Journal of LEADERSHIP AND MANAGEMENT

Volume 12 Issue 1
Published January 2026

Edited by

Sue Kong, Ph.D.

Adam Szpaderski, Ph.D.

Published by
Institute of Management and Leadership

JOURNAL OF
LEADERSHIP AND MANAGEMENT

Volume 12, Issue 1
Published January 2026

Edited by

Sue Kong, Ph.D.

Adam Szpaderski, Ph.D.

Institute of Management and Leadership
A Program of the Health, Prosperity & Leadership Institute

HPL Publications

Institute of Management and Leadership

Institute of Management and Leadership is a program of
Health, Prosperity, and Leadership Institute

Publisher:

HPL Publications

PO Box 564, Douglassville, PA 19518, USA

Digital Version ISSN: 2391-6087

Print Version ISSN: 2998-1042

Print ISBN:

Contents

Journal of Leadership and Management®
An International Journal of Strategic, Behavioral and Public Aspects of Leadership in Management
Cabell's Listed
A journal of the Institute of Leadership and Management Association, PO Box 564, Douglassville PA 19518. 484-332-3331. https://www.jleadershipmanagement.org

What Skills are Developed by Individuals Who Volunteer as Leaders in a Civic Organization?

Eric B Gresch, Georgia Gwinnett College, egresch@ggc.edu
Daniel T Hall, High Point University
William B Holmes, Georgia Gwinnett College

Online published: Jan 2026 Print published: Jan 2026 Editor: Sue Kong	Authorship Roles and Conflict of Interest Statement is on file at the Journal of Leadership and Management offices, available on request. Contact editors@jleadershipmanagement.org

Abstract
Volunteer leaders serve a critical role that enables many nonprofit organizations to achieve their organizational goals (Boezeman & Ellemers, 2014). In the process of engaging in activities that support a nonprofit organization's progress toward its goals, many volunteer leaders gain and refine important leadership skills. While some previous research has focused on volunteer leaders, Morrison and Greenshaw (2018) noted that there is limited literature pertaining to specific competencies and skills that are needed by volunteer leaders in nonprofits. Research has not yet fully explored a number of phenomena relating to volunteer leadership, including the types of skills developed by individuals serving as volunteer leaders. With this research gap in mind, our study investigates the types of skills gained by volunteer leaders in a civic organization. Results of the study reveal that the types of leadership skills developed by volunteer leaders tended to align closely with the four skill requirement categories in the strataplex described by Mumford et al. (2007); additionally, participants reported increased self-confidence. Implications for research and practice are discussed.

KEYWORDS
Leadership Skills, Nonprofit, Civic Organization, Volunteer Leaders, Skills Development, Self-confidence

Acknowledgements: The authors are grateful to Civitan International and its members for participating in this study.

Introduction
Many nonprofit organizations rely heavily, if not exclusively, on volunteer leaders to help accomplish organizational goals (Boezeman & Ellemers, 2014). Volunteer leaders are non-paid individuals with formally defined roles in an organization (Morrison & Greenhaw, 2018). In the process of assisting a nonprofit organization reach its goals, volunteer leaders may develop and refine a number of professional skills and abilities.

Jäger et al. (2009) recognized that the practices utilized by individuals leading volunteers is an under-researched phenomenon and Morrison and Greenshaw (2018) recognized that there is limited literature pertaining to specific competencies and skills that are needed by volunteer leaders in nonprofits. Given that serving nonprofit organizations provides volunteer leaders the opportunity to learn and develop a variety of skills needed by leaders, there is an opportunity to advance the existing literature by identifying specific skills that volunteer leaders acquire and refine while serving in their leadership roles. Thus, the purpose of this study is to identify skills that volunteer leaders gain through their participation in leadership positions within a nonprofit community organization.

Literature Review

Critical Leadership Skills Needed in Organizations

A variety of skills, including interpersonal skills and problem-solving skills, are frequently recognized as critical for organizational leaders. A Harvard Business Review survey found that the most important skills for organizational leaders at every level include a) inspiring and motivating others b) displaying high integrity and honesty c) solving problems and analyzing issues d) driving for results e) communicating powerfully and prolifically f) collaborating and promoting teamwork and g) building relationships (Zenger & Folkman, 2014).

Likewise, a recent survey conducted by Training Magazine and Wilson Learning identified similar skills as important leadership skills in Worldwide Inc. (Leimback, 2023). In the survey, the top seven leadership skills identified by organizations included: a) coaching/ developing others b) communication skills c) team leadership d) strategy development and alignment e) emotional intelligence skills f) change leadership and g) interpersonal relationship skills.

Volunteer Leader Skills Development within Nonprofit Organizations

In the process of volunteering in a leadership role within a nonprofit organization, volunteer leaders can gain and develop a variety of different skills and abilities. Palanski et al. (2022) identified a number of professional development benefits enjoyed by individuals that serve in leadership roles in volunteer contexts; benefits included utilizing and practicing existing skills, development of new skills, prompting self-awareness and development, providing the challenge of motivating others without formal workplace rewards and punishments, and providing greater freedom to experiment than is often allowed in the workplace.

Lester et al. (2017) recognized that there is very little research on how participation in a community organization can develop leadership skills. In their description of multi-domain leadership, the authors asserted that leadership development can be accelerated by an individual's pursuit of leadership opportunities in multiple domains including opportunities within the domain of community. Consistent with the view held by Lester et al. that leadership development is an outcome of participation within community organizations, Gordon and Gordon (2017) found that active membership in volunteer organizations including civic, fraternal, professional or religious, may provide individuals a way to gain new skills as well as enhance higher-level leadership skills in a non-threatening, collaborative environment.

The approach to leadership adopted by volunteer leaders may differ from paid leaders. In research comparing volunteer leaders to paid leaders in a national youth sports organization, Posner (2015) found that volunteer leaders engaged more frequently in certain leadership behaviors than paid leaders, including exhibiting behaviors they expected of followers, communicating a positive vision of the future, inspiring followers to direct their efforts in support of the organization's vision, encouraging innovation among followers, empowering followers, and demonstrating genuine concern for followers.

Because volunteer leaders often lead other volunteers rather than paid employees, the particular skills developed by volunteer leaders may reflect the different type of leadership approach that is necessary when leading volunteers. Boezeman and Ellemers (2014) argue that because volunteer work is unpaid and not required, volunteer leadership requires an approach that focuses on non-instrumental and non-coercive concerns. Underscoring the importance of communication skills development, they found that it is imperative for leaders to communicate to volunteers how the organization improves people's lives in order to assist volunteers in their efforts to carry out their work for the organization.

Background on Civic Organizations

Civic organizations represent a unique type of organization, with characteristics that separate them from for-profit organizations as well as some other types of nonprofit organizations. Civic organizations are characterized as voluntary associations that depend on members' contributions of money, time, effort and skill to work in support of a common purpose (Andrews et al., 2010). Civic organizations differ from for-profit and nonprofit bureaucratic organizations that are characterized by centralized decision-making and reliance on hired employees to complete the work. Instead, civic organizations are characterized as depending on members' voluntary efforts, decentralized decision-making across local units, and governance through elected volunteer leaders. The accomplishments achieved by civic associations are the result of member and supporter voluntary participation (Andrews et al., 2010; Knoke & Prensky, 1984; Smith, 2000).

Leadership practices required to generate commitment to voluntary organizations differ significantly from those used to generate compliance in work organizations (Andrews et al., 2010; Walton, 1985). With civic organizations characterized by voluntary participation, decentralized decision making, and voluntary elected leaders, it is necessary for leaders to work toward achieving the organization's goals without relying on coercive compliance (Andrews et al., 2010). The demand for effective leadership is felt at all levels of civic organizations, especially at the local level, with local chapters required to recruit, train, and support individuals who can serve in the many local leadership positions, requiring a major commitment to leadership development (Andrews et al., 2010). The significant reliance of civic organizations on work completed by volunteers points to the need to take a closer look at the particular skills developed by volunteer leaders in their efforts to lead volunteers.

Gap Addressed by our Research

Jäger et al. (2009) recognized that the practices utilized by individuals leading volunteers is an under-researched phenomenon; the literature they found addressing the topic was primary popular management literature rather than research incorporating academic rigor. Since then, some research on volunteer leaders has been conducted in different areas of focus.

Bowers (2012) reported that in searching of EBSCO, ProQuest, Sage, and Emerald Insight databases, 386 results matched one or more of the following terms: "volunteer leadership," "volunteer leader," "voluntary leadership," "voluntary leader," "voluntarism" and "leadership," "volunteerism" and "leadership," and "leading volunteers." However, in the research articles that were included in the results, the primary focus of those articles was limited to three general categories: volunteer satisfaction and motivation, service learning, and the impact of employee volunteerism on corporate engagement. The high concentration of research articles focusing on a few general categories indicate that research has not yet fully explored a number of phenomena relating to volunteer leadership, including the types of skills developed by individuals serving as volunteer leaders.

More recently, Gordon and Gordon (2017) interviewed leaders in two civic organizations, finding that volunteer leaders benefited from formal and informal training, the opportunity to practice new skills and hone existing skills, and recognition that learned skills were transferable to other settings including paid employment. While their research acknowledged volunteer leaders were able to practice and refine skills, they did not identify the specific leadership skills developed. Additional research on identifying specific skills developed by volunteer leaders is needed. Morrison and Greenshaw (2018) recognized that there is limited literature pertaining to specific competencies and skills that are needed by volunteer leaders in nonprofit and volunteer organizations. With this gap in mind, our study seeks to advance the existing research by identifying specific knowledge, skills, and abilities gained by volunteer leaders in a civic organization.

By analyzing survey responses from a unique dataset gathered by the researchers, this study contributes to the understanding of the skills developed by volunteer leaders serving in a civic organization, Civitan International. In this research study, survey data from 65 leaders in the civic organization is used to identify skills that volunteer leaders acquired and refined in their role. Unitizing and categorizing the comments from participant responses allowed the researchers to identify the skills that the volunteer leaders developed and improved through their service.

Theoretical/Conceptual Framework

Mumford, Campion and Morgeson (2007) proposed a model of four categories of leadership skill requirements consisting of cognitive skills, interpersonal skills, business skills, and strategic skills that were tested on a sample of professional employees working for the U.S. government. The model incorporates nine leadership skills taxonomies previously proposed; each of which included a variety of skills that fell within the four categories proposed by Mumford et al. Descriptions of the four categories are listed below.

1) Cognitive skill requirements include communication skills such as speaking, active listening, writing, and reading comprehension as well as active learning and critical thinking skills.
2) Interpersonal skill requirements include social perceptiveness, coordination (with others), negotiation, and persuasion.
3) Business skill requirements include operations analysis, and management of personnel resources, financial resources and material resources.
4) Strategic skill requirements include visioning, systems perception, systems evaluations, identification of key causes, problem identification, and solution appraisal.

Mumford et al. (2007) also visualized a strataplex of "strata" (levels of leadership) and "plex" (segments of the four categories) illustrating that strategic skill requirements are relatively more important for senior level managerial jobs than junior level managerial jobs.

Use of Open-ended, Qualitative Items to Evaluate Skills Developed by Volunteer Leaders

As little prior research focused on identifying specific skills gained by volunteer leaders in a civic organization, the researchers focused their efforts on identifying those skills. The researchers adopted an exploratory approach to gather data. Consistent with an exploratory approach, the researchers utilized a survey design including an open-ended qualitative item to gather information on skills developed by survey participants. Open-ended, qualitative items provide survey respondents full freedom of expression and enable the researcher to identify issues salient to the survey respondent and the strength of the respondent's feelings (Foddy, 1993; Iarossi, 2006). As a result, responses to open-ended items can provide insights that cannot be captured by using closed-ended items. Including an open-ended, qualitative survey item provided the opportunity for the volunteer leader survey participants to identify skills and other related issues that might be different than skills utilized by leaders in other organizational contexts. Thus, the data gathered helps us answer the following research question: What types of leadership skills are developed by volunteer leaders in a civic organization?

Methods

Survey Instrument

The survey included an open-ended, qualitative survey item as well as demographic items. The open-ended survey item read, "In a few sentences, please describe how Civitan has helped you develop and demonstrate your leadership skills." Demographic items related to gender and years of service.

Research Venue

The venue chosen for study was Civitan International. Civitan International is a nonprofit, civic organization founded in Birmingham, Alabama in 1917 with a mission "to build good citizenship by providing a volunteer organization of clubs dedicated to serving individual and community needs, with an emphasis on helping people with developmental disabilities" (Civitan International, 2025a). Common ways in which local clubs serve community needs include volunteering for soup kitchens, building homes, participating in local Special Olympics events, and fundraise for the Civitan International Research Center (Civitan International, 2025c). Civitan International is a volunteer-based civic organization with only a few paid staff at the organization's headquarters; the rest of the organization is led by volunteers (Civitan International, 2025b). One of the authors had been an active member of the organization for many years and has served in several leadership positions.

Participants

Almost all survey participants were Civitan members serving in District Level and Club Level positions at the time of the survey. Survey participants were in the United States, where a large majority of organization's members and leaders reside. The organizational structure is geographically based; the structure at the time of the survey is included in Table 1. Below the International level, each of the eight large geographic regions containing multiple districts (e.g., Region 1 comprises districts in Alabama and Mississippi, Region 2 Georgia, South Carolina, and Florida Districts). In turn, each district contains multiple areas (e.g. North Carolina East contains nine areas); each area contains individual, community-based clubs (2 to 15 clubs). Many of the survey participants previously held leadership positions at multiple organizational levels. In contrast to many employment-based leadership paths in which an individual tends to follow a leadership path that often moves only upward in an organization, in Civitan it is not unusual for an individual to return to lower levels of leadership after serving in a higher-level position. For example, Past International Presidents have subsequently served as District Governors.

Table 1 Civitan Leadership Organizational Structure

Level	Units	Leadership positions
International*	1	President, President Elect, Immediate Past President, Treasurer, Secretary, and Regional Directors.
Regions	8	Each Region (a bundle of Districts) is represented by one elected Regional Director who serves on the International Board.
Districts	22	Each District (a bundle of Areas) is represented by a Governor, Governor Elect, Past Governor, Treasurer, Secretary, and committee chairs.
Areas	126**	Each Area (a bundle of Local Clubs) is represented by one Area Director appointed by the District Governor.
Local Clubs	876***	President, President Elect, Immediate Past President, Treasurer, Secretary, and committee chairs.
Members	24,812***	Anyone 18+ can become a member.

*Two Canadian districts, four European districts, two Asian districts, and a small number of International Clubs at Large are excluded from this table because they were not recruited.

**Number is approximate.
***Membership data at the time of survey collection was reported by the Civitan International Membership Director (L. Stephens, personal communication, November 01, 2014).

Data Collection

Consistent with the protocol approved by the institutional review board (IRB), researchers initially mailed surveys to each district's Secretary along with a request for the Secretary to proceed with the following protocol: District Secretaries were to distribute the researchers' invitations to the other district board members at the board's next meeting and provide time for interested board members to complete the survey. The district Secretaries would then collect and return the completed surveys to the researchers.

Data Analysis

Content analysis of written comments is a commonly used procedure that utilizes textual data to make inferences regarding a person's thoughts, intentions and attitudes (Morris, 1994). In the text analysis process, words, phrases, or paragraphs are highlighted and coded. Consistent with this process, the primary documents (participant written responses) were coded with a phrase or sentence as the unit of analysis (Krippendorff, 2004). Each phrase or sentence that referred to a specific idea was separated as a unit. As part of the process of identifying and separating the units, all possible ideas were recognized and captured in separate comments. Overall, 118 unitized comments relating to the question posed to survey participants were identified.

After the written comments were unitized, each comment was discussed by two of the researchers and compared to the four skill requirement categories of the strataplex model described by Mumford et al. The researchers reached a consensus on the particular skill requirement category that most closely aligned with each comment and categorized each comment accordingly. Subsequently a third researcher was asked to independently code the comments.

To be confident in categorization of each unitized comment, the degree of agreement between the third researcher and the first two researchers was calculated. Overall agreement was strong (95.8%). In instances where there were differences in the categorization of unitized comments, all three researchers reviewed the categorization to determine the rationale for the difference. The researchers determined differences were due to typical reasons – some words had multiple meanings, and some phrases were interpreted differently due to the context of other words. After discussing differences in each case, the coding was updated until 100% agreement was achieved.

Results

Findings

A total of 118 unitized comments were generated from 65 respondents in 15 Civitan International districts. Years of Civitan service reported by respondents averaged 19.4 years with a median of 17.0. Sixty percent of respondents were female, 40 percent were male.

Qualitative analysis results are included in Table 2 and includes a frequency analysis of unitized comments that represented each of the four categories of skill requirements: cognitive skills (28.0%, $n = 33$), interpersonal skills (26.3%, $n = 31$), business skills (36.4%, $n = 43$), and strategic skills (3.4%, $n = 4$). Most unitized comments matched one of the four categories of skill requirements, however several participants included written comments relating to improved self-confidence. Self-confidence is not a skill, but the authors concluded it was appropriate to report statements on the topic (5.9%, $n = 7$) as the statements signaled that self-confidence was a salient matter to the participants.

Table 2 Unitized Comments Categorization and Summary

Category	Unitized Comment Examples	*n*	% of total
Cognitive skill requirements	*"Being rather shy, it has helped me tremendously to talk in front of my peers."* *"The experience as Club President and President-Elect especially helped me develop and hone my abilities to communicate, both one-on-one and to a group."* *"Provide the ability to learn from members and others".*	33	28.0%
Interpersonal skill requirements	*"These people work for free! You have to make them "want" to do it!"* *"Serving on the board showed how bringing people together can get things done."* *"You learn to work with all kinds of people."*	31	26.3%
Business skill requirements	*"The experience ... helped me develop and hone my abilities to organize people."* *"(I) have become a mentor for other leaders."* *"Civitan has helped me learn to delegate responsibility to others."*	43	36.4%
Strategic skill requirements	*"By serving in these roles it... showed me just how Civitan works behind the scenes."* *"Honestly the most valuable application has been to lead the West Ashley Club into a new phase of action, service, and modernization."*	4	3.4%
Increased Self Confidence	*"Having been in a leadership position, has made a more confident and assertive person.* *"It has helped me… develop more self-confidence."*	7	5.9%

Discussion and Practical Implications

This research provides insights into the types of skills developed by individuals leading volunteers, addressing the calls of Jäger et al. (2009), Bowers (2012) and Morrison and Greenshaw (2018) for more research into the phenomenon. This study also helps fill in the research gap identified by Lester et al. (2017) by recognizing how participation in a community organization can develop the leadership skills of their volunteers.

Analysis of participant responses indicated the types of leadership skills developed by Civitan volunteer leaders tended to align closely with the four skill requirement categories in the strataplex described by Mumford et al. (2007); additionally, the open response format enabled participants to report increased self-confidence as a salient issue.

The category of cognitive skill requirements included a total of 33 unitized comments (28.0%), with many comments focusing on communications in general and oral communication skills in particular, as well as skills associated with active listening and critical thinking. A total of 31 unitized comments (26.3%) were categorized as interpersonal skills, with many of the unitized comments reporting the survey participant learned how to work well with others, improved the survey participant's abilities to negotiate and persuade, as well as the increased ability to effectively work with others who differ in background, personality, and workstyle.

The numerous comments categorized as cognitive skills requirements and interpersonal skills is consistent with the findings by Boezeman and Ellemers (2014) that stressed the importance of communication skills in volunteer leader positions. In reporting gaining skills such as speaking, active listening, negotiation and persuasion, participants reported that they gained communication skills captured in the strataplex categories of cognitive skill requirements and interpersonal skill requirements noted by Mumford et al. (2007). The numerous comments recognizing participant development of communication skills is logical considering that strong communication skills are needed to achieve the organization's goals without relying on coercive compliance (Andrews et al., 2010).

The category of business skills included a total of 43 unitized comments (36.4%), the highest percentage, with many of the responses noting skills gained in the management of personnel resources, including delegating, organizing, developing and motivating others. Responses also noted skill development in event planning and operations analysis. While previous research on volunteer leaders acknowledged the development of cognitive skills and interpersonal skills, the result of this study also recognizes the prevalence of business skills development.

A total of four unitized comments (3.4%) were categorized as strategic skills, with unitized comments including references to viewing the organization with a systems perspective, identification of key causes, as well as expressing a vision for one's organizational unit. Strategic skills are more often required at the highest levels of leadership in an organization (Mumford et al., 2007). The relatively low percentage of participant comments referencing strategic skills could potentially indicate that strategic skills were simply not needed in the leadership positions held by survey participants. Alternatively, the low percentage could point to an important gap between the strategic skills needed and actual skills developed by organizational leaders.

The category of increased self-confidence included a total of seven unitized comments (5.9% of all comments); participants reporting an increase in self-confidence is consistent with Gordan and Gordan's (2017) conclusion that volunteering for a leadership role in a service organization may confer a benefit of increased personal and professional confidence.

There are practical implications of this research for individuals who wish to develop their leadership skills as part of their professional development. Based on the responses provided by participants, serving as a leader in a volunteer organization provides opportunities to gain and develop cognitive, interpersonal, and business skills. Having an alternative means of developing leadership skills outside the opportunities provided by one's employer may be especially helpful to individuals whose employer is unable or unwilling to provide leadership skills training. This extraorganizational volunteerism (Peloza & Hassay, 2006) performed outside one's role as an employee would enable an individual to enhance these skill sets without being dependent on their employer to provide those opportunities.

In a similar fashion, for an employer that may want to offer an employee the opportunity to develop leadership skills but lacks the resources to do so, encouraging an employee to pursue a leadership position in civic organization could be a cost-effective means of outsourcing of training to develop cognitive, interpersonal, and business skills. Not only do volunteer leaders develop a variety of different skills and abilities (Palanski et al., 2022), these leaders can transfer skills gained by leading volunteer to their workplaces (Gordon & Gordon, 2017).

Limitations and Recommendations for Future Research

Because this study was designed to capture skills gained over the entire time the survey participant had been a member of the organization, the skills reported by participants could have been acquired at any leadership level the individual held during their time with the organization. This research does not imply that the percentage of skills included within each category represents the level of skill required for the participant's current leadership position. The survey was administered to leaders surveyed in district-level leadership positions, which represents mid-level organizational leadership. While some of the survey participants had previously served at higher levels of leadership in the organization, relatively few participant comments were categorized as strategic skills requirements, with most comments representative of skills requirements associated with lower and middle levels of leadership according to the strataplex described by Mumford et al. (2007). The study's participants were volunteer leaders from a single civic organization; future research focusing on volunteer leaders at other civic organizations could provide additional insights.

In considering skills requirements needed at different levels of organizational leadership in civic organizations, future research could also explore differences in skills gained by volunteers who serve civic organizations at different leadership levels, including the highest-level leadership positions, the lowest-level leadership positions, as well as non-leadership positions. Such research could identify differences in the types of skills developed at different leadership levels in the organization. Additionally, future research could further explore relationships between skills gained by volunteer leaders and levels of self-confidence.

References

Andrews, K. T., Ganz, M., Baggetta, M., Han, H., & Lim, C. (2010). Leadership, membership, and voice: Civic associations that work. *American Journal of Sociology*, *115*(4), 1191-1242. https://doi.org/https://doi.org/10.1086/649060

Boezeman, E. J., & Ellemers, N. (2014). Volunteer leadership: The role of pride and respect in organizational identification and leadership satisfaction. *Leadership*, *10*(2), 160-173. https://doi.org/https://doi.org/10.1177/1742715012467487

Bowers, K. M. (2012). *An exploration of the leadership behavior of volunteer leaders* (Publication Number 3541964) Doctoral dissertation, Indiana Wesleyan University ProQuest Dissertations & Theses].

Civitan International. (2025a, April 08). *Mission and Creed*. https://civitan.org/mission-and-creed/

Civitan International. (2025b, May 01). *Civitan International Leadership*. https://civitan.org/leadership/

Civitan International. (2025c, May 08). *Civitan International Research Center*. https://civitan.org/circ/

Foddy, W. (1993). *Constructing questions for interviews and questionnaires: Theory and practice in social research*. Cambridge University Press.

Gordon, P. A., & Gordon, B. A. (2017). The role of volunteer organizations in leadership skill development. *Journal of Management Development*, *36*(5), 712-723. https://doi.org/https://doi.org/10.1108/JMD-06-2016-0099

Iarossi, G. (2006). *The power of survey design: A user's guide for managing surveys, interpreting results, and influencing respondents*. World Bank Publications.

Jäger, U., Kreutzer, K., & Beyes, T. (2009). Balancing acts: NPO-leadership and volunteering. *Financial Accountability & Management*, *25*(1), 79-97.

Knoke, D., & Prensky, D. (1984). What relevance do organization theories have for voluntary associations? *Social Science Quarterly*, *65*(1), 3-20.

Krippendorff, K. (2004). *Content analysis: An introduction to its methodology*. Sage.

Leimback, M. (2023, May 9). Leadership Development in the Age of Disruption. *Training*. https://trainingmag.com/leadership-development-in-the-age-of-disruption/#

Lester, G. V., Palanski, M., Hammond, M., & Clapp-Smith, R. (2017). Multi-domain leadership: A whole person approach to leading in the workplace...and beyond. *Organizational Dynamics*, *46*(3), 133-139. https://doi.org/https://doi.org/10.1016/j.orgdyn.2016.11.001

Morris, R. (1994). Computerized content analysis in management research: A demonstration of advantages & limitations. *Journal of Management*, *20*(4), 903-931. https://doi.org/https://doi.org/10.1016/0149-2063(94)90035-3

Morrison, C. C., & Greenhaw, L. L. (2018). What skills do volunteer leaders need? A Delphi study. *Journal of Leadership Education*, *17*(4), 54-71. https://doi.org/https://doi.org/10.12806/V17/I4/R4

Mumford, T. V., Campion, M. A., & Morgeson, F. P. (2007). The leadership skills strataplex: Leadership skill requirements across organizational levels. *The Leadership Quarterly*, *18*(2), 154-166. https://doi.org/https://doi.org/10.1016/j.leaqua.2007.01.005

Palanski, M. E., Hammond, M. M., & Khazanchi, S. (2022). Leader development in work and volunteer contexts: Expected practice and unexpected opportunities. *Organizational Dynamics*, *51*(4), 100935. https://doi.org/https://doi.org/10.1016/j.orgdyn.2022.100935

Peloza, J., & Hassay, D. N. (2006). Intra-organizational Volunteerism: Good Soldiers, Good Deeds and Good Politics. *Journal of Business Ethics*, *64*(4), 357-379. https://doi.org/10.1007/s10551-005-5496-z

Posner, B. Z. (2015). An investigation into the leadership practices of volunteer leaders. *Leadership & Organization Development Journal*, *36*(7), 885-898. https://doi.org/https://doi.org/10.1108/LODJ-03-2014-0061

Smith, D. H. (2000). *Grassroots associations*. Sage.

Walton, R. (1985). From Control to Commitment in the Workplace. *Harvard Business Review*, *63*(2), 76-84. https://hbr.org/1985/03/from-control-to-commitment-in-the-workplace

Zenger, J., & Folkman, J. (2014). The skills leaders need at every level. *Harvard Business Review*, *7*. https://hbr.org/2014/07/the-skills-leaders-need-at-every-level

Journal of Leadership and Management®
An International Journal of Strategic, Behavioral and Public Aspects of Leadership in Management
Cabell's Listed
A journal of the Institute of Leadership and Management Association, PO Box 564, Douglassville PA 19518. 484-332-3331. https://www.jleadershipmanagement.org

AI Integration in Higher Education and Leadership Development

Liaoliao Li, Kutztown University of Pennsylvania, lli@kutztown.edu

Online published: Jan 2026 Print published: Jan 2026 Editor: Sue Kong	Authorship Roles and Conflict of Interest Statement is on file at the Journal of Leadership and Management offices, available on request. Contact editors@jleadershipmanagement.org

ABSTRACT

Artificial intelligence (AI) tools such as ChatGPT, Claude, and Copilot are increasingly integrated into higher education. However, limited research examines students' perception on AI in relation to their leadership development. To fill this research gap, the present paper examines undergraduate students' AI use, trust in AI, and readiness for virtual leadership. A survey titled "College Students' Perspectives on Leadership-Related Courses" was administered in Fall 2025 to 155 undergraduates at a public university on the U.S. East Coast. Results show that while most students have held leadership roles, few have taken leadership-related courses, and only some actively use AI tools for leadership or career guidance. Students have neutral confidence in leading remote teams and agree that leadership programs should include virtual leadership training. The t-test results do not present statistically significant difference in leadership confidence between AI users and non-users, though AI users report slightly higher average confidence. The study discusses that AI integration may support leadership learning, but AI use alone does not directly enhance students' self-perceived leadership confidence.

KEYWORDS

Artificial Intelligence, Leadership Development, Higher Education, Perceptions

Introduction

Since early 2010s, Artificial Intelligence (AI) has experienced dramatic growth. AI platforms such as ChatGPT, Claude, and Copilot can assist people with generating text, creating content, searching for information, etc. Prior literature has had many discussions about the importance of incorporating AI technology into higher education to improve students' learning progress. Southworth et al. (2023) talk about a program at the University of Florida to integrate AI tools across its curriculum for all undergraduate students. Cowling et al. (2023) find that the popular AI platform ChatGPT can enhance research practices and strengthen students' learning. Kabanda (2025) analyzes the advantages of using AI tools in teaching and learning, its role in academic research, and responsibilities of educators in addressing academic integrity and administrative issues related to AI use. Kovacevic et al. (2025) examine the opportunities and challenges of the current digitalization in higher education through questionnaires and interviews. Hoang (2025) conducts a survey on leadership and AI integration in language teaching and discusses e-leadership theory and the ethical considerations in AI use. Khairullah et al. (2025) review the significant impact that AI has on reshaping traditional administrative processes, teaching methodologies, learning process and development of leadership skills. Marc (2025) argues that adapting to AI advancements is essential and also discusses faculty's concerns about students' AI use and the importance of academic integrity.

Fewer studies focus on students' perceptions of AI tools and their leadership development. Sposato (2024) proposes interdisciplinary approaches in organizational leadership research and education. Goryunova and Jenkins (2024) suggest educators to incorporate AI technology into their leadership program in addition to traditional learning tools. Ojedeji and Adejuwon (2025) recommend transforming leadership education along with the fast development of AI technology and specifically discuss the comprehensive robust capacity-building frameworks. Bartlett and Bartlett (2024) specifically examine the use of ChatGPT in community college leadership training to create a more personalized and effective learning experience. Jenkins and Khanna (2025) suggest integrating AI into pedagogical approaches to support both educators and students and foster leadership development.

To address the research gap regarding to students' perceptions and use of AI tools in relation to their leadership development, the authors administered a survey titled "College Students' Perspectives on Leadership-Related Courses" in Fall 2025 to 155 undergraduates at a public university on the U.S. East Coast. The survey covered several key areas: whether students use AI tools, their confidence in leading teams remotely, their trust in those tools, and their readiness for virtual leadership. The main objectives of the research are (1) to examine how undergraduates utilize AI tools in leadership-related contexts, and (2) to assess whether AI usage correlates with their self-reported leadership confidence. The findings suggest that although integrating AI into leadership education may have potential advantages, there is no clear evidence of a direct effect on students' self-perceived leadership confidence.

Main analysis and results

This paper aims to examine the relationship between AI tool adoption and leadership development among college students. The survey received a response rate of approximately 45.2%, resulting in 70 responses. The sample includes 25 freshmen (35.7%), 18 sophomores (25.7%), 18 juniors (25.7%), and 8 (11.4%) seniors or above. One student did not identify his/her class year. Participants represent a wide range of majors, including accounting, general business, marketing, finance, management, entrepreneurship, criminal justice, education, information technology, mathematics, personal financial planning, social work, sports management, studio arts, supply chain management, and undecided fields.

The main survey results are shown in Figure 1.

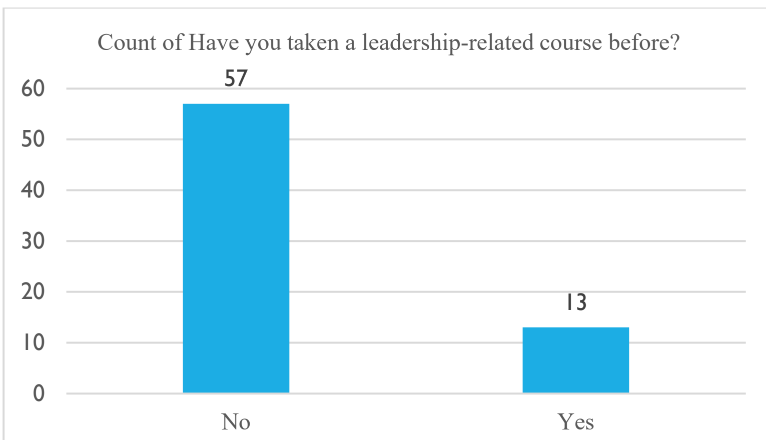

Figure 1. Have you taken a leadership-related course before?

Majority of the students have not taken any leadership-related course (81.4%), which may indicate the limited availability of leadership programs (Figure 2).

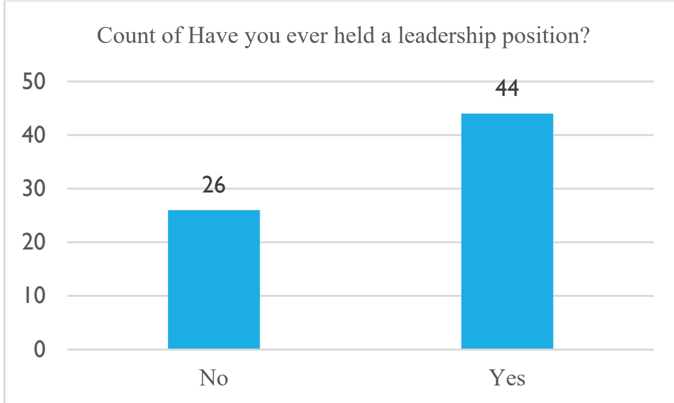

Figure 2. Have you ever held a leadership position (e.g., team leader, manager, student club president, etc.)?

Approximately 62.9% of students in the sample have held a leadership position in different circumstances. This finding suggests a potential gap between the leadership education students have received and their practical leadership experiences, highlighting the need to offer more leadership-related courses (Figure 3).

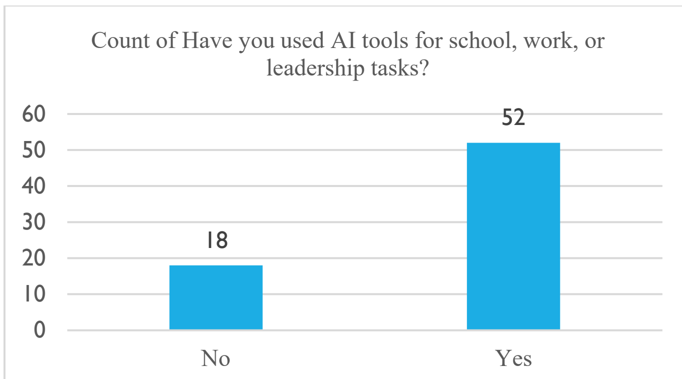

Figure 3. Have you used AI tools (e.g., ChatGPT, Claude, Copilot) for school, work, or leadership tasks?

Around 25.7% of the students in the sample reported that they have not used AI tools. To effectively adapt to the fast-evolving business environment driven by advancement in AI technology, students should gain both technical proficiency and ethical application in using AI tools (Figure 4).

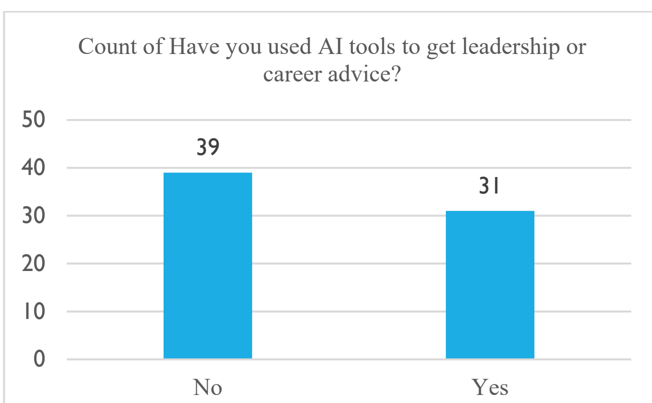

Figure 4. Have you used AI tools (e.g., ChatGPT, Claude, Copilot) to get leadership or career advice?

Compared to the previous question, fewer students (44.3%) reported that they have consulted AI tools for leadership improvement. This finding suggests an opportunity to better prepare students for academic and professional environments in which AI proficiency is increasingly essential (Figure 5).

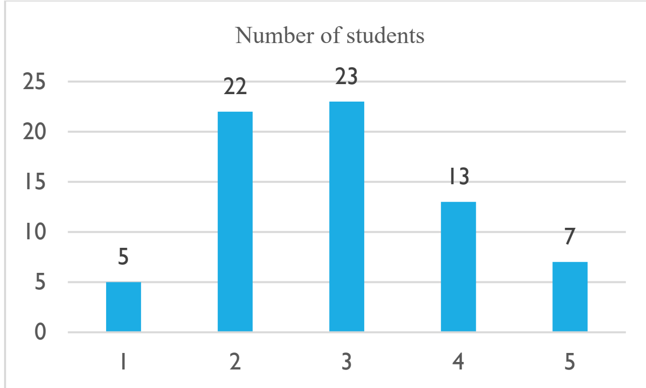

Figure 5. I feel confident leading a team that I have never met in person. (Scale used throughout: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

A mean score of 2.93, close to the midpoint of 3, represents a neutral response. On average, students do not strongly feel confident or unconfident; rather, their attitudes are generally undecided or indifferent. This suggests that students may lack extensive experience, strong opinions, or self-assessments related to leading in virtual settings (Figure 6).

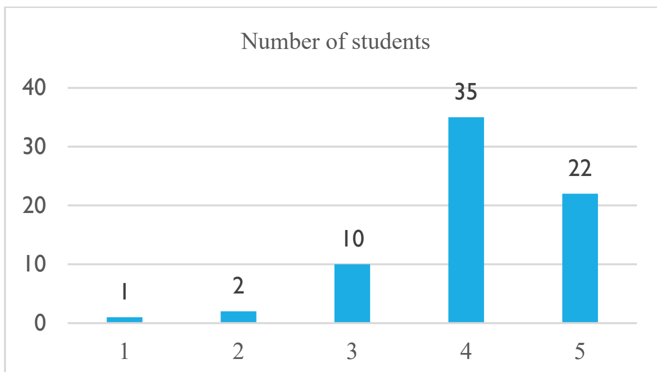

Figure 6. Leadership programs should teach how to manage remote/virtual teams effectively.

The mean score of 4.07 shows that generally students agree that leadership programs should provide them knowledge on effectively managing remote teams. Universities and colleges should expand and strengthen curriculum components focused on virtual leadership. This may include integrating team communication, digital collaboration tools, conflict resolution in virtual settings. Offering experiential learning opportunities, such as virtual team projects, simulations, or remote internships, would also help students develop effectiveness of their remote leadership (Figure 7).

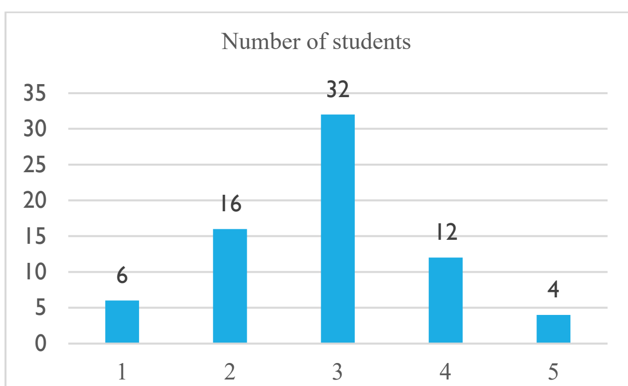

Figure 7. I trust AI tools to give useful career or leadership guidance.

A mean score of 2.89 suggests that, on average, students hold a slightly neutral-to-disagreeing attitude toward the usefulness of AI tools when seeking leadership guidance. The possible reasons of their response are that (1) students may not fully understand how AI tools can support leadership development; (2) students have not used AI for leadership-related tasks, and then may be unsure of its benefits; (3) students may prefer advice from their instructors, parents, advisors, or peers, perceiving human mentorship more personalized and trustworthy; and (4) students might question if AI can provide reliable leadership advice, especially in complicated situations (Figure 8).

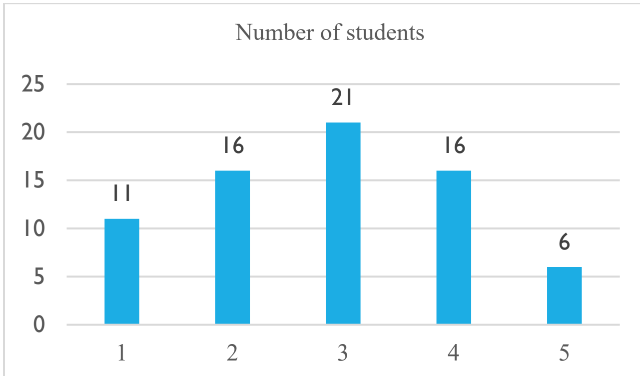

Figure 8. I would use AI tools as a practice coach to rehearse leadership conversations.

With an average score of 2.86, students show limited willingness to use AI tools for mock leadership conversations, possibly caused by their uncertainties about the reliability and accuracy of AI-generated communication.

To further investigate differences in leadership confidence between undergraduate students who use AI tools and those who do not, the following hypotheses are proposed.

H_0: There is no statistically significant difference in leadership confidence between undergraduate AI users and non-users.

H_1: Undergraduate students who use AI tools report significantly higher leadership confidence than those who do not.

The t-test is conducted, and the results are shown in Table 1.

Table 1. Results of t-test.

Group	Mean Confidence	Sample Size
Students used AI	3.00	52
Students not used AI	2.72	18

t(approx.) = -0.9272 and p = 0.3571

There is no statistically significant difference in leadership confidence between students who have used AI tools and those who have not since p = 0.3571 > 0.05, although AI users show slightly higher average confidence (3.00 vs. 2.72). These results align with Jenkins & Khanna (2025). AI tools do not directly transform into leadership capability. It would be more efficient to incorporate AI into leadership development programs to enhance the personalized leadership learning experience, as suggested by Chen (2025). The possible reasons of this phenomenon are that (1) students may not have used AI tools deeply enough to influence their leadership confidence; (2) confidence in leadership is influenced more by interpersonal experience, teamwork, education, and/or mentorship than by tool use alone.

Although the test results are not significant, the slightly higher average for AI users proposes potential benefits such as students experienced with AI tools may develop digital skills that support their leadership development, and AI users might be more comfortable with digital communication tools, indirectly increasing their confidence in virtual contexts.

Conclusion

While AI tools are increasingly present in higher education, the present study suggests that their usage for leadership purposes remains limited. Most students have engaged in leadership roles but have not taken leadership-related courses, indicating an urgent demand for formal leadership courses. Students also have neutral trust in AI for leadership guidance and less willingness to use AI as a practice tool, reflecting their uncertainty about reliability and applicability of AI in complex interpersonal circumstances.

The quantitative results reinforce these perceptions. Although AI users report slightly higher average leadership confidence than non-users, the difference is not statistically significant. This aligns with prior research suggesting that simply interacting with AI tools does not directly build leadership capability. Leadership confidence appears to be shaped more strongly by interpersonal experience, formal instruction, mentorship, and opportunities for practice than by digital tool use alone.

Despite the lack of a significant relationship between AI use and leadership confidence, several important implications are highlighted for higher education. Students' strong preference for virtual leadership training represents their growing need to succeed in increasingly hybrid and remote work environments. Additionally, greater exposure to AI's capabilities may increase students' confidence in leveraging these tools productively.

Several limitations should be acknowledged. The study draws from a single institution, which may limit the generalizability of the findings. The use of self-reported survey data also introduces potential biases, and future research could incorporate performance-based measures or supervisor evaluations to gain a bigger picture of leadership development. Expanding the sample across diverse institutions, as well as examining specific types of AI use (e.g., generative AI for coaching, analytics tools for decision making), may provide clearer insights into where AI meaningfully contributes to leadership growth.

Overall, this study contributes to the prior literature discussing that although AI tools have the potential to enhance leadership education, they are not yet meaningfully linked to students' leadership confidence. Instead, their value may lie in supporting well-designed leadership development programs rather than replacing traditional pedagogical approaches. As higher education continues to adapt to rapid technological advancement, ongoing exploration of how to integrate AI into leadership learning environments will be essential.

References

Bartlett, J., & Bartlett, M. (2024). Enhancing community college leadership development through AI: Enriching the andragogical approach. In J. Cohen & G. Solano (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference (pp. 1213–1219). Las Vegas, NV: Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/p/224119

Chen, Z. (2025). From traditional to technological: Integrating AI tools into leadership development programs. Leadership & Organization Development Journal, 46(4), 543–558. https://doi.org/10.1108/LODJ-12-2024-0810

Cowling, M., Crawford, J., Allen, K.-A., & Wehmeyer, M. (2023). Using leadership to leverage ChatGPT and artificial intelligence for undergraduate and postgraduate research supervision. Australasian Journal of Educational Technology, 39(4), 89–103. https://doi.org/10.14742/ajet.8598

Goryunova, E., & Jenkins, D. (2024). Macro view of the place and impact of artificial intelligence on the design, content, delivery, and student engagement in graduate leadership education programs. Journal of Leadership Studies, 18(2), 35–42.

Hoang, N. H. (2025). E-leadership in the AI era: Exploring Vietnamese EFL teachers' digital leadership development in AI integration. Education and Information Technologies, 30, 16895–16928. https://doi.org/10.1007/s10639-025-13451-6

Jenkins, D., & Khanna, G. (2025). AI-enhanced training, education, and development: Exploration and insights into generative AI's role in leadership learning. Journal of Leadership Studies, 18(4), 81–97. https://doi.org/10.1002/jls.70004

Kabanda, M. (2025). Artificial intelligence integration in higher education: Enhancing academic processes and leadership dynamics. SSRN. https://ssrn.com/abstract=5255069

Khairullah, S. A., Harris, S., Hadi, H. J., Sandhu, R. A., Ahmad, N., & Alshara, M. A. (2025). Implementing artificial intelligence in academic and administrative processes through responsible strategic leadership in higher education institutions. Frontiers in Education, 10. https://doi.org/10.3389/feduc.2025.1548104

Kovacevic, M., Dagen, T., & Rajter, M. (2025). Leading AI-driven student engagement: The role of digital leadership in higher education. Education Sciences, 15(6), 775. https://doi.org/10.3390/educsci15060775

Marc, M. (2025). Higher education leadership: The faculty response to artificial intelligence usage by students. Journal of Leadership and Management, 11(2), 17–32.

Ojedeji, S. O., & Adejuwon, A. M. (2025). Training future educational leaders: Incorporating AI in capacity building and professional development. Unilorin Journal of Lifelong Education, 8(2), 133–148. https://ujlle.org.ng/index.php/ujlle/article/view/302

Southworth, J., Migliaccio, K., Glover, J., Glover, J. N., Reed, D., McCarty, C., Brendemuhl, J., & Thomas, A. (2023). Developing a model for AI across the curriculum: Transforming the higher education landscape via innovation in AI literacy. Computers and Education: Artificial Intelligence, 4, 100127.

Sposato, M. (2024). Leadership training and development in the age of artificial intelligence. Development and Learning in Organizations: An International Journal, 38(4), 4–7.

Journal of Leadership and Management®
An International Journal of Strategic, Behavioral and Public Aspects of Leadership in Management
Cabell's Listed
A journal of the Institute of Leadership and Management Association, PO Box 564, Douglassville PA 19518. 484-332-3331. https://www.jleadershipmanagement.org

IT-Enabled Team Autonomy and Team Innovativeness

U. Yeliz Eseryel, East Carolina University, eseryelu17@ecu.edu
Deniz Eseryel, Aurora Consulting

Online published: Jan 2026 Print published: Jan 2026 Editor: Sue Kong	Authorship Roles and Conflict of Interest Statement is on file at the Journal of Leadership and Management offices, available on request. Contact editors@jleadershipmanagement.org

Abstract

Team innovativeness is a critical driver of sustained competitive advantage, yet prior research has largely treated information technology (IT) as a homogeneous input to innovation, focusing on investment levels rather than how IT is enacted in teamwork. Drawing on work design theory and sociotechnical perspectives, this study introduces IT-enabled team autonomy as a key mechanism through which IT influences innovation. We conceptualize IT-enabled autonomy as the extent to which a team's use of IT affords discretion over work processes, decision making, and scheduling, and examine its effects on team innovativeness, operationalized through idea generation and idea implementation.

Using survey data collected from 150 team members, we empirically test the relationship between IT-enabled autonomy and team innovativeness. The results provide strong support for our hypotheses, demonstrating that IT-enabled autonomy has a significant positive effect on overall team innovativeness, as well as on both idea generation and idea implementation. These findings suggest that IT contributes to innovation not merely by providing resources or capabilities, but by structurally enabling teams to self-organize, experiment, and make timely decisions in their daily work.

This study makes three key contributions. First, it advances innovation research by unpacking how specific IT affordances shape team-level autonomy. Second, it extends IS literature by shifting attention from IT investment to IT-enabled work design. Third, it offers actionable guidance for managers, emphasizing the importance of selecting and configuring IT systems that enhance teams' autonomy in processes, decisions, and scheduling to foster sustained innovation.

KEYWORDS
IT-Enabled Autonomy; Team Innovativeness; Idea Generation; Idea Implementation; Team Autonomy; IT Affordances

Acknowledgements: The authors would like to thank Mr. Penghui Li for his contributions to data collection and analysis.

Introduction

Innovativeness is a critical factor in teams' ability to create a sustainable competitive advantage (Kim, Min, & Cha, 1999). "In digitally mediated teamwork, innovativeness increasingly depends on how technology enables self-management, coordination, and distributed leadership in day-to-day work—not only on organizational resources."
(Eseryel & Eseryel, 2013; Eseryel, Crowston, & Heckman, 2021; Crowston et al., 2007)

A team's ability to innovate is recognized as one of the determinant factors for team to survive and succeed (Doyle, 1998; Quinn, 2000). Innovativeness is the capacity to an organization or system that can do things new or different for adding value (Garcia & Calantone, 2002). Innovativeness could be measured by the number of new product or ideas (Garcia & Calantone, 2002).

Organizational innovativeness increases when teams have more autonomy and freedom in their work (Amabile, 1996). When members of an organization lack autonomy and freedom, they may be more restricted in their ideation, creativity, and resulting innovativeness. Nonautonomous teams tend to only adopt the most straightforward top-down decisions (Amabile, 1998).

According to Dibrell, Davis, and Craig (2008), for an organization or a team to have a capacity for sustained innovation, has to be guaranteed that they have not only the resources they need but also the structure or processes to deal problems creatively. This aligns with prior evidence that digital infrastructures shape how teams enact decision-making and coordination, which in turn influences innovation outcomes (Boonstra, Eseryel, & van Offenbeek, 2018; Eseryel, Wei, & Crowston, 2020).

In their analysis of the influence of product and process innovation on firms' financial performance, they found that managers' emphasis on Information Technology (IT), specifically the level of IT investments, played a significant mediating role (Dibrell, Davis, & Craig, 2008). While much research highlighted the importance of IT use or IT investments for firm innovativeness, all IT are not created equal. Building on this line of work, an important unanswered question concerns how IT matters for innovation, rather than simply how much organizations invest in IT.

Although prior research has demonstrated that IT resources and investments can enable innovation (Dibrell, Davis, & Craig, 2008), considerably less attention has been paid to the organizational and team-level structures through which IT is enacted in everyday work. Innovation at companies increasingly emerges at the team level, where creative problem solving depends not only on access to IT but also on whether teams are structurally enabled to use IT with discretion and flexibility (Negoita, Lapointe, & Rivard, 2018). In particular, when IT is configured to support self-organization and team discretion, it can create the conditions for idea generation and implementation to occur more continuously in distributed work (Eseryel, 2014; Eseryel, 2019; Crowston et al., 2007; Eseryel, Crowston, & Heckman, 2021).

Drawing on work design theory (Morgeson & Humphrey, 2006) and information systems research on affordances and sociotechnical systems (Leonardi, 2011; Sarker et al., 2019), we argue that a critical, yet underexplored mechanism is IT-enabled team autonomy—the extent to which a team's use of IT affords autonomy over work scheduling, decision making, and work methods or processes. This conceptualization also complements research streams on IT-enabled knowledge creation and IT-enabled open innovation, which emphasize that digital tools influence innovation by shaping how people create, share, and enact new ideas (Eseryel, 2014; Eseryel, 2024f). Accordingly, this study answers the research question of "How does IT-enabled team autonomy influence team innovation?"

Literature Review

IT use is known to provide a competitive advantage for the implementation of strategic performance and the facilitation of core competencies (Dibrell, Davis, & Craig, 2008). Beyond investment and access, prior research suggests IT can enable innovation by changing leadership and self-leadership dynamics that guide how individuals and teams use technology in their work (Eseryel & Eseryel, 2013; Lehrer et al., 2021; Eseryel, 2020b; Eseryel, 2024b).

Das, Zahra, and Warkentin (1991) suggest that linking jobs, tasks and strategy to IT allows firms to compete mission more effectively. Information Technologies are seen as enablers and capacity builders for sustained innovation (King & Burgess, 2006). Using IT not only makes resources feasible for new products but also provides team-members with collaborative structures and processes to creatively deal with the problems and to connect the innovation with a current business (Bhaskaran, 2006).

Team innovativeness

Product and service innovation is a vital part of the regular business processes (Eisenbeiss, Knippenberg, & Boerner, 2008). "*Innovativeness refers to the inclination for the organization to engage in innovative behavior*" (Auh & Menguc, 2005). Zaltman, Duncan, and Holbek (1973) pointed out that there are two stages of innovation: initiation and implementation. This distinction is particularly important in IT-enabled contexts, where digital tools can accelerate not only idea creation but also the practical implementation of innovations by reducing coordination and execution barriers (Eseryel, 2019; Eseryel, 2014; Eseryel et al., 2014b). The initiation stage is also referred to as openness to innovation or new-idea generation. Levitt (1962) observed that "*being willing to destroy the old is the heart of innovation and the means to enormous profits*".

Research about team innovativeness and team innovation identified that team process is an antecedent of innovativeness. Thus, it is important to investigate factors related to team innovativeness. West's team climate theory (1990) suggests that support for innovation and climate for excellence are key factors in teams' ability to innovate. Specifically, team collaboration process that supports innovation and innovativeness is important for innovation. Lee and Runge (2001) found that IT is widely and successfully used in innovative teams. To understand the type of IT support these teams need, we need to understand how companies use teams. More and more, companies started depending on self-managing or self-leading teams. Self-managing and self-leading teams provide team members more authority over work processes (Stewart, Courtright, and Manz, 2011); Team members have the authority to recruit and fire their members, to build up their own schedules, to determine budgets, to order materials that they need, and to control quality (Barker, 1993; Stewart, Manz, & Sims, 1999). Empirical studies of self-organizing and self-managing technology-enabled teams show that internal governance and distributed decision-making are central mechanisms through which teams coordinate work and sustain participation over time (Eseryel, Wei, & Crowston, 2020; Crowston et al., 2007b; Wei et al., 2017; Wei, Crowston, & Eseryel, 2021). This trend increased the shift of power from team managers or formal team leaders to the members of the teams. Nowadays, more and more teams have authority over how to work together, how to schedule their work, and how to make decisions. This shift is important and it should be supported by the IT that the teams use to work together.

Types of Support Provided By IT

While IT is widely and successfully used in innovative teams (Lee & Runge, 2001), investing in IT does not automatically lead to superior innovation or performance in teams (Powell & Dent-Micallef, 1997). The true source of competitive advantage is how IT is used for effective coordination and decision-making processes, in alignment with strategic innovativeness goals.

IT is not merely an input to innovation but a sociotechnical enabler that reshapes how teams organize, decide, and experiment in pursuit of novel outcomes (Leonardi, 2013; Negoita et al., 2018). Relatedly, research on competing logics in IT governance indicates that technology's effects depend on how stakeholders enact structures of control, discretion, and coordination around IT use (Boonstra et al., 2018).

This perspective moves beyond treating IT use or IT investment as homogeneous drivers of innovativeness and instead emphasizes variation in how IT structures team-level autonomy, which may be central to sustained team innovation. We call team-level autonomy provided by IT as "IT-enabled autonomy" and define it as a combination of (1) IT-enabled process autonomy, (2) IT-enabled decision autonomy, and (3) IT-enabled scheduling autonomy, following Morgeson and Humphrey (2006).

IT-Enabled Process Autonomy

Research shows that innovative outcomes depend heavily on organizational climate, rather than individual talent (Ekvall, 1991). Key climate dimensions supporting high innovativeness require team members to freedom and autonomy about their work processes (Ekvall, 1991). Similarly, it was known for a long time that creativity and innovation, are not tied to personality traits, rather they are process problems (Osborn, 1963). Parnes (1992) summarizes 50 years of research, suggesting that innovativeness can be systematically developed through structured creative problem solving process.

Team process autonomy improves new product development speed, and consequently a company's innovativeness (Carbonell and Rodriguez-Escudero, 2011). Team autonomy enables a team local control over their task (process) and prevents interference from functional managers (Emmanuelides, 1993). Such autonomy contributes to the team's strong feeling of responsibility over the project's outcomes, which in turn leads to higher work effectiveness (Zirger and Hartley, 1994; Bonner et al., 2002).

Information Technologies that allow the generation of high quantity of ideas, enable group brainstorming that enables freewheeling, combination, and association of ideas by deferring judgement would increase innovativeness in ideas. To apply it to the IT solutions, teams who use information technologies that allow them to choose and structure their creative problem solving process that fits their needs would be in a more advantageous position to innovate. Thus, there is a relationship the autonomy provided by a team's IT and that team's innovativeness: IT-enabled process autonomy allows teams to adapt, redesign, and experiment with new workflows and routines through digital infrastructures, a capability that is central to learning-driven innovation (Sarker et al., 2019; Moe, Stray, & Dingsøyr, 2018). From an implementation perspective, autonomy-supportive IT can increase implementation effectiveness by aligning technology with local practices and decision rights (Eseryel & Wolf, 2005; Eseryel & Eseryel, 2020c). Accordingly, IT-enabled process autonomy should support innovativeness by enabling teams to create and recombine knowledge, experiment with new practices, and adopt open-innovation behaviors in how ideas are developed and refined (Eseryel, 2014; Eseryel, 2024f; Eseryel et al., 2014b).

IT-Enabled Decision Autonomy

Autonomy is long known to increase motivation and therefore creativity in individuals. Decision autonomy in teams reduce decision-making time, thereby reduce product development cycle and helps teams to respond quickly to any environmental turbulence (McDonough & Barczak, 1991; Reilly et al., 2003). When a team has a high degree of autonomy over project decisions, team members are more likely to increase the information sharing, coordination, and creative consideration within the team (Hoegl & Parboteeah, 2006). Therefore, we expect IT-enabled decision autonomy in teams to increase team innovativeness.

IT-Enabled Scheduling Autonomy

First, IT-enabled scheduling autonomy allows teams to flexibly allocate time, sequence interdependent tasks, and adjust work rhythms as ideas evolve, supporting experimentation and iterative innovation (Leonardi, 2011; Parker, Van den Broeck, & Holman, 2017). For example, technology-supported self-organizing teams often rely on temporal coordination mechanisms—such as meeting rhythms and shared schedules—to synchronize interdependent work (Crowston et al., 2007a; Eseryel, Crowston, & Heckman, 2021).

Second, IT-enabled decision autonomy enables decentralized sensemaking and timely local decisions by reducing information asymmetries and dependence on hierarchical approval, which accelerates innovation cycles (Vaast et al., 2017; Yoo, Henfridsson, & Lyytinen, 2010). Such scheduling and timing discretion may be especially important when leadership is distributed and enacted through team members' technology use rather than centralized managerial control (Eseryel & Eseryel, 2013; Eseryel, Crowston, & Heckman, 2021).

Since "IT-enabled autonomy" is defined as the process autonomy, decision-making autonomy, and scheduling autonomy that IT provides team members with, we posit that;

Hypothesis 1: IT-Enabled autonomy influences team innovativeness positively.

Hypothesis 1a: IT-Enabled autonomy influences (new) idea generation positively.

Hypothesis 1b: IT-enabled autonomy influences (new) idea implementation positively.

Because IT-enabled autonomy is not solely a technological property but also reflects how IT is selected, configured, and encouraged in use, leadership may be an important practical lever for increasing IT-enabled autonomy in teams. Transformational IT leadership and related IT-based leadership behaviors can shape how individuals and teams take initiative with IT and enact self-leadership in their work (Eseryel, 2024b; Eseryel & Biernath, 2024; Eseryel et al., 2024d; Lehrer et al., 2021).

Research Method

Data Collection and Sample

The survey questions were adapted from well-known instruments in English, discussed by the co-authors, and translated into Chinese by the third author, and after pre-testing for meaning with 5 Chinese employees, the final survey was executed online. Overall, 200 questionnaires are sent out and 169 were filled out. 19 questionnaires were removed due to incomplete responses. Participants ranged in age from 26-40 years old. 61% of the employees' assigned gender at birth was male, and 39% were female.

Measurement Independent Variable: IT-Enabled Autonomy

Measurements of the IT-Enabled Autonomy are based on the work design questionnaire developed by Morgeson and Humphrey (2006). The questionnaire assesses three areas of work design autonomy, namely processes-autonomy, and decision-autonomy, and scheduling-autonomy. These questions were used to conceptualize the teamwork autonomy provided to teams by IT. For instance, question of "the job allows me to make my own decisions about how to schedule my work" is changed to "using IT allows my team to make our own decisions about to schedule our work". Or question of "the job provides me with significant autonomy in making decisions" is converted to "using IT provides my team with significant autonomy in making decisions". A 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree) was used for measuring the IT-Enabled Autonomy (See Appendix-I). This approach of adapting established instruments to IT-specific organizational constructs is consistent with prior survey-based work operationalizing IT-related readiness, culture, and leadership constructs in organizational settings (Eseryel, Eseryel, & den Breejen, 2021; Eseryel & den Breejen, 2024).

The converted constructs and the language have been examined by pre-answering. Similar to prior IT-change readiness research, we prioritized semantic equivalence and respondent comprehensibility through iterative review and pretesting before translation (Eseryel, Eseryel, & den Breejen, 2021; Eseryel & den Breejen, 2024). Several people are asked about how well they can understand the adjusted question and their suggestion on the correction of language errors. The final adjusted English version is the final questionnaire (See appendix I). Then, the questionnaire has been translated to Chinese. The Chinese version is examined by Chinese people and after that, the final version is published online.

Measurement Dependent variable: Team Innovativeness

To measure the dependent variable team innovativeness, items needed to include both idea development and idea implementation following Axtell et al. (2000). The team innovativeness was tested using 14-items, which originated from West & Anderson's (1996) NHS hospital innovation studies. These were operationalized explicitly in Axtell et al. (2000) as a content checklist of innovation types, which was then used to measure idea generation and idea implementation behaviors. In our study, all items were rated on the 7-point scale ranging from 1 (e.g., no new ideas implemented) to 7 (e.g., many new ideas implemented). Survey questions in "Part B. Team Innovativeness" provide the items used to measure this variable and its two components, namely, idea generation and idea implementation (See Appendix I).

Results

Factor analysis

The survey was composed of 22 items abstracted from existing constructs. Each variable was measured using 2 to 7 questions and the internal correlation of the variables were examined by factor analysis. Factor analysis aims to identify the underlying variables and factors which mostly can represent the pattern of correlations observed items. In this research, two parallel factor analyses were conducted. The first 8 items that represented the independent variable of IT-Enabled Autonomy are examined in order to test the underlying dimensions of the construct. The remaining 14 items consisted of two underlying dimensions of the dependent variable team innovativeness.

The factor analysis of items related to IT-Enabled Autonomy are same as those conceptualized in the theoretical section. The three variables of the IT-Enabled Autonomy are decision autonomy, schedule autonomy, and process autonomy. The detailed results of factor analysis for each variable are illustrated in Table 1.

Table 1: Rotated Factor Matrix Using VARIMAX for IT-Enabled Autonomy

Items	Process Autonomy	Decision Autonomy	Schedule Autonomy
PA1	0.718		
PA2	0.732		
DA1		0.746	
DA2		0.741	
DA3		0.756	
SA1			0.798
SA2			0.761
SA3			0.734

The dependent variable of this research has two sub-variables; (new) idea generation and (new) idea implementation. Results of factor analysis demonstrate that all the relevant items measuring team innovativeness successfully loaded onto their two underling variables (Table 2).

Table 2: Rotated Factor Matrix Using VARIMAX for Team Innovativeness

Items	Idea Generation	Idea Implementation
NIG1	0.937	
NIG2	0.913	
NIG3	0.924	
NIG4	0.977	
NIG5	0.947	
NIG6	0.961	
NIG7	0.796	
NII1		0.961
NII2		0.978
NII3		0.939
NII4		0.975
NII5		0.978
NII6		0.947
NII7		0.550

Reliability Testing

Reliability analysis is conducted to test internal consistency and to assess the reliability of summative scale where items are added to the total score. Value of Cronbach's Alpha is the demonstration of reliability. According to Malhotra (2007), a Cronbach's alpha equal or higher than 0.9 indicate external internal consistency; a Cronbach's alpha of higher than 0.8 but less than 0.9 indicates good internal consistency, and a Cronbach's alpha of higher than 0.7 but less than 0.8, indicates acceptable internal consistency. Table 3 presents the Cronbach's Alpha ranging from 0.91 to 0.94. This indicates an excellent and reliable internal consistency of different factors. Table 3 also presents the means, standard deviations and correlation coefficients for all variables (P < 0.05).

Table 3: Cronbach's Alpha, Means, SDs and Correlation Coefficients

Variable	Items	α	Mean	SD	1	2	3	4	5
IV1: Idea generation	7	0.92	5.40	1.15	1				
DV1a: Decision autonomy	3	0.93	3.56	2.47	0.43[b]	1			
DV1b: Schedule autonomy	3	0.91	3.40	2.25	0.68[b]	0	1		
DV1c: Process autonomy	2	0.94	4.33	2.32	0.44[b]	0	0	1	
IV2: Idea implementation	7	0.93	4.89	1.05	0.90[b]	0.48[b]	0.68[b]	0.39[b]	1

Note: a: p-value<0.05 two-tailed b: p-value<0.01 two-tailed

Hypothesis Testing

Hypothesis 1 proposed that IT-Enabled Autonomy positively influences team innovativeness.

Since Team Innovativeness was operationalized as new idea generation and new idea implementation, we tested two sub-hypotheses.

Regression analysis supported hypothesis 1a. Variables of the IT-Enabled Autonomy consisting of process-autonomy, decision autonomy, and schedule-autonomy explained 83.8% of the variance in new idea generation, with a good model fit with F (2) =258.30, $p<0.05$ (See Table 4). All beta coefficients were positive indicating a positive relationship between the variables and the DV. Among all three components of the IT-Enabled Autonomy, schedule autonomy (β=0.568) has strongest positive effect on new idea generation, followed by the process- and decision-autonomy, both of which had nearly the same effect (β=0.438, and β=0.437 respectively). Therefore, we concluded that IT-Enabled autonomy influences idea generation positively.

Table 4: Regression Results for Hypothesis 1 Regarding IT-Enabled Autonomy and Idea Generation

Variables	Beta
Decision autonomy	0.437[b]
Schedule autonomy	0.677[b]
Process autonomy	0.438[b]
R^2	0.842[b]
adjusted R^2	0.838
F-value	258.3[b]

Notes: a: p-value<0.01 b: p-value<0.05 c: p-value<0.10

Regression analysis also supported hypothesis 1b. Variables of the IT-Enabled Autonomy consisting of process-autonomy, decision autonomy, and schedule-autonomy explained 84.7% of the variance in new idea implementation, with a good model fit with F (2) =275.76, p<0.05. (See Table 5). All beta coefficients were positive indicating a positive relationship between the variables and the DV. Among all three components of the IT-Enabled Autonomy, schedule autonomy (β=0.684) has strongest positive effect on new idea implementation. This is followed by the decision autonomy (β=0.479, and process autonomy (β=0391). Therefore, we concluded that IT-Enabled autonomy influences idea implementation positively.

Given our empirical results, our hypothesis is supported: IT-Enabled Autonomy has a positive influence on team innovativeness.

Table 5: Regression Results for IT-Enabled Autonomy and Idea Implementation

Variables	Beta
Decision autonomy	0.479[b]
Schedule autonomy	0.684[b]
Process autonomy	0.391[b]
R^2	0.850[b]
adjusted R^2	0.847[b]
F-value	275.76[b]

Notes: a: p-value<0.01 b: p-value<0.05 c: p-value<0.10

Discussion

Although team innovativeness is a concept that has been widely discussed and IT has been identified as a contributor to that, specific ways in which IT contributes to team innovation had not been investigated. This study shows that IT features and affordances that provide team members autonomy with respect to scheduling, decision-making, and processes increase their team's idea generation as well as idea implementations. Therefore, we conclude that IT-Enabled Autonomy has a strong positive influence on team innovativeness. This extends research streams on IT-enabled innovation by specifying a work-design mechanism—IT-enabled autonomy—through which technology can support both the creation and implementation of innovations (Eseryel, 2014; Eseryel, 2019; Eseryel, 2024f; Eseryel et al., 2014b).

The managerial and executive implication of our study is the importance of not only increased investment in IT, but also of evaluating the affordances that IT provides team members. Managers and executives ensure the evaluation of any potential IT investment with respect to the level of autonomy that new IT affords team members with respect to scheduling, decision-making, and work processes. In addition, leaders influence autonomy outcomes by modeling and reinforcing discretionary IT use and by configuring systems to support self-leadership and distributed decision-making. Transformational IT leadership may therefore be a practical pathway for increasing IT-enabled autonomy and strengthening innovation-related outcomes (Eseryel, 2024b; Eseryel & Biernath, 2024; Eseryel et al., 2024d).

The data collected for this survey are from mainland China. Therefore, future research could ensure widespread applicability of this research using a larger sample that includes team members from different geographic regions. Future work could also examine whether national and organizational IT culture differences influence how autonomy is perceived and enacted through IT across settings (Eseryel, Eseryel, & den Breejen, 2021; Boonstra et al., 2018).

APPENDIX-I: Survey Instrument Used for Collecting Data on the Key Constructs

Part A. Team Use of IT for team tasks	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1. Using IT allows my team to make our decisions about how to schedule our work.	❐	❐	❐	❐	❐	❐	❐
2. Using IT allows my team to decide on the order in which things are done on the job.	❐	❐	❐	❐	❐	❐	❐
3. Using IT helps our team to plan how to do our work.	❐	❐	❐	❐	❐	❐	❐
4. The IT gives me more chances to use my personal initiative or judgment on carrying out the work in our team	❐	❐	❐	❐	❐	❐	❐
5. Using IT helps my team to make a lot of decisions on our own.	❐	❐	❐	❐	❐	❐	❐
6. Using IT provides my team with significant autonomy in making decisions	❐	❐	❐	❐	❐	❐	❐
7. Using IT helps my team to make decisions about what methods we use to complete our work.	❐	❐	❐	❐	❐	❐	❐
8. Using of IT gives my team considerable opportunity for independence and freedom in how we do our work.	❐	❐	❐	❐	❐	❐	❐
9. Using IT helps our team to decide on our own how to go about doing our work.	❐	❐	❐	❐	❐	❐	❐

Part B. Team innovation

This part deals with the **generation of new ideas in your team**. Please indicate to what extent your team develops ideas concerning the following aspects of work.

Idea generation concerning ...	No new ideas generated 1	2	3	4	5	6	Many new ideas generated 7
1. new targets or objectives	❐	❐	❐	❐	❐	❐	❐
2. new methods to achieve work targets	❐	❐	❐	❐	❐	❐	❐
3. new working methods or techniques	❐	❐	❐	❐	❐	❐	❐
4. new information or recording systems	❐	❐	❐	❐	❐	❐	❐
5. new products or product improvements	❐	❐	❐	❐	❐	❐	❐
6. new processes	❐	❐	❐	❐	❐	❐	❐
7. other aspects of work	❐	❐	❐	❐	❐	❐	❐

The following part deals with the **implementation of the ideas generated by your team**. Please indicate to what extent the ideas concerning the following aspects of work also are implemented.

Idea implementation concerning ...	No new ideas implemented 1	2	3	4	5	6	Many new ideas implemented 7
1. new targets or objectives	❐	❐	❐	❐	❐	❐	❐
2. new methods to achieve work targets	❐	❐	❐	❐	❐	❐	❐
3. new working methods or techniques	❐	❐	❐	❐	❐	❐	❐
4. new information or recording systems	❐	❐	❐	❐	❐	❐	❐
5. new products or product improvements	❐	❐	❐	❐	❐	❐	❐
6. new processes	❐	❐	❐	❐	❐	❐	❐
7. other aspects of work	❐	❐	❐	❐	❐	❐	❐

References

Amabile, T. M. (1996). Creativity in context: Updates to the social psychology of creativity. Westview Press.

Amabile, T. M. (1998). How to kill creativity. Harvard Business Review, 76(5), 76–87.

Auh, S., & Menguc, B. (2005). Balancing exploration and exploitation: The moderating role of competitive intensity. Journal of Business Research, 58(12), 1652–1661. https://doi.org/10.1016/j.jbusres.2004.11.007

Axtell, C. M., Holman, D. J., Unsworth, K. L., Wall, T. D., & Waterson, P. E. (2000). Shopfloor innovation: Facilitating the suggestion and implementation of ideas. Journal of Occupational and Organizational Psychology, 73(3), 265–285. https://doi.org/10.1348/096317900167029

Barker, J. R. (1993). Tightening the iron cage: Concertive control in self-managing teams. Administrative Science Quarterly, 38(3), 408–437. https://doi.org/10.2307/2393374

Bhaskaran, S. (2006). Incremental innovation and business performance: Small and medium-size food enterprises in a concentrated industry environment. Journal of Small Business Management, 44(1), 64–80. https://doi.org/10.1111/j.1540-627X.2006.00154.x

Bonner, J. M., Ruekert, R. W., & Walker, O. C., Jr. (2002). Upper management control of new product development projects and project performance. Journal of Product Innovation Management, 19(3), 233–245. https://doi.org/10.1111/1540-5885.1930233

Boonstra, A., Eseryel, U. Y., & van Offenbeek, M. (2018). Stakeholders' enactment of competing logics in IT governance: Polarization, compromise, or synthesis? European Journal of Information Systems, 27(4), 415–433. https://doi.org/10.1057/s41303-017-0055-0

Carbonell, P., & Rodríguez-Escudero, A. I. (2011). Antecedents and consequences of using information in new product development teams. Journal of Product Innovation Management, 28(2), 213–227. https://doi.org/10.1111/j.1540-5885.2011.00787.x

Crowston, K., Howison, J., Chengetai, M., & Eseryel, U. Y. (2007). The role of face-to-face meetings in technology-supported self-organizing distributed teams. IEEE Transactions on Professional Communication, 50(3), 185–203. https://doi.org/10.1109/TPC.2007.902654

Crowston, K., Li, Q., Wei, K., Eseryel, U. Y., & Howison, J. (2007). Self-organization of teams in free/libre open source software development. Information and Software Technology, 49(6), 564–575. https://doi.org/10.1016/j.infsof.2007.02.004

Das, S. R., Zahra, S. A., & Warkentin, M. E. (1991). Integrating the content and process of strategic MIS planning with competitive strategy. Decision Sciences, 22(5), 953–984. https://doi.org/10.1111/j.1540-5915.1991.tb00382.x

Dibrell, C., Davis, P. S., & Craig, J. (2008). Fueling innovation through information technology in SMEs. Journal of Small Business Management, 46(2), 203–218. https://doi.org/10.1111/j.1540-627X.2008.00240.x

Eisenbeiss, S. A., van Knippenberg, D., & Boerner, S. (2008). Transformational leadership and team innovation: Integrating team climate principles. Journal of Applied Psychology, 93(6), 1438–1446. https://doi.org/10.1037/a0012716

Emmanuelides, P. A. (1993). Toward an integrative framework of performance in product development projects. Journal of Engineering and Technology Management, 10, 363–392. https://doi.org/10.1016/0923-4748(93)90005-8
Ekvall, G. (1991). The organizational culture of idea management: A creative climate for the management of ideas. In J. Henry & D. Walker (Eds.), Managing innovation (pp. 73–79). Sage.
Eseryel, U. Y. (2014). IT-enabled knowledge creation for open innovation. Journal of the Association for Information Systems, 15(11), 805–834. https://aisel.aisnet.org/jais/vol15/iss11/3/
Eseryel, U. Y. (2019). The case of “Med-Global”: IT-enabled innovation and implementation by non-IT business unit leaders. Strategy & Leadership, 47(2), 43–48. https://doi.org/10.1108/SL-01-2019-0013
Eseryel, U. Y. (2024). IT-enabled open innovation types and behaviors. Journal of Leadership and Management, 10(2), 77–105.
Eseryel, U. Y., & den Breejen, M. (2024). Individuals’ IT-change readiness in healthcare organizations. Journal of Applied Business and Economics, 26(3), 274–298. https://doi.org/10.33423/jabe.v26i3
Eseryel, U. Y., & Eseryel, D. (2013). Action-embedded transformational leadership in self-managing global information technology teams. Journal of Strategic Information Systems, 22(2), 103–120. https://doi.org/10.1016/j.jsis.2013.02.001
Eseryel, U. Y., & Wolf, N. (2005). Enterprise architecture as a context for ERP implementation. Journal of Enterprise Architecture, 1(2), 7–24.
Eseryel, U. Y., Crowston, K., & Heckman, R. (2021). Functional and visionary leadership in self-managing virtual teams. Group & Organization Management, 46(2), 424–460. https://doi.org/10.1177/1059601120955034
Eseryel, U. Y., Eseryel, D., & den Breejen, M. (2021). IT culture elements that influence individual readiness to change in healthcare organizations. International Journal of Information Systems and Change Management, 12(4), 293–318. https://doi.org/10.1504/IJISCM.2021.10047283
Eseryel, U. Y., Wei, K., & Crowston, K. (2020). Decision-making processes in community-based free/libre open source software-development teams with internal governance: An extension to decision-making theory. Communications of the Association for Information Systems, 46(20), 484–510. https://doi.org/10.17705/1CAIS.04620
Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: A literature review. Journal of Product Innovation Management, 19(2), 110–132. https://doi.org/10.1111/1540-5885.1920110
Hoegl, M., & Parboteeah, K. P. (2006). Team reflexivity in innovative projects. R&D Management, 36(2), 113–125. https://doi.org/10.1111/j.1467-9310.2006.00420.x
Kim, Y., Min, B., & Cha, J. (1999). The roles of R&D team leaders in Korea: A contingent approach. R&D Management, 29(2), 153–166. https://doi.org/10.1111/1467-9310.00126
King, S. F., & Burgess, T. F. (2006). Beyond critical success factors: A dynamic model of enterprise system innovation. International Journal of Information Management, 26, 59–69. https://doi.org/10.1016/j.ijinfomgt.2005.10.006
Lee, S., & Runge, J. (2001). Adoption of information technology in small business: Testing drivers of adoption for entrepreneurs. Journal of Computer Information Systems, 42(1), 44–57. https://doi.org/10.1080/08874417.2001.11647083
Leonardi, P. M. (2011). When flexible routines meet flexible technologies: Affordance, constraint, and the imbrication of human and material agencies. MIS Quarterly, 35(1), 147–167. https://doi.org/10.2307/23043493
Leonardi, P. M. (2013). Theoretical foundations for the study of sociomateriality. Information and Organization, 23(2), 59–76. https://doi.org/10.1016/j.infoandorg.2013.02.002
Levitt, T. (1962). Innovation in marketing: New perspectives for profit and growth. McGraw-Hill.
Malhotra, N. K. (2007). Marketing research: An applied orientation (5th ed.). Pearson.
McDonough, E. F., & Barczak, G. (1991). Speeding up new product development: The effects of leadership style and source of technology. Journal of Product Innovation Management, 8(3), 203–211. https://doi.org/10.1016/0737-6782(91)90009-S
Moe, N. B., Stray, V., & Dingsøyr, T. (2018). Understanding coordination in global software engineering: A mixed-method study on the use of Scrum. Journal of Systems and Software, 133, 38–56. https://doi.org/10.1016/j.jss.2017.07.017
Morgeson, F. P., & Humphrey, S. E. (2006). The Work Design Questionnaire (WDQ): Developing and validating a comprehensive measure for assessing job design and the nature of work. Journal of Applied Psychology, 91(6), 1321–1339. https://doi.org/10.1037/0021-9010.91.6.1321
Negoita, B., Lapointe, L., & Rivard, S. (2018). Designing IT to enable distributed cognition: A sociotechnical perspective. MIS Quarterly, 42(4), 1119–1141. https://doi.org/10.25300/MISQ/2018/13292
Osborn, A. F. (1963). Applied imagination: Principles and procedures of creative problem solving (3rd ed.). Scribner.
Parker, S. K., Van den Broeck, A., & Holman, D. (2017). Work design influences: A synthesis of multilevel factors that affect the design of jobs. Academy of Management Annals, 11(1), 267–308. https://doi.org/10.5465/annals.2014.0054

Parnes, S. J. (1992). Sourcebook for creative problem solving: A fifty-year digest of proven innovation processes. Creative Education Foundation Press.

Powell, T. C., & Dent-Micallef, A. (1997). Information technology as competitive advantage: The role of human, business, and technology resources. Strategic Management Journal, 18(5), 375–405. https://doi.org/10.1002/(SICI)1097-0266(199705)18:5<375::AID-SMJ876>3.0.CO;2-7

Quinn, J. B. (2000). Outsourcing innovation: The new engine of growth. Sloan Management Review, 41(4), 13–28.

Reilly, R. R., Lynn, G. S., & Aronson, Z. H. (2003). The role of executive sponsorship in new product development projects. Journal of Product Innovation Management, 20(6), 443–455. https://doi.org/10.1111/1540-5885.00045

Sarker, S., Chatterjee, S., Xiao, X., & Elbanna, A. (2019). The sociotechnical axis of cohesion for the IS discipline. MIS Quarterly, 43(3), 695–717. https://doi.org/10.25300/MISQ/2019/13747

Stewart, G. L., Courtright, S. H., & Manz, C. C. (2011). Self-leadership: A multilevel review. Journal of Management, 37(1), 185–222. https://doi.org/10.1177/0149206310383911

Stewart, G. L., Manz, C. C., & Sims, H. P., Jr. (1999). Teamwork and group dynamics. John Wiley.

Vaast, E., Safadi, H., Lapointe, L., & Negoita, B. (2017). Social media affordances for connective action: An examination of microblogging use during the Gulf of Mexico oil spill. MIS Quarterly, 41(4), 1179–1205. https://doi.org/10.25300/MISQ/2017/41.4.11

West, M. A. (1990). The social psychology of innovation in groups. In M. A. West & J. L. Farr (Eds.), Innovation and creativity at work (pp. 309–333). Wiley.

West, M. A., & Anderson, N. R. (1996). Innovation in top management teams. Journal of Applied Psychology, 81(6), 680–693. https://doi.org/10.1037/0021-9010.81.6.680

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). The new organizing logic of digital innovation. Information Systems Research, 21(4), 724–735. https://doi.org/10.1287/isre.1100.0322

Zaltman, G., Duncan, R., & Holbek, J. (1973). Innovations and organizations. Wiley.

Zirger, B. J., & Hartley, J. L. (1994). A conceptual model of product development cycle time. Journal of Engineering and Technology Management, 11, 229–251. https://doi.org/10.1016/0923-4748(94)90004-3

Journal of Leadership and Management®
An International Journal of Strategic, Behavioral and Public Aspects of Leadership in Management
Cabell's Listed
A journal of the Institute of Leadership and Management Association, PO Box 564, Douglassville PA 19518. 484-332-3331. https://www.jleadershipmanagement.org

Effects of AI-Based Model-Facilitated Learning and Stealth Assessment Framework for Developing Systems Thinking Leadership Skills

Deniz Eseryel, Aurora Consulting, deniz@eseryel.com
U. Yeliz Eseryel, East Carolina University

Online published: Jan 2026 Print published: Jan 2026 Editor: Sue Kong	Authorship Roles and Conflict of Interest Statement is on file at the Journal of Leadership and Management offices, available on request. Contact editors@jleadershipmanagement.org

Abstract

In a world increasingly characterized by dynamic complexity, effective decision-making necessitates leaders to develop systems thinking skills. This involves developing tools to understand the intricate structures of complex systems. Yet theoretical and didactic reflections on developing systems thinking are generally hard to find in the leadership literature. On the other hand, modern research on cognition and human learning, combined with emerging AI technologies, offers new possibilities for facilitating and assessing higher-order thinking skills such as systems thinking. This paper proposes an AI-based model-facilitated learning and stealth assessment framework for promoting systems thinking leadership competencies. It presents a study to demonstrate the implementation of two different intelligent scaffolding methods, (1) learning by using models and (2) learning by building models. The paper investigates these models' effectiveness in promoting systems thinking leadership skills in the context of a complex lake ecosystem. The findings suggest that while both approaches are effective in promoting learners' systems thinking skills, learning by building models becomes more effective when the level of problem complexity increases. The implications of this study are discussed in the context of integrated approaches to AI-based learning and assessment of complex problem solving.

KEYWORDS
Systems Thinking; Understanding Complex Systems; Dynamic Decision Making; Complex Problem Solving; System Dynamic Modeling; Model Based Learning; AI-Based Stealth Assessment

Introduction

Leadership in the era of artificial intelligence (AI) requires deep understanding of complex systems. AI has made systems thinking more crucial by introducing unprecedented complexity, interconnectedness, and autonomous behaviors that traditional, linear, and piece-meal analysis cannot handle (Qudrat-Ullah, 2025). As artificial intelligence becomes increasingly integrated into societal, economic, and organizational systems, it introduces new dependencies, potential biases, and feedback loops that necessitate a comprehensive, systemic approach to mitigate harmful consequences.

Recent *Future of Jobs Report* published by the World Economic Forum (2023) highlights the importance of systems thinking on top of the list of ten skills predicted to grow in importance for workers over the next seven years. A review of empirical studies also shows that systems thinking is highly correlated with higher leadership performance (Dörner, 1989; Ellis et al,, 1995; Funke, 1989; Gomez and Probst, 1987; Ossimitz, 1990, 1996; Palaima & Skaržauskienė, 2010).

Systems thinking calls for understanding complex systems. Complex systems have a large number of components that have dynamic interrelationships among them. These components produce synergies that are not easily foreseen by the observer. Complex systems involve multiple interconnected levels that operate at multiple time scales. For instance, in order for a leader to make an ecological decision about the impact of building housing around a lake, they must *understand the complex lake ecosystem*, in other words, the complex interplay among the biotic components, such as plants, animals, and microorganisms, and the physical and chemical interactions of abiotic components, such as sunlight, water, temperature, soil, rocks, etc.

Numerous studies have highlighted various challenges in comprehending concepts essential for understanding complex systems across diverse fields (see, for instance, Dörner, 1996; Hmelo-Silver & Azevedo, 2006; Jacobson, 2000; Kozma, 2000; Milrad, Spector, & Davidsen, 2002). Reasoning about a complex system, due to its numerous interconnected components, demands a significant amount of working memory resources and often leads to counterintuitive conclusions. (Feltovich, Coulson, & Spiro, 2001; Narayanan & Hegarty, 1998). Thus, it is no surprise that extant research (e.g., Dörner, 1996; Funke, 1991; Hmelo-Silver & Pfeffer, 2004) shows that most people perceive complex systems as collections of parts, lacking a deep understanding of the dynamic interrelationships among system components and the overall functioning of the system. Humans generally lack the ability to provide causal and structural explanations, nor can they anticipate and explain changes in underlying causes and structures. (Dörner, 1996; Feltovich, Spiro, Coulson, & Feltovich, 1996). Hence, one of the main challenges that largely hinders the development of systems thinking leadership skills is the lack of ability to build a mental model of a complex system (Eseryel & Law, 2012b; Frensch & Funke, 1995; Seel, 2006).

Despite its importance, little is known about how to assess and facilitate the development of systems thinking leadership skills. Theoretical and didactic reflections on developing systems thinking are generally hard to find in the leadership literature (Ossmitz, 2000). The purpose of this paper is to describe an AI-based model-facilitated learning and stealth assessment framework to address this gap. Following the description of the framework, a study is presented that demonstrates two approaches of AI-based model-facilitated learning and stealth assessment framework, (i) learning from models and (ii) learning by building models and to investigate their effectiveness in facilitating leadership students' development of systems thinking skills in the context of dynamic decision-making regarding a complex lake eco-system.

AI-Based Model-Facilitated Learning and Stealth Assessment Framework

There is evidence to suggest that model-facilitated learning could be effective in promoting deeper learning and understanding of complex systems (Clement & Rea-Ramirez, 2008; Gibbons, 2001, 2003; Jonassen, Strobel, & Gottdenker, 2005; Milrad, Spector, & Davidsen, 2002; Seel, 2003; Spector, 2003). While there are different interpretations of model-facilitated learning, our previous investigations show that modeling techniques adapted from the field of system dynamics has the most promise to be used as a basis of both facilitating and assessing the development of systems thinking leadership skills (Eseryel, Ifenthaler, & Ge, 2013; Eseryel & Law, 2010).

Founded by Forrester (1961) as a way to model complex business and organizational processes to aid dynamic managerial decision-making, system dynamics, also represents a way to support deep learning of complex systems (Senge, 1990; Sterman, 1994). System dynamics professionals employ two primary tools to model the dynamic feedback relationships among the components of a complex system: (1) *causal influence diagrams* and (2) *stock-and-flow diagrams*.

As illustrated in Figure 1, a causal influence diagram consists of arrows denoting the causal links among system variables (Eseryel, 2015). Each causal link is assigned a polarity, either positive (+) or negative (-), to signify the direction of change in the dependent variable when the independent variable changes. A positive link signifies a direct relationship, meaning that as the cause increases, the effect also increases, and vice versa. For example, in Figure 1, an increase in the number of contagious people means an increase in the number of incubating mosquitos above what it would otherwise have been. On the other hand, a negative link indicates an inverse causal relationship; in other words, if the cause increases the value of the effect decreases or vice versa. For instance, in Figure 1, an increase in the number of incubating people means the number of susceptible people will fall below what it would otherwise have been.

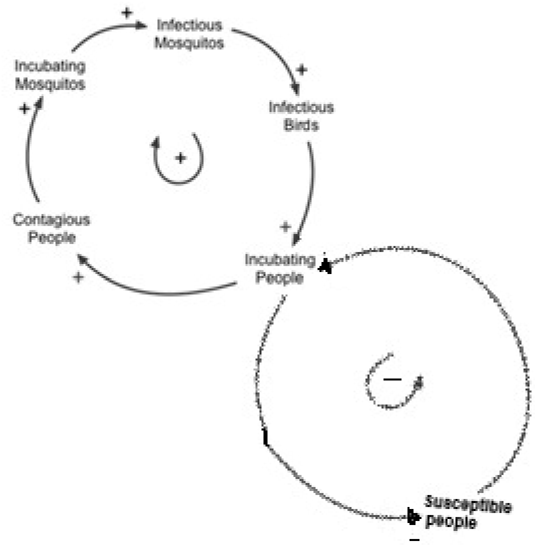

Figure 1. Sample causal influence diagram of an epidemic

In a causal influence diagram, important feedback loops are emphasized by a loop identifier that indicates whether the loop is a positive (reinforcing) or negative (balancing) feedback loop. For instance, in Figure 1, there are two primary feedback loops; the first one on the left is a positive feedback loop while the other one on the right is a negative feedback loop.

In a positive feedback loop, a variable continuously reinforces its own growth or collapse by continuously feeding back upon itself. Several familiar phrases, such as the snowball effect or the vicious cycle, characterize the phenomenon of positive feedback: a worsening of one element in a causal chain brings about further degradation of the element; conversely, positive changes in a system element trigger further improvement. On the other hand, negative feedback loop is characterized by a goal-directed behavior. If the current value of the variable of interest exceeds the desired level, the loop structure decreases its value, while if it falls below the desired level, the loop structure increases its value. Terms like self-governing, self-regulating, self-equilibrating, homeostatic, or adaptive all suggest the presence of a goal. These terms define negative feedback loops or systems. When a positive and a negative loop are combined, as in Figure 1, a variety of patterns are possible. For instance, it's possible that a positive feedback loop causes early exponential growth, but then, after a delay, a negative feedback loop takes over and dominates the system's behavior.

Causal influence diagrams are well-suited to represent the interdependencies and feedback processes of a complex problem situation. A general advantage of a causal influence diagram is that it supports a holistic view of a complex and dynamic system in a single figure represented on a single page or screen. Such representations address a common deficiency in human reasoning, namely, the tendency to ignore significant portions of a complex system (Dörner, 1980; Senge, 1990). As Figure 1 indicates, delayed effects can also be represented, which is an additional challenge; all too often, humans expect to see nearly instantaneous effects of a decision or action but real systems often involve significant delays.

One of the most significant limitations of causal diagrams is their inability to represent the stock and flow structure of systems, which are the two fundamental concepts in system dynamics theory. Hence, following the creation of a causal influence diagram, system dynamicists typically transform it into a stock-and-flow model, which include mathematical equations to represent the stocks (i.e., accumulators), flow rates, variables, and any constraints that may be assumed to govern the system (Figure 2). In this way, the simpler causal influence diagram is elaborated and transformed into the basis for a mathematically driven simulation model that can be manipulated to test overall system behavior when certain variables in the model are changed.

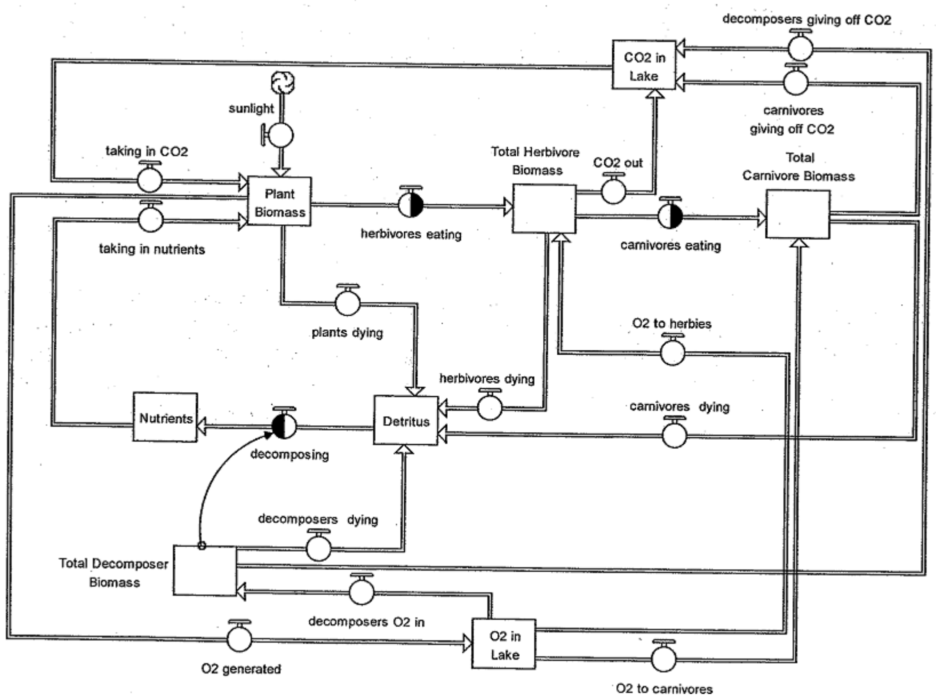

Figure 2. Stock-and-flow model of the ecosystem of Lake Mirabile that guide the Food Chain

A mathematically elaborated stock-and-flow diagram can serve as the basis for an executable simulation, with the help of computer-based systems such as STELLA (Steed, 1992), that shows how all of the components change over time or how the behavior changes when certain critical variables are manipulated. What cannot be represented in a causal influence diagram are the effects of non-linear relationships among system components, but stock-and-flow diagrams that are mathematically based can do just that. Understanding the impact of non-linear relationships in a complex system is a particular shortcoming of human reasoning. Stock-and-flow models can address that weakness in human decision-making and policy formulation and support learning about complex systems. Stock-and-flow models inform a number of so-called management flight simulators that are designed to allow users to manipulate one or more critical components in order to achieve a desired outcome, such as a stable and sustainable population growth (Davidsen, 1996; Sterman, 1994). When the critical components are changed, the behavior of the system changes, and users can see the consequences of making a particular decision or following a particular policy.

In the proposed AI-based model-facilitated learning and assessment framework, the tools developed by system dynamicists could be used in two basic ways to support the development of systems thinking skills: (1) learning from system dynamics models; and (2) learning by creating system dynamics models (Alessi, 2000; de Jong, 2006b; Spector, 2000). Either type of model (causal influence or stock-and-flow) can be used to support either approach.

In *learning from system dynamics models*, an executable stock-and-flow diagram can be used to help leaders identify which variables seem to have a significant impact on system behavior in various circumstances. Leaders' overall learning process revolves around exploring a model by altering the values of input variables and observing the resulting values of output variables. In this process, they encounter the rules of the simulated domain or uncover certain aspects of these rules (de Jong, 2006a). By changing one or more variables and observing system behavior, a learner can develop such an understanding. In addition, stock and flow diagrams can help learners understand the nature and extent of delayed effects. Moreover, by allowing learners to manipulate one or more key variables, a stock-and-flow model can help learners realize the impact of non-linear relationships on system behavior; such effects are often counter-intuitive as humans are more accustomed to reasoning about linear relationships.

In *learning by building system dynamics models*, leaders must construct a system dynamics model that can be simulated to replicate phenomena observed in a real system. Students can be provided with a description of a complex system or a scientific problem situation and asked to create either a causal loop diagram or, for more sophisticated learners, a stock-and-flow model of a certain phenomenon. The primary objective of a leader is to construct a model in a manner that closely resembles the behavior of a theoretical model or a real-world phenomenon. (van Joolingen, de Jong, Lazonder, Savelsbergh, & Manlove, 2005; White, 1993). This approach aligns with the fundamental concepts of constructionism (Harel & Papert, 1991; Kafai, 2006), of which the main focus is on "knowledge construction that takes place when students are engaged in building objects" (Kafai & Resnick, 1996, p.2).

Learning by building system dynamics models can be a highly engaging means of promoting model-facilitated learning (learning what happens, when, and why). It is important to realize that one cannot simply expect those new to a complex domain with little or no knowledge of system dynamics to begin creating very good causal influence or stock-and-flow diagrams. However, one can help learners develop the capacity to create meaningful representations of complex systems by a graduated set of activities that involve active modeling. Asking learners to transform a text-based description of a complex system or problematic situation into a causal influence diagram could be an initial step. Such an initial step need not involve any of the language of causal influence diagrams or system dynamics. Rather, it is possible to simply present the problem situation, ask learners to indicate the key factors influencing the situation, describe each factor, indicate how those factors are related, and describe those relationships. That is in fact the essence of an annotated causal influence diagram and can be depicted as such, either by the learner or by a computer-based system. The learner is then in a position to reflect upon the diagram and compare it with diagrams created by others. This would be a simple learning by modeling activity.

With learners who know something about stock-and-flow diagrams, a relatively simple learning by modeling activity would be to present a partially complete stock-and-flow model along with data about system behavior. Learners can then be asked to provide the missing parts of the model in order to account for the reported behavior. A more challenging activity would be to provide the students with a robust causal influence diagram and data about actual system behavior, and have the learner create a stock-and-flow model that when executed provides data consistent actual data.

AI-Based Stealth Assessment of the Development of Systems Thinking Skills

In addition to serve as a basis for model-facilitated learning, system dynamic tools can also support assessment of the development of systems thinking leadership skills. For instance, there is growing literature on the use of causal influence diagrams as an alternative form of assessment for complex problem solving competencies (Eseryel, 2006; Eseryel et al., 2013; Spector & Koszalka, 2004). To construct a causal influence diagram for a complex problem, one must identify the problem variables that influence the problem state and the causal relationships between these variables. Additionally, it's crucial to articulate the various causes that affect a problem state, the available solution approaches, and the trade-offs associated with each solution approach. As such, causal influence diagrams offer affordances that make them an ideal tool for eliciting learners' structural knowledge and causal reasoning. These diagrams present new, authentic, and unencountered scenario-based questions that require learners to make predictions about future events or draw inferences about past occurrences. (Dörner, Kreuzig, Reither, & Stäudel, 1983; Jonassen, 2000, 2004; Jonassen & Cho, 2008; Jonassen & Wang, 1993). Therefore, causal influence diagrams are uniquely suited to elicit and continuously track a learner's mental model progression during model-facilitated learning. Continuous progression of a learner's causal influence diagram of a complex system can be compared with that of a domain expert to assess whether the instructional intervention is facilitating desired conceptual changes or whether particular misconceptions in students' mental models are preventing their learning. Figure 3 depicts this assessment framework.

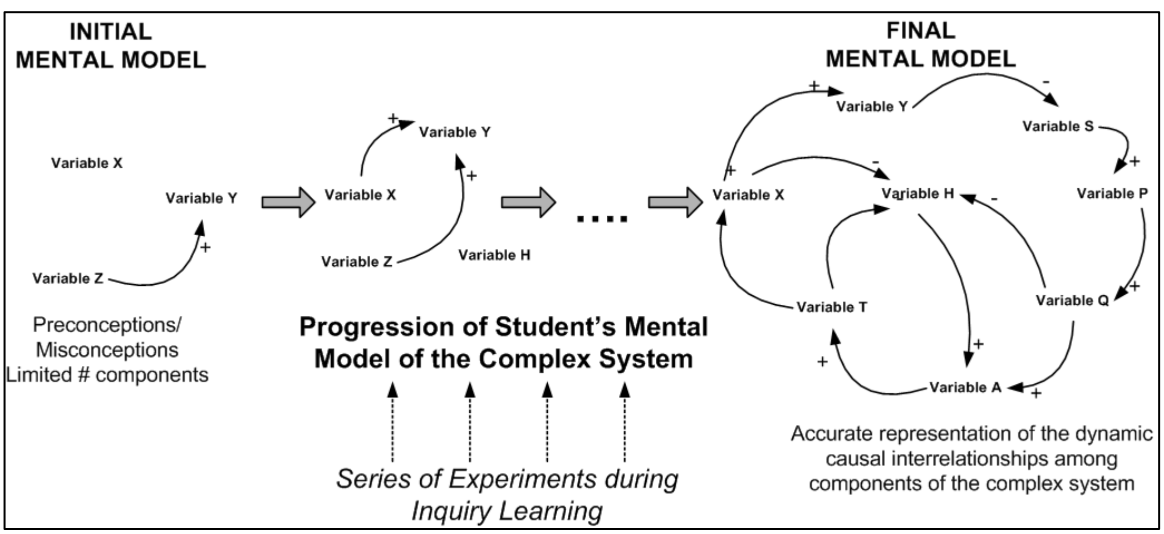

Figure 3. Model-facilitated learning and embedded assessment framework

Based on previous research, this assessment framework assumes that novices initially have preconceptions or misconceptions about the problem space (Eseryel & Law, 2012b; Ifenthaler, Masduki, & Seel, 2011; Snow, 1990). As one's expertise level increases, these initial assumptions are gradually replaced by more comprehensive and causal explanations (Berliner, 2002; Eseryel et al., 2013; Seel, Al-Diban, & Blumschein, 2000; Snow, 1990). Hence, in the context of complex problem-solving, effective learning can be described as a process that facilitates the transition of learners' problem spaces from the state of preconceptions or misconceptions to the state of comprehensive, causal explanations (see Figure 3).

To make this framework a reliable assessment tool, we need to create a similarity metric that compares how novice problem spaces evolve over time through instructional interventions. This metric should help us determine whether the problem conceptualizations of advanced learners or experts are similar to or different from those of novices, allowing us to evaluate the effectiveness of any specific instructional strategy.. In studies with different complex domains, it was found that a similarity metric to compare two causal influence diagrams should have three measures: (1) surface similarity; (2) semantic similarity; and (3) structural similarity (Eseryel, 2006; Spector, Christensen, Sioutine, & McCormack, 2001; Spector & Koszalka, 2004). Recently, Pirnay-Dummer, Ifenthaler, and Spector (2010) devised a computer-based tool, called HIMATT (Highly Integrated Model Assessment Technology and Tools), for comparing the similarity of sets of causal influence diagrams based on an expanded version of these three measures. By using specific automated comparison algorithms, HIMATT calculates similarities between a given pair of frequencies f1 (e.g. expert solution) and f2 (e.g. learner solution) across four structural (surface, graphical, structural, and gamma matching) and three semantic (concept, propositional, and balanced propositional matching) measures, which results in a measure of $0 \leq s \leq 1$, where $s = 0$ is complete exclusion and $s = 1$ is identity (Ifenthaler, 2010a, 2010b; Pirnay-Dummer & Ifenthaler, 2010; Pirnay-Dummer et al., 2010).

Reliability scores exist for the single measures integrated into HIMATT (see Pirnay-Dummer et al., 2010). They range from $r = .79$ to $r = .94$ and are tested for the semantic and structural measures separately and across different knowledge domains. Validity scores are also reported separately for the structural and semantic measures. Convergent validity lies between $r = .71$ and $r = .91$ for semantic comparison measures and between $r = .48$ and $r = .79$ for structural comparison measures (see Pirnay-Dummer et al., 2010). In a recent study by Eseryel and colleagues (2013), the assessment framework and the accompanying HIMATT analysis method was validated against an established research and analysis method for complex problem solving, namely the protocol analysis method (cf. Ericsson & Simon, 1993).

The power of this assessment method is that it can be seamlessly integrated in an AI-based model-facilitated learning environment and act as a *stealth* assessment (cf., Shute, 2015). It continuously tracks students' mental model progressions and compares individual student progress to the reference expert model, making it an integral part of the learning environment. Such immediate and continuous feedback could help instructors in introducing just-in-time information to address apparent misconceptions or to modify the design of the instructional intervention to bring about desired changes in learners' mental models. In addition, it is possible to program automated AI-based scaffolds, for instance, in the form of a question-prompt, that would provide instant guidance to support learners' understanding of a complex system.

Purpose of the Study

The purpose of this study was to demonstrate the utility of the AI-based model-facilitated learning and stealth assessment framework described above and to investigate the effects of its different approaches, namely (1) *learning from system dynamics models* (a.k.a. model-using); and (2) *learning by building system dynamics models* (a.k.a. model-building), on leadership students' dynamic decision-making of a complex lake ecosystem. Thus, the following research question was posed: *Given different levels of problem complexity, is learning-from-system-dynamics models more effective than learning-by-building-system-dynamics-models in a model-facilitated learning environment?*

Method

Participants

Participants included 273 mixed-ability ninth-grade students in the leadership track from an ethnically and economically diverse rural high school in the midwest of the United States. This school's core value is a focus on leadership and runs a program that creates a safe environment for students to learn and practice leadership. The school's mission is geared toward every student developing personal leadership, interpersonal leadership, team leadership, and organizational leadership.

Each of the 273 students were randomly assigned to one of ten classes. Out of the ten classes, five were randomly assigned to the experimental condition, which involved using a model (i.e., model-using group), while the other five were randomly assigned to the control condition, which involved building a model (i.e., model-building group). Out of the 237 students who provided both consent and parental assent forms, 118 were assigned to the experimental group, while 119 were assigned to the control group. There were 50.63% (n=120) males and 49.36% (n=117) females.

Materials

For the purposes of this study, a model-facilitated inquiry learning environment called *Food Chain* was utilized. *Food Chain* was designed to facilitate students' deep learning of the complex ecosystem of Lake Mirabile, an hypothetical lake that contains eight species, two from each of the four trophic levels: sunfish and shiners (the carnivores); copepods and daphnia (herbivores); green algae and diatoms (the primary producers); bacteria and fungi (the decomposers). Food Chain was built on the STELLA system dynamics modeling platform developed by the isee systems. The stock-and-flow model (see Figure 2) guiding the system simulation is based on the expert domain model, which depicts the dynamic interrelationships among the various species of the lake, including additional environmental factors. Students can also develop their own stock-and-flow diagrams related to a given problem scenario in the STELLA platform and simulate what happens in Lake Mirabile. Hence, *Food Chain* can support both learning-from-models and learning-by-modeling approaches.

When students enter the Food Chain environment, they are provided with a series of problems in increasing complexity similar to the idea of model progression also found in earlier work by White and Frederiksen (1990). For instance, the first inquiry challenge in Food Chain asks students to find two species out of eight that can live together in a lake for 90 days. Hence, the main task of the learners is to infer the characteristics of the model underlying the simulation in Figure 2 by first discovering that a higher-order categorization of the species is possible as carnivores, herbivores, primary producers, and the decomposers; and then discovering the inter-dependencies among these categories within the lake ecosystem.

In the *learning-from-models* mode, *Food Chain* supports students while they carry out a sequence of activities that correspond to the steps in the scientific inquiry method (Figure 4). Each challenge in *Food Chain* is organized around the steps in the scientific method. After understanding the challenge, the students are guided to, in sequence, develop hypothesis; state hypothesis; test hypothesis; and explain the results. In each step, Food Chain scaffolds the students. For instance, in the develop hypothesis step, when the students click on any species a hypertext card opens up that provides requisite domain knowledge about that species such as the properties of its preferred location, its physical characteristics, nutritional requirements, and the atmospheric gases (i.e., carbon dioxide and oxygen) that it produces and requires (see Figure 4). In the state hypothesis step, worksheets are provided for the students to write their formal hypothesis in the correct form along with their justification explaining the rationale behind their hypothesis. Hypotheses of the form, "We hypothesize that sunfish and daphnia will be able to survive in the lake for 90 days because...." are expected.

During the test hypothesis step, students test their hypotheses via simulating. Only the species that have been clicked on in the develop hypothesis step are considered to be in the lake in the ensuing simulation. When the students click on the Run button they start to visualize the changes in the lake ecosystem as Food Chain simulates what happens during the 90 days when the selected two species are put in the lake together. Status indicator lamps for each species in the lake will initially glow green to indicate that they are being included in the simulation, and that their initial number is within the normal bounds. As the simulation progresses, these lamps may begin to glow yellow, indicating that the associated population has either grown large or small enough to be considered at risk. Should a lamp begin to go red and flash that species and/or carrying capacity variable is either at peril of disappearing from the ecosystem or has achieved unsustainable proportions.

At the end of the simulation, changes in the population indices of the species and in carrying capacity indices of oxygen, carbon dioxide, nutrients, and detritus are provided by various graphs and charts, which show the causes of death of the species, such as natural causes, starvation, and asphyxiation (see Figure 4). Interactions with these charts and graphs help students regulate their cognition and discover the interrelationships among the different species. During the explain the results step, the students are provided with a worksheet to explain their findings, articulate their understanding of what had happened during the experiment, and state which hypothesis should be tested next.

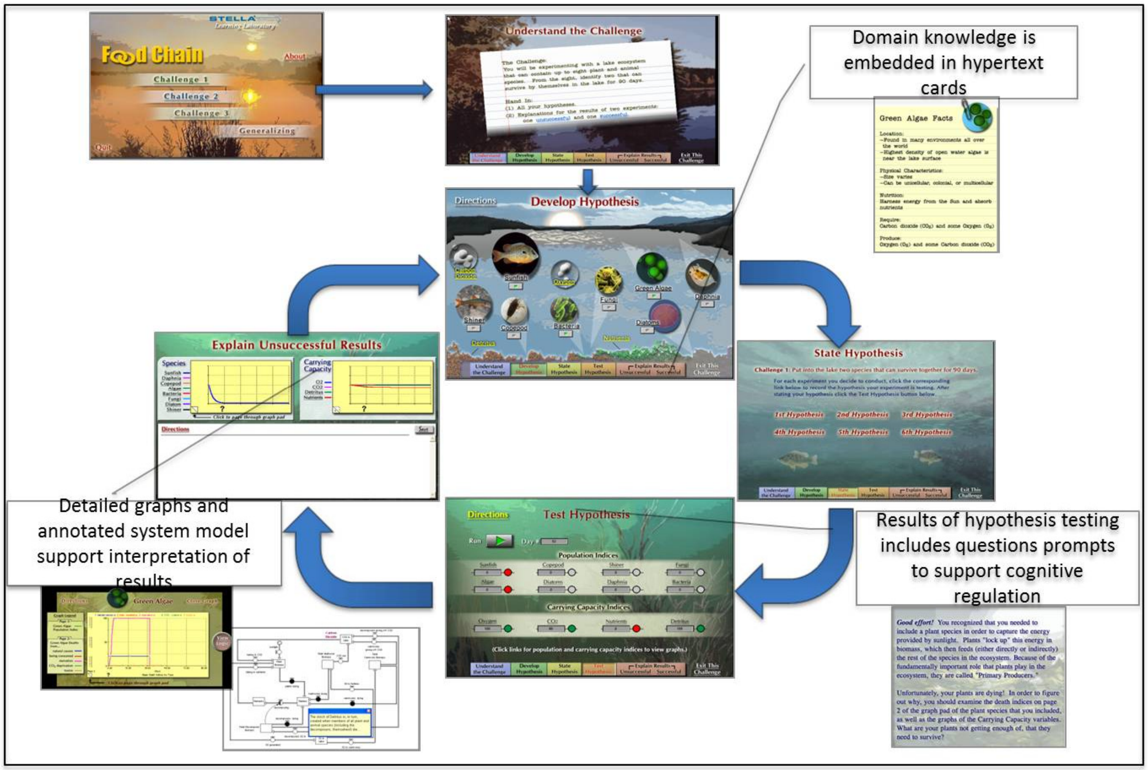

Figure 4. Food Chain model-facilitated inquiry learning environment

Finally, *Food Chain* scaffold students' inquiry process by intelligent question prompts. As students construct their hypothesis about possible interrelationships among constituents of the complex lake ecosystem, the embedded assessment system automatically compares student hypothesis with the expert stock-and-flow model (see Figure 2) running in the background of the simulation. After the students run the hypothesis they see the consequences of their assumptions and what happens in the lake ecosystem through various graphs and other visuals. As the students are guided to explain these findings to construct a new hypothesis they receive an intelligent question-prompt that stems from the analysis of the embedded assessment system asking the students to consider the interrelationships between two system components selected based on how their hypothesis compare with the expert model of the lake ecosystem. For instance, if a student included a plant and an herbivore in their hypothesis, a question prompt is dynamically generated by *Food Chain* to reinforce the requirement of having a primary producer in the lake ecosystem and guide the students further to think about what was needed for the plants to survive. An example of a dynamic question prompt is shown in Figure 5.

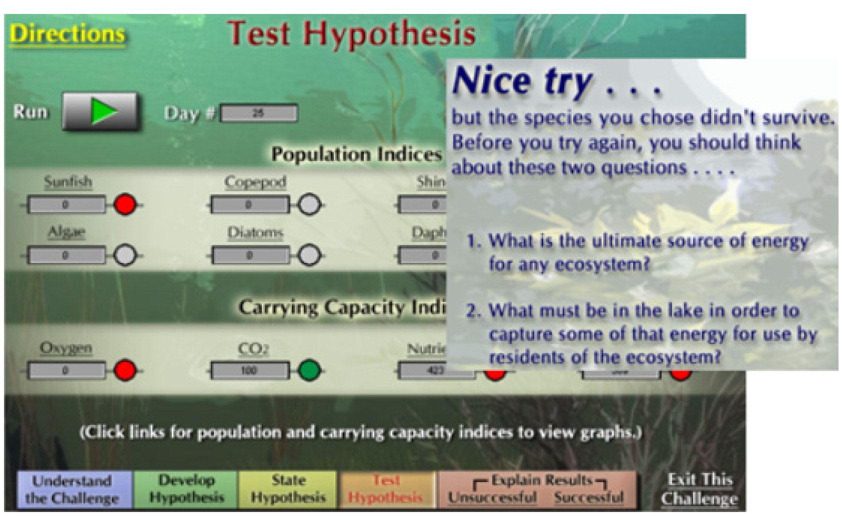

Figure 5. A sample question prompt received by participants

In the *learning-from-models* mode, following their hypothesis-testing while students are trying to interpret the results to construct a new hypothesis, they are given access to the stock-and-flow diagram that is similar to that of the domain experts underlying the system simulation. The stock-and-flow diagram is revealed piece-by-piece as students click on the *enter* tab on their keyboard; each piece is accompanied by an annotation that explains the relationships among the system constituents like telling a digital story of the complex ecosystem of Lake Mirabile (see Figure 6). In this way, the expert model underlying the simulation is made transparent to the students in an effort to support the cognitive regulation of the students during inquiry learning.

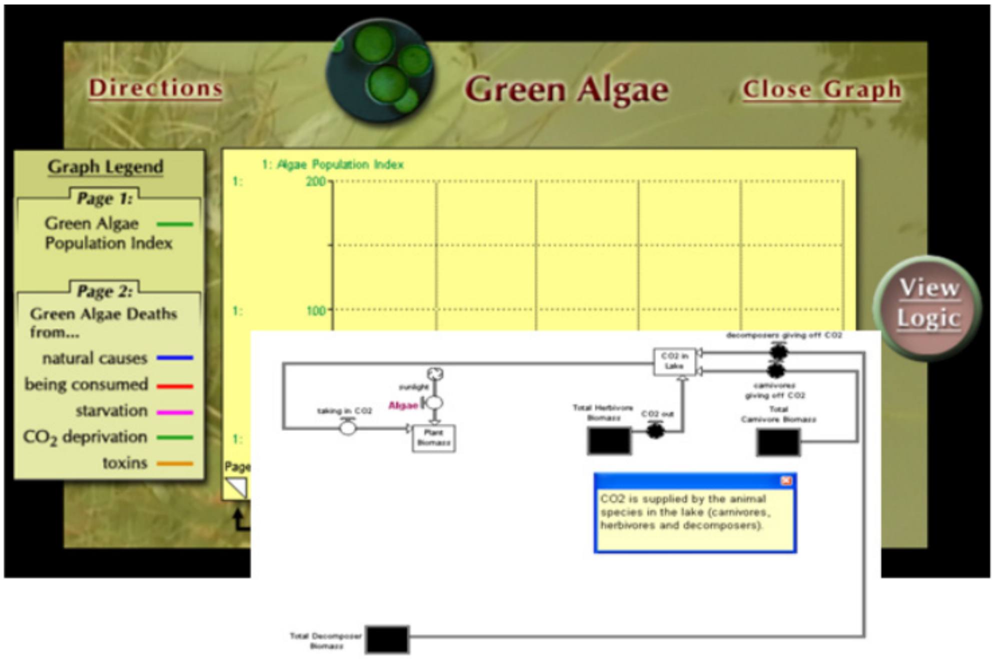

Figure 6. Dynamic model progression scaffold received by participants in the learning-from-models mode

In the *learning-by-modeling* mode, students go through the steps of the scientific inquiry as in the learning-from-models mode. However, they do not receive the dynamic model progression to scaffold their cognitive regulation. Instead, students engage in an iterative process of constructing and revising their own stock-and-flow models of the complex lake ecosystem to explain the phenomenon they are investigating during scientific inquiry and testing their model through the STELLA simulation interface (Figure 7). Therefore, the environment provides opportunities to enhance the transparency of the learning process. Hypotheses become visible as models or components of models, and students' predictions can be displayed as model outputs. Additionally, the validity of models is continuously and automatically evaluated using HIMATT analysis tools in comparison to domain-expert models (cf. Eseryel et al., 2013).

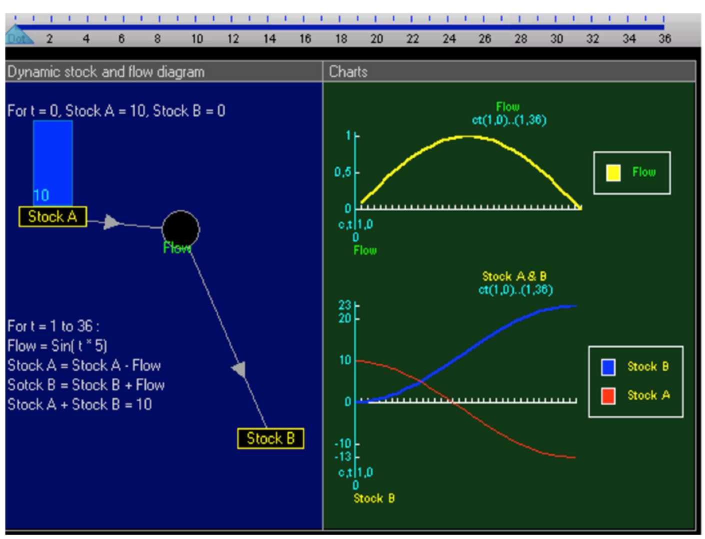

Figure 7. Model-building and testing interface using STELLA simulation interface

Procedure

Participants in both study conditions interacted with the *Food Chain* model-facilitated inquiry-learning environment for three weeks. In the first week, the participants were introduced to the Food Chain model-facilitated inquiry-learning and embedded assessment system and were asked to design their own experiments and test their hypotheses to answer a very simple complex problem (challenge# 1): Which two species (out of eight) can survive in Lake Mirabile by themselves for 90 days? This first week was intended to familiarize students with the simulation environment and to teach about scientific reasoning processes of hypothesis generation and testing. During this initial run, students in both conditions had access to domain-specific knowledge related to the species in Lake Mirabile but they did not engage in any model-based activity. In other words, students in the learning-from-models condition did not see the underlying stock-and-flow diagram depicting the dynamic interrelationships among the constituents of the lake ecosystem underlying the simulation; students in the learning-by-modeling condition did not engage in any system modeling activity. At the end of each inquiry-cycle, students only received a text-based verification feedback of whether or not their hypotheses were correct and the intelligent question-prompt to scaffold their cognitive regulation.

In the second week, participants tackled another problem scenario with mid-level complexity (challenge# 2), in which they were asked to identify the smallest number of species that will enable Sunfish to survive for 90 days in Lake Mirabile. Their entire hypotheses, experimental designs, and elaborated reports of the findings were collected in the system.

During the third week, participants tackled a very complex and ill-structured problem scenario (challenge# 3), which called for environmental policy-making. In this problem scenario, students were asked to play the role of an environmental scientist and evaluate the proposal to build 100 new houses on the shoreline at Lake Mirabile from an environmental impact standpoint. All of their hypothesis, results of their experiments, and their elaborated report of recommendations and assessment were collected in the system.

During the second and third weeks, the only difference between the two study conditions was the type of model-facilitated learning activity with which the students engaged. Students in the learning-from-models condition had access to the underlying stock-and-flow diagram depicting the dynamic interrelationships among the constituents of the lake ecosystem underlying the simulation; students in the learning-by-modeling condition engaged with constructing, testing, and revising their stock-and-flow models of the lake ecosystem under investigation.

Data Analysis

Stealth assessments within a learning environment are considered a viable method for drawing inferences about learners' behaviors (Chung & Baker, 2003). In the *Food Chain*, students engaged in inquiry-based learning to solve three progressively complex ecology problems. For each problem, they were asked to go through the inquiry process at least six times. Each inquiry cycle in Food Chain simulation involved the following steps. First, students individually developed a hypothesis using their prior knowledge and information given by the software. Then, they observed the results and analyzed the charts generated by the simulation environment for each variable. Finally, they explained the results. A computer-generated intelligent question prompt and an annotated dynamic model progression were provided to the students in the learning-from-models condition to interpret their findings and revise their hypotheses while the students in the learning-by-modeling condition only received computer-generated intelligent question-prompts and were engaged with constructing, testing, and revising their stock-and-flow models of the lake ecosystem under investigation.

All of students' activities and by-products of these activities were stored in the system and the HIMATT (Pirnay-Dummer, Ifenthaler, & Spector, 2010) analysis function was applied. The automated analysis function produces measures, which range from surface-oriented structural comparisons to integrated semantic similarity measures. Those measures include four *structural* (surface, graphical, structural, and gamma matching, also referred as SFM, GRM, STM, and GAM) and three *semantic* (concept, propositional, and balanced semantic matching, also referred as CCM, PPM, & BSM) indicators (Figure 8).

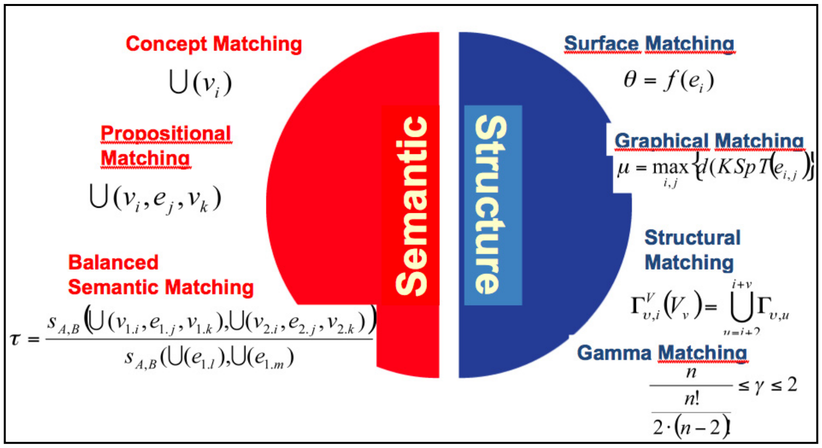

Figure 8. HIMATT measures for comparing structural and semantic similarity of student and expert models

Each of the participants' protocols was compared automatically against a reference solution. The reference solution included the stock-and-flow diagram developed by domain experts, which was used to guide the *Food Chain* model-facilitated inquiry learning environment. HIMATT uses specific automated comparison algorithms to calculate similarities between a given pair of frequencies or sets of properties. The similarity index s for each of the seven measures results in a measure of $0 \leq s \leq 1$, where $s = 0$ is complete exclusion and $s = 1$ is complete similarity. Reliability scores for the HIMATT measures range from $r = .79$ to $r = .94$ (Pirnay-Dummer, et al., 2010). Convergent validity scores lies between $r = .71$ and $r = .91$ for semantic comparison measures and between $r = .48$ and $r = .79$ for structural comparison measures (Pirnay-Dummer, et al., 2010).

Based on the HIMATT measures, the dependent variable *complex learning* was identified as a combination of semantic and structural properties: PREP = (CCM+PPM)+(SFM*GRM*STM). The variable is reported for the pre-test ($PREP_{pre}$) and post-test ($PREP_{post}$) results. Based on previous research using the HIMATT measures, the aggregation of structural and semantic measures best reflects individual's problem representation as it includes strong weights of semantic complexity; however, does not neglect the overall structural components (Eseryel et al., 2013).

Repeated measures ANOVA analysis was conducted to examine change on *complex learning* measure both after challenge 1, after challenge 2, and after challenge 3 in the *Food Chain*. All the analyses were conducted with the Statistical Package for the Social Sciences (SPSS).

Results

Table 1 summarizes the descriptive statistics for the dependent variable (complex learning) for both model-using (MU) and model-building (MB) groups along the three challenges: (T1) simpler complex problem where none of the groups engaged in model-using or model-building activities but only went through the scientific inquiry process supported by the *Food Chain* simulation and intelligent question-prompts; (T2) a problem with mid-level complexity, where MU and MB groups engaged with corresponding model-facilitated activities; and (T3) very complex, environmental policy analysis problem, where MU and MB groups engaged with corresponding model-facilitated activities.

Table 1. Descriptive statistics for the complex learning measure

	Model-Using (MU) Group Mean (SD)			*Model-Building (MB) Group* Mean (SD)		
	T1	T2	T3	T1	T2	T3
Complex Learning	1.44 (0.89)	3.45 (0.49)	4.33 (1.16)	1.64 (1.04)	3.75 (0.89)	6.92 (1.30)

As seen in Table 1, participants in the MB condition had slightly higher mean scores than the participants in the MU condition in complex learning after the first challenge in the Food Chain, during none of the groups engaged with in model-using or model-building activities. However, the repeated measures ANOVA analyses did not indicate significant differences between the two groups in this dependent variable. This result indicated that the participants in both conditions were comparably on equal basis when they completed the first challenge following only the simulation-based inquiry learning.

The results of the multiple repeated measures (three inquiry challenges) ANOVA with between-subject factors (2 groups) for complex learning scores revealed that there were statistically significant differences between the two groups throughout the three challenges [$F(2, 237) = 42.66$, $p < .01$, $\eta2 = .53$]. In the post-hoc analysis, the third challenge was attributed to the significant interaction effect for the time and group $F(2, 237) = 49.86$, $p < .01$, $\eta2 = .57$. As shown in Table 3, MB group scores were higher in the third challenge than the MU group.

These findings supported the hypothesis that the proposed AI-based model-facilitated learning and assessment framework is effective in facilitating the development of systems thinking skills. Both model-building and model-using were effective in facilitating deep understanding of a complex lake ecology system. However, in highly complex problem-solving tasks, like environmental policy decision-making, model-building was more effective than model-using.

Discussion

In this era of rapid technological progress, AI has become a pivotal force in transforming organizational dynamics, particularly in the field of leadership. Recent leadership reviews suggest that as artificial intelligence becomes an integral part of workflows, decisions can no longer be considered isolated managerial actions; hence, artificial intelligence is increasingly conceptualized as a force multiplier of system complexity, rather than just a decision-making tool (Aziz et al., 2025). Thus, leaders must comprehend how algorithmic outputs impact organizational, social, and ethical systems. In this context, AI shifts leadership practice from linear problem-solving to holistic system sensemaking (Carlucci & Skaržauskienė, 2010). In other words, artificial intelligence emphasizes the crucial necessity of systems thinking skills for effective leadership that can deal with complex problem-solving situations in today's world that increasingly calls for dynamic decision-making (Qudrat-Ullah, 2025). Systems thinking emphasizes interdependence, feedback loops, nonlinearity, and unintended consequences. AI systems function precisely through these dynamics, often operating at speeds and scales surpassing human cognitive capabilities.

How do leaders develop such crucial systems thinking skills? This paper proposed an AI-based model-facilitated learning and stealth assessment framework to address the gap in the leadership literature. We investigated the effects of two different approaches within the proposed framework: (1) learning from models (i.e., system model-using); and (2) learning by modeling (i.e., system model-building). The findings suggest that while both approaches are effective in facilitating the development of learners' systems thinking skill, as the problem complexity increases, model-building is more effective than model-using.

One possible explanation of this finding could stem from the important role of cognitive regulation skills during complex problem solving (cf. Azevedo, Guthrie, & Seibert, 2004; Eseryel & Law, 2012b; Pieschl, Stahl, & Bromme, 2008). In a previous study, we had found a cross-lagged association between learners' understanding of complex systems and their cognitive regulation (Eseryel & Law, 2012a); furthermore, task complexity was found as an important determinant of the level of cognitive regulation skill that was required of the learner: the more complex the task is the more demand is placed on the learner for higher-levels of cognitive regulation skills (Eseryel & Law, 2012a). Hence, the findings of this study suggest that model-building serve as a more effective cognitive regulation scaffold during learning of complex systems and supports learners' mental model transition as they piece-by-piece discovered the interdependencies among the different species in the complex lake ecosystem in Food Chain. On the other hand, learners in the model-using group may be so cognitively overloaded by the complexity of the problem that even though they had access to the expert model they had not internalized it as their own mental models to be able to effectively respond to the highly complex problem scenario. It may also be possible that learners with misconceptions kept rejecting all or the parts of the expert model since it cannot be readily accommodated into their existing mental models due to their existing misconceptions (Ifenthaler & Eseryel, 2013; Piaget, 1985; Posner, Strike, Hewsn, & Gertzog, 1982; Vosniadou, 1994). Future research studies should investigate these issues further.

References

Alessi, S. (2000). Building versus using simulations. In J. M. Spector & T. M. Anderson (Eds.), *Integrated and holistic perspectives on learning, instruction, and technology: Understanding complexity* (pp. 175-196). Dordrecht: Kluwer Academic Publishers.

Aziz, M. F., Rajesh, J. I., Jahan, F., McMurray, A., Ahmed, N., Narendran, R., & Harrison, C. (2025). AI-powered leadership: A systematic literature review. *Journal of Managerial Psychology*, 40(5), 604-630.

Azevedo, R., Guthrie, J. T., & Seibert, D. (2004). The role of self-regulated learning in fostering students' conceptual understanding of complex systems with hypermedia. *Journal of Educational Computing Research, 30*(1), 87-111. doi:10.2190/DVWX-GM1T-6THQ-5WC7

Berliner, D. C. (2002). Learning about and learning from expert teachers. *International Journal of Educational Research, 35*(5), 463–482. doi:10.1016/S0883-0355(02)00004-6

Carlucci, D., Lerro, A., Skaržauskienė, A. (2010). Managing complexity: Systems thinking as a catalyst of the organization performance. *Measuring Business Excellence*, 14(4), 49-64. doi: https://doi.org/10.1108/13683041011093758

Chung, G. K. W. K., & Baker, E. L. (2003). An exploratory study to examine the feasibility of measuring problem-solving processes using a click-through interface. *Journal of Technology, Learning and Assessment, 2*(2), 3-29.

Clement, J. J., & Rea-Ramirez, M. A. (Eds.). (2008). *Model based learning and instruction in science* (Vol. 2). NY: Springer.

Davidsen, P. I. (1996). Educational features of the system dynamics approach to modelling and simulation. *Journal of Structural Learning, 12*(4), 269-290.

de Jong, T. (2006a). Computer simulations: Technological advances in inquiry learning. *Science, 312*, 532-533.

de Jong, T. (2006b). Scaffolds for computer simulaiton based scientific discovery learning. In J. Elen & R. E. Clark (Eds.), *In dealing with complexity in learning environments* (pp. 107-128). London: Elseiver.

Dörner, D. (1980). On the difficulties people have in dealing with complexity. *Simulation & Games*(11), 87-106.

Dörner, D. (1989). *Die logik des misslingens. Strategisches denken in komplexen situationen*. Reinbek: Rowohlt.

Dörner, D. (1996). *The logic of failure: Why things go wrong and what can we do to make them right* (R. Kimber & R. Kimber, Trans.). New York: Holt.

Dörner, D., Kreuzig, H. W., Reither, F., & Stäudel, T. (1983). *Lohhausen. Vom Umgang mit Unbestimmtheit und Komplexität. [Lohhausen. On dealing with uncertainity and complexity]*. Bern: Huber.

Ellis, K., Gregory, A., Mears-Young, B.R. and Ragsdell, G. (1995). *Critical issues in systems theory and practice*. New York, NY: Plenum Press.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data* (revised ed.). Cambridge, MA: The MIT Press.

Eseryel, D. (2006). *Expert conceptualizations of the domain of instructional design: An investigative study on the DEEP assessment methodology for complex problem-solving outcomes.* (Doctoral Dissertation). Retrieved from Dissertations and Theses database. (UMI No. 3241853)

Eseryel, D. (2015). Causal influence diagrams. In J. M. Spector (Ed.), *Encyclopedia of educational technology*. Thousand Oaks, CA: Sage Publications, Inc.

Eseryel, D., Ifenthaler, D., & Ge, X. (2013). Validation study of a method for assessing complex ill-structured problem solving by using causal representations. *Educational Technology Research & Development, 61*(3), 443-463. doi:10.1007/s11423-013-9297-2

Eseryel, D., & Law, V. (2010). Promoting learning in complex systems: Effect of question prompts versus system dynamics model progressions as a cognitive-regulation scaffold in a simulation-based inquiry-learning environment. In *Proceedings of the 9th International Conference of the Learning Sciences*. Chicago, IL.

Eseryel, D., & Law, V. (2012a). *Complexity, cognitive regulation, and understanding of a complex science system*. Paper presented at the Annual Meeting of the American Educational Research Association, Vancouver, British Columbia.

Eseryel, D., & Law, V. (2012b). Effect of cognitive regulation in understanding complex science systems during simulation-based inquiry learning. *Technology, Instruction, Cognition, & Learning, 9*(1-2), 111-132.

Feltovich, P. J., Coulson, R. L., & Spiro, R. J. (2001). Learner's (mis)understanding of important and difficult concepts. In K. D. Forbus & P. J. Feltovich (Eds.), *Smart machines in education: The coming revolution in educational technology* (pp. 349-375). Menlo Park, CA: MIT Press.

Feltovich, P. J., Spiro, R. J., Coulson, R. L., & Feltovich, J. (1996). Collaboration with and among minds: Mastering complexity, individually and in groups. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 25-44). Mahwah, NJ: Erlbaum.

Forrester, J. W. (1961). *Industrial dynamics*. Cambridge, MA: MIT Press.

Frensch, P. A., & Funke, J. (Eds.). (1995). *Complex problem solving: The European perspective*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Funke, J. (1989). *Komplexes problemlösen*. Berlin: Springer.

Funke, J. (1991). Solving complex problems: Exploration and control of complex systems. In R. J. Sternberg & P. A. Frensch (Eds.), *Complex problem solving: Principles and mechanisms* (pp. 185-222). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Gibbons, A. S. (2001). Model-centered instruction. *Journal of Structural Learning and Intelligent Systems, 14*(4), 511-540.

Gibbons, A. S. (2003). Model-centered learning and instruction: Comments on Seel (2003). *Technology, Instruction, Cognition, and Learning, 1*(3), 511-540.

Gomez, P. & Probst, G. B. J. (1987). *Vernetztes denken im management*. Bern: Die Orientierung.

Harel, I., & Papert, S. (1991). *Constructionism*. Norwood, NJ: Ablex.

Hmelo-Silver, C. E., & Pfeffer, M. G. (2004). Comparing expert and novice understanding of a complex system from the perspective of structures, behaviors, and functions. *Cognitive Science, 28*, 127-138.

Ifenthaler, D. (2010a). Relational, structural, and semantic analysis of graphical representations and concept maps *Educational Technology Research and Development, 58*(1), 81-97.

Ifenthaler, D. (2010b). Scope of graphical indices in educational diagnostics. In D. Ifenthaler, P. Pirnay-Dummer, & N. M. Seel (Eds.), *Computer-based diagnostics and systematic analysis of knowledge* (pp. 213-234). New York: Springer.

Ifenthaler, D., & Eseryel, D. (2013). Facilitating complex learning by mobile augmented reality learning environments. In R. Huang, J. M. Spector, & Kinshuk (Eds.), *Reshaping learning: The frontiers of learning technologies in a global context* (pp. 415-438). New York: Springer.

Ifenthaler, D., Masduki, I., & Seel, N. M. (2011). The mystery of cognitive structure and how we can detect it. Tracking the development of cognitive structures over time. *Instructional Science, 39*(1), 41-61. doi:10.1007/s11251-009-9097-6

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology Research & Development, 48*(4), 63-85. doi:10.1007/BF02300500

Jonassen, D. H. (2004). *Learning to solve problems: An instructional design guide*. San Francisco, CA: Pfeiffer.

Jonassen, D. H., & Cho, Y. H. (2008). Externalizing mental models with mindtools. In D. Ifenthaler, P. Pirnay-Dummer, & J. M. Spector (Eds.), *Understanding models for learning and instruction. Essays in honor of Norbert M. Seel* (pp. 145-160). New York: Springer.

Jonassen, D. H., Strobel, J., & Gottdenker, J. (2005). Model building for conceptual change *Interactive Learning Environments, 13*(1-2), 15-37.

Jonassen, D. H., & Wang, S. (1993). Acquiring structural knowledge from semantically structured hypertext. *Journal of Computer-Based Instruction, 20*(1), 1-8.

Kafai, Y. B. (2006). Constructionism. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 35-47). Cambridge, UK: Cambridge University Press.

Kafai, Y. B., & Resnick, M. (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Milrad, M., Spector, J. M., & Davidsen, P. I. (2002). Model facilitated learning. In S. Naidu (Ed.), *Learning and teaching with technology: Principles and practices* (pp. 13-27). London: Kogan Page.

Narayanan, N. H., & Hegarty, M. (1998). On designing comprehensible interactive hypermedia manuals. *International Journal of Human-Computer Studies, 48*, 267–301.

Ossimitz, G. (1990). *Materialien zur systemdynamik*. Wien: HPT.

Ossimitz, G. (1996). *Stand und perspektiven der forschung zum systemischen denken*. Wien: Holder-Pichler-Tempsky.

Ossimitz, G. (2000). *Entwicklung systemischen denkens*. München: Profil.

Palaima, T. & Skaržauskienė, A. (2010). Systems thinking in a complex world. *Baltic Journal of Management*, 5(3), 330 – 355. http://dx.doi.org/10.1108/17465261011079749

Piaget, J. (1985). *The equilibrium of cognitive structures*. Chicago: University of Chicago Press.

Pieschl, S., Stahl, E., & Bromme, R. (2008). Epistemological beliefs and self-regulated learning with hypertext. *Metacognition & Learning, 3*, 17-37.

Pirnay-Dummer, P., & Ifenthaler, D. (2010). Automated knowledge visualization and assessment. In D. Ifenthaler, P. Pirnay-Dummer, & N. M. Seel (Eds.), *Computer-based diagnostics and systematic analysis of knowledge* (pp. 77-115). New York: Springer.

Pirnay-Dummer, P., Ifenthaler, D., & Spector, J. M. (2010). Highly integrated model assessment technology and tools. *Educational Technology Research and Development, 58*(1), 3-18. doi:10.1007/s11423-009-9119-8

Posner, G., Strike, K. A., Hewsn, P. W., & Gertzog, W. A. (1982). Accomodation of a scientific conception: Towards a theory of conceptual change. *Science Education, 66*(2), 211-227.

Qudrat-Ullah, H. (2025). Integrating Systems Thinking and AI. In H. Qudrat-Ullah (Ed.). *Navigating complexity: AI systems thinking for smarter decisions* (pp. 39-68). Cham: Springer. https://doi.org/10.1007/978-3-031-82742-6_3

Seel, N. M. (2003). Model-centered learning and instruction. *Technology, Instruction, Cognition, and Learning, 1*(1), 59-85.

Seel, N. M. (2006). Mental models and complex problem solving. In J. Elen & R. E. Clark (Eds.), *Handling complexity in learning environments: Theory and research* (pp. 43-66): Elseiver, Ltd.

Seel, N. M., Al-Diban, S., & Blumschein, P. (2000). Mental models and instructional planning. In J. M. Spector & T. M. Anderson (Eds.), *Integrated and holistic perspectives on learning, instruction and technology: Understanding complexity* (pp. 129-158). Dordrecht: Kluwer Academic Publishers.

Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday.

Shute, V. L. (2015). Stealth assessent. In J. M. Spector (Ed.), *Encyclopedia of educational technology*. Thousand Oaks, CA: Sage Publications, Inc.

Snow, R. E. (1990). New approaches to cognitive and conative assessment in education. *International Journal of Educational Research, 14*(5), 455-473.

Spector, J. M. (2000). System dynamics and interactive learning environments: Lessons learned and implications for the future. *Simulation and Gaming, 31*(4), 509-516.

Spector, J. M. (2003). Problems with problem-based learning: Comments on model-centered learning and instruction in Seel (2003). *Technology, Instruction, Cognition, and Learning, 1*(4), 359-374.

Spector, J. M., Christensen, D. L., Sioutine, A. V., & McCormack, D. (2001). Models and simulations for learning in complex domains: Using causal loop diagrams for assessment and evaluation. *Computers in Human Behavior, 17*(5-6), 517-545.

Spector, J. M., & Koszalka, T. A. (2004). *The DEEP methodology for assessing learning in complex domains (Tech. Report No. NSF-03-542)* (NSF-03-542). Retrieved from Syracuse, NY:

Steed, M. (1992). STELLA, a simulation construction kit: Cognitive process and educational implications. *Journal of Computers in Mathematics and Science Teaching, 11*(1), 39-52.

Sterman, J. D. (1994). Learning in and about complex systems. *System dynamics review, 10*(2-3), 291-330.

van Joolingen, W. R., de Jong, T., Lazonder, A. W., Savelsbergh, E. R., & Manlove, S. (2005). Co-Lab: Research and development of an on-line learning environment for collaborative scientific discovery learning. *Computers in Human Behavior, 21*, 671-688.

Vosniadou, S. (1994). Capturing and modelling the process of conceptual change. *Learaning and Instruction, 4*, 45-69.

White, B. Y. (1993). ThinkerTools: Causal models, conceptual change, and science education. *Cognition and Instruction, 10*(1), 1-100.

World Economic Forum (2023). **The Future of Jobs Report 2023**. Geneva: World Economic Forum. https://www.weforum.org/publications/the-future-of-jobs-report-2023/