system can be reused, adapted, and shared among educators, contributing to the dissemination of effective teaching practices and the maintenance of instructional quality (Masterman & Vogel, 2007). This affordance is especially relevant in vocational education contexts, where instructional practices are often shaped by individual experience rather than formalized pedagogical frameworks.

Finally, the literature suggests that LAMS enhances pedagogical alignment by supporting the coherent integration of learning objectives, activities, and assessment. By focusing on what learners do rather than on content delivery alone, LAMS aligns closely with contemporary learner-centered and competency-based approaches in vocational education (Conole, 2013). This alignment makes the system particularly suitable for laboratory-based instruction in vocational and technical education and training.

Overall, the pedagogical affordances of LAMS identified in the literature suggest that the system constitutes a robust learning design tool capable of supporting structured, collaborative, and reflective learning in vocational laboratory environments. These affordances align closely with the instructional demands of vehicle engineering workshops and broader TVET contexts, reinforcing the relevance of LAMS as a pedagogical resource for vocational education.

4.4 Lack of Studies Specifically in Vehicle Engineering Laboratories

Despite the growing body of international research on learning design systems and laboratory-based learning, the literature reviewed in this study reveals a notable lack of studies specifically focused on vehicle engineering laboratories within vocational education and training (VET). While learning design frameworks and systems such as the Learning Activity Management System (LAMS) have been examined in various educational contexts, including higher education and teacher training, their application in vehicle engineering workshops remains largely underexplored (Dalziel et al., 2016; Campbell & Cameron, 2009).

Existing studies on vocational education tend to address laboratory learning at a general level, often emphasizing broad pedagogical principles such as experiential learning, workplace learning, and competency-based education (Billett, 2011; Rauner & Maclean, 2008). However, these studies rarely differentiate between specific vocational disciplines or examine the unique instructional demands of vehicle engineering education. As a result, the particular challenges associated with automotive technologies, diagnostic procedures, and safety-critical operations are insufficiently addressed in the learning design literature.

Research focusing on learning design systems typically emphasizes their pedagogical affordances, such as structured activity sequencing, collaboration, and reflection (Conole, 2013; Dalziel, 2003). Although these features are highly relevant to vehicle engineering workshops, empirical evidence demonstrating their effectiveness in this specific context remains limited. Most published studies examine the use of LAMS in general educational settings or in teacher education programs, rather than in vocational laboratories that require the integration of complex technical skills and procedural knowledge (Dennis, 2007).

Reports from international organizations further highlight this gap by noting that vocational education research often struggles to keep pace with rapid technological developments in technical fields (CEDEFOP, 2017; OECD, 2021). In the case of vehicle engineering, advancements in electronic systems, diagnostic tools, and alternative powertrains have significantly transformed laboratory practices, yet these developments are rarely reflected in research on learning design and instructional technologies.

The absence of studies specifically targeting vehicle engineering laboratories has important implications for both research and practice. Without discipline-specific evidence, educators may face difficulties in selecting and adapting pedagogical tools that effectively address the unique demands of automotive education. This gap also limits the ability of policymakers and curriculum designers to make evidence-based decisions regarding the integration of learning design systems in vocational laboratory instruction.

Overall, the literature converges on the recognition that while learning design systems such as LAMS hold considerable pedagogical potential for vocational education, further research is needed to examine their application in vehicle engineering laboratories. Addressing this gap represents an important direction for future research and could contribute significantly to the development of structured, safe, and pedagogically grounded laboratory learning in vocational and technical education.

5. Conclusions

5.1 Summary of Key Insights

This literature review provides a comprehensive synthesis of international research on structured laboratory learning, learning design systems, and the pedagogical role of the Learning Activity Management System (LAMS) within vocational and technical education and training (TVET). Across the reviewed studies, a consistent emphasis emerges on the necessity of pedagogically structured learning environments to support effective skill development in vocational laboratories.

A key insight concerns the central role of structure in laboratory-based vocational education. The literature converges on the view that structured learning sequences—characterized by clear objectives, guided practice, and opportunities for reflection—are essential for supporting the integration of theoretical knowledge and practical skills (Billett, 2011; Tynjälä, 2008). This insight is particularly relevant for complex and safety-critical environments such as vehicle engineering workshops, where unstructured instructional approaches may lead to fragmented learning and increased safety risks (Rauner & Maclean, 2008).

Another important insight relates to the instructional challenges faced by vocational laboratories. The reviewed studies consistently identify increasing technological complexity, learner heterogeneity, time constraints, and safety requirements as critical factors that complicate laboratory teaching in technical fields (CEDEFOP, 2017; OECD, 2021). These challenges reinforce the need for pedagogical frameworks capable of organizing laboratory activities in a coherent and transparent manner.

The literature further highlights the pedagogical value of learning design systems as tools that support structured, learner-centered, and collaborative instruction. Learning design systems enable educators to explicitly plan, visualize, and implement learning sequences that align instructional objectives with laboratory practice (Dalziel, 2003; Conole, 2013). In this context, LAMS emerges as a particularly relevant platform due to its focus on activity sequencing, collaboration, and reflective learning (Campbell & Cameron, 2009; Dennis, 2007).

A further insight concerns the relevance of learning design systems for TVET more broadly. The reviewed literature suggests that structured learning design contributes to instructional consistency, quality assurance, and alignment with workplace requirements, all of which are central priorities in contemporary vocational education (OECD, 2018; Dalziel et al., 2016). These insights underscore the potential of systems such as LAMS to support effective laboratory instruction across diverse vocational domains.

Finally, the synthesis of findings reveals a clear gap in the literature regarding the application of learning design systems in vehicle engineering laboratories. While the pedagogical affordances of LAMS are well documented in general educational contexts, empirical and discipline-specific studies in automotive and vehicle engineering education remain limited. This gap highlights the need for further research and underscores the contribution of the present review in framing future investigations in this area.

5.2 Pedagogical Value of LAMS for Vocational Laboratories

The synthesis of the reviewed literature highlights the substantial pedagogical value of the Learning Activity Management System (LAMS) for vocational laboratory education. Vocational laboratories represent complex learning environments where the effective development of professional competence depends on the structured integration of theoretical knowledge, practical skills, and reflective practice. The literature consistently indicates that learning design systems such as LAMS are well positioned to support these pedagogical requirements.

A primary pedagogical value of LAMS lies in its capacity to structure laboratory learning processes in a coherent and transparent manner. By enabling educators to design sequenced learning activities that guide learners through preparation, execution, and reflection, LAMS supports the development of procedural understanding and professional reasoning (Dalziel, 2003, 2006). This structured approach aligns closely with established theories of vocational learning, which emphasize guided participation and scaffolded practice as essential conditions for effective skill acquisition (Billett, 2011).

Another significant pedagogical contribution of LAMS concerns its support for learner engagement and active participation. The system's emphasis on activity-based learning encourages learners to take an active role in the learning process rather than passively following instructions. Research suggests that such engagement enhances learners' motivation and facilitates deeper learning, particularly in laboratory-based contexts where hands-on experience is central to educational outcomes (Campbell & Cameron, 2009).

LAMS also demonstrates pedagogical value through its support for collaborative learning and peer interaction. Vocational education increasingly recognizes collaboration as a key component of professional competence, especially in technical fields that require teamwork and communication. Through integrated collaborative tools, LAMS facilitates peer discussion, shared problem-solving, and collective reflection, thereby supporting the development of social and cognitive skills relevant to workplace practice (Dennis, 2007; Schaap et al., 2012).

Reflection constitutes another critical pedagogical dimension supported by LAMS. The ability to embed reflective activities within learning sequences enables educators to prompt learners to critically evaluate their laboratory experiences and connect practical actions with theoretical concepts. Reflective practice is widely regarded as essential for transforming experience into learning in vocational education, particularly in environments characterized by complex procedures and safety considerations (Tynjälä, 2008).

Furthermore, LAMS contributes to pedagogical consistency and quality assurance in vocational laboratories. By making learning designs explicit and reusable, the system supports the dissemination of effective instructional practices and promotes consistency across different laboratory sessions and instructors (Dalziel et al., 2016; Masterman & Vogel, 2007). This consistency is especially valuable in vocational education settings, where instructional approaches may otherwise vary significantly depending on individual teaching styles.

Overall, the pedagogical value of LAMS for vocational laboratories lies in its ability to operationalize learning design principles in practice. By supporting structured, collaborative, and reflective laboratory learning, LAMS addresses key instructional challenges in vocational education and offers a pedagogically grounded framework for enhancing laboratory-based instruction. These qualities suggest that LAMS represents a valuable pedagogical resource for vocational laboratories, including those in vehicle engineering education.

5.3 Recommendations for Educators

Based on the synthesis of the reviewed literature, several pedagogically grounded recommendations can be proposed for educators working in vocational and laboratory-based education, particularly in vehicle engineering workshops. These recommendations aim to support the effective integration of learning design principles and systems such as the Learning Activity Management System (LAMS) into vocational teaching practice.

First, educators are encouraged to adopt a structured approach to laboratory instruction by explicitly designing learning sequences that guide learners through distinct phases of preparation, execution, and reflection. Research consistently demonstrates that structured learning environments enhance the integration of theoretical knowledge and practical skills and reduce cognitive overload in complex laboratory settings (Billett, 2011; Tynjälä, 2008). Learning design systems can support this process by enabling educators to visualize and plan laboratory activities in a coherent and pedagogically aligned manner.

Second, vocational educators should emphasize scaffolded learning in laboratory instruction. Gradually increasing task complexity and providing guided support at critical stages of the learning process can help learners develop confidence and procedural understanding, particularly in safety-critical environments such as vehicle engineering workshops (Rauner & Maclean, 2008). LAMS supports scaffolded instruction by allowing educators to design sequenced activities that respond to learners' developmental needs.

Third, educators are encouraged to integrate collaborative learning and peer interaction into laboratory activities. The literature highlights collaboration as a key component of effective vocational learning, supporting problem-solving, communication, and professional reasoning skills (Schaap et al., 2012). Learning design systems facilitate collaboration by embedding discussion, group work, and shared tasks within laboratory learning sequences, thereby fostering active learner engagement.

Fourth, reflective practice should be systematically incorporated into vocational laboratory instruction. Reflection enables learners to critically examine their laboratory experiences, identify errors, and connect practical actions with underlying theoretical principles (Tynjälä, 2008). Educators can use learning design systems such as LAMS to embed reflective prompts and activities at strategic points within laboratory sessions, supporting deeper and more meaningful learning.

Fifth, educators should consider the use of learning design systems as tools for pedagogical consistency and quality assurance. By making instructional designs explicit and reusable, systems such as LAMS support the sharing of effective teaching practices and contribute to the maintenance of instructional quality across different laboratory sessions and instructors (Dalziel et al., 2016). This is particularly relevant in vocational education contexts characterized by diverse learner populations and varying instructional conditions.

Finally, vocational educators are encouraged to engage in continuous professional development related to learning design and educational technologies. International research emphasizes that effective integration of digital pedagogical tools requires not only technical competence but also pedagogical understanding (Conole, 2013; OECD, 2021). Professional development initiatives that focus on learning design principles can support educators in leveraging systems such as LAMS to enhance laboratory-based teaching and learning.

5.4 Directions for Future Empirical Research

The synthesis of the reviewed literature highlights several important directions for future empirical research concerning the use of learning design systems, and particularly the Learning Activity Management System (LAMS), in vocational and laboratory-based education. Although existing studies provide valuable insights into the pedagogical affordances of learning design systems, there remains a clear need for empirical evidence that examines their effectiveness in discipline-specific vocational contexts.

First, future research should focus on empirical investigations within vehicle engineering laboratories. As identified in this review, the majority of existing studies on LAMS have been conducted in general educational or teacher education contexts, with limited attention given to technical vocational laboratories. Empirical studies examining the implementation of LAMS in vehicle engineering workshops could provide valuable evidence regarding its impact on skill acquisition, procedural accuracy, and safety awareness among vocational learners.

Second, comparative studies are needed to examine the effectiveness of learning design systems relative to traditional laboratory teaching approaches. Experimental or quasi-experimental research designs could compare structured laboratory instruction supported by LAMS with conventional instructor-centered laboratory teaching in terms of learning outcomes, learner engagement, and knowledge transfer. Such studies would contribute to a more robust understanding of the added value of learning design systems in vocational education.

Third, future research should explore learner-centered outcomes, including motivation, self-regulation, and reflective competence. The literature suggests that LAMS supports collaborative and reflective learning processes; however, empirical evidence examining these outcomes in vocational laboratory settings remains limited. Mixed-methods studies combining quantitative measures with qualitative data could provide deeper insights into learners' experiences and perceptions.

Fourth, longitudinal studies represent an important direction for future research. Vocational competence develops over time through repeated practice and reflection. Longitudinal research examining the sustained use of LAMS across multiple laboratory sessions or academic terms could shed light on its long-term impact on skill development, professional identity formation, and employability-related competencies.

Fifth, future research should consider the professional development of vocational educators in relation to learning design systems. Investigating how educators design, adapt, and implement learning sequences using LAMS, as well as the challenges they encounter, could inform the development of targeted professional development programs and support the effective integration of learning design in vocational education.

Finally, cross-institutional and cross-cultural studies could contribute to the generalizability of research findings. Vocational education systems vary significantly across countries and educational contexts. Comparative studies examining the use of LAMS in different vocational education systems could provide valuable insights into contextual factors that influence the effectiveness of learning design systems in laboratory-based education.

Overall, future empirical research grounded in vocational laboratory practice is essential to advance the evidence base for learning design systems and to support their informed adoption in vocational and technical education and training.

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