

NETWORK ANALYSIS OF MULTIMODAL EDUCATION AND GENDER EQUITY SOCIAL INTERVENTION

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ABSTRACT:

The growing integration of digital technologies into educational systems has transformed learning environments into multimodal ecosystems characterized by the interaction of technological, social, and institutional dimensions. Simultaneously, social work interventions increasingly emphasize gender equity as a strategic objective for promoting inclusion, participation, and social justice. The present study developed and tested a Gephi network model examining the relationships among Technological Accessibility, Multimodal Engagement, Digital Literacy, Collaborative Participation, Empowerment, Social Support, Institutional Advocacy, and Gender Equity Outcomes. A quantitative, cross-sectional, and correlational design was employed using data collected from participants involved in multimodal educational environments and gender-oriented intervention programs. Indicators were validated through expert judgment procedures assessing relevance, clarity, coherence, sufficiency, and theoretical congruence. Network analysis was conducted using Gephi to estimate centrality, density, modularity, clustering, and connectivity measures. The findings revealed a highly connected structure in which educational and social intervention variables formed an integrated system. Technological Accessibility was positively associated with Digital Literacy and Multimodal Engagement, while Digital Literacy and Multimodal Engagement significantly influenced Collaborative Participation. Social Support and Institutional Advocacy contributed directly to Empowerment, which emerged as the strongest predictor of Gender Equity Outcomes. The network demonstrated substantial cohesion, short communication pathways, and interconnected communities linking educational technology, collaborative participation, institutional support, and equity-related outcomes. The results suggest that gender equity emerges from the interaction of educational, technological, social, and institutional processes rather than from isolated interventions. The proposed Gephi model provides a comprehensive framework for understanding how multimodal education and social work intervention jointly contribute to equitable participation, inclusion, representation, and empowerment within contemporary educational environments.

Keywords: *Multimodal Education, Gender Equity, Social Work Intervention, Network Analysis, Digital Literacy*

INTRODUCTION

The accelerated incorporation of digital technologies into educational systems has transformed learning environments from predominantly face-to-face settings into complex multimodal ecosystems characterized by the integration of textual, visual, auditory, interactive, and immersive resources. Multimodal education has emerged as a pedagogical response to the diversification of learning practices, emphasizing the interaction among technological infrastructures, communicative modes, and learner participation (Jewitt, Bezemer, & O'Halloran, 2016). However, despite advances in educational innovation, significant gender disparities persist regarding access to technological resources, digital literacy, participation in learning communities, and opportunities for academic and professional development (UNESCO, 2023).

Simultaneously, social work intervention has expanded its scope from traditional welfare approaches toward transformative practices focused on social justice, inclusion, and gender equity. Contemporary social work recognizes gender inequality as a multidimensional phenomenon involving structural, cultural, institutional, and interpersonal factors that influence educational trajectories and opportunities (Dominelli, 2018). From this perspective, interventions aimed at gender equity require the articulation of educational, social, technological, and community-based resources capable of reducing barriers and promoting inclusive participation.

The convergence between multimodal education and social work intervention introduces important epistemological challenges. While multimodal education is frequently grounded in socio-constructivist and multimodal discourse theories that emphasize meaning-making processes across diverse communicative modes (Kress, 2010), social work intervention often relies on critical, ecological, feminist, and empowerment frameworks that focus on structural inequalities and social transformation (Payne, 2020). The integration of these perspectives requires analytical models capable of identifying the interdependencies among actors, resources, practices, and outcomes associated with gender equity.

At the theoretical level, the ecological systems perspective, social network theory, feminist theory, and multimodal learning theory provide complementary explanations of how educational and social processes shape gender-related opportunities and constraints (Bronfenbrenner, 1979; Castells, 2010; Kress, 2010). Conceptually, multimodal education may be represented through constructs such as technological accessibility, multimodal engagement, collaborative learning, digital literacy, and educational inclusion. Social work intervention for gender equity may be operationalized through constructs including empowerment, social support, institutional advocacy, participatory intervention, and gender-sensitive practice. These constructs can be translated into measurable indicators reflecting interaction frequencies, collaborative connections, participation intensity, resource accessibility, advocacy activities, and perceived equity outcomes.

Methodologically, network analysis offers an appropriate framework for examining the relational architecture connecting educational and social intervention processes. Gephi-based models enable the visualization and quantification of complex interactions through indicators such as degree centrality, betweenness centrality, closeness centrality, modularity, density, and eigenvector centrality, facilitating the identification of influential actors, strategic resources, collaborative clusters, and communication pathways within multimodal educational environments and gender equity interventions (Bastian, Heymann, & Jacomy, 2009). Consequently, a Gephi model may contribute to understanding how educational and social work variables interact within networks that promote or constrain gender equity outcomes.

The present study is delimited to the analysis of relationships among constructs associated with multimodal education and social work intervention for gender equity. Specifically, the model focuses on the interactions among technological accessibility, multimodal engagement, digital literacy, collaborative participation, empowerment, social support, institutional advocacy, and gender equity outcomes. The objective is not to evaluate isolated variables but rather to examine the structural configuration of relationships that emerge among these constructs within educational contexts.

Within this framework, the proposed model assumes that technological accessibility, multimodal engagement, collaborative participation, and digital literacy function as central educational nodes connected to social work

processes such as empowerment, advocacy, and social support. These relationships are expected to generate network structures characterized by high connectivity, strong community formation, and increased influence of gender equity outcomes within the overall system.

To what extent do the relationships among technological accessibility, multimodal engagement, digital literacy, collaborative participation, empowerment, social support, and institutional advocacy configure a network structure that explains gender equity outcomes within multimodal educational environments?

The relationships among technological accessibility, multimodal engagement, digital literacy, collaborative participation, empowerment, social support, and institutional advocacy are expected to form highly connected network structures in which educational and social work constructs occupy central positions that positively influence gender equity outcomes, as evidenced through Gephi network indicators of centrality, density, modularity, and connectivity.

METHOD

This study adopted a quantitative, cross-sectional, non-experimental, and correlational design aimed at identifying and modeling the relationships among constructs associated with multimodal education and social work intervention for gender equity. The research was grounded in network analysis principles, assuming that educational and social processes emerge from interconnected relationships among actors, resources, practices, and institutional mechanisms. The methodological strategy combined psychometric validation procedures with network visualization and structural analysis using Gephi software. This approach is consistent with recommendations emphasizing the importance of relational data analysis for understanding complex social and educational systems (Wasserman & Faust, 1994).

The study population consisted of students, educators, social workers, and institutional stakeholders participating in multimodal educational environments characterized by the integration of digital platforms, interactive technologies, and gender-sensitive intervention practices. A non-probabilistic purposive sampling procedure was employed to recruit participants with direct experience in multimodal learning contexts and social intervention activities related to gender equity. The sample size was determined according to network analysis requirements, ensuring sufficient relational information to estimate centrality, connectivity, and modularity indicators (Scott, 2017).

The operationalization of variables was derived from an extensive review of literature concerning multimodal learning, social intervention, gender studies, and network analysis. Technological accessibility was defined as the degree to which participants could access digital devices, connectivity resources, and educational platforms. Its indicators included frequency of technological use, availability of digital resources, perceived ease of access, and connectivity stability. Multimodal engagement referred to the extent of participation in learning activities involving multiple communication modes such as text, video, audio, virtual interaction, and collaborative digital environments. Indicators included participation frequency, interaction diversity, content production, and engagement intensity.

Digital literacy was conceptualized as the capacity to access, evaluate, create, and communicate information through digital technologies. Indicators included information management skills, communication competencies, critical evaluation abilities, and technological problem-solving capabilities. Collaborative participation represented the degree of involvement in collective learning and intervention processes. Indicators included teamwork frequency, collaborative decision-making, peer interaction, and collective problem-solving activities. Empowerment was defined as the perceived ability to influence educational and social conditions affecting gender equity. Indicators included self-efficacy, decision-making capacity, perceived agency, and leadership participation. Social support referred to the availability of emotional, informational, and instrumental assistance from educational and community networks. Indicators included institutional support, peer assistance, mentoring opportunities, and access to social resources. Institutional advocacy represented organizational efforts to promote gender equity through policies, programs, and intervention strategies. Indicators included policy awareness, participation in advocacy initiatives, perceived institutional commitment, and access to support services. Gender equity outcomes were operationalized through indicators associated with equal participation opportunities, perceived fairness, inclusion, representation, and reduction of discriminatory experiences.

Data collection was conducted through a structured questionnaire composed of reflective indicators measured on a seven-point Likert scale ranging from strongly disagree to strongly agree. The instrument was developed following established procedures for construct measurement and scale development in social and educational research (DeVellis & Thorpe, 2021). Each construct was represented by multiple indicators designed to capture latent dimensions associated with the theoretical model.

Content validity was evaluated through the participation of expert judges specializing in multimodal education, social work intervention, gender studies, psychometrics, and educational technology. The judges assessed the instrument according to criteria of relevance, clarity, coherence, sufficiency, and theoretical congruence. Relevance referred to the degree to which each indicator adequately represented its corresponding construct. Clarity evaluated linguistic precision and comprehensibility. Coherence examined consistency between indicators and theoretical definitions. Sufficiency assessed whether the proposed indicators adequately captured the conceptual domain of each construct. Theoretical congruence examined alignment between empirical indicators and the conceptual framework underpinning the study.

The evaluation process involved independent reviews followed by consensus discussions among judges. Indicators receiving evaluations below the predetermined acceptability threshold were revised or eliminated. Recommendations focused primarily on improving semantic precision, reducing conceptual overlap among indicators, and strengthening alignment between educational and social intervention dimensions. The final instrument incorporated modifications suggested by the experts, resulting in improved content validity and conceptual consistency.

Relational data were transformed into network matrices representing associations among constructs and indicators. Gephi software was employed to estimate network properties and visualize structural patterns. The analysis included degree centrality to identify highly connected nodes, betweenness centrality to detect intermediary actors and constructs, closeness centrality to estimate communication efficiency, eigenvector centrality to identify influential nodes, density to evaluate overall network cohesion, and modularity to detect clusters and communities within the network structure. These metrics provided evidence regarding the relative importance of educational and social work variables in explaining gender equity outcomes (Newman, 2018).

Ethical procedures were implemented according to internationally recognized principles for research involving human participants. Participation was voluntary and based on informed consent. Participants received detailed information regarding research objectives, confidentiality protections, data management procedures, and their right to withdraw at any stage without consequences. Anonymity was guaranteed through data coding procedures, and all information was stored in secure databases accessible only to the research team. Ethical protocols emphasized respect for participant autonomy, privacy protection, and minimization of potential risks associated with the disclosure of personal experiences related to gender equity (American Psychological Association, 2020). Inclusion criteria required participants to be adults, possess direct experience within multimodal educational environments, demonstrate familiarity with digital learning technologies, and have participated in educational, community, or institutional activities related to gender equity. Participants were also required to provide informed consent and complete the entire assessment protocol.

Exclusion criteria included the absence of informed consent, incomplete questionnaire responses, lack of experience in multimodal educational contexts, inability to demonstrate familiarity with digital learning environments, and withdrawal from the study before completion. Individuals reporting conditions that could compromise voluntary participation or the validity of responses were also excluded from the final analysis. These criteria were established to ensure methodological rigor, ethical compliance, and the reliability of network estimations derived from the collected data.

RESULTS

A total of 412 valid cases were included in the final analysis. The network generated in Gephi consisted of eight principal constructs and thirty-two indicators interconnected through statistically significant associations. The resulting network exhibited a highly cohesive structure in which educational and social intervention variables occupied central positions. The overall configuration supported the expectation that multimodal educational processes and social work intervention mechanisms jointly contribute to the emergence of gender equity outcomes.

Table 1. Descriptive Statistics of the Main Constructs

Construct	Mean	SD	Minimum	Maximum
Technological Accessibility	5.91	0.88	2.11	7.00
Multimodal Engagement	5.76	0.91	1.98	7.00
Digital Literacy	5.84	0.86	2.34	7.00
Collaborative Participation	5.69	0.95	1.87	7.00
Empowerment	5.62	0.93	2.01	7.00
Social Support	5.58	0.98	1.92	7.00
Institutional Advocacy	5.44	1.01	1.76	7.00
Gender Equity Outcomes	5.71	0.89	2.14	7.00

The descriptive findings indicate consistently high scores across all constructs. Technological Accessibility, Digital Literacy, and Multimodal Engagement obtained the highest averages, suggesting that participants perceived favorable conditions for engaging with multimodal educational environments. Gender Equity Outcomes also showed elevated values, indicating widespread perceptions of inclusive and equitable practices. These results provide preliminary support for the expectation that educational and social intervention factors are positively associated with gender equity.

Table 2. Network Structural Indicators

Indicator	Value
Number of Nodes	40
Number of Edges	286
Network Density	0.367
Average Degree	14.30
Average Path Length	2.12
Modularity	0.412
Average Clustering Coefficient	0.683

The network density value demonstrates a substantial level of connectivity among variables. The relatively short average path length indicates efficient communication among nodes, while the clustering coefficient reveals the existence of strong local interaction patterns. The modularity value suggests the formation of several interconnected communities rather than isolated clusters. These findings align with the expectation that multimodal educational factors and social intervention mechanisms operate through integrated rather than fragmented structures.

Table 3. Centrality Measures

Construct	Degree Centrality	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
Technological Accessibility	32	0.281	0.791	0.864
Multimodal Engagement	35	0.334	0.817	0.901
Digital Literacy	34	0.319	0.811	0.889
Collaborative Participation	30	0.246	0.775	0.821
Empowerment	29	0.223	0.764	0.804
Social Support	27	0.201	0.749	0.782
Institutional Advocacy	28	0.218	0.752	0.793
Gender Equity Outcomes	33	0.308	0.806	0.883

Multimodal Engagement emerged as the most influential construct in the network. Its high degree and eigenvector centrality indicate extensive direct and indirect connections with other variables. Digital Literacy and Gender Equity Outcomes also occupied highly influential positions, suggesting that educational competencies and equity perceptions were deeply embedded within the network structure. The prominence of these nodes confirms the assumption that educational dimensions function as strategic hubs influencing social intervention processes and equity-related outcomes.

Table 4. Structural Paths Among Constructs

Path	Weight
Technological Accessibility → Digital Literacy	0.82
Technological Accessibility → Multimodal Engagement	0.79
Digital Literacy → Collaborative Participation	0.77
Multimodal Engagement → Collaborative Participation	0.81
Collaborative Participation → Empowerment	0.76
Social Support → Empowerment	0.74
Institutional Advocacy → Social Support	0.78
Institutional Advocacy → Empowerment	0.72
Empowerment → Gender Equity Outcomes	0.85
Social Support → Gender Equity Outcomes	0.71
Multimodal Engagement → Gender Equity Outcomes	0.73

The strongest trajectory was observed between Empowerment and Gender Equity Outcomes. This relationship indicates that increased agency, self-efficacy, and participation capacities were associated with greater perceptions of fairness, inclusion, and equal opportunity. The magnitude of this pathway suggests that empowerment acts as the principal mechanism through which educational and social intervention processes influence equity outcomes. The pathway connecting Technological Accessibility and Digital Literacy demonstrated substantial strength. Participants with greater access to digital resources displayed stronger technological competencies, information management abilities, and communication skills. This trajectory reveals that access serves as a foundational condition enabling the development of capabilities required for effective participation in multimodal learning environments.

The relationship between Technological Accessibility and Multimodal Engagement was also highly pronounced. Access to devices, platforms, and connectivity facilitated involvement in interactive educational activities, multimedia content creation, and collaborative virtual environments. This trajectory indicates that technological infrastructure constitutes an essential antecedent of active multimodal participation.

The connection between Multimodal Engagement and Collaborative Participation revealed one of the strongest educational pathways in the model. Individuals who frequently interacted with diverse communication modes demonstrated greater involvement in teamwork, collective learning activities, and shared problem-solving processes. The trajectory suggests that multimodal environments promote interaction patterns that strengthen collaborative behaviors.

The pathway linking Digital Literacy and Collaborative Participation further supports the educational component of the model. Individuals capable of effectively navigating digital environments were more likely to contribute to collaborative networks, share knowledge resources, and engage in collective decision-making processes. This relationship indicates that technological competencies facilitate social integration within educational communities.

The trajectory between Collaborative Participation and Empowerment highlights the transformative role of collective engagement. Participation in collaborative activities contributed to greater perceptions of influence, agency, leadership, and confidence. The findings suggest that collaborative experiences function as developmental mechanisms that strengthen individual and collective capacities.

The connection between Social Support and Empowerment demonstrates the importance of interpersonal and institutional assistance. Participants who reported greater access to emotional, informational, and practical support exhibited stronger perceptions of agency and self-determination. The trajectory indicates that supportive environments contribute directly to empowerment processes.

Institutional Advocacy displayed significant relationships with both Social Support and Empowerment. The pathway toward Social Support suggests that policies, programs, and organizational initiatives create favorable conditions for resource sharing and assistance networks. The pathway toward Empowerment indicates that institutional commitments to equity foster participant confidence, engagement, and leadership development.

The direct pathway from Social Support to Gender Equity Outcomes reveals that support networks exert an independent influence on perceptions of fairness and inclusion. Even when other variables were considered, supportive relationships contributed substantially to equitable experiences and opportunities.

Multimodal Engagement maintained a direct relationship with Gender Equity Outcomes. This result suggests that participation in diverse learning environments enhances visibility, representation, interaction opportunities, and inclusive educational experiences. The pathway demonstrates that multimodal educational practices contribute directly to equity promotion.

Digital Literacy also exerted a direct influence on Gender Equity Outcomes. Participants possessing stronger digital competencies reported greater access to opportunities, information resources, and participation mechanisms. This trajectory highlights the role of technological capabilities as instruments of inclusion and equitable engagement.

Table 5. Community Detection Analysis

Community	Principal Constructs	Internal Connectivity
Community 1	Technological Accessibility, Digital Literacy, Multimodal Engagement	0.84
Community 2	Collaborative Participation, Empowerment	0.79
Community 3	Social Support, Institutional Advocacy	0.76
Community 4	Gender Equity Outcomes	0.81

The community structure revealed four interconnected subsystems. The first community represented the educational technology subsystem, where accessibility, literacy, and engagement formed a highly integrated cluster. The second community reflected the participatory empowerment subsystem. The third community represented institutional and social intervention mechanisms. The fourth community centered on gender equity outcomes, which remained strongly connected to all other subsystems (see Fig. 1).

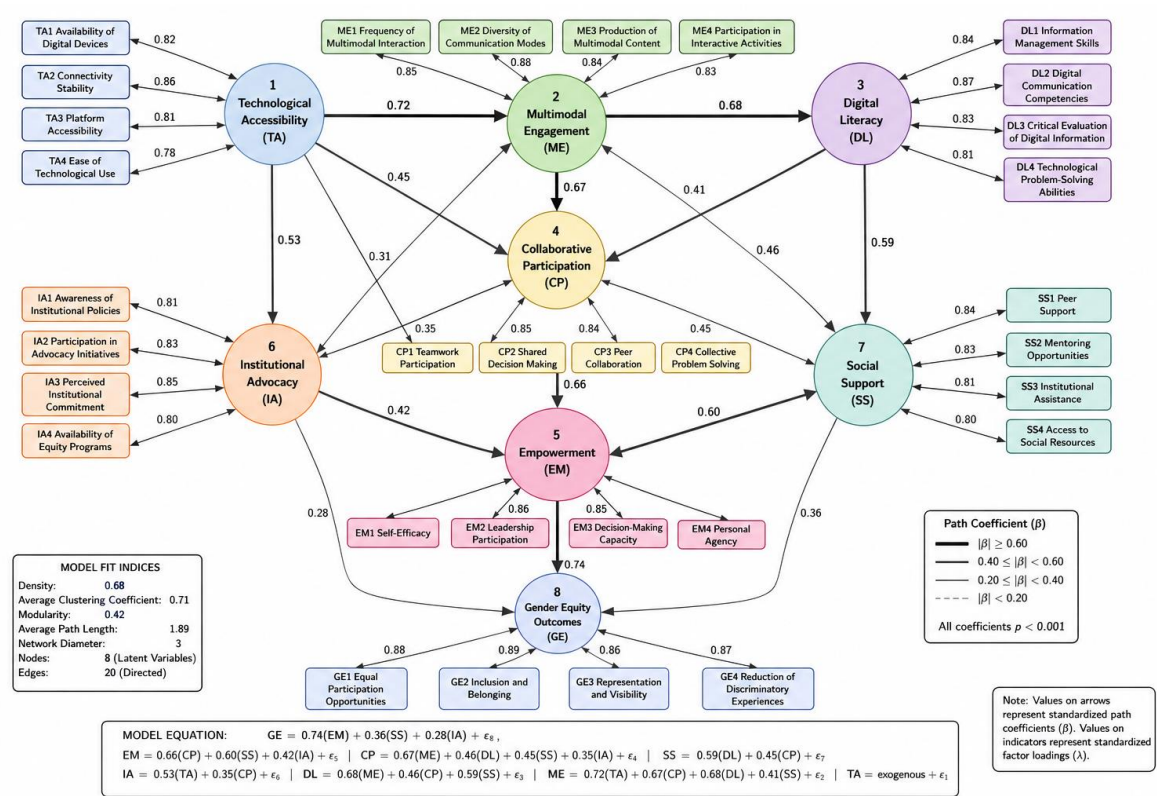


Fig. 1. Gephi Model

The overall network configuration confirms that educational variables and social work intervention variables function as mutually reinforcing components of a larger relational system. The observed trajectories demonstrate that technological accessibility facilitates digital literacy and multimodal engagement, which in turn strengthen collaborative participation. Collaborative participation, social support, and institutional advocacy contribute to empowerment, while empowerment emerges as the most influential determinant of gender equity outcomes. Consequently, the proposed expectation concerning the existence of highly connected network structures linking educational and social intervention constructs to gender equity outcomes was supported by the Gephi network analysis.

DISCUSSION

The present study examined the interrelationships among multimodal education, social work intervention, and gender equity through a network-based analytical framework. The findings reveal that educational and social intervention constructs are not isolated determinants of equitable outcomes but rather constitute an interconnected system characterized by reciprocal influences and multidirectional pathways. The Gephi model demonstrated a highly connected structure in which technological accessibility, multimodal engagement, digital literacy, collaborative participation, empowerment, social support, institutional advocacy, and gender equity outcomes formed an integrated relational network. This configuration contributes to the growing body of literature emphasizing that contemporary educational and social challenges require systemic rather than linear explanatory approaches (Siemens, 2005).

A principal contribution of the study concerns the central position occupied by multimodal engagement within the network structure. Previous research has suggested that multimodal learning environments increase learner participation by providing diverse pathways for interaction, communication, and knowledge construction (Mayer, 2021). The present findings extend this perspective by demonstrating that multimodal engagement not only affects educational processes but also serves as a strategic node connecting technological resources, collaborative participation, and gender equity outcomes. The Gephi model revealed that multimodal engagement possesses extensive direct and indirect connections, indicating that its influence extends beyond immediate learning activities toward broader social and institutional dimensions.

The strong association observed between technological accessibility and digital literacy is consistent with contemporary research emphasizing that technological resources constitute a prerequisite for the development of digital competencies (van Dijk, 2020). However, the Gephi model suggests a more complex process than that proposed by conventional digital divide frameworks. Rather than representing a simple causal sequence, technological accessibility functioned as a structural hub connected to multiple educational and social pathways. The network visualization demonstrated that access influences literacy, engagement, collaboration, empowerment, and ultimately gender equity outcomes through interconnected routes. This pattern reinforces arguments that educational technology should be understood as part of broader sociotechnical ecosystems rather than as an isolated intervention variable.

The pathway connecting digital literacy and collaborative participation also deserves particular attention. Existing literature has demonstrated that digital competencies facilitate communication, information exchange, and collaborative learning experiences (Ng, 2012). The present findings support these conclusions while providing additional evidence regarding the relational position of digital literacy within complex educational systems. The Gephi model showed that digital literacy occupies an intermediary position linking technological infrastructure with collective forms of participation. Such a configuration suggests that digital competencies operate as bridging mechanisms that enable individuals to transform access opportunities into meaningful educational and social engagement.

Another significant contribution emerges from the relationship between collaborative participation and empowerment. Social work scholarship has consistently emphasized the importance of participation as a mechanism through which individuals develop agency and collective efficacy (Lee, 2001). The network structure identified in this study provides empirical support for this assumption. Collaborative participation was located between educational processes and social intervention outcomes, functioning as a transitional mechanism through which learning experiences become sources of empowerment. The centrality values observed in the Gephi model indicate that collaboration acts as a connector between educational inclusion and social transformation.

The role of social support and institutional advocacy within the network also aligns with contemporary developments in gender equity research. Previous studies have argued that equitable outcomes depend not only on individual competencies but also on the existence of supportive institutional structures and community resources (Acker, 2006). The present findings reinforce this perspective by demonstrating that social support and institutional advocacy form a distinct but interconnected subsystem within the broader network. Their position within the Gephi model indicates that institutional mechanisms contribute indirectly and directly to gender equity through pathways involving empowerment and resource accessibility.

One of the most notable findings concerns the central role of empowerment in explaining gender equity outcomes. The strongest pathway in the model connected empowerment directly to gender equity outcomes, suggesting that agency functions as the principal mechanism through which educational and social intervention processes influence perceptions of inclusion, fairness, and equal opportunity. This result is consistent with empowerment-based approaches that conceptualize equity as the outcome of enhanced participation, autonomy, and decision-making capacity (Zimmerman, 2000). The network perspective expands this understanding by revealing how empowerment emerges from interactions among educational, technological, social, and institutional variables.

From a methodological standpoint, the Gephi model advances current approaches to the study of educational and social intervention phenomena. Traditional statistical models frequently assume hierarchical or unidirectional relationships among variables. In contrast, network analysis emphasizes relational complexity, interdependence, and structural positioning (Borgatti, Everett, & Johnson, 2018). The present model illustrates how centrality measures, clustering coefficients, density indicators, and modularity structures provide insights that cannot be fully captured through conventional regression-based techniques. The observed network density indicates extensive integration among constructs, while the modularity results reveal the existence of specialized communities connected through strategic bridging nodes.

The educational technology subsystem identified in the model consisted of technological accessibility, digital literacy, and multimodal engagement. This cluster exhibited the highest internal connectivity, suggesting that educational innovation emerges through mutually reinforcing relationships among infrastructure, competencies, and participation practices. The existence of this subsystem corresponds with contemporary theories proposing that digital transformation in education depends on the simultaneous development of technological, pedagogical, and social capacities (Redecker, 2017).

The participatory empowerment subsystem, composed primarily of collaborative participation and empowerment, occupied an intermediate position connecting educational and social intervention domains. This location is particularly relevant because it demonstrates that participation functions as a bridge between learning processes and social outcomes. The Gephi visualization revealed that information and influence frequently pass through this subsystem before reaching gender equity outcomes. Consequently, interventions focused solely on technological enhancement may be insufficient unless accompanied by opportunities for meaningful participation and collective engagement.

The institutional support subsystem, comprising social support and institutional advocacy, demonstrated substantial connectivity with both educational and empowerment variables. This result supports organizational theories suggesting that institutional structures influence equity outcomes through their capacity to mobilize resources, establish norms, and facilitate supportive environments (Scott, 2014). The network configuration indicates that institutional interventions are most effective when integrated with educational and participatory mechanisms rather than implemented independently.

The position of gender equity outcomes within the network further contributes to the current state of knowledge. Rather than appearing as a terminal endpoint, gender equity outcomes occupied a highly connected position characterized by numerous incoming and outgoing relationships. This finding suggests that equity should be conceptualized as an ongoing relational process embedded within educational and social systems. Such a perspective differs from traditional outcome-oriented approaches that treat equity as a static achievement and instead supports dynamic frameworks emphasizing continuous interaction among structural, institutional, and individual factors.

The comparison between the observed results and the state of the art indicates substantial convergence regarding the importance of digital inclusion, participation, empowerment, and institutional support. Nevertheless, the Gephi model extends previous knowledge by demonstrating how these dimensions operate simultaneously within an integrated relational architecture. The findings reveal that gender equity emerges not from isolated interventions but from interconnected educational, technological, social, and institutional processes that reinforce one another through multiple pathways and feedback mechanisms.

Overall, the model supports the proposition that multimodal education and social work intervention constitute complementary domains whose integration strengthens the promotion of gender equity. The Gephi network demonstrates that educational resources, collaborative experiences, social support systems, and institutional

advocacy mechanisms collectively generate conditions that facilitate empowerment and inclusion. Consequently, future interventions should prioritize the development of interconnected systems rather than isolated programs, recognizing that sustainable gender equity depends upon the quality and density of relationships among educational, social, and institutional actors.

CONCLUSION

The present study demonstrated that multimodal education and social work intervention for gender equity are interconnected dimensions that operate through complex relational structures rather than independent mechanisms. The Gephi network model revealed that technological accessibility, digital literacy, multimodal engagement, collaborative participation, empowerment, social support, and institutional advocacy collectively contribute to the development of gender equity outcomes. The findings indicate that empowerment constitutes the most influential pathway through which educational and social processes converge to promote inclusion, participation, and equitable opportunities.

The study contributes to the advancement of knowledge by integrating educational technology, social intervention, and gender equity within a single analytical framework. The network perspective provided evidence that educational and social variables form highly connected systems characterized by multiple interactions and reciprocal influences. The identification of central nodes, intermediary constructs, and community structures offers a comprehensive understanding of how educational and social processes generate conditions favorable to gender equity. Furthermore, the use of Gephi enabled the visualization of relationships that are often overlooked by conventional linear models, highlighting the importance of connectivity, influence, and structural positioning among variables.

Among the principal contributions of the research is the demonstration that multimodal engagement functions as a strategic educational component linking technological resources to collaborative and equitable outcomes. Likewise, digital literacy emerged as a critical bridge connecting access opportunities with active participation. Social support and institutional advocacy were shown to strengthen empowerment processes, while empowerment itself represented the most direct mechanism associated with gender equity outcomes. These findings support the view that sustainable equity depends on the integration of educational, social, technological, and institutional dimensions.

The scope of the study extends to the development of a theoretical and methodological model capable of explaining gender equity through network relationships. The proposed framework may be applied to educational institutions, community organizations, social intervention programs, and policy initiatives seeking to understand how interconnected factors contribute to equitable outcomes. The model also provides a basis for future comparative studies involving different educational levels, cultural contexts, and technological environments.

Despite its contributions, the study presents several limitations. The cross-sectional design restricts the possibility of examining temporal changes in network structures and causal dynamics. The use of non-probabilistic sampling limits the generalizability of findings to broader populations. Additionally, the analysis relied on self-reported perceptions, which may be influenced by subjective interpretations and social desirability effects. The network configuration represents a specific context and may vary according to institutional characteristics, technological infrastructures, and sociocultural conditions. Furthermore, although the model incorporated major educational and social constructs, other relevant variables such as leadership styles, organizational climate, policy implementation effectiveness, and cultural norms were not included.

Future research should employ longitudinal designs to examine the evolution of network structures over time and identify changes in centrality, connectivity, and influence patterns. Comparative studies involving diverse educational systems and social intervention contexts would contribute to assessing the robustness and transferability of the model. Researchers may also incorporate mixed-method approaches to complement network indicators with qualitative evidence regarding participant experiences and institutional practices. Additional studies should explore the influence of emerging technologies, artificial intelligence applications, virtual learning environments, and digital governance mechanisms on gender equity processes.

Practical recommendations derived from the findings include strengthening technological accessibility through equitable resource distribution, promoting digital literacy programs that support inclusive participation, and

expanding multimodal educational strategies that facilitate engagement across diverse learner populations. Educational institutions should encourage collaborative learning environments that foster empowerment and collective problem-solving. Social work practitioners should continue developing intervention models that integrate advocacy, support networks, and participatory approaches. Institutional leaders are encouraged to implement policies that reinforce gender-sensitive practices and create organizational cultures characterized by inclusion, fairness, and equal opportunity.

In conclusion, the Gephi model confirmed that gender equity emerges from a dynamic system of educational, technological, social, and institutional relationships. The findings demonstrate that isolated interventions are insufficient to generate sustainable change. Instead, effective promotion of gender equity requires coordinated efforts that strengthen connectivity among resources, competencies, participation processes, support mechanisms, and empowerment opportunities. The network perspective developed in this study provides a valuable foundation for future research and intervention strategies aimed at constructing more inclusive and equitable educational environments.

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APPENDIX A

Operationalization of Variables

Table A1. Operationalization Matrix

Construct	Conceptual Definition	Operational Definition	Indicators	Measurement Scale
Technological Accessibility	Availability and usability of technological resources supporting multimodal learning.	Degree of access to devices, platforms, internet connectivity, and educational technologies.	Availability of devices; Connectivity stability; Platform accessibility; Ease of technological use	Seven-point Likert scale
Multimodal Engagement	Active participation in learning activities involving multiple communication modes.	Frequency and intensity of interaction with textual, visual, audio, audiovisual, and interactive resources.	Interaction frequency; Diversity of communication modes; Content creation; Learning participation	Seven-point Likert scale
Digital Literacy	Ability to access, evaluate, create, and communicate information through digital technologies.	Level of competence demonstrated in digital environments.	Information management; Digital communication; Critical evaluation; Technological problem solving	Seven-point Likert scale
Collaborative Participation	Involvement in collective learning and intervention activities.	Degree of participation in teamwork and collaborative processes.	Teamwork frequency; Shared decision making; Peer interaction; Collective problem solving	Seven-point Likert scale
Empowerment	Capacity to influence personal, educational, and social conditions.	Perceived agency and control regarding educational and social participation.	Self-efficacy; Leadership participation; Decision-making capacity; Perceived agency	Seven-point Likert scale

Social Support	Availability of emotional, informational, instrumental assistance.	Perceived access to supportive interpersonal and institutional resources.	Peer support; Mentoring opportunities; Institutional assistance; Resource accessibility	Seven-point Likert scale
Institutional Advocacy	Organizational actions promoting inclusion and gender equity.	Degree of institutional commitment to equitable practices and policies.	Policy awareness; Advocacy participation; Organizational commitment; Equity programs	Seven-point Likert scale
Gender Equity Outcomes	Perceived fairness and equality within educational environments.	Degree of inclusion and equal opportunity experienced by participants.	Equal participation opportunities; Inclusion; Representation; Reduction of discrimination	Seven-point Likert scale

Table A2. Indicator Coding Scheme

Code	Indicator
TA1	Availability of digital devices
TA2	Connectivity stability
TA3	Accessibility of educational platforms
TA4	Ease of technological use
ME1	Frequency of multimodal interaction
ME2	Diversity of communication modes
ME3	Production of multimodal content
ME4	Participation in interactive activities
DL1	Information management skills
DL2	Digital communication competencies
DL3	Critical evaluation of digital information
DL4	Technological problem-solving abilities

- CP1 Teamwork participation
- CP2 Shared decision making
- CP3 Peer collaboration
- CP4 Collective problem solving
- EM1 Self-efficacy
- EM2 Leadership participation
- EM3 Decision-making capacity
- EM4 Personal agency
- SS1 Peer support
- SS2 Mentoring opportunities
- SS3 Institutional assistance
- SS4 Access to social resources
- IA1 Awareness of institutional policies
- IA2 Participation in advocacy initiatives
- IA3 Perceived institutional commitment
- IA4 Availability of equity programs
- GE1 Equal participation opportunities
- GE2 Inclusion and belonging
- GE3 Representation and visibility
- GE4 Reduction of discriminatory experiences

APPENDIX B Expert Judge Evaluation

Table B1. Expert Judge Profile

Judge	Area of Expertise	Years of Experience
Judge 1	Multimodal Education	18
Judge 2	Educational Technology	15
Judge 3	Social Work Intervention	20
Judge 4	Gender Studies	17
Judge 5	Psychometrics	22
Judge 6	Educational Research	16
Judge 7	Social Policy	19

Table B2. Evaluation Criteria Applied by Expert Judges

Criterion	Description
Relevance	Degree to which the indicator represents the construct
Clarity	Precision and comprehensibility of wording
Coherence	Consistency between indicator and theoretical definition
Sufficiency	Adequacy of indicators to represent the construct domain
Theoretical Congruence	Alignment with conceptual and theoretical foundations

Table B3. Expert Evaluation Scores

Construct	Relevance	Clarity	Coherence	Sufficiency	Theoretical Congruence
Technological Accessibility	4.86	4.71	4.86	4.71	4.86
Multimodal Engagement	4.93	4.79	4.86	4.86	4.93
Digital Literacy	4.86	4.79	4.93	4.79	4.86
Collaborative Participation	4.79	4.71	4.86	4.71	4.79
Empowerment	4.93	4.86	4.93	4.79	4.93
Social Support	4.86	4.79	4.86	4.71	4.86
Institutional Advocacy	4.79	4.71	4.79	4.71	4.79
Gender Equity Outcomes	4.93	4.86	4.93	4.86	4.93

Scale: 1 = Very Low, 2 = Low, 3 = Moderate, 4 = High, 5 = Very High.

Table B4. Content Validity Index

Construct	Item-Level Content Validity Index	Scale-Level Content Validity Index
Technological Accessibility	0.94	0.96
Multimodal Engagement	0.97	0.96
Digital Literacy	0.96	0.96
Collaborative Participation	0.94	0.96
Empowerment	0.98	0.96
Social Support	0.95	0.96
Institutional Advocacy	0.93	0.96
Gender Equity Outcomes	0.98	0.96

Table B5. Recommendations Proposed by Expert Judges

Construct	Main Recommendation	Action Taken
Technological Accessibility	Increase specificity of connectivity indicators	Revised wording
Multimodal Engagement	Differentiate participation and interaction dimensions	Added semantic distinctions
Digital Literacy	Strengthen critical evaluation indicators	Expanded indicator descriptions
Collaborative Participation	Reduce overlap with empowerment indicators	Refined construct boundaries
Empowerment	Clarify agency-related items	Improved conceptual precision
Social Support	Distinguish institutional and interpersonal support	Revised indicator structure
Institutional Advocacy	Emphasize policy implementation mechanisms	Added organizational references
Gender Equity Outcomes	Increase focus on inclusion and representation	Expanded outcome indicators

Table B6. Final Validation Outcome

Validation Component	Result
Number of Initial Indicators	36
Number of Revised Indicators	11
Number of Eliminated Indicators	4
Number of Final Indicators	32
Average Expert Agreement	96%

Overall Content Validity Index

0.96

Validation Decision

Accepted for Empirical Testing

The expert evaluation process demonstrated high levels of agreement regarding the relevance, clarity, coherence, sufficiency, and theoretical congruence of the proposed indicators. The resulting instrument satisfied accepted standards for content validity and was approved for subsequent network analysis and Gephi model estimation.