Integrating Socio-Technical Perspectives in University Learning: The Importance of Socio-Technical Inquiry Learning (STIL) for Preparing Competent Graduates

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Abstract. Contemporary higher education faces the challenge of preparing graduates who are not only technically competent but also possess high social awareness. This article analyzes the importance of integrating socio-technical perspectives in university learning through the Socio-Technical Inquiry Learning (STIL) framework. Through literature review and learning practice analysis, this research demonstrates that traditional learning focused solely on content mastery is inadequate for preparing students to face the complexities of the modern workplace. The STIL framework integrates six socio-technical system components with five inquiry learning stages (5E Model) to create authentic and meaningful learning experiences. Analysis results show that STIL implementation can enhance systems thinking abilities, generic science skills, and students' social awareness. The primary recommendation is the adoption of the STIL framework in university curricula to produce graduates ready to face complex and dynamic professional challenges.

Keywords: Socio-technical learning, STIL, higher education, systems thinking, social awareness

Introduction

Digital transformation and globalization have fundamentally changed the higher education landscape. Universities worldwide are now challenged to produce graduates who not only master technical knowledge in their fields but also have the ability to adapt to rapid technological changes and understand the social implications of their professional decisions (Dhina et al., 2024). In this context, social aspects in learning become increasingly crucial to consider. Inquiry-based learning has proven effective in facilitating knowledge construction and developing higher-order thinking skills. A recent meta-analysis by Çalik and Wiyarsi (2024) shows that inquiry-based learning has an effect size of 1.27 in developing critical thinking skills, indicating significant and substantial impact. Research by Aditomo et al. (2013) further confirms that IBL can effectively stimulate students' curiosity and develop their inquiry spirit in higher education contexts. However, in an era of technological complexity and interconnected social challenges, traditional learning approaches that separate technical aspects from their social contexts become inadequate. The Socio-Technical Inquiry Learning (STIL) framework emerges as a response to the need for integrating socio-technical perspectives in university learning. STIL not only develops students' technical competencies but also prepares them to become socially responsible professionals capable of contributing to solving complex challenges in society. This article aims to analyze the importance of social aspects in university learning and recommend STIL implementation as a comprehensive learning framework.

Methods

This research employs a systematic literature review approach to analyze the development of socio-technical learning in higher education contexts. Data were obtained from various academic sources including international journals, conference proceedings, and research reports published between 2020-2024. Inclusion criteria encompassed articles discussing inquiry-based learning, socio-technical systems, and higher education innovations.

Analysis was conducted through narrative synthesis to identify trends, challenges, and opportunities in developing learning that integrates social and technical aspects. The STIL framework was developed based on theoretical integration between inquiry learning theory and socio-technical systems, with validation through expert review from higher education practitioners.

Result and Discussion

Contemporary University Learning Challenges

Analysis of learning practices in universities reveals significant gaps between workplace needs and higher education outputs. Recent studies in Learning, Media and Technology by Swist and Gulson (2023) emphasize that current higher education systems face challenges in integrating artificial intelligence, automation, algorithms, and datafication into educational decision-making systems. This condition aligns with findings that although educators acknowledge inquiry-based learning as a promising approach, its implementation in practice remains limited due to challenges in teacher preparation and institutional support (Justice et al., 2009). More critically, research by Bider (2024) in the Socio-Technical Perspectives in Information Systems proceedings identifies that inquiry implementation in science education often focuses narrowly on hands-on investigation without integrating reasoning, modeling, and argumentation components crucial for comprehensive learning. Systems thinking studies in education by Moyer (2024) show that traditional linear thinking approaches cannot recognize complex patterns and relationships, thus hindering the development of systems thinking and generic science that require active knowledge construction processes through holistic inquiry.

Theoretical Foundations of Socio-Technical Learning

The integration of socio-technical systems with inquiry learning is grounded in three mutually reinforcing theoretical pillars. First, Vygotsky's social constructivism theory emphasizes that learning occurs through social interaction within the zone of proximal development, where technology serves as a cognitive mediator expanding students' capabilities in understanding complex phenomena. Second, activity theory developed by Engeström views learning as an activity system involving subjects (students), objects (learning concepts), mediating tools (technology), learning communities, scientific rules, and role division in professional teams. Third, situated learning theory emphasizes the importance of authentic contexts in learning, where knowledge cannot be separated from situations and activities in which it is used. In university learning contexts, these three theories unite to create learning environments that not only facilitate deep conceptual understanding but also develop students' abilities to apply these concepts in professional practice contexts considering social, ethical, and technological aspects simultaneously.

The STIL (Socio Technical Inquiry Learning) Framework

Based on theoretical integration between inquiry learning and socio-technical systems, the Socio-Technical Inquiry Learning (STIL) framework was developed to systematically integrate six socio-technical system components with inquiry learning stages in university learning contexts. The STIL framework is designed to create learning that not only develops systems thinking abilities and generic science skills but also prepares students to actively participate in increasingly complex and technology-based professional practices.

Tabel 1. Socio Technical Inquiry Learning (STIL) Framework

STIL FRAMEWORK	
STS COMPONENTS	INQUIRY STAGES (5E)
1. Goals 2. People 3. Technology 4. Infrastructure 5. Culture 6. Process	→ Engagement → Exploration → Explanation → Elaboration → Evaluation

The STIL framework operationalizes learning through systematic integration between six socio-technical system components and five inquiry learning stages (5E Model) as developed by Bybee et al. (2006) and adapted to higher education contexts (Spronken-Smith, 2012). The **Goals** component encompasses systems thinking development, generic science skills enhancement, field content mastery, and professional competency achievement integrated in every learning stage.

The **People** component involves students as active learners, lecturers as facilitators, laboratory assistants as support systems, and collaborative learning team formation reflecting professional team dynamics (Archer-Kuhn & MacKinnon, 2020).

The **Technology** component integrates various instruments and technological devices not merely as measurement or demonstration tools, but as learning mediators enabling students to understand relationships between theoretical principles and their applications in professional contexts.

The **Infrastructure** component encompasses optimizing laboratory spaces, classrooms, and discussion areas to create conducive learning environments for collaborative inquiry. The **Culture** component focuses on developing research culture, scientific collaboration, inquiry attitudes, and scientific ethics that become foundations for professional practice.

The **Process** component operationalizes five inquiry learning stages adapted to socio-technical contexts: Engagement, Exploration, Explanation, Elaboration, and Evaluation.

STIL Operationalization in University Learning
STIL framework implementation in university learning follows an integrative and iterative learning cycle, where each stage mutually reinforces developing deep understanding of phenomena in study fields considering professional practice contexts (van Schalkwyk et al., 2015).
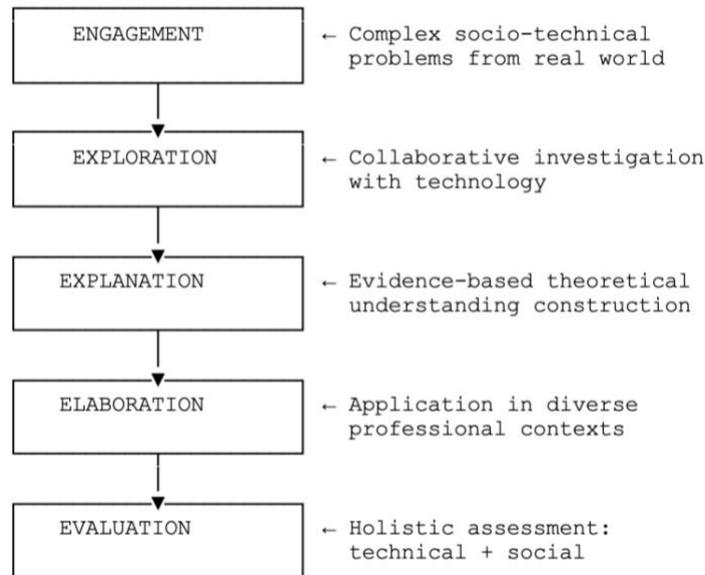
Figure 1. STIL Learning Cycle in University Context

The **Engagement** stage is designed to identify socio-technical problems in study fields through authentic scenarios reflecting real-world challenges in professional practice. According to the World Economic Forum (2024), systems thinking in education has great potential for preparing learners for the future of work and tackling complex challenges through holistic approaches.

The **Exploration** stage facilitates students to investigate phenomena through direct investigation using technology relevant to their study fields while considering social implications of their findings (Kamarudin et al., 2024). The **Explanation** stage encourages students to construct theoretical understanding based on exploration experiences, emphasizing relationships between scientific principles and practical applications. The **Elaboration** stage expands understanding through concept application in more complex and diverse contexts, including ethical and social considerations (Bond & Blevins, 2020). The **Evaluation** stage assesses not only conceptual understanding but also students' abilities to apply knowledge in professional contexts considering social responsibility.

STIL Contributions to Higher Education Development

The STIL framework provides various contributions to higher education advancement through theoretical innovations, methodological development, and practical implementation adaptable to diverse contexts (Chalmers & Gardiner, 2015). Its theoretical contribution lies in developing an integrated framework that systematically combines socio-technical system perspectives with inquiry-based learning. This approach creates a new paradigm for higher education that addresses contemporary needs in professional preparation aligned with 21st-century challenges.

Methodological contributions include developing systematic approaches to implementing inquiry-based learning in authentic professional contexts, with special emphasis on collaborative learning and technology integration (Spronken-Smith & Walker, 2010). Framework operationalization through structured learning modules provides practical guidance for educators wanting to apply similar approaches in their teaching contexts.

Practical contributions lie in demonstrating that the STIL framework can effectively enhance learning outcomes in cognitive and metacognitive dimensions while developing social competencies essential for professional practice (Sadman, 2024). Research at the University of Northern Colorado shows that systems thinking approaches can amplify students' critical thinking powers and connect learning with real-world applications. Focus on professional preparation contributes to developing graduates better prepared to face contemporary challenges across various industry sectors.

Conclusion

Integrating socio-technical perspectives in university learning through the STIL framework is an urgent need to prepare graduates competent to face modern workplace complexities. STIL offers a holistic learning approach by integrating six socio-technical system components and five inquiry learning stages to create authentic and meaningful learning experiences. STIL implementation not only enhances students' technical abilities but also develops social awareness, systems thinking abilities, and collaborative skills essential for professional success. This framework can be adapted across various study fields and institutional contexts, making it a flexible solution for higher education innovation. The primary recommendation is gradual adoption of the STIL framework in university curricula, beginning with pilot projects in specific study programs before expanding institutionally. Management support, faculty training, and infrastructure development become keys to successful STIL implementation in transforming university learning toward education more relevant and responsive to societal needs.

Acknowledgments

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