A Dual-Method Examination of Nursing Students' Teamwork in Simulation-Based Learning: Combining CORDTRA and Ordered Network Analysis to Reveal Patterns and Dynamics

Dual-Method Insights into Nursing Students' Teamwork in Simulation Learning

Mamta Shah
Elsevier
Philadelphia, Pennsylvania, USA
m.shah@elsevier.com

Yuanru Tan
University of Wisconsin-Madison
Madison, Wisconsin, USA
yuanru.tan@wisc.edu

Brendan Eagan
University of Wisconsin-Madison
Madison, Wisconsin, USA
beagan@wisc.edu

Brittny Chabalowski
Elsevier
Livingston, Montana, USA
b.chabalowski@elsevier.com

Yahan Chen
University of Wisconsin-Madison
Madison, Wisconsin, USA
chen2254@wisc.edu

Abstract

This study examines nursing students' teamwork during a simulated pediatric scenario by combining Chronologically Ordered Representations of Discourse and Tool-Related Activity (CORDTRA) with Ordered Network Analysis (ONA). CORDTRA revealed each dyad's progression and critical moments during the scenario, while ONA illustrated how roles were divided. Our findings show that patient and parent interactions, education, and assessments were typically shared between students, whereas technical tasks such as dosage calculations were led by one student with support from the other. These findings highlight the nuanced ways in which manikin-based simulations foster essential teamwork skills, such as communication, task delegation, and problem-solving. This study highlights the methodological benefit of integrating CORDTRA and ONA to capture both temporal and relational dynamics, along with the practical implication that targeted feedback and debriefing informed by these approaches can enhance nursing students' individual and team performance, and by extension their practice readiness.

CCS Concepts

• Education; • Social and Professional Computing; • Applied Computing;

Keywords

Learning Analytics, Ordered Network Analysis, Visualization Techniques, Nursing Education, Simulations, CORDTRA

ACM Reference Format:

Mamta Shah, Yuanru Tan, Brendan Eagan, Brittny Chabalowski, and Yahan Chen. 2025. A Dual-Method Examination of Nursing Students' Teamwork in Simulation-Based Learning: Combining CORDTRA and Ordered Network Analysis to Reveal Patterns and Dynamics: Dual-Method Insights into Nursing Students' Teamwork in Simulation Learning. In LAK25: The 15th International Learning Analytics and Knowledge Conference (LAK 2025), March 03–07, 2025, Dublin, Ireland. ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3706468.3706512

LAK 2025, Dublin, Ireland

ACM ISBN 979-8-4007-0701-8/25/03
https://doi.org/10.1145/3706468.3706512

1 Introduction

Higher education equips students with essential skills for their future professions, encompassing both domain-specific knowledge and professional competencies such as critical thinking, problemsolving, and communication. A recent meta-analysis underscores the efficacy of simulation-based learning in developing a wide array of professional skills across various fields, including medical education [1]. The study revealed substantial positive effects of simulations on technical performance, diagnostic capabilities, and problem-solving skills. However, teamwork skills, while showing improvement, demonstrated only moderate positive effects. This finding is noteworthy given the critical importance of collaboration in healthcare settings. The limited gains in teamwork skills from simulations may stem from methodological constraints [2]. In response to this challenge, a recent invitation for researchers and practitioners to embrace learning analytics (LA) in health professions education is timely [3]. In several recent studies, LA methods have aided researchers to construct models of learner behavior and cognition from multiple data sources obtained from simulated environments [4, 5]. Furthermore, scholars have applied multiple LA methods to generate visualizations of various grain sizes and provide a richer spectrum of interpretation on complex learning processes [6, 7].

This study builds upon these opportunities to examine how undergraduate nursing students engage in teamwork when participating in manikin-based simulations. Effective teamwork is an important marker of practice readiness for nurses because it directly impacts care quality, patient outcomes, and safety for both patients and healthcare professionals [8]. As nursing is moving in the direction of competency-based education, we operationalized teamwork using The Essentials: Core Competencies for Professional Nursing Education framework [9]. High-fidelity manikin-based simulations provide an ideal context for examining nursing students' performance because this simulation modality offers a close approximation of real-world clinical experiences, and aids students in practicing relational, communicative, and collaborative skills associated with teamwork [10]. To understand the dynamics in students' teamwork in a pediatric scenario, this study adopted a dual-method approach: Chronologically Ordered Representations of Discourse and Tool-Related Activity (CORDTRA) and Ordered Network Analysis (ONA). These two approaches have been widely used to study teamwork in collaborative learning practices.

2 Theory

2.1 Theoretical Framework: The Essentials

The Essentials comprises 10 domains of competency, along with leveled sub-competencies, applicable to entry-level and advanced-level nurses. By instituting this framework, nursing programs ensure students possess the expected cognitive, social and psychomotor readiness employers desire for patient care practice within and across spheres of care, the lifespan and population diversity. This study examined competencies across four domains for entry-level nurses: Person-Centered Care (2), Interprofessional Partnerships (6), Informatics and Healthcare Technologies (8), and Professionalism (9). Key competencies include engaging individuals with empathy and compassion (2.1), effective communication (2.2), clear team communication (6.1), applying team dynamics (6.2), leveraging team abilities (6.3), conflict management (6.4), using electronic tools (8.1), managing healthcare data (8.2), appropriate technology use (8.3), and demonstrating professional behavior (9.2). These competencies, combined with the performance objectives of the simulation scenario, informed the operationalization of four constructs; Interprofessional Communication (IPC), Intraprofessional Communication (ITC), Therapeutic Communication (TC), and Tool & Data Use (T&D), as detailed in Table 1.

2.2 Analytical Techniques: CORDTRA and ONA

Table 1: Codebook

Code	Definition	Example
Intraprofessional Communication (ITC)	Function and communicate as a team in executing plan of care	Jacqlyn, would you mind calling the lab for me and seeing if the blood culture came back . . .
Interprofessional Communication (IPC)	Communicate with members of the healthcare team in executing plan of care	So right now, her fever is at 103.5, so we wanted to get that down, but I only have orders for an ibuprofen tablet.
Therapeutic Communication (TC)	Engage with the individual in establishing a caring relationship. Employing a participatory approach to nursing care	OK, we'll turn off the big lights and we can use the dim lights in here, so that helps with the headache.
Tool & Data Use (T&D)	Use/refer to appropriate tools and/or generate data throughout the care process	Tom is referring to the Medical Administration Record as he continues to calculate the dosage.

Chronologically Ordered Representations of Discourse and ToolRelated Activity (CORDTRA) is a method for analyzing and visualizing interactions in collaborative learning environments [11]. CORDTRA labels data from various sources like chat logs, video recordings, and tool usage logs based on dimensions such as interaction type, participant role, tool use, or material engagement. These events are then plotted on a two-dimensional grid, with time on the horizontal axis and activity categories on the vertical axis. The resulting diagram displays multiple timelines simultaneously, with each event represented as a point. This multi-dimensional visualization allows researchers to observe parallel processes of interactions among students, instructors, materials, and tools. Grounded in sociocultural and situated learning theories, CORDTRA emphasizes the context-dependent nature of learning. It offers a unique approach to quantify, visualize, and interpret complex learning processes to gain insights into knowledge construction dynamics in technology-enhanced learning environments [12].

Ordered Network Analysis (ONA), on the other hand, quantifies and visualizes network data by transforming coded qualitative data into directed, weighted networks [13]. ONA tracks the order and strength of connections between codes, which are represented as nodes in a network graph. It begins by accumulating connections between codes at the line level (such as utterances), aggregating these connections over entire conversations, and projecting them into a two-dimensional space using dimensional reduction techniques. ONA generates network models at both individual and group levels, which helps compare patterns of interaction and assess how these patterns vary across individuals or groups. By

focusing on ordered co-occurrences, ONA provides a structured view of how coded interactions unfold over time.

2.3 Research Questions

CORDTRA and ONA have been applied independently in educational and professional settings, including classroom interactions, online discussions, problem-solving tasks, and project-based learning. Researchers are increasingly applying ONA in nursing education. For example, Zhao et al. [14] used ONA to analyze communication dynamics in high- versus low-performing nursing teams. Yan et al. [15] examined ordered behavior connections in manikinbased simulations, focusing on individual students' roles in group tasks. CORDTRA has been paired with Epistemic Network Analysis (ENA) to study nursing students' collaborative communication patterns in simulations, though ENA's undirected nature did not capture directional discourse connections [16]. This paper builds on these studies by exploring the benefits of combining CORDTRA's temporally ordered visualizations with ONA's quantification of behavioral connections. Together, these methods provide a comprehensive approach to answer two research questions: (1) What patterns emerge in nursing student dyads' teamwork during a pediatric simulation scenario? (2) How do students in a dyad function as a team in a pediatric simulation scenario?

3 Methods

This paper reports findings for eight students who completed a pediatric scenario (PED12) in pairs using manikin-based simulations at a private institution in southwestern United States in Fall 2022. Dyad 1 comprised Alicia and Jessica, Dyad 2 included Tom and Nina, Dyad 3 was formed by Jacqlyn and Ivanka, and Dyad 4 encompassed Nancy and Katelyn (all pseudonyms).

3.1 Simulation Scenario

The purpose of PED12 is to provide students with the opportunity to conduct a focused neurologic assessment for a pediatric patient, administer antibiotics, educate parents on information resources, and ensure patient safety by preventing a medication error. Mandy Rhodes, a 4-year-old Caucasian female, is admitted to the pediatric unit with a fever and possible bacterial meningitis. She is placed on droplet isolation, blood was drawn, and a head CT scan and lumbar puncture were completed. Her frightened mother has been searching the Internet looking for information about meningitis. The scenario takes place Friday at 1600. The scenario has five main objectives: (a) provide patient-centered care through communication and parent education on reliable resources; (b) collaborate with the health care team to prevent a medication error; (c) apply standards of care for a pediatric patient with possible bacterial meningitis by recognizing abnormal findings and administering antibiotics; (d) ensure safety by maintaining isolation, utilizing proper medication administration techniques, and reporting near misses or errors; and (e) evaluate factors influencing care quality by recognizing the risk of medication errors and assessing the patient's response to interventions. A nursing lab manager oriented each dyad to the simulation space and scenario objectives at the start of their respective sessions. She also provided a nurse's hand-off to the dyads, provided a voice-over for Mandy and role-played other parts (e.g., pharmacist, provider). The instructor for Pediatric Health Theory and Application + Practicum at the participating institution role played as the patient's mother.

3.2 Transcript, Codebook, and Data Analysis

A 140-minute video capturing the four dyads' participation was transcribed using manual and automated methods, with utterances segmented at natural pauses. The 1466-line dataset included metadata for speaker (e.g., student name), modality (dialog, action), phase (nurse hand-off and orientation, scenario), and student pair
(e.g., Jacqlyn & Ivanka). Codes for the data were informed by the AACN Essentials and binary coding was applied using social moderation (see Table 1). We analyzed the data qualitatively to examine students' utterances using CORDTRA diagrams, generated using Microsoft Excel. CORDTRA visualized the progression of teamwork across utterances (X-Axis) and allowed comparisons of dyads by activity distribution (Y-Axis). We used the ONA R package to generate ONA network graphs [17]. In our study, speakers' utterances were treated as lines, with each speaker within a dyad serving as a unit of analysis, resulting in an individual ONA network for each speaker. In addition to creating an ONA network for each speaker, we also created an ONA difference network for each dyad. Conversations were defined as combinations of dyad and phase to capture co-occurrences between students within the same dyad, reflecting the actual experimental conditions. A stanza window size of ten lines was chosen to accumulate connections, as this configuration yielded the highest variance in the ONA model after testing various sizes. Codes in Table 1 were served as nodes in the resulting ONA network graphs.

4 Results

For each dyad, we describe what patterns emerged in their teamwork (RQ1) and how students in a dyad function as a team in the pediatric simulation scenario (RQ2) by interpreting CORDTRA diagrams and ONA graphs.

4.1 Dyad 1

Figure 1a is a CORDTRA diagram showing that Dyad 1 began their simulation experience by reviewing the patient's Electronic Health Record (EHR) and their notes (T&D) as they received a nurse's handoff. They proceeded to interact with the patient and mother and perform assessments (T&C). The highlight event of Dyad 1's teamwork is visible between utterances 60-80 where this dyad recognized a medication error (T&D), informed the mother about it (TC) and promptly took action to address it (IPC) while supporting one another with relevant information (ITC). Their participation for the remainder of the simulation was mainly centered on caring for the patient (TC) in collaboration with each other (ITC).

Overall, Dyad 1 had 24 utterances of T&D (11 dialogs, 13 actions). These were associated with drug classification and dosage ("Ok so we have cefotaxime every 6 hours first dose now"). The dyad had 9 utterances of IPC, 8 of which involved a dialog to prevent the medication error ("OK, so she has an order for cefotaxime 850 mg IV..But you sent me. Cefa…cefa….what's the other one? Ceftriaxone"). 21 utterances of ITC were recorded for Dyad 1, of which 18 were about (a) confirming orders ("Yep. I have the same thing"), (b) going over the assessments ("Did you do your H's?..And then you checked PERRLA.."), and (c) discussing an intravenous (IV) tubing issue ("This tubing won't prime"). ITC actions involved students reviewing the EHR together and offering support to inspect the IV tubing. Lastly, 38 utterances of TC were documented for Dyad 1, of which only 3 were actions intended to comfort the patient (Jessica turned off the lights). Over 35 dialog utterances of TC, Dyad 1 introduced themselves and informed the patient and mother about the assessments, sought the patient's consent to perform the assessments, and communicated with the mother about the medication error.

As shown in Figure 1b, Alicia's ONA network (green, left) features TC with the largest node size and self-connection circle, while IPC is absent. In contrast, Jessica's network (blue, right) shows both TC & IPC with relatively large nodes. This indicates that, while both Alicia and Jessica communicated with the patient and her mother, Alicia tended to engage predominantly in inward-facing or between-nurse activities such as sharing assessment duties (ITC). Jessica, on the other hand was more outward-facing through her engagement in the nurse-doctor communication (IPC). Additionally, in their difference network (blue-green, center), a dual-colored edge between ITC and TC is evident. This shows that Alicia has a stronger connection from TC to ITC compared to Jessica, indicating a pattern where Alicia engaged with patients and parent first and then communicated with her partner. Such outward-facing and inward-facing characteristics of Alicia and Jessica demonstrate that they embraced distinct but complementary roles to meet multiple goals of the scenario.

4.2 Dyad 2

Figure 2a demonstrates that Dyad 2 started their simulation by noting and referring to patient information (T&D) and they continued to do so throughout the session. Their care process was mostly characterized by dyadic (nurse-child) and triadic (nurseparent-child) communications (TC). The highlight event of Dyad 2 built up gradually from utterance ~135 as the team got caught up in calculating medication dosage (ITC) culminating at about utterance ~185 as a hopeful attempt to call the health care provider for clarification (IPC). Dyad 2 had 20 utterances of T&D, of which 7 were dialogs to assure the mother the prescribed medication would not interfere with the patient's allergies ("Let me. . .check the MAR. . . to see what the doctors put in"); and, discussing dosage calculations ("So there's 850 milligrams in the bag and there's 50 [milligrams], so that's her weight."). 13 T&D actions were documented such as taking notes during nurse's handoff, verifying doctor's orders on the MAR, and using the EHR & Medical Administration Record (MAR) as sources of information to aid in dosage calculation. Only 1 instance of IPC was recorded for Dyad 2. This was an action, when Tom proceeded to call the healthcare provider for clarifying the orders before the dyad administered the antibiotic medication to the patient. This dyad engaged in 40 utterances of ITC. 34 of these were dialogs associated with role distribution ("And while he's doing that, is it OK if I assess Mandy?", coordinating next steps ("Perfect. Do we want to maybe hang the antibiotics then?") and thinking aloud while calculating dosage ("I don't know if I'm just doing math wrong. . .so maybe we should call the doctor just to clarify the order"). The remaining utterances of ITC were 6 actions centered on the issue of calculating the right dosage (Tom is going over his calculation with Nina). Dyad 2 engaged in 64 utterances of TC. Of these, 58 utterances were dialogs focused on establishing rapport with the patient ("Oh, your birthday just passed. How old did you turn?"), explaining their care process ("We're going to be monitoring her and assessing her and seeing.. if we need to kind of adjust our course.."), responding to the mother's concern ("I know there's a wealth of information online.. but it's good to ask those

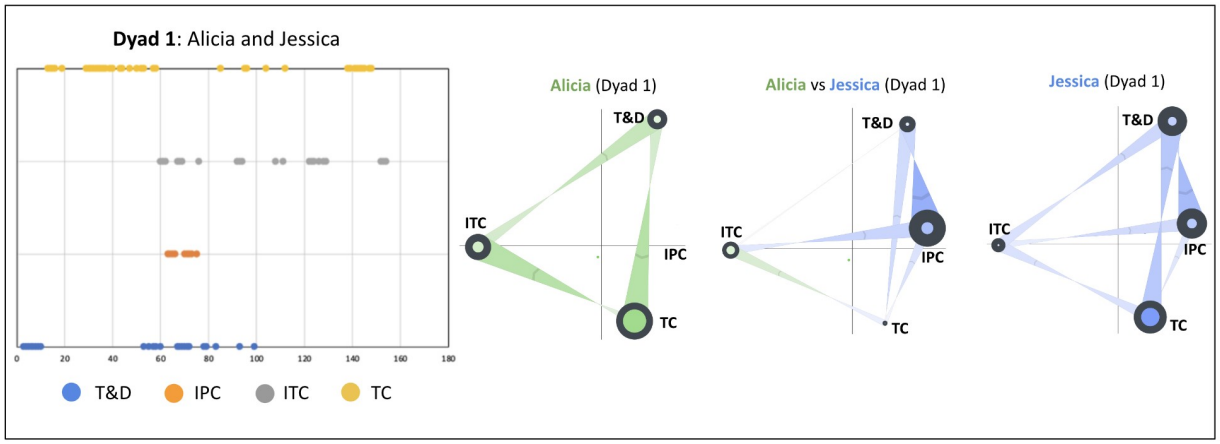

Figure 1: (a) CORDTRA Diagram and (b) ONA Plots for Dyad 1.

questions just for clarification..”), seeking consent (“I’m gonna move your Barbie over, is that OK?”), acknowledging medical history (“I know she does have the allergy to azithromycin..”). 6 actions of TC were mostly focused on reducing patient discomfort (Nina raises the back of Mandy’s bed).

The ONA graphs in Figure 2b shows that Tom in Dyad 2 engaged predominantly in inward-facing communication through ITC while showing limited use of IPC. This is reflected in Tom’s network (pink, left), where ITC has a large node size and IPC has a very small node size. In contrast, Nina’s network (cyan, right) features TC as the only node with a noticeably large size. Specifically, this node forms relatively fewer connections with other nodes but shows more self-connections, as indicated by its colored circle. Unlike Alicia and Jesica of Dyad 1, both Tom and Nina were in-ward facing.

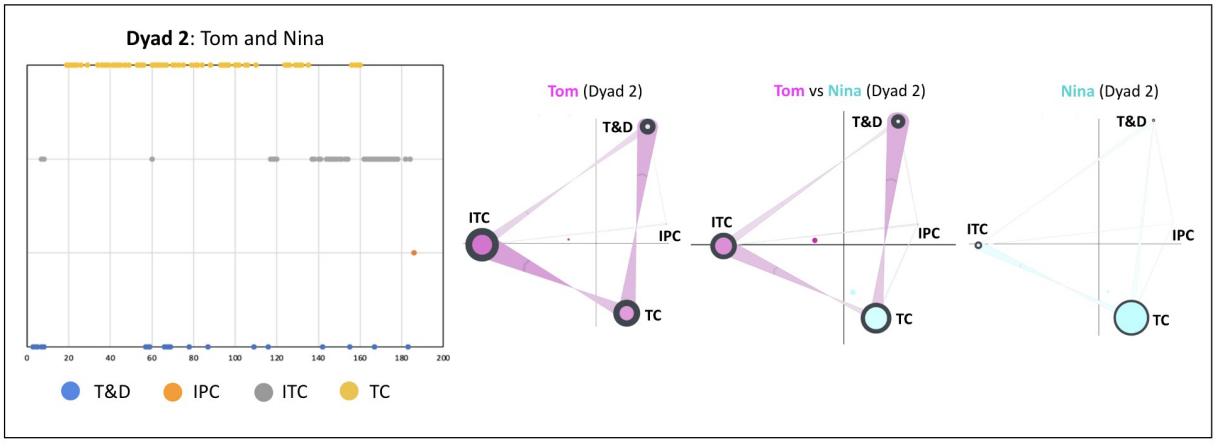

Figure 2: (a) CORDTRA Diagram and (b) ONA Plots for Dyad 2.

Even as Nina focused predominantly on the compassionate aspect of patient care (TC) and Tom filled up the more technical part of practice (T&D), they both leaned on each other’s support (ITC).

4.3 Dyad 3

Figure 3a shows Dyad 3 engaged in T&D and TC throughout the scenario. Utterances of ITC are sparse, and they mostly occur in the second half of their time in the session. Dyad 3, like Dyad 1 and Dyad 2 engaged in unique IPC event; that is, to ensure the patient was given medication in liquid form for her fever. For Dyad 3, 42 utterances of T&D were recorded, of which 16 were dialogs and 26 were actions. Most interactions were intended to provide and seek relevant information from the mother. For instance, “..So yeah, so azithromycin is a macrolide, so we’re going to want to give her a Cephalosporin..” Actions supported the dialogs by way of documenting and checking assessment notes, referring to the drug classification book, and looking for information on the EHR and MAR. For IPC, 20 utterances were recorded for Dyad 3. All 3 actions were phone calls to distinct members/sections of the healthcare team- lab, pharmacy, physician. The remaining 17 utterances of IPC were dialogs seeking an update on the patient’s lab reports (“Hi…I’m wondering if the blood culture results are back for the patient in room 1..”) and coordinating a liquid medication for fever reduction on the request of the mother (“She has pharmacy orders for .. ibuprofen, 170 milligrams orally, but it is a tablet. . .Mom said that she’s not going to be able to take the tablet form”). 11 utterances of ITC were observed for Dyad 3, the fewest recorded across all dyads for this construct of teamwork. Of these, 7 were actions of affirmation and support (Jacqlyn is standing alongside Isabella as the latter speaks with the physician). The 4 dialog utterances centered on informing the patient about nurses’ roles (“Alright, so Jacqlyn is gonna do some assessments if that’s OK with you, Mandy”) and delegating tasks (“Jacqlyn, would you mind calling lab for me and seeing if the blood culture came back..”). Lastly, 60 utterances of TC were recorded for Dyad 3. 5 of these were actions intended to comfort the patient (Jacqlyn places the cold pack under Mandy’s neck). Dialogs with the patient centered on establishing rapport, performing assessments, seeking consent, responding to questions, and providing comfort. For instance, “Oh no, this is not a shot. I’m just going to take your temperature really quick, OK?” Interactions with the mother were aimed at verifying information, responding to her questions, educating her, and offering assurance of quality care. For instance, “[We] definitely want to make sure that we’re giving her something that will fight that specific infection.” As shown in Figure 3b, both Jacqlyn and Ivanka demonstrate highest engagement with T&D and TC, as shown by the large node sizes for these nodes and the strong connections between them. Specifically, as indicated by the chevron, Jacqlyn’s network (brown, left) shows a stronger connection from TC to T&D, while Ivanka’s network (purple, right) shows the reverse pattern. Although the difference is subtle (brown-purple, center), it might suggest that Jacqlyn used information gained through patient communication to inform their tool and data use, whereas Ivanka utilized information from tools and data to enhance their communication with patients. Unlike members of Dyads 1& 2, Jacqlyn and Ivanka mostly engaged in their roles in the simulation independent of each other’s support.

4.4 Dyad 4

Figure 4a demonstrates that Dyad 4 also engaged in T&D and TC throughout the scenario like Dyad 3. Like Dyads 2 and 3, instances of IPC occurred towards the end for Dyad 4; however, unlike all dyads, Dyad 4 engaged in ITC throughout the scenario. They logged 46 utterances of T&D, the most recorded across all dyads for this construct of teamwork. Dialogs enabled the students to assure the mother of patient well-being and safety ("So the medications for azithromycin that we are going to avoid are like a Clindamycin, amoxicillin, amoxil..So those are going to be out of the question for us."). This dyad also referred to patient data to discuss conditions of administering fever medication ("We can do Tylenol or Ibuprofen if [the temperature] is over 102.."). 18 utterances of IPC were recorded for Dyad 4 during a phone call to the provider. Over 16 dialog utterances, Dyad 4 verified the doctor's orders for the antibiotic treatment for treating suspected bacterial meningitis and how it had to administered (e.g., "And do you just want it with the 56 that we have going right now. . .IV piggyback?"). Dyad 4 engaged in 86 utterances of ITC, the most that were recorded across all dyads for this construct of teamwork. Over 74 dialog utterances, Dyad 4's discussions centered on administering the antibiotic ("So we're going to be doing 850 milligrams of that antibiotic for her"). Dyad 4 also recorded the most utterances for TC (70 dialogs, 7 actions). Conversations were centered on walking the patient and mother through every aspect of care (assessments, information, comfort, decisions and procedures). For instance, "But I do know that the antibiotics will be given an IV for her. So. what we'll do is we're going to hang it up along with that other bag and it will go through the tube into her."

As shown in Figure 4b, this dyad also demonstrated a clear distinction between outward-facing and inward-facing roles. Katelyn's network (red, left) features a large node size for ITC, with a prominent self-connection circle, indicating a strong focus on continuous interaction with her partner. Specifically, T&D is the only node with a relatively strong connection to ITC, and the strength of this connection from T&D is greater than the reverse. This suggests that Katelyn often solicited information from tools and data before communicating with her colleague. In contrast,

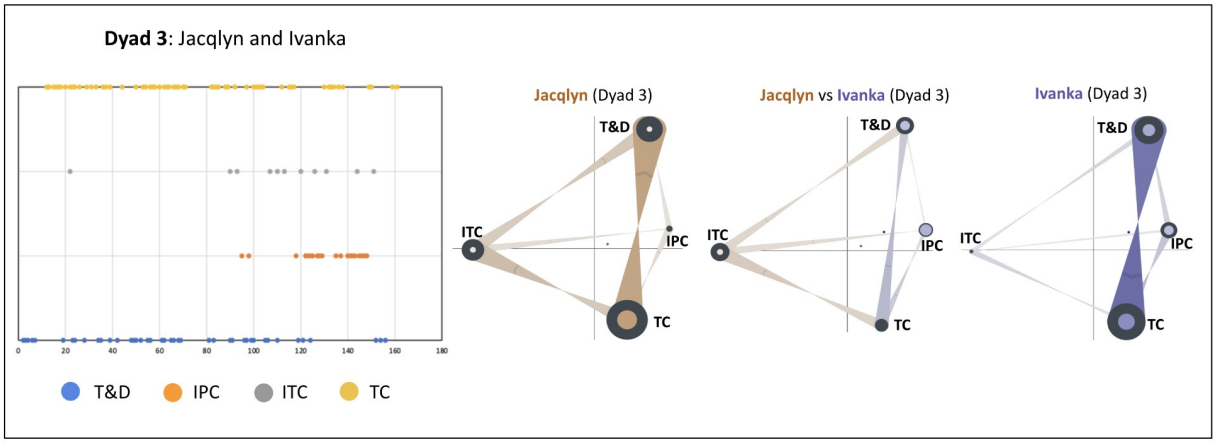

Figure 3: (a) CORDTRA Diagram and (b) ONA Plots for Dyad 3.

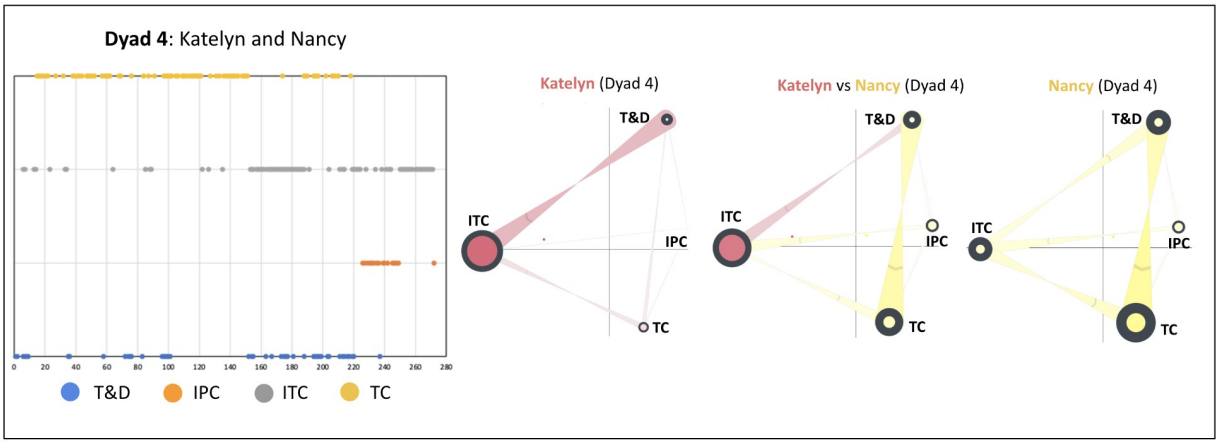

Figure 4: (a) CORDTRA Diagram and (b) ONA Plots for Dyad 4.

Nancy (yellow, right) engaged in ITC, but not to the extent that Katelyn did. Instead, Nancy's network shows a more balanced weights distribution, with relatively similar node sizes across all four codes and slightly more connections from T&D to TC. This indicates that while Katelyn primarily focused on working closely with her partner, Nancy also communicated with the external team members (IPC) and used information (T&D) to nurture caring relationships with patients and their family (TC).

5 Discussion and Conclusion

Building upon the demonstrated benefits of applying dual-methods to study complex learning processes [6-7], this study combined CORDTRA and ONA to analyze nursing students' teamwork during a pediatric scenario. By integrating these methods, we demonstrated how temporal and relational aspects of teamwork can be analyzed comprehensively, revealing nuanced patterns critical for healthcare practice readiness. Students exhibited competencies such as communication, task delegation, and problem-solving, offering insights into how simulation fosters collaborative skills. For researchers, this dual-method approach enables the study of teamwork dynamics across disciplines and simulation scenarios, with potential applications in real-time analytics and automated visualization tools. For educators, it emphasizes the importance of targeted debriefing informed by detailed analyses, offering evidence-based strategies for improving teamwork competencies. This aligns with competency-based education frameworks like the AACN Essentials [9], providing tools to assess and strengthen collaborative skills. While the small sample size (eight students) limits generalizability, this study's strength lies in its methodological contribution. By linking observed teamwork patterns to professional competencies, this study offers a foundation for future research connecting teamwork behaviors to measurable learning outcomes. Expanding this methodology to larger cohorts and integrating it with summative assessments will provide a deeper understanding of how simulations impact learning. Additionally, incorporating real-time analytics could enable adaptive feedback during simulations, further enhancing their educational value. Ultimately, simulation-based learning holds transformative potential to advance nursing education, improve teamwork in healthcare, and contribute to better patient outcomes, quality, and safety [2, 10, 14-15].

Acknowledgments

This work was funded in part by the National Science Foundation (DRL-2100320, DRL-2201723, DRL-2225240), the Wisconsin Alumni Research Foundation, and the Office of the Vice Chancellor for
Research and Graduate Education at the University of WisconsinMadison. The opinions, findings, and conclusions do not reflect the views of the funding agencies, cooperating institutions, or other individuals.

References

[1] Chernikova, O., Heitzmann, N., Stadler, M., Holzberger, D., Seidel, T., & Fischer, F. 2020. Simulation-Based Learning in Higher Education: A Meta-Analysis. Review of Educational Research, 90(4), 499-541.
[2] Saragih, I. D., Suarilah, I., Hsiao, C. T., Fann, W. C., & Lee, B. O. 2024. Interdisciplinary simulation-based teaching and learning for healthcare professionals:
A systematic review and meta-analysis of randomized controlled trials. Nurse Education in Practice, 103920.
[3] Hibbard, S. T., McClure, J., & Kellogg, S. 2024. Embracing learning analytics in health professions education. New Directions for Teaching and Learning (pp.1-10).
[4] Everett-Thomas, R., Joseph, L., & Trujillo, G. 2021. Using virtual simulation and electronic health records to assess student nurses' documentation and critical thinking skills. Nurse education today, 99, 104770.
[5] Rochlen, L. R., Putnam, E. M., Tait, A. R., Du, H., & Popov, V. 2023. Sequential Behavioral Analysis: A Novel Approach to Help Understand Clinical DecisionMaking Patterns in Extended Reality Simulated Scenarios. Simulation in Healthcare, 18(5), 321-325.
[6] Lund, K., Quignard, M., & Shaffer, D. W. (2017). Gaining insight by transforming between temporal representations of human interaction. Journal of Learning Analytics, 4(3), 102–122.
[7] Nath, D., Gasevic, D., Fan, Y., & Rajendran, R. 2024. CTAM4SRL: A Consolidated Temporal Analytic Method for Analysis of Self-Regulated Learning. In Proceedings of the 14th Learning Analytics and Knowledge Conference (pp. 645-655).
[8] Husarek, K., Loborec, V., Čunović, M., Ilić, P., Krajačić, J., & Smrekar, M. 2024. Factors Related to Effective Teamwork Performance in Nursing: Narrative Literature Review. Croatian Nursing Journal, 8(1).
[9] American Association of Colleges of Nursing. 2021. The essentials: Core competencies for professional nursing education.
[10] Handeland, J. A., Prinz, A., Ekra, E. M. R., & Fossum, M. 2021. The role of manikins in nursing students' learning: A systematic review and thematic metasynthesis. Nurse Education Today, 98, 104661
[11] Hmelo-Silver, C. & Jeong, H. 2021. An overview of CSCL methods. International handbook of computer-supported collaborative learning, 65-83.
[12] Hong, D., Chakraburty, S., Zou, X., Chen, Y., & Hmelo-Silver, C. E. 2023. Visual Representations for Studying Collaborative Inquiry. Interdisciplinary Journal of Problem-Based Learning, 17(2).
[13] Tan, Y., Ruis, A. R., Marquart, C. L., Cai, Z., Knowles, M., & Shaffer, D. W. 2023. Ordered network analysis. In Advances in Quantitative Ethnography: 4th International Conference, ICQE 2022
[14] Zhao, L., Tan, Y., Gašević, D., Shaffer, D. W., Yan, L., Alfredo, R., … & MartinezMaldonado, R. 2023. Analyzing Verbal Communication in Embodied Team Learning Using Multimodal Data and Ordered Network Analysis. In International Conference on Artificial Intelligence in Education (pp. 242-254). Cham: Springer Nature Switzerland.
[15] Yan, L., Tan, Y., Swiecki, Z., Gašević, D., Williamson Shaffer, D., Zhao, L., … & Martinez-Maldonado, R. 2023. Characterizing individual-level collaborative learning behaviors using ordered network analysis and wearable sensors. In International Conference on Quantitative Ethnography (pp. 66-80). Cham: Springer Nature Switzerland.
[16] Shah, M., Chabalowski, B. & Eagan, B. 2024. Examining Nursing Students' Communication and Collaboration Patterns in Manikin-Based Simulations. Poster presented at the 6th International Conference on Quantitative Ethnography. Philadelphia, PA, November 3-7, 2024
[17] Marquart, C., Tan, Y., Cai, Z., Shaffer, D.W.: Ordered network analysis. 2022. https://epistemic-analytics.gitlab.io/qe-packages/ona/cran/