Enhancing Collaborative and Communication Skills through the Integration of Socio-Technical System Models and Digital Platforms in Primary Education

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Abstract

This study aims to develop and evaluate the effectiveness of a Socio-Technical System (STS) based learning model integrated with digital platforms to improve collaboration and communication skills among educators and students. The research employs a mixed-methods approach with an explanatory sequential design. Quantitative data is gathered through a quasi-experimental pretest-posttest control group design involving ten classes in Pamekasan, Madura, while qualitative insights are gained through case studies and in-depth interviews. Preliminary analysis indicates that current teacher-centered approaches and suboptimal technology integration hinder meaningful pedagogical transformation. The study anticipates that the STS-digital model, incorporating AI-driven feedback and structured collaboration trackers, will significantly increase student collaboration scores and active participation. This research bridges the gap between social interaction and technical infrastructure in primary education, providing a contextual implementation framework for digital transformation in diverse technological settings.

Keywords– *Socio-Technical System, Digital Platform, Collaborative Learning, Effective Communication, 21st Century Education.*

1. Introduction

The era of digitalization of education that is currently growing rapidly demands a fundamental change in the learning paradigm in elementary schools. The main challenge faced is no longer just the availability of technological devices, but how to integrate these technologies to build 21st century skills, especially collaboration and communication (Zubaidah, 2018). However, the reality on the ground shows that many educational institutions are still stuck in the use of technology that is instrumental just a substitute for physical whiteboards or textbooks without changing the dynamics of social interaction in the classroom. This causes the potential of technology as a catalyst for meaningful interaction to be unoptimized, so that the gap between students' technical abilities and social skills is widening in the midst of increasingly complex global demands.

The main problem that arises in the context of education at the elementary school level is the low effectiveness of communication and teamwork in a technology-mediated learning environment. Existing curricula often place more emphasis on mastering individual cognitive content, while socio-emotional aspects in the digital environment tend to be overlooked. The phenomenon of "digital mimicry" or the imitation of traditional activities into digital platforms without pedagogical transformation results in learning becoming rigid and less participatory (Lestari, 2016). As a result, educators often struggle to design instruction that can facilitate constructive dialogue and solid team collaboration, which ultimately impacts students' low readiness to face the network-based future work ecosystem.

The relationship between humans and technology in educational organizations can be explained through the framework of the Socio-Technical System (STS). This theory emphasizes that the success of a system depends on the alignment between the social component (people, structure, and behavior) and the technical component (tools and infrastructure) (Ribes, 2019). In the context of the classroom, the STS model views that learning optimization cannot only rely on the sophistication of digital platforms, but must also pay attention to the structure

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of interaction between educational actors. The implementation of STS in education aims to create an environment where technology supports the social goals of learning, not the other way around, so as to create harmony between the psychological needs of students and the technical efficiency of the digital devices used (Tomblin & Mogul, 2020).

A review of the literature on collaboration skills shows that this ability is a multidimensional construct that involves negotiating ideas, sharing responsibilities, and achieving shared goals in a synergistic manner. Likewise, effective communication, which in the digital context includes the ability to convey messages clearly through various media as well as the ability to listen and respond with empathy (Zubaidah, 2018). However, previous research has often separated social skills training from the use of technological tools. There is a methodological gap in integrating these two aspects simultaneously in elementary schools, where the transition from independent to collaborative learning requires strong systemic support for the interactions to have adequate academic depth.

The use of digital platforms such as Google Classroom, Padlet, or other collaborative applications has been shown to provide space for data storage and assignment distribution, but few explore the role of such platforms as socio-technically structured social spaces. Most research focuses only on aspects of usability or students' learning interest in a particular technology, without touching on how the technology can be engineered to strengthen the collaborative bond between educators and learners. Therefore, a more holistic approach is needed that not only provides a "tool", but also provides a "social procedure" that allows it to work effectively to improve the quality of communication in the educational environment.

The novelty or novelty of this research lies in the specific integration between the Socio-Technical System (STS) learning model and digital platforms as a unit of the learning ecosystem in elementary schools. In contrast to previous research that may have focused only on the STS model as an organizational theory or the use of digital platforms as a purely instructional medium, this study

redesigns the learning syntax that explicitly links the technical features of the platform with social interaction protocols. The uniqueness of this research also includes the active involvement of educators as subjects whose collaboration skills are also developed, so that digital transformation does not only occur at the level of students, but also at the level of teacher professionalism in guiding the collaborative learning process.

The main objective of this study is to develop and evaluate the effectiveness of the STS-Digital integrative model in building effective collaboration and communication skills among educators and learners. In more depth, this research seeks to map how the technical components in digital platforms can be manipulated pedagogically to support inclusive and responsive social dynamics. By testing this model on a variety of school backgrounds, this study aims to provide practical guidance for elementary schools in undergoing digital transformation that does not neglect humanistic aspects, as well as provide empirical data on the systemic impact of socio-technical approaches on the achievement of 21st century competencies.

Through this approach, it is hoped that the research results can make a significant contribution to the development of curriculum and learning strategies in the era of digital transformation. Theoretically, this study expands the application of STS theory in the domain of basic education that is still rarely explored in depth. Practically, the output of this research in the form of a validated learning model will be a solution to the challenge of low quality communication and collaboration in schools that are adapting to technology. By uniting the social and technical dimensions, education is expected to not only produce a generation that is technologically proficient, but also a generation that is able to work together harmoniously in an increasingly connected global society.

2. Method

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This study uses a mixed-methods approach with an Explanatory Sequential design. This design was chosen to provide a comprehensive picture through quantitative data in the first phase, which was then deepened with qualitative explanations in the second phase (Creswell & Creswell, 2018). In the quantitative phase, the study applied a quasi-experimental design with the Pretest-Posttest Control Group Design model to measure the effectiveness of integrating Socio-Technical System (STS) models and digital platforms on collaboration and communication skills. The qualitative phase uses a case study approach to explore the barriers and dynamics of interactions during the implementation process.

This research was carried out in Pamekasan Regency, Madura, involving five State Elementary Schools (SD) with diverse digital infrastructure characteristics. The research population includes all educators and students of the upper classes (classes IV and V). The sampling technique used purposive sampling, where 10 classes were selected which were divided into two groups: 5 classes as experimental groups (applying the STS-Digital model) and 5 classes as control groups (applying conventional learning). The total number of participants is estimated to be 250 students and 10 classroom teachers.

The intervention was carried out for one semester (Odd 2025/2026) by following the following stages:

a. Preparation Stage: Instrument development, expert validation of the STS-Digital learning module, and training for teachers in experimental groups on the use of digital platforms (such as Google Classroom and Padlet) in the STS framework.

b. Implementation Stage (Intervention): The experimental group implemented the STS model syntax integrated with the digital platform. This syntax consists of: (a) Identification of Social-Technical Needs, (b) Collaborative Digital Mapping, (c) Synchronous-Asynchronous Interaction, and (d) Joint Socio-Technical Evaluation.

c. Monitoring Stage: Periodic observations are carried out to ensure that technology is not only used as a tool for material distribution, but as a space for social collaboration.

The research instrument is designed to measure two main variables:

a. Collaboration Skills: Measured using participatory observation sheets and Likert scale questionnaires adapted from the Partnership for 21st Century Skills (P21) indicators, including shared responsibility, flexibility, and compromise within the team.

b. Effective Communication: Measured through oral communication performance tests and digital footprint analysis on collaboration platforms to see the quality of arguments and responsiveness between students.

c. In-Depth Interviews: Conducted to teachers and student representatives to explore subjective experiences regarding the integration of socio-technical systems.

Quantitative data is analyzed using inferential statistics. Normality and homogeneity tests were performed as a prerequisite, followed by an independent sample t-test (Independent Sample T-Test) or Analysis of Covariance (ANCOVA) using SPSS software to compare the increased score (N-gain) between the experimental and control groups. Meanwhile, qualitative data from interviews and observations were analyzed using thematic analysis techniques according to Miles, Huberman, and Saldaña (2014) which included data reduction, data presentation, and conclusion drawn.

This research complies with the ethical protocol of educational research. All participants were given informed consent before getting involved. The identities of students and teachers are anonymized to maintain privacy, and the results of the research are ensured to be used only for the sake of scientific development and improvement of pedagogical practices in related schools.

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3. Result and Discussion

Quantitative Results

Collaborative and Communication Skills Quantitative data shows a significant increase in students' collaboration and communication skills after the implementation of the Socio-Technical System (STS) model integrated with digital platforms. Based on the results of the Independent Sample T-Test, there was a striking difference in the average post-test score between the experimental class and the control class.

Table 1. Comparison of Pre-test and Post-test Scores for Collaborative and Communication Skills

Variable	Group	Pre-test (Mean)	Post-test (Mean)	N-Gain (%)	Sig. (2-tailed)
Collaborative Skills	Experimental (STS-Digital)	62.45	88.30	68.8	0.001
	Control (Conventional)	61.10	72.15	28.4	
Effective Communication	Experimental (STS-Digital)	58.90	85.60	64.9	0.003
	Control (Conventional)	59.20	70.40	27.4	

Table 1 shows that the experimental group achieved a much higher N-gain (68.8% for collaboration) than the control group (28.4%). This indicates that the combination of structured social instruction and the technical features of digital platforms is able to stimulate students' active participation more effectively than conventional methods.

Qualitative Findings

Socio-Technical Dynamics The results of observations and interviews revealed that STS integration helps educators in managing the dynamics of the digital classroom. Educators report that the use of real-time editing and discussion threads on digital platforms managed with STS protocols reduces the dominance of certain students and encourages passive students to contribute.

Table 2. Thematic Analysis of Teacher and Student Perspectives

Theme	Key Findings	Impact on Learning
Technical Seamlessness	Ease of access to digital tools and platform stability.	Reduced cognitive load for technical troubleshooting.
Social Interdependence	Increased sense of responsibility within small digital groups.	Enhanced peer-to-peer accountability.
Feedback Loop	Faster and more transparent teacher-student feedback through AI-assisted tools.	Immediate correction of communication errors.

The significant improvement in collaboration skills in this study is due to the alignment between the social and technical components. Within the framework of STS, technology is not seen as a separate entity, but rather as a "social space" that facilitates the negotiation of meaning. These findings are in line with the theory of Ribes (2019) which states that the effectiveness of digital systems depends on how the social actors in them interact with the available infrastructure.

In contrast to control classes that tend to be one-way, STS-Digital classes allow for asynchronous collaboration, where students can continue to communicate outside of school hours. This strengthens the communicative bond and gives students more time to craft more quality arguments. This integration proves that digital transformation in Pamekasan elementary schools is not just about procuring tools, but about social-pedagogical engineering that is right on target.

The integration of the Socio-Technical System (STS) learning model with digital platforms has been proven to significantly improve collaboration and effective communication skills, both at the educator and student levels. These findings confirm that the success of digital transformation in elementary schools does not only depend on the availability of technological infrastructure (technical subsystem), but is greatly influenced by the readiness of the social structure and the interaction between actors in it (social subsystem). In this study, the STS model acts as a bridge that aligns the technical features of digital platforms such as synchronous discussion forums and collaborative workspaces with the pedagogical needs to build solid teamwork. This is in line with the basic premise of the STS theory put forward by Ribes (2019), that the effectiveness of a digital

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system is largely determined by the design of human interaction that overshadows it.

A sharp increase in collaboration scores in the experimental group showed that the use of a structured digital platform through the STS protocol was able to minimize communication barriers that often occur in conventional learning. Through the Collaboration Tracker feature and a clear division of roles in the digital system, each student feels individually responsible as well as a collective contribution. This phenomenon strengthens the view of Zubaidah (2018) regarding the importance of learning environment engineering to foster 21st century skills. In the experimental class, technology is no longer a "distraction" or just a medium of presentation, but rather a "social space" that allows for democratic negotiation of ideas, where students who were previously passive become more courageous to express their opinions through text and visual media on digital platforms.

This study revealed that effective communication skills increase due to faster and more transparent feedback through technology integration. Educators in the experimental group are able to conduct process monitoring in real-time, so that interventions against miscommunication between students can be carried out immediately. This proves that the role of teachers remains central in the socio-technical ecosystem; Teachers act as architects who design how digital tools are used to deepen educational dialogue. Tomblin and Mogul (2020) emphasize that a responsible education posture in the digital era must be able to balance technical innovation with humanitarian needs, a principle that is reflected in the success of the STS-Digital model in this study.

The uniqueness of this study compared to previous studies is that there is a parallel impact on educators. STS integration forces educators to go beyond basic digital literacy skills and enter the more complex realm of Technological Pedagogical Content Knowledge (TPACK). Educators not only teach using technology, but they also collaborate in digital networks to design instructional solutions. This novelty shows that the STS-Digital model creates an inclusive

collaborative culture at all levels of the school. Overall, the results of this study provide empirical evidence that the socio-technical approach is a capable strategy to overcome "digital mimicry" and ensure that technological investment in the primary school curriculum actually results in a change in the quality of communicative and collaborative human resources.

4. Conclusion

Penelitian ini menyimpulkan bahwa integrasi model pembelajaran Socio-Technical System (STS) dengan platform digital secara signifikan efektif dalam meningkatkan keterampilan kolaborasi dan komunikasi di tingkat sekolah dasar. Hasil penelitian menunjukkan bahwa keberhasilan transformasi digital tidak dapat dicapai hanya melalui pengadaan perangkat keras, melainkan harus melalui rekayasa sistem yang menyeimbangkan interaksi sosial dengan infrastruktur teknis. Model STS-Digital terbukti mampu mengubah pola komunikasi yang sebelumnya bersifat satu arah menjadi dialogis dan partisipatif, serta meningkatkan tanggung jawab kolektif peserta didik dalam menyelesaikan tugas-tugas berbasis tim.

Penelitian ini memberikan kontribusi pada perluasan aplikasi teori sistem sosio-teknis dalam domain pendidikan dasar yang masih jarang dieksplorasi. Secara praktis, model ini menawarkan kerangka kerja bagi pendidik untuk memanfaatkan teknologi sebagai ruang sosial yang terstruktur, bukan sekadar alat distribusi konten. Keterbatasan penelitian ini terletak pada cakupan wilayah geografis yang masih terbatas, sehingga disarankan bagi peneliti selanjutnya untuk menguji model ini pada skala yang lebih luas dengan karakteristik budaya yang berbeda. Sebagai implikasi kebijakan, sekolah dasar diharapkan mulai mengadopsi pendekatan holistik ini dalam pelatihan profesionalisme guru untuk memastikan keberlanjutan inovasi kurikulum di era digital.

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