

# **Advancing Educational Assessment Through Network Models: Insights from an Introductory Computer Science Course**

*Application for 2023-2024 Graduate Research and Creativity Activity (GRACA) Grant*

*Doctoral Student: Saiteja Malisetty; Faculty Mentor: Dr. Hesham H. Ali*

*College of Information Science and Technology*

## **Project Description**

### **Description of Project**

In today's ever-changing world of education, finding better ways to assess students is crucial for understanding and advancing their learning experiences [1]. Traditional approaches to educational assessment often struggle to capture the intricate factors influencing learning outcomes [2-5]. It is in this context that network models, widely used in various disciplines like social sciences, biology, and information technology, emerge as a promising approach for advancing educational assessment [6-10]. The application of network models in education offers a transformative perspective that allows for a more comprehensive understanding of student interactions, collaborations, and performance within the educational ecosystem. In today's data-driven education era, network models provide an unprecedented opportunity to reveal hidden patterns, optimize educational strategies, and elevate the quality of education.

The motivation behind integrating network models into educational assessment lies in their ability to uncover the complex, interconnected relationships that underlie learning [7, 8]. Traditional assessment methods often focus on measuring individual knowledge and skills, overlooking the broader aspects of student engagement [3,4]. Traditional statistical methods may fall short in capturing the multifaceted relationships and interactions within a learning ecosystem [11]. Network models offer a dynamic and holistic perspective, aligning with the evolving nature of education and the importance of understanding not only learning outcomes but also the process of learning [12]. Network models also provide a dynamic view of education by considering not only academic achievements but also the social and interactive aspects of learning. This holistic perspective aligns with the modern educational paradigm, emphasizing not just what students know but also how they engage with content, peers, and instructors.

The application of network models in educational assessment represents a shift from static, linear evaluation to dynamic, interconnected perspectives. Historically, educational assessment primarily focused on evaluating individual knowledge and skills, neglecting the broader context of learning [3]. Network models introduce a transformative dimension to assessment by recognizing the interconnected nature of learning. They acknowledge that students are not isolated entities but integral parts of a dynamic network within the educational environment. This shift aligns with the broader goals of contemporary education, emphasizing not only learning outcomes but also the process of learning [13].

Network models offer the potential to uncover hidden patterns and identify influential factors within the learning network. This innovative approach opens doors to personalized learning pathways, early intervention for struggling students, and the optimization of course components to foster a supportive learning environment. By harnessing the power of network models, educators and institutions can adapt their practices to meet the evolving needs of students in the digital age, ultimately advancing the quality of education and preparing learners for the challenges of an interconnected world.

The selection of the CIST 1400 dataset for our project is driven by its unique suitability as a rich source of educational data within the College of Information Science and Technology at UNO. This dataset, centered around the introductory computer science course, offers an exceptional opportunity to showcase the application of network models in educational assessment. With its diverse set of course components, such as Challenge activities, Many Small Programs, Quizzes, Recitations, and participation grades, the CIST 1400 dataset encapsulates the complexity of modern educational environments. These components represent various facets of the learning journey, including individual assignments, collaborative efforts, and student engagement. Lastly, the availability of data for both in-person and online course formats enables a comparative analysis, allowing us to explore potential differences in the impact of course components

across these delivery modes. This dataset presents a unique opportunity to apply network models to educational assessment within the context of introductory computer science, furthering our understanding of how these models can advance the quality of education in this domain.

### Research Questions

Our research questions are rooted in understanding student performance within the introductory computer science course, CIST 1400, and utilizing network models for analysis:

1. **Impact of Course Components:** Our primary research question revolves around the exploration of which course components wield the most significant influence on students' final grades in CIST 1400, using network-based parameters. Additionally, we aim to distinguish how these impacts diverge when comparing in-person and online course formats.
2. **Distinguishing High and Low Performers:** Leveraging network models, we aspire to differentiate between the best-performing students and those who underperform, both in the in-person and online formats. We intend to delve into the implications of these distinctions, seeking insights into what sets apart high achievers from their peers.
3. **Course Component Associations:** Another focal point of our research involves identifying which course components, as assessed by network-based parameters, exhibit stronger associations with student performance in each format. This inquiry is poised to inform curriculum design and pedagogical strategies tailored to advance student learning experiences.
4. **Tailoring Educational Strategies:** Building on our findings, we will explore the potential for tailoring course components based on the outcomes of network analysis. Our goal is to optimize student learning journeys, leveraging network models to adapt and personalize educational strategies effectively.

### Methodology

This research project employs a comprehensive methodology that integrates data collection, network modeling, analysis, and interpretation to address the research questions posed. Our approach is structured and iterative, ensuring rigor and depth in the investigation.

1. **Data Collection:** The foundation of this project is the collection of data from the introductory computer science course, CIST 1400. We will gather relevant information pertaining to course components, student grades, and demographic details. Data will be collected for both the in-person and online course formats, enabling comparative analysis.
2. **Data Preprocessing:** The collected data will undergo rigorous preprocessing, encompassing cleaning, formatting, and transformation. This phase is essential to ensure data consistency and readiness for analysis. It includes addressing missing values, outliers, and data normalization.
3. **Network Modeling:** Network models will be constructed using the preprocessed data. This phase involves creating networks that represent the relationships and interactions between course components, students, and their performance metrics. Network-based parameters like Jaccard similarity, modularity, and clustering coefficient will be employed to capture these relationships.
4. **Analysis and Interpretation:** Network models will serve as the basis for our analysis. We will employ various network analysis techniques to address our research questions. This includes assessing the impact of course components on student performance, distinguishing high and low performers, identifying course component associations, and exploring opportunities for tailored educational strategies.
5. **Summarization and Reporting:** The research findings will be meticulously summarized and reported. Visualizations and statistical analyses will aid in presenting the outcomes. We will translate network analysis results into actionable insights for educational practitioners and curriculum designers.

## Project Timeline

Dates	Research Activities
Spring 2024	Complete an in-depth literature review on current Assessment methods in Education.
May 2024	Data Collection and Preprocess the data including cleaning, formatting, and transforming.
June 2024	Construct Network Models and identify the key patterns from the networks.
July 2024	Summarize and interpret research findings based on network analysis.
August 2024	Finalize the research report and prepare for the UNO Research and Creative Activity Fair

## Student/Faculty Mentor Roles

*Doctoral Student:* Saiteja Malisetty, a doctoral student in the College of Information Science & Technology, is actively involved in a collaborative research project with Dr. Hesham H. Ali. In this project, Saiteja is responsible for collecting, analyzing, and interpreting data from the introductory computer science course, CIST 1400. His tasks include preparing the data for analysis, build network models and using network-based parameters like Jaccard similarity and modularity to analyze the network models, and documenting the research findings. He will also present the research at the UNO Research and Creative Activity Fair in March 2025.

*Faculty Member:* Dr. Hesham H. Ali, a distinguished Professor of Computer Science and Director of the University of Nebraska Omaha (UNO) Bioinformatics Core Facility, serves as Saiteja's faculty mentor. Dr. Ali, who is also Saiteja's doctoral supervisor and dissertation chair, plays a pivotal role in guiding and mentoring Saiteja throughout the research project. He oversees the project's progress, assists in formulating research questions, and ensures the research maintains high quality standards. Dr. Ali's extensive expertise in computational approaches, graph theory, and network models, greatly enriches the depth and scope of the research.

## Previous Internal Funding:

I was a recipient of a GRACA award in 2021 for my project, "New Assessment Approaches Using Population Analysis for Simulation-Based Medical Training: A Pilot Study with a Focus on Complex Surgical Skills" [14]. Dr. Ali also served as my mentor for this project. I also presented the project in the 2022 student research and creativity activity fair. Our Current project differs from the previously funded projects in the following aspects.

- Shift in Research Domain:** Unlike my previous funded project that primarily focused on simulation-based medical training and assessment of complex surgical skills, this project represents a significant departure in terms of research domain. We are shifting our attention from the medical field to the realm of computer science education. This transition reflects our commitment to applying advanced network modeling techniques to diverse educational contexts, showcasing our adaptability and versatility in research.
- Educational Assessment vs. Medical Training:** While my previous project is primarily concerned with assessing the progress and skills of medical trainees, the current project is centered around educational assessment within the context of an introductory computer science course (CIST 1400). This change in focus underscores our intention to investigate how network models can offer insights into student performance, curriculum design, and pedagogical strategies within the field of computer science, providing a fresh perspective on educational research.
- Broader Applicability:** The shift from medical training assessment to educational assessment highlights the broader applicability of network analysis techniques. In this project, we aim to uncover the impact of various course components on student performance, identify patterns among high and low performers, and explore how different formats (online and in-person) influence student outcomes. These research questions extend beyond the medical training context, demonstrating the versatility of network models in addressing diverse research inquiries and contributing to the advancement of educational assessment methodologies.

## Budget Justification

I'm requesting stipend of \$5,000, which is essential to support my full-time engagement in this research project over the summer, which is estimated to require approximately 450 hours of dedicated work. This financial support covers living expenses during this intensive research period, allowing for a high level of focus and dedication.

Budget Item	Description	Cost
Stipend	The stipend will cover the living cost for the summer. This project is estimated at 450 hours for completion.	\$5,000

## References

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6. Malisetty, S., Ali, H. H., Rastegari, E., & Siu, K. C. (2023). An Innovative Comparative Analysis Approach for the Assessment of Laparoscopic Surgical Skills. *Surgeries*, 4(1), 46-57.
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8. Thelagathoti, R. K., & Ali, H. H. (2022). The Comparison of Various Correlation Network Models in Studying Mobility Data for the Analysis of Depression Episodes. In *BIOSIGNALS* (pp. 200-207).
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12. Risku, H., Windhager, F., & Apfelthaler, M. (2013). A dynamic network model of translatorial cognition and action. *Translation Spaces*, 2(1), 151-182.
13. Adams, D. (1993). Defining educational quality. Improving Educational Quality Project Publication, 1.
14. Malisetty, S. (2022). New Assessment Approaches Using Population Analysis for Simulation-Based Medical Training: A Pilot Study with a Focus on Complex Surgical Skills.

September 27<sup>th</sup>, 2023

Dear GRACA Review Committee:

I am pleased to write this letter to support Saiteja Malisetty's proposal titled, "Advancing Educational Assessment Through Network Models: Insights from an Introductory Computer Science Course." Saiteja is a fifth year Ph.D. student in the college PhD program. Prior to joining the college's doctoral program, he earned a graduate degree from the relatively new UNO joint program in data science. His diverse background, with a nice blend of mathematical and computational foundation, prepares him well to take on complex IT problems. He has completed all the course requirements for his degree, and he expects to defend his dissertation proposal next Month.

The main focus of Saiteja's dissertation is to develop complex network models for providing a population-based assessment of training and education, particularly as related to new models of delivery such as training medical students in virtual environments or education via online environments. He has been the leading graduate student in an exciting joint project that we are working on in collaboration with a research group at UNMC. The group is currently focused on developing a rigorous assuagement tool for simulation-based training in the domain of medical education. He has published several papers from this project, in major journals and international conferences, and participated in various academic events during which he presented his work to a wide group of audience. New and innovative methods of education and training are currently being explored by many research groups locally, nationally, and internationally. However, the lack of objective and robust evaluation mechanisms for training and education in virtual or online environments has been limiting the rapid advancement in adopting these new approaches.

The proposed study is based on utilizing graph theory and network science to develop a rigorous assessment tool to help educators and trainers in evaluating the effectiveness in educating students in learning computer programming concepts, which is now needed for everybody. In particular, he is looking into analyzing data collected from various sections of the famous "introduction to Computer Science" course that has been representing a major challenge for educators everywhere. Early results from his analysis are promising and the proposed research questions in this proposal represent exciting next steps in this exciting and important domain.

Saiteja is a strong student with excellent potential. He is currently one of the top doctoral students in the college. He has shown the ability to work independently as well as with other members of the group in an interdisciplinary setting. I strongly recommend him for the GRACA award. Please feel free to contact me if you require further information.

Sincerely,



Hesham H. Ali, Ph.D.  
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