From Post-Disaster Support to Educational Equity: Conceptualizing a Volunteer-Driven Online Peer-to-Peer Learning Ecosystem at Scale

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Abstract

This study examines a grassroots, volunteer-driven peer-to-peer (P2P) educational initiative that emerged following a catastrophic earthquake and evolved into a sustainable educational program lasting over two years. Employing an interpretive case study approach—including participant observation, focus groups, and questionnaires—we explore the motivations and experiences of both tutors and learners, the perceived effectiveness of the online P2P model, and the barriers and enablers to scaling such initiatives. Our key findings indicate that while age proximity fosters trust and effective communication, it also poses authority challenges for tutors. Tutor engagement was fueled mainly by intrinsic motivators such as pursuing educational impact and community belonging. Learners reported significant gains in confidence, self-expression, and accelerated comprehension, attributing this to personalized, interactive sessions. Both cohorts called for a dedicated platform with enhanced features, such as built-in scheduling to overcome logistical hurdles. Finally, we articulate transferable principles for scaling P2P models, including flexible micro-volunteering pathways, strategic recruitment, and diversified funding.

Keywords: peer tutoring, peer mentoring, community-based education, volunteer teaching, P2P.

1. Introduction

Volunteer-driven tutoring has gained prominence worldwide as a strategy to support learners, particularly in response to crises or to address educational inequities [11], [6]. In such contexts, peer-assisted learning (PAL) strategies can extend educational opportunities, especially to those excluded from formal systems [5]. Grounded in cognitive and social constructivism, peer-to-peer (P2P) learning leverages social interactions to foster cognitive development, creating collaborative environments where knowledge is co-constructed through peer engagement [23], [18], [15], [12]. Research highlights that P2P learning enhances academic achievement, social connectedness, and psychological well-being [30], proving especially beneficial for students with limited cultural, social, or academic capital [8]. Moreover, PAL benefits both tutors and tutees [23], [30], [4], [1], [12]. Further refining the concept, Byl & Topping [4] distinguish between peer tutoring (focused on subject knowledge) and peer mentoring (emphasizing supportive relationships). They also differentiate reciprocal peer feedback (two-way, between similar near-peers) from nonreciprocal feedback (one-way, between far-peers with differing age or skill levels).

Advances in ICT and expanding Internet access, combined with the global shift to online learning accelerated by COVID-19 [21], [19], [20], [18], [16], have created fertile ground for developing online P2P learning models that support students during disruptions to formal education systems. This potential materialized in March 2023 with the launch of the Earthquake Solidarity Project, a grassroots

effort established to deliver both academic and emotional support to middle school students in southern Türkiye following a devastating natural disaster. This paper reports on the evolution of that initiative into a two-year-plus educational program and, to our knowledge, offers the first empirical study of volunteer-driven, nonreciprocal far-peer tutoring and mentoring delivered online in a post-disaster setting.

Informed by this real-world case, our research distills transferable principles for designing and scaling similar P2P initiatives, thereby helping to address educational inequities and enhance educational access for students in need more broadly. Our investigation was guided by three research questions:

RQ1: What factors influence the motivation and sustained participation of volunteers and learners in online P2P educational programs?

RQ2: How do volunteers and learners perceive the effectiveness of the online P2P learning model?

RQ3: What barriers, facilitators, and key design requirements underpin the scaling of volunteer-driven, online P2P educational initiatives toward widespread adoption?

2. Literature Review

2.1. Peer-Assisted Learning

A large body of research demonstrates the effectiveness of peer tutoring programs in supporting students across multiple domains [5],[12]. These programs promote not only academic success but also positive social and emotional outcomes [5],[12]. In a meta-analysis of 24 studies, Hidayat & Saad [12] found that peer tutoring significantly improves academic performance and yields modest but meaningful gains in students' self-concept, critical thinking, and attitudes toward school. Furthermore, Donald & Ford [8] suggest that peer learning extends beyond academic development by connecting students to essential support services and fostering a sense of belonging through collaborative peer networks.

Further research examines the specific structures of these interactions, particularly comparing nonreciprocal models with reciprocal models. Studies focusing on nonreciprocal arrangements show consistent benefits across different age groups. For instance, in primary education, Tymms et al. [31] found that nonreciprocal peer tutoring, involving older tutors (aged 10) and younger tutees (aged 8), produces modest but consistent gains in reading and mathematics attainment for both groups. Similarly, Capp et al. [5] reported that a nonreciprocal peer tutoring program in a K–8 school, with middle-school students tutoring upper-elementary tutees, led to modest academic gains but more substantial social–emotional benefits, high satisfaction among participants and parents, and practical recommendations for future implementation. Building on this body of research, Byl & Topping [4] conducted a more nuanced investigation within the university setting that examined not only the reciprocal versus nonreciprocal dimension but also distinguished between peer tutoring and peer mentoring. Their study involving first-year students found that different nonreciprocal models yielded distinct advantages: nonreciprocal peer tutoring delivered the greatest gains in academic engagement and involvement, while nonreciprocal peer mentoring proved most effective at enhancing both social integration and persistence. The particular success of nonreciprocal peer mentoring in boosting student persistence was attributed to the unique position of the mentors — typically higher-year students who had navigated the same early university stage relatively recently. This proximity in experience allowed mentors to better relate to their mentees' challenges, offer relevant guidance based on their greater experience and understanding of common struggles, and serve as effective role models [4].

Despite the demonstrated benefits of PAL, its potential has been less explored and realized in online and hybrid educational settings. Research highlights a critical gap between the potential of digital platforms to facilitate PAL and the actual engagement levels achieved in practice. Kotturi et al. [14] emphasize that merely providing technological tools for peer interaction is insufficient; without explicit curricular integration and performance incentives, student participation often falters, as learners fail to perceive the inherent value in these collaborative activities. Rasheed et al. [23] addressed this by scaffolding online PAL through structured group formation, system design features fostering collaboration, and incentives against social loafing. Their experiment with 120 students

showed significant academic gains when participants were prepared and motivated to engage actively. Building on this foundation, Mendieta-Aragón et al. [18] found that students acting as asynchronous video tutors in hybrid courses reported enhanced motivation, mastery, creativity, and communication skills. Tutees likewise preferred peer-generated videos over traditional materials. Synthesizing these studies, three key lessons emerge: (1) structured facilitation is crucial in digital PAL ecosystems; (2) incentives (grading, badges, recognition) counteract participation fatigue; and (3) reciprocal value creation (e.g., alternating tutor/tutee roles) deepens engagement.

However, these insights are drawn from stable academic environments, leaving their applicability to post-crisis settings—with their unique challenges of scalability, volunteer retention, and learner resilience—largely unexplored.

2.2. Volunteer-Driven and Community-Based Education

The scalability of PAL hinges on volunteerism and community engagement. Large-scale initiatives, such as Action Tutoring in the UK, show that programs thrive when fueled by intrinsically motivated volunteers seeking social impact, yielding academic gains for pupils and significant personal benefits for the volunteers themselves [11]. The importance of community ownership and local leadership is further magnified in unstable or resource-scarce contexts. Studies in post-conflict and rural settings demonstrate that sustainability is built on genuine community participation, trust in local leadership, and flexible program structures tailored to community needs [29], [10]. Essentially, sustainable programs are those co-created and actively supported by the community. The convergence of volunteerism, community engagement, and technology becomes particularly relevant in post-disaster recovery. Reporting on a service-learning initiative after Hurricane Katrina, Evans-Cowley [9] described how volunteer professionals guided students in disaster-recovery projects, using online forums and project-management tools to sustain collaboration across geographic distances. Collectively, these studies highlight core principles of motivation, ownership, and flexibility, but leave a critical gap in understanding their application in online settings.

2.3. Research Gap

While a substantial body of research has established the benefits of PAL and explored the dynamics of volunteer-driven community education, these domains have largely been investigated separately, with limited attention to their integration or the specific affordances of educational technology. The literature highlights successful models in stable academic environments or community-based initiatives, but a critical gap emerges at their intersection, particularly in volatile settings.

This gap is particularly evident in post-disaster contexts, where challenges of compromised infrastructure, inconsistent access, and heightened emotional needs demand flexible socio-technical systems. To our knowledge, no empirical study has comprehensively investigated a volunteer-based, nonreciprocal far-peer tutoring and mentoring model delivered entirely online in such a setting.

By addressing this multifaceted gap, this study moves beyond documenting a single case to offer transferable principles for designing a scalable and participatory online P2P learning ecosystem that integrates motivated volunteers, purpose-built digital platforms, and diversified funding mechanisms.

3. Research Methodology

We employed an interpretive case study methodology to uncover meaning through participant interpretations of their context [13]. Aligned with our exploratory goals [24], this approach facilitated a holistic examination of volunteer motivations, learner engagement, the operational intricacies of the online P2P ecosystem, and the broader contextual factors that enabled its sustainability beyond the initial crisis.

The Earthquake Solidarity Project was selected as a single holistic case [32] due to its unique trajectory from emergency response to a two-year-plus educational program [2]. By examining this case, we aim to show how this solidarity-based approach not only addressed urgent needs but also

fostered a resilient, community-centric solution for enduring educational support.

3.1. Case Description

The Earthquake Solidarity Project was launched in March 2023 in response to the devastating earthquake that hit southern Türkiye on 6 February. Its founder, driven by firsthand experiences with past earthquakes, initiated this endeavor to offer both academic and emotional support to affected middle school students. The post-disaster educational landscape was dire: schools were destroyed or damaged, reconstruction was slow, and many students lacked access to safe school buildings for months.

Across the affected regions, traditional, in-person classes were suspended. In Hatay, one of the hardest-hit provinces, schooling resumed incrementally over subsequent months, with existing facilities shared among multiple schools in a double-shift system. Furthermore, widespread family relocation due to housing destruction severed students' connections to their teachers and peers, fundamentally disrupting educational continuity.

The program targeted students in grades 6 to 8, with mathematics chosen as the core subject due to its foundational role in the curriculum and the founder's expertise. Volunteer tutors were recruited through online forms and brief interviews; students applied via the same process. The volunteer tutors came from diverse academic backgrounds — including undergraduate, master's, and PhD students, as well as recent graduates — and participated remotely from various Turkish cities. Before the program began, all volunteers attended an online orientation on trauma-informed pedagogy, led by a licensed psychologist. A flexible 12-week curriculum based on the national syllabus was crafted and tailored to the needs of each class. Although the project began without institutional funding, it later secured modest sponsorships to cover essential operational costs such as Zoom subscriptions and digital learning materials. To promote personalized support, the program utilized small classes of 5–6 students per tutor. The first author, along with three members of the Hypatia community, coordinated scheduling, class assignments, and weekly follow-ups. Beyond academic instruction, the initiative also aimed to foster emotional connection, a sense of belonging, and solidarity.

Initially designed as a short-term intervention ending in June 2023, the project's success and the strong commitment of both tutors and learners led to its extension until all enrolled students completed middle school in June 2025. In total, the initiative supported over 300 learners and engaged more than 40 volunteer educators, demonstrating its sustainability and growth beyond original expectations.

3.2. Data Collection Techniques

To gain a holistic understanding of the Earthquake Solidarity Project, we employed multiple data collection techniques, enabling methodological triangulation and the capture of rich qualitative and quantitative insights. All collected data are available at `https://p2p.lasd.pl`.

Documentation Analysis. We first analyzed project documentation, specifically the Tutoring Session Report — a concise, regularly updated spreadsheet in which volunteer tutors recorded session dates, tutee attendance, brief lesson synopses, and overall session status. This document provided valuable data on the project's operations, particularly important given that our formal research began over a year after the project's inception.

Participant Observation. Once the research commenced, the first author adopted the role of a participant observer. In line with Spradley [27], she engaged in "complete participation", transforming her ordinary involvement into a deliberate ethnographic stance. By diligently recording fieldnotes during significant events and interactions, she captured key aspects of the project's evolution and operational dynamics as they naturally unfolded.

Focus Groups. As the project neared completion, we held four semi-structured focus group sessions with key stakeholders: two with learners (L1: n=5, 58 minutes; L2: n=5, 50 minutes) and two with volunteer tutors (T1: n=4, 54 minutes; T2: n=5, 70 minutes). We employed purposive sampling to select learners who represented a variety of age groups (ranging from 13 to 15 years old) and who

had interacted with different tutors during the program, enabling us to capture a wide range of learner experiences shaped by diverse teaching styles and interpersonal dynamics. Four participants had completed the program one or two years prior to the focus group, providing them with sufficient temporal distance to reflect holistically on the initiative's long-term impact. Tutors were similarly chosen for their diversity in educational, personal backgrounds, and gender, with all having experience working with learners from different age groups while being at various life stages—including recent graduates, master's students, and early-career professionals—with ages spanning 22 to 29. This heterogeneity offered a richer view of motivations, challenges, and pedagogical strategies.

Guided by a set of open-ended questions, the sessions explored participant experiences, challenges, and perspectives on the P2P education model. Tutor groups also discussed strategies for scaling and sustaining similar volunteer-driven P2P education initiatives, with an emphasis on volunteer motivation and willingness to participate. All participants consented to the use of their real names.

Questionnaires. Finally, to complement our qualitative findings and reach a wider set of participants, we administered two structured questionnaires — one for tutoring recipients and another for tutors. Both instruments primarily used 5-point Likert-type items, supplemented by an open-ended question to elicit additional feedback. The tutee questionnaire focused on emotional support, academic improvements, satisfaction with the P2P model, and learning format preferences. Meanwhile, the tutor questionnaire explored preparedness, perceptions of program effectiveness, key motivators, and commitment to future volunteering. Notably, the tutee response rate was relatively low, likely because outreach relied on the project's original communication channel, which many graduates from 2023 and 2024 had stopped actively monitoring.

3.3. Data Analysis Techniques

To derive meaningful insights from the diverse data collected, we employed both qualitative and quantitative analysis techniques, each meticulously selected to match the inherent characteristics of the corresponding data. Given the volume and heterogeneity of the data, we initially conducted independent analyses—examining each dataset in isolation to generate preliminary insights. Subsequently, we performed systematic triangulation across data sources and methods. This approach enabled us to synthesize findings into robust interpretations grounded in multiple lines of evidence, thereby enhancing the validity and depth of the study.

Thematic Analysis. We applied thematic analysis [3] to all qualitative data from fieldnotes, focus group transcriptions, and open-ended questionnaire responses. The first two authors conducted the analysis. To preserve contextual integrity, we analyzed each dataset sequentially, thus preventing inadvertent conflation of narratives from distinct sources. To ensure transparency and rigor, the resulting codebooks defining the initial codes and themes are available at `https://p2p.lasd.pl`.

Diverging Stacked Bar Charts and Descriptive Statistical Analysis. We visualized responses to Likert-type items using diverging stacked bar charts. This technique provided an intuitive graphical summary of participants' attitudes, levels of satisfaction, and perceptions of effectiveness while respecting the ordinal nature of the data. Additionally, we employed descriptive statistics to summarize other quantitative measures, such as volunteers' intended time commitments for future initiatives. Because our questionnaires targeted the entire program population, inferential statistics were not applicable.

3.4. Threats to Validity

To systematically address potential limitations, we structure our discussion of threats to validity following established frameworks for case studies [32],[25]. However, as our study is exploratory and does not seek to establish causal relationships, internal validity is not investigated.

Construct Validity. A potential threat to construct validity is that the focus group sessions were moderated by the project founder. Specifically, recipients of free tutoring might have felt obliged to provide positive responses due to social desirability bias stemming from gratitude for the program.

To reduce this bias, we emphasized the value of critical feedback during sessions and offered an anonymous questionnaire channel. Another threat lies in the risk of misinterpreting what participants said or over-relying on subjective data (the reliance on participants' perceptions, feelings, experiences, and memories), which may reflect biased or incomplete perspectives. To mitigate both these threats, we employed data and method triangulation.

External Validity.   The Earthquake Solidarity Project is a unique and highly context-specific case. Therefore, direct generalization of its findings to other educational initiatives, particularly those operating in different cultural contexts or without a comparable crisis catalyst, is limited. Nonetheless, our study provides rich, transferable insights into the P2P education model. These insights can theoretically inform and practically guide similar community-driven projects.

Reliability.   A potential threat to reliability in this study stems from the inherently interpretive nature of qualitative data analysis, particularly in thematic analyses, where different researchers might derive varying insights from the same dataset.

Moreover, the first author's role as a participant-observer introduces a unique contextual lens that, while enriching the data with insider perspectives, may limit replicability by others unfamiliar with the project's history. To mitigate this, we ensured that fieldnotes were systematically recorded and cross-referenced with other data sources. We also reduced the risk of misinterpretation by audio-recording and transcribing verbatim all focus group sessions.

To enhance reliability, two researchers independently analyzed the data. Their findings were then systematically compared and reconciled through discussion to resolve discrepancies, achieve consensus, and enrich the final interpretations.

Finally, we documented our data analysis procedures in detail, providing a clear audit trail of our research process. For instance, the codebooks developed during thematic analysis, along with the coded transcriptions, are made available to enhance the traceability of our interpretations.

4.   Findings

4.1.   Insights from Documentation and Participant Observation

Analysis of tutoring session reports from the project's initial phase, a 12-week program concluding at the end of the Spring 2023 semester, reveals key operational dynamics within the digitally-mediated, post-disaster context. Persistent technical challenges, particularly internet connectivity issues for students in rural or temporary housing, were recurring impediments to consistent attendance, yet overall engagement remained high. Tutors demonstrated adaptability and commitment, proactively delivering one-on-one follow-up sessions for students with repeated absences. In cases of student attrition, follow-ups with families identified geographic relocation and persistent connectivity barriers as primary causes. Moreover, tutors responded dynamically to evolving student needs; noting learner fatigue in the final three weeks, they integrated more interactive and game-based activities to sustain motivation. From Week 8 onward, scheduling conflicts also emerged as a notable attendance constraint.

The program's socio-emotional impact was evident at the voluntary end-of-semester virtual graduation ceremony. Attended by over 100 participants, this event showcased the project's broader impact through powerful emotional testimonials from students and parents. One student vividly captured the sentiment, stating, *"Everything was dark... You became our stars and illuminated our path."* This culminating event highlighted the strong community spirit and significant emotional support fostered by the initiative, extending its value beyond academic outcomes.

In the subsequent 2023/2024 academic year, the initiative continued with a reduced cohort of returning students (7th and 8th graders). The program expanded beyond core academics, offering specialized activities such as peer mentorship sessions where successful high school students shared study strategies and transitional experiences. This period of sustained success, set against the clear limitations of Zoom, laid the groundwork for a more ambitious solution: a dedicated P2P platform.

During the 2024/2025 academic year, the program entered its final phase, exclusively support-

ing 8th grade students as they completed middle school. This further reduced student-to-tutor ratio facilitated enhanced personalization and responsiveness, reinforcing strong tutor–student bonds and maintaining high motivational levels among participants.

Participant observation fieldnotes provide further insights, capturing the enduring nature of the project's impact long after the initial crisis response. Illustrating this, two years after its inception, on the anniversary of the earthquake, a parent shared: *"You were there when no one else held our children's hands. My older daughter graduated with your help, and my younger one is still learning with you. This meant everything to us."*

Analysis of additional participant observation fieldnotes revealed the potential for scaling the initiative into a nationwide program to support students in need. At the same time, these notes underscore the inherent limitations of the current approach, including constrained volunteer availability, lack of financial support, and the inadequacy of generic platforms like Zoom for fostering deep interaction and community. It was this very tension—between the project's demonstrated positive impact and its underlying vulnerabilities—that catalyzed a vision for a dedicated P2P education platform. This platform would establish a sustainable ecosystem for peer-driven learning, addressing educational inequities across Turkey through dedicated features that support meaningful connections and growth for both learners and university-level tutors.

4.2. Focus Group Insights: Volunteer Tutor Perspectives

4.2.1. Operational Challenges and Pedagogical Considerations in P2P Tutoring

Technical and Environmental Barriers. Tutors recognized that online P2P learning both broadens access and introduces new challenges. On the one hand, digital lessons enable learners in remote or underserved areas to receive quality support. On the other hand, sessions are sometimes cut short by internet dropouts, power outages, or a lack of appropriate devices. Tutors also pointed out in-home distractions—such as family interruptions—that undermine learners' concentration.

Interaction and Engagement Challenges in Online Learning. Tutors agreed that passive lectures fail to capture attention, and that monitoring engagement online is considerably harder than in a traditional classroom. To address this, they recommended incorporating interactive elements — breakout discussions, real-time quizzes, collaborative annotation tools — alongside socio-emotional check-ins to recreate the supportive atmosphere of in-person classes. When these features were effectively integrated, tutors observed notably higher learner motivation and deeper cognitive involvement.

The Double-Edged Sword of Age Proximity: Fostering Trust and Challenging Authority. Teaching peers close in age was identified as both an opportunity and a challenge. Tutors agreed that age proximity lowers affective barriers, fostering trust and openness, and that near-peer tutors can better understand tutee challenges from their own recent experience. However, this proximity also creates authority gaps: several tutors feared that tutees might view them as "just another friend," making classroom management more difficult.

Personalization and Learner-Centered Approaches. Volunteers recognized that learning preferences vary widely: some tutees thrive in groups, others in one-on-one settings. As Nefise (T2) observed, *"In a group setting, not everyone is comfortable being open. If a tutee doesn't understand something, they might hesitate to ask."* Thus, an effective P2P platform should offer both formats to accommodate these different needs.

Personalization emerged as critical for digital P2P effectiveness. Participants consistently emphasized that tailoring lessons to individual preferences substantially improves outcomes. Elif Naz (T2) recommended that *"a short test should be done before matching a mentor and a tutee. Personality compatibility is crucial."* This focus on personalization highlights a key advantage of P2P models over more standardized educational approaches.

4.2.2. Systemic Enablers and Constraints for Volunteer-Driven P2P Initiatives

Flexible Time Commitment and Micro-Volunteering. Time availability emerged as the key constraint for volunteering in future initiatives. Although most tutors reported that committing 1 to 2 hours a week was realistic, they also noted that their capacity could expand during emergency periods, suggesting that perceived urgency could boost volunteer engagement. They consistently stressed that academic and personal obligations fluctuate, making fixed schedules challenging. Therefore, they advocated for micro-volunteering options. They proposed that instead of rigid weekly commitments, allowing tutors to select sessions on an ad-hoc basis would better align learner needs with tutor availability.

Multifaceted Motivation Drivers for Volunteer Tutors. Our analysis uncovered a rich motivation framework driving tutor engagement, comprising both intrinsic and extrinsic factors. At the core, creating educational impact consistently ranked highest as an intrinsic motivator. As Elif (T1) reflected, *"Being able to contribute to the younger generation both academically and socially would be deeply meaningful."* This sense of purpose was further reinforced by the emotional fulfillment of witnessing tutee growth. Belonging to a supportive community represented another strong intrinsic driver, with Elif Naz (T2) describing *"being part of something that outlives its individual members is very meaningful."*

On the extrinsic side, professional development benefits — such as enhancing one's CV and receiving formal recognition (reference letters, certificates) — were frequently cited by career-focused volunteers. While financial compensation was mentioned by several participants, it was consistently positioned as supplementary rather than primary.

Multi-Modal Feedback Channels. Tutors expressed varied preferences for feedback, yet there was strong consensus on the need for anonymous mechanisms. Şebnem (T2) noted, *"anonymity helps ensure more transparent and sincere feedback,"* and Elif (T1) added, *"Sometimes students can't express themselves face-to-face, but in written and anonymous formats, they may be more open."* Several tutors also valued direct one-on-one discussions to clarify specific points.

4.3. Focus Group Insights: Learner Perspectives

4.3.1. The Power of Age Proximity and Empathetic Tutoring

Middle school learners consistently highlighted the value of reduced hierarchical distance between themselves and their tutors. They emphasized that a smaller age gap facilitates more comfortable and effective communication. As Umut (L2) explained, *"teachers who are close to our age understand us more easily."* Participants also reported that the tutors could more effectively convey complex concepts compared to their regular teachers, attributing this to generational proximity and similar thought patterns.

When discussing their ideal interaction styles, learners expressed a preference for a balanced mix of guidance and camaraderie. As Elif Dağ (L2) articulated, *"It would be best if the communication is both guidance-focused and friendly—someone who gives direction while also maintaining a warm and approachable tone."*

4.3.2. Empowering Confidence and Self-Expression

Learners highlighted the positive impact of peer tutoring on their confidence and self-expression. As Rüveyda (L1) shared, *"One of the most important things for me when I joined these sessions was how much it boosted my self-confidence. I started speaking better, expressing myself more clearly, and improving my social skills."*

This transformation extended beyond the program itself, transferring to regular school settings. Hicran (L2) contrasted the two environments: *"In a classroom setting, if there's something I don't understand, I don't speak up... But here, I can say it easily."* Supporting this observation, Azra (L2) confirmed, *"Communicating with university students {tutors} had an impact on me—I started expressing myself more confidently at school."* Beyond confidence gains, learners reported cognitive benefits as well. Hicran (L2) noted accelerated comprehension: *"Something that would take me three weeks to grasp on my own, I can understand here in one week."*

4.3.3. Benefits of Small Groups and Personalized Interaction

Learners described the P2P learning environment as one that fosters a more personalized and interactive experience. They frequently cited smaller class sizes as a key factor enabling greater participation and individualized attention. As Elif Dağ (L2) noted, *"Smaller groups are better. Because the tutors are close to our age, we feel more comfortable. They motivate us."*

Learners also found this setup more conducive to concentration and engagement. They highlighted the benefit of being able to revisit challenging concepts and receive immediate feedback. Melek (L2) identified this as *"the biggest advantage,"* explaining that tutees get *"a second chance to hear something we didn't understand at school—or learning it here first and reinforcing it later in school."*

4.3.4. Technical and Logistical Barriers

The online P2P model presented several practical obstacles. Connectivity issues and home distractions interrupted the learning flow. Azra (L1) cited *"power outages or no internet,"* while Hicran (L2) raised concerns about the health effects of *"extended time spent in front of a screen."* The home learning environment itself could also present challenges. Umut (L2) remarked, *"Sometimes we have guests at home, and it becomes hard to find a quiet space. That makes it harder to concentrate and stay focused."* Scheduling also posed a persistent challenge, with Başak (L1) identifying timetable conflicts as *"the biggest issue"* and Elif Dağ (L2) noting, *"lesson times sometimes clash with other plans."*

4.3.5. Envisioned P2P Learning Platform Features

When asked to envision an ideal P2P platform, learners identified several key features. They emphasized the value of flexibility in session formats, supporting both one-on-one sessions (for depth and personalized pacing) and small-group formats (for peer motivation and collaborative problem-solving). To manage content effectively, they suggested a shared digital library containing practice exams and guided walkthroughs, complemented by occasional "inspiration sessions" where tutors could share study strategies and success stories. They also called for administrative tools like a built-in scheduling system to streamline session coordination.

For tracking progress effectively, participants proposed a three-tiered approach: (1) automated self-assessments and mock exams feeding into an AI-powered dashboard that pinpoints recurring errors and recommends personalized practice plans; (2) qualitative tutor feedback providing concise comments on strengths and areas for growth; and (3) anonymous leaderboards to foster healthy competition and sustain motivation. When considering broader implications, learners envisioned that a dedicated P2P platform, if implemented at scale, could democratize educational access, reduce reliance on private tutoring centers, and cultivate global learning communities.

4.4. Questionnaire Insights

Quantitative data from questionnaires confirms the overwhelmingly positive experiences of both volunteer tutors and learners (see Figure 1). While Zoom was viewed as an adequate tool for P2P sessions, both groups strongly advocated for a dedicated educational platform equipped with features like dedicated assignment areas, student discussion forums, and enhanced whiteboard functionality.

Regarding motivation, tutors prioritized intrinsic factors over financial compensation as their primary drivers. However, compensation was identified as a powerful lever for increasing potential time commitment: volunteers indicated a willingness to provide 2.6 hours/week unpaid (median: 2.0), but indicated readiness for an additional 3.4 paid hours (median: 2.0), an increase particularly pronounced among those who valued compensation more highly. Notably, the vast majority of learners expressed interest in becoming volunteer tutors themselves in the future.

Insights from open-ended responses provided a roadmap for future development. Tutors proposed creating a dynamic community where users could seamlessly switch between learner and educator roles, supported by AI-enhanced tutor-tutee pairings and opportunities for non-teaching volunteers to

contribute resources. They also recommended leveraging advertising, social media, public announcements, and donor support to attract more participants. Learners, meanwhile, emphasized expanding the variety of subjects and increasing the availability of one-on-one classes.
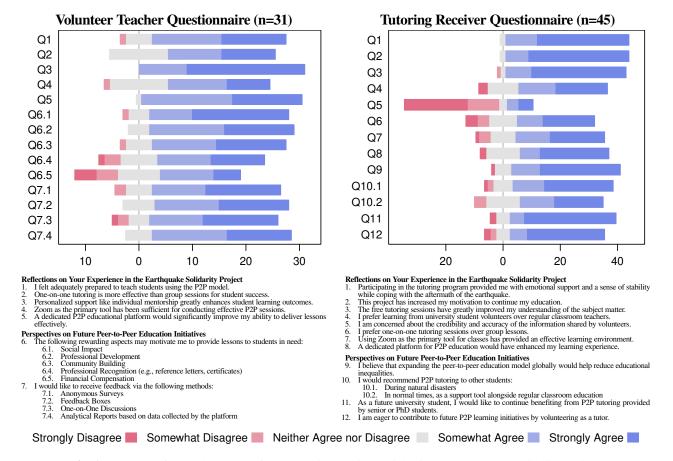

Volunteer Teacher Questionnaire (n=31)

Tutoring Receiver Questionnaire (n=45)

Reflections on Your Experience in the Earthquake Solidarity Project
1. I felt adequately prepared to teach students using the P2P model.
2. One-on-one tutoring is more effective than group sessions for student success.
3. Personalized support like individual mentorship greatly enhances student learning outcomes.
4. Zoom as the primary tool has been sufficient for conducting effective P2P sessions.
5. A dedicated P2P educational platform would significantly improve my ability to deliver lessons effectively.

Perspectives on Future Peer-to-Peer Education Initiatives
6. The following rewarding aspects may motivate me to provide lessons to students in need:
    6.1. Social Impact
    6.2. Professional Development
    6.3. Community Building
    6.4. Professional Recognition (e.g., reference letters, certificates)
    6.5. Financial Compensation
7. I would like to receive feedback via the following methods:
    7.1. Anonymous Surveys
    7.2. Feedback Boxes
    7.3. One-on-One Discussions
    7.4. Analytical Reports based on data collected by the platform

Reflections on Your Experience in the Earthquake Solidarity Project
1. Participating in the tutoring program provided me with emotional support and a sense of stability while coping with the aftermath of the earthquake.
2. This project has increased my motivation to continue my education.
3. The free tutoring sessions have greatly improved my understanding of the subject matter.
4. I prefer learning from university student volunteers over regular classroom teachers.
5. I am concerned about the credibility and accuracy of the information shared by volunteers.
6. I prefer one-on-one tutoring sessions over group lessons.
7. Using Zoom as the primary tool for classes has provided an effective learning environment.
8. A dedicated platform for P2P education would have enhanced my learning experience.

Perspectives on Future Peer-to-Peer Education Initiatives
9. I believe that expanding the peer-to-peer education model globally would help reduce educational inequalities.
10. I would recommend P2P tutoring to other students:
    10.1. During natural disasters
    10.2. In normal times, as a support tool alongside regular classroom education
11. As a future university student, I would like to continue benefiting from P2P tutoring provided by senior or PhD students.
12. I am eager to contribute to future P2P learning initiatives by volunteering as a tutor.

Strongly Disagree █   Somewhat Disagree █   Neither Agree nor Disagree █   Somewhat Agree �   Somewhat Agree █   Strongly Agree █

Fig. 1. Responses from volunteers (left) and tutoring receivers (right) in the Earthquake Solidarity Project.

5. Discussion

Interpreting our findings through several theoretical frameworks illuminates the interplay of individual, social, and technological factors that shape user engagement within online communities and can inform the design and sustainability of P2P learning platforms.

Self-Determination Theory (SDT) [26] provides a compelling narrative about the pivotal role of psychological needs in sustaining volunteer engagement within P2P learning ecosystems. Our findings show that intrinsic motivators dominate, directly satisfying all three of SDT's core needs: the desire for educational impact and witnessing tutee growth fulfills the need for *Competence*; the emotional fulfillment from tutor-learner bonds and community belonging satisfies the need for *Relatedness*; and the strong advocacy for flexible time commitment and micro-volunteering expresses the need for *Autonomy*. Crucially, this demand for *Autonomy* is not a desire for unbridled freedom but a practical need to align altruistic goals with real-life constraints.

By advocating for ad-hoc scheduling and urgency-responsive availability, tutors exemplify SDT's *integrated regulation*, where actions harmonize intrinsic values with extrinsic demands (e.g., time scarcity). These insights underscore the need for P2P platforms to prioritize features that holistically support volunteers by satisfying their needs for *Autonomy* (through flexibility), *Competence* (by highlighting impact), and *Relatedness* (by fostering community), thereby sustaining engagement.

Shifting focus, **Social Identity Theory (SIT)** [28] sheds light on the nuanced role of age proximity in sculpting tutor–learner dynamics. Learners' preference for tutors close in age underscores SIT's

premise that a shared *in-group* identity, based on age, reduces hierarchical distance, fostering openness, trust, and communication. Yet, tutors' apprehensions about blurred authority boundaries highlight a core SIT conflict: this shared identity simultaneously weakens the *out-group* distinction required for a traditional instructor role. This creates a tension between camaraderie and guidance—a challenge created by the tutor simultaneously occupying both *in-group* (peer) and *out-group* (authority) roles. This suggests that P2P platform design should reinforce tutors' professional identity (e.g., through badges) to maintain authority while leveraging the benefits of *in-group* rapport.

Augmenting this perspective, **Social Capital Theory (SCT)** [22] explains the relational benefits that drive engagement in P2P learning. Tutors' sense of belonging to a community that *"outlives its individual members"* and learners' comfort in smaller, personalized groups reflect the accumulation of *bonding social capital* (the strong, trusting ties within a group), which fosters trust and reciprocity. Additionally, tutors' aspiration for professional development indicates the creation of *bridging social capital* (links to external resources and networks), as the platform allows volunteers to convert their participation into tangible professional assets, including an enhanced CV and valuable references. This highlights the need for platforms to incorporate trust-building mechanisms (e.g., reputation systems) to intentionally cultivate both forms of social capital, thereby sustaining participation.

Finally, **Media Richness Theory (MRT)** [7] helps interpret the impact of communication modalities on engagement. In line with MRT's principle that complex, equivocal tasks like teaching require richer media, our findings reveal a clear demand for a richer communication environment, evidenced by tutors' advocacy for interactive elements and learners' appreciation for immediate feedback. This suggests that platform designers should prioritize integrating richer media to optimize user experience.

5.1. Theoretical Implications

This study's analysis of how a grassroots P2P initiative evolved from crisis response to an enduring socio-technical infrastructure yields key theoretical implications at the intersection of digital volunteering and peer learning. First, extending Self-Determination Theory to "crisis-catalyzed volunteerism," we find that acute situational urgency can intensify intrinsic motivations such as impact and solidarity, overriding barriers like time scarcity and facilitating sustained engagement.

Second, we add nuance to Social Identity Theory by identifying a "dual-identity paradox": the tutor's shared *in-group* identity with learners fosters trust but weakens the *out-group* distinction required for authority. To explain how effective tutors navigate this, we introduce the concept of "pedagogical code-switching": the ability to strategically shift between a peer identity (to build rapport) and an instructor identity (to guide learning). We propose that this capacity is a critical, yet previously unarticulated, skill for effective classroom management in non-reciprocal, far-peer tutoring.

Finally, by tracing how an improvised online learning environment morphed into a long-term learning infrastructure, we identify the socio-technical mechanisms that convert spontaneous volunteer energy into resilient educational ecosystems. Collectively, these insights provide a transferable analytic lens for scholars examining future crises that catalyze digitally mediated learning communities.

5.2. Design Principles for Sustainable P2P Learning Ecosystems

Our findings offer a blueprint for designing and sustaining volunteer-driven P2P educational ecosystems that expand equitable access to quality learning. We propose four key design principles:

Design for Flexible yet Continuous Engagement. P2P platforms should offer a hybrid model that combines stable, long-term group sessions with flexible micro-volunteering options for one-on-one support. This approach maximizes both tutor participation and learner continuity. To streamline coordination, platforms should integrate automated scheduling and communication tools.

Build a Diversified Resource Strategy. Sustainable operations depend on diversified resource streams. This includes securing financial support through sponsorships, grants, or corporate partnerships, as well as forging strategic collaborations with educational institutions and NGOs to gain access

to vital resources, expand recruitment pools, and broaden community reach.

Foster a Mutually Beneficial Volunteer Ecosystem. To sustain volunteer engagement, programs should offer a blend of professional development, formal recognition (e.g., certificates, digital badges), and community-building opportunities. Where feasible, these can be supplemented with financial incentives. Integrating anonymous, multi-modal feedback channels into the platform can further support ongoing improvement and foster a sense of belonging.

Enable Data-Informed Personalization. Platforms should leverage personalization as a core advantage of the P2P model. This can be achieved by using brief pre-assessments to inform matching algorithms that create compatible and effective tutor-learner pairings. This data-informed approach is critical for improving outcomes for diverse learners.

Together, these design principles operationalize a vision for solidarity-based learning, guiding the creation of scalable learning ecosystems that advance educational equity.

5.3.   Future Research

Future research should build on these human-centered principles by exploring the strategic integration of GenAI to create a more effective and scalable ecosystem. The central challenge is not to replace human connection but to amplify it. For tutors, this means designing AI "co-pilots" that support time-constrained volunteers by generating personalized lesson plans and pedagogical suggestions. For learners, AI tutors could provide persistent scaffolding through 24/7 practice, making their limited time with human mentors more impactful. Ultimately, designing and evaluating such human-AI partnerships will be a defining challenge for creating sustainable and equitable learning systems in the "post-COVID-19 and generative AI era" [17].

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