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Digital Education for Lake Water-Quality Monitoring Using Saprobic Indicators and a Socio-Psychological Approach

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Abstract

Telaga Ngipik is an urban freshwater ecosystem in Gresik, East Java, with considerable ecological and community value; however, translating environmental information into sustained public monitoring remains challenging. This community service program developed and implemented a digital education platform that integrated phytoplankton-based saprobic indicators with socio-psychological assessment and community mentoring. The program was conducted from 12 May to 20 July 2026 with two non-equivalent community groups (100 participants enrolled: 50 intervention and 50 comparison). The intervention combined participatory needs assessment, application co-design, environmental education, technical training, field mentoring, and digital monitoring practice. Detailed outcome summaries were available for the 50 intervention participants, while complete-case psychometric analyses were available for 42 respondents. The application translated saprobic information into accessible visual categories and achieved a System Usability Scale score of 84.2. Program records also indicated a 42.5% increase in technical competence, an environmental-stewardship intention indicator of 88%, and a 65% increase in self-initiated monitoring activity. Psychometric analyses showed inter-item correlations of .55 for Being Away, .36-.62 for Coherence, .47-.90 for Compatibility, .03-.68 for Fascination, and .19-.91 for the separately defined Health item set; all five summary variables were non-normally distributed. Because complete comparison-group outcome estimates and raw denominators for several aggregate indicators were unavailable, these outcomes are interpreted descriptively rather than as definitive controlled effects. Overall, the program demonstrates the feasibility of integrating digital bioindicator communication, environmental education, and community participation in lake monitoring, although stronger comparative evaluation is required before causal effectiveness can be established.

Keywords: citizen monitoring; digital environmental education; lake water quality; saprobic indicator; socio-psychological assessment

Abstrak

Telaga Ngipik merupakan ekosistem air tawar perkotaan di Gresik, Jawa Timur, yang memiliki nilai ekologis dan sosial, tetapi informasi lingkungan belum selalu mudah diterjemahkan menjadi pemantauan masyarakat yang berkelanjutan. Program pengabdian kepada masyarakat ini mengembangkan dan menerapkan platform edukasi digital yang mengintegrasikan indikator saprobik berbasis fitoplankton dengan asesmen sosial-psikologis dan pendampingan masyarakat. Program dilaksanakan pada 12 Mei-20 Juli 2026 pada dua kelompok komunitas non-ekuivalen (100 peserta terdaftar: 50 intervensi dan 50 pembanding).

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Intervensi mencakup identifikasi kebutuhan partisipatif, co-design aplikasi, edukasi lingkungan, pelatihan teknis, pendampingan lapangan, dan praktik pemantauan digital. Dokumen program yang diserahkan memuat ringkasan hasil terperinci untuk 50 peserta intervensi; analisis psikometrik complete-case tersedia untuk 42 responden. Aplikasi mengubah informasi saprobik menjadi kategori visual yang mudah dipahami dan memperoleh skor System Usability Scale 84,2. Catatan program juga melaporkan peningkatan kompetensi teknis 42,5%, indikator niat kepedulian lingkungan sebesar 88%, dan peningkatan aktivitas pemantauan mandiri 65%. Analisis psikometrik menunjukkan korelasi antarbutir sebesar 0,55 untuk Being Away, 0,36-0,62 untuk Coherence, 0,47-0,90 untuk Compatibility, 0,03-0,68 untuk Fascination, dan 0,19-0,91 untuk kumpulan butir Health yang diperlakukan terpisah; seluruh variabel ringkasan tidak berdistribusi normal. Karena estimasi hasil lengkap kelompok pembanding dan denominator mentah untuk beberapa indikator agregat tidak tersedia dalam catatan analitik yang diserahkan, hasil tersebut ditafsirkan secara deskriptif dan bukan sebagai efek terkontrol yang definitif. Program menunjukkan kelayakan integrasi komunikasi bioindikator digital, edukasi lingkungan, dan partisipasi masyarakat untuk pemantauan danau, namun evaluasi komparatif yang lebih kuat masih diperlukan sebelum efektivitas kausal dapat disimpulkan.
Kata kunci: edukasi lingkungan digital; indikator saprobik; kualitas air danau; pemantauan warga; asesmen sosial-psikologis

INTRODUCTION

Telaga Ngipik, located in Gresik Regency, East Java, is an urban freshwater ecosystem used by surrounding communities for fisheries, recreation, local economic activities, and other environmental services. Freshwater systems in rapidly urbanizing and industrial areas are particularly vulnerable to nutrient enrichment, organic loading, land-use change, and declining ecological quality. Contemporary water-management literature increasingly emphasizes the integration of scientific evidence with sustained community participation because citizen-generated observations can complement formal monitoring networks and strengthen local stewardship when adequate training, feedback, and institutional support are provided (Njue et al., 2019; Capdevila et al., 2020; Dominguez-Rendón et al., 2024). At Telaga Ngipik, water-quality deterioration, environmental pressure, and limited public capacity to interpret ecological information were identified as the central partner concerns. However, a verified recent numerical dataset describing local water quality was not available for this report; therefore, no additional local figures are presented.

The practical challenge extends beyond generating water-quality information to ensuring that biological indicators are understandable and usable by non-specialists. Phytoplankton and other aquatic biota can provide ecologically meaningful information about water conditions, while citizen-science approaches can broaden the spatial and temporal coverage of observation and increase public engagement (Aura et al., 2021; Malthus et al., 2020). Smartphone- and web-based monitoring tools can translate environmental observations into accessible records and visual outputs; nevertheless, usability, training, data quality, and sustained motivation remain important determinants of continued use (Carrion et al., 2020; Lewis, 2018; Capdevila et al., 2020). These considerations were directly relevant to Telaga

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Ngipik, where the program sought to translate saprobic information into a practical digital interface for community monitoring.

Environmental education can improve knowledge, attitudes, intentions, and behavior, but cognitive gains do not automatically result in sustained pro-environmental action. Systematic reviews indicate that local relevance, active participation, partnerships, practical tasks, feedback, and repeated engagement are important for translating environmental learning into action (Ardoin et al., 2020; Grilli & Curtis, 2021; van de Wetering et al., 2022; Rau et al., 2022). Citizen-science initiatives may also strengthen environmental citizenship when participants move beyond passive data collection toward collaborative interpretation and local decision-making (Hadjichambis et al., 2021; Dominguez-Rendón et al., 2024). Accordingly, this program combined technical monitoring with participatory education rather than relying solely on a stand-alone application.

The socio-psychological component was designed to explore how participants perceived and emotionally related to the lake environment. Contemporary research on perceived restorativeness highlights dimensions such as Being Away, Coherence, Compatibility, and Fascination, while also recognizing that scale structure, item wording, and context influence interpretation (Pasanen et al., 2018; Jang & Son, 2020; Menardo et al., 2021; Ríos-Rodríguez et al., 2021). Connection with natural environments is also positively associated with pro-environmental behavior, although behavioral outcomes are shaped by multiple contextual and psychological determinants (Whitburn et al., 2020; Okumah et al., 2020; Panno et al., 2020). A separate Health item set was also analyzed in the program dataset. Because this item set was not one of the four PRS dimensions specified in the study framework, it is treated as a distinct construct rather than as a PRS subscale.

The program's distinctive contribution lies in integrating three elements within a single community-empowerment model: phytoplankton-based saprobic communication, a mobile/web monitoring interface, and socio-psychological reflection supported by field mentoring. This design responds to evidence that effective community water monitoring depends not only on technical capacity but also on the quality of interaction among citizens, institutions, and scientific facilitators (Capdevila et al., 2020; Njue et al., 2019). The program also sought to establish a pathway toward local ownership through the involvement of Pokmaswas, community representatives, student facilitators, and a local monitoring cadre.

The program therefore aimed to develop and implement an accessible digital platform for saprobic-based lake monitoring while strengthening community capacity to understand, use, and sustain environmental monitoring at Telaga Ngipik. The measurable outputs available for reporting were application usability, reported changes in technical competence, environmental-stewardship intention, self-initiated monitoring activity, and psychometric characteristics of the socio-psychological item sets. Because complete intervention-versus-comparison outcome estimates were unavailable, the findings are reported descriptively and are not interpreted as definitive between-group effects.

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METHODS

This community service activity implemented the research-based program entitled "Development of an Environmental Quality Assessment Application for Telaga Ngipik Based on the Saprobic Index and a Socio-Psychological Approach." The implementation plan followed a non-equivalent two-group pretest-posttest framework. A total of 100 community participants were enrolled and allocated to an intervention group (n=50) and a comparison group (n=50). The intervention group received environmental education, application training, field mentoring, and socio-psychological activities, whereas the comparison group continued routine community activities during the primary implementation period. Group allocation was non-random and followed existing community-group participation. Detailed allocation records and complete baseline-comparability statistics were unavailable; accordingly, these characteristics are acknowledged as limitations rather than reconstructed retrospectively.

The program was conducted at Telaga Ngipik and in the surrounding community in Gresik, East Java, Indonesia, from 12 May to 20 July 2026. Field activities were carried out at the lake, while training, demonstrations, discussions, and evaluation were delivered through face-to-face and field-based sessions. The site was reported to be approximately 12 km, or about 25 minutes' travel, from the university campus.

The partner groups were the Telaga Ngipik Environmental Watch Group (Pokmaswas) and the Telaga Ngipik Village Community Group. Participants included fish farmers, PKK cadres, youth representatives, and other residents involved in or living near the lake ecosystem. Eligibility was based on involvement in community or lake-related activities, willingness to participate, and the ability to take part in environmental-monitoring and application activities. Four undergraduate students served as field facilitators and community liaisons, while lecturers acted as technical facilitators and evaluators.

Three denominators corresponded to different stages of the program: 100 participants were enrolled in the two-group design; outcome summaries were available for 50 intervention participants; and 42 complete responses were available for the psychometric and Shapiro-Wilk analyses. A complete attrition or exclusion log was not available for the eight intervention participants without complete psychometric records, and complete post-intervention outcome estimates for the comparison group were also unavailable. The analyses therefore distinguish clearly among enrolled participants, intervention-outcome records, and complete-case psychometric data.

The intervention comprised preparation, participatory needs assessment, application co-design, environmental education, technical workshops, field mentoring, evaluation, handover, and follow-up. Participants learned water-sample collection, phytoplankton bioindicator identification, interpretation of saprobic information, environmental data recording, and use of the mobile/web interface. Weekly field assistance supported independent sampling and application use. Following evaluation, application procedures and supporting educational materials were handed over to designated local representatives. Although eco-branding was

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mentioned during program planning, no corresponding measurable outcome was available; it was therefore not included in the interpretation of intervention outcomes.

The application functioned as both an educational and a data-recording tool. It translated phytoplankton-based saprobic information into color-coded visual categories of water quality, supported data entry, and was designed to operate under conditions of limited connectivity. Perceived usability was assessed using the System Usability Scale (SUS), a widely used standardized measure of usability (Lewis, 2018).

The evaluation focused on technical competence in digital water-quality assessment, environmental-stewardship intention, self-initiated monitoring activity, application usability, and socio-psychological item responses. Aggregate program indicators were reported as a 42.5% increase in technical competence, an environmental-stewardship intention indicator of 88%, a 65% increase in self-initiated monitoring activity, and a SUS score of 84.2. Because the underlying pretest and posttest values, raw denominators, comparison-group estimates, confidence intervals, and effect-size calculations were unavailable for these aggregate indicators, they are presented as descriptive program measures rather than inferential treatment effects.

The socio-psychological assessment included items grouped under Being Away, Coherence, Compatibility, and Fascination, consistent with constructs commonly used in perceived-restorativeness research. A separate 12-item Health set (IK1-IK12) was also analyzed. A formal adaptation protocol, complete item wording, content-validity index, Cronbach's alpha, McDonald's omega, and validated scoring interpretation were not available. Consequently, the available inter-item correlations are presented as preliminary psychometric information, and the instrument is not described as locally validated. Inter-item Pearson correlations were available for Being Away and as ranges for the other item sets. Shapiro-Wilk tests were available for 42 complete cases and indicated non-normal distributions for all five summary variables. Descriptive means and rankings were also available. Because complete comparison-group outcomes and final software details were unavailable, no additional inferential comparisons, effect sizes, or confidence intervals were generated. Future analyses should consider non-parametric or robust procedures when distributional assumptions are not satisfied.

The service team coordinated with relevant institutional and community authorities, informed participants about program procedures and data use, obtained informed consent, and protected participant confidentiality. Separate consent was reported for identifiable photographs, although photographs are not included in this publication-ready version. An ethics-approval or institutional-permission identifier was not available and therefore is not reported. Sustainability was supported through the planned local monitoring cadre, Komunitas Peduli Telaga Ngipik, and designated local champions from Pokmaswas and the village community. The application, monitoring procedures, and educational materials were intended for continued use after the formal program period. Student facilitators were integrated into

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campus experiential-learning activities, while local representatives were expected to coordinate periodic monitoring and communication with the service team.

RESULTS

The results are presented according to the analytical denominator available at each stage of the program. A total of 100 participants were enrolled and divided equally between intervention and comparison groups. Program-outcome summaries were available for 50 intervention participants, while psychometric analyses were based on 42 complete intervention records. Complete post-intervention outcome estimates for the comparison group were unavailable; consequently, no between-group effectiveness estimate is reported.

Table 1. Participant flow and available analytical denominators

Stage	Intervention	Comparison	Total / analytic n
Enrolled in two-group program	50	50	100
Program-outcome summaries available	50	Not reported	50
Complete psychometric records	42	Not reported	42

Note. A complete attrition/exclusion log and complete comparison-group posttest outcomes were unavailable. Denominators are therefore reported separately for each analytical stage rather than combined into a single sample size.

The digital application translated phytoplankton-based saprobic information into real-time, user-friendly visual categories. Four aggregate program indicators were available for the intervention group. These values are retained as reported; however, the corresponding raw pretest and posttest values, comparison-group estimates, denominators for each percentage, confidence intervals, and effect sizes were unavailable. The indicators should therefore be interpreted descriptively rather than as evidence of a controlled intervention effect.

Table 2. Reported program summary indicators for the intervention group

Indicator	Reported result	Interpretive note
Technical competence in digital water-quality assessment	42.5% increase	Descriptive aggregate change; raw denominator and comparison estimate unavailable
Environmental-stewardship intention	88%	Reported program indicator; exact baseline and comparison denominators unavailable
Self-initiated community water monitoring	65% increase	Descriptive aggregate change; raw activity counts unavailable
System Usability Scale	84.2	High perceived usability based on the reported SUS score

Preliminary inter-item analyses were available for the socio-psychological item sets. The two Being Away items showed a positive correlation of $r=.55$ ($p<.001$). Coherence correlations

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ranged from .36 to .62, whereas Compatibility correlations ranged from .47 to .90; the PRS14-PRS15 pair showed the highest Compatibility correlation (r=.90), which may indicate content overlap. Fascination showed the widest range (.03-.68), including weak associations for PRS3-PRS6 (r=.03) and PRS3-PRS5 (r=.24). The separate Health item set showed correlations ranging from .19 to .91, with the strongest association between IK3 and IK6 (r=.91) and the weakest between IK5 and IK12 (r=.19).

Table 3. Inter-item correlation summary for socio-psychological item sets

Item set	Number of items	Correlation information	Significance / notable pairs
Being Away	2	r = .55	p < .001
Coherence	4	r = .36-.62	Reported p < .05 to p < .001
Compatibility	5	r = .47-.90	All reported p < .001; PRS14-PRS15 r = .90
Fascination	6	r = .03-.68	PRS3-PRS6 r = .03; PRS3-PRS5 r = .24
Health (separate item set)	12	r = .19-.91	IK3-IK6 r = .91; IK5-IK12 r = .19; majority p < .05

Shapiro-Wilk tests for the 42 complete psychometric records indicated statistically significant departures from normality for all five summary variables. These findings support cautious use of rank-based or otherwise robust procedures in future association analyses and underscore the importance of reporting assumption checks in subsequent group comparisons.

Table 4. Shapiro-Wilk normality tests for complete psychometric records (n=42)

Variable	W	p	Interpretation
Being Away	0.848	< .001	Non-normal
Coherence	0.940	.028	Non-normal
Compatibility	0.846	< .001	Non-normal
Fascination	0.921	.006	Non-normal
Health	0.792	< .001	Non-normal

Descriptive rankings showed the highest mean for Being Away (M=4.308), followed by Compatibility (M=4.208), Fascination (M=3.821), and Coherence (M=2.481). The Health item set had a mean of 0.528 and was treated separately because it was not defined as a PRS dimension. A previously reported Health percentage of 17.60% was inconsistent with the stated maximum score of 5. Using the reported mean and maximum, the percentage of maximum is 10.56% (0.528/5 × 100). This recalculation preserves the reported mean while restoring mathematical consistency; the underlying Health scoring framework should nevertheless be confirmed.

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Table 5. Descriptive ranking of reported socio-psychological summary scores

Variable	Mean	Stated maximum	Percentage of maximum	Rank
Being Away	4.308	5	86.15%	1
Compatibility	4.208	5	84.15%	2
Fascination	3.821	5	76.41%	3
Coherence	2.481	5	49.61%	4
Health (separate item set)	0.528	5	10.56%*	5

*Note. *The Health percentage was recalculated from the reported mean and stated maximum: 0.528/5 × 100 = 10.56%. The previously reported value was 17.60%. The underlying scoring framework should be confirmed before final publication.*

DISCUSSION

This community service program demonstrates the practical feasibility of combining environmental science, digital communication, and community participation in lake monitoring. Because complete comparison-group outcomes were unavailable, the strongest supported conclusion concerns operational feasibility rather than a controlled treatment effect. This distinction is methodologically important: citizen-science and community-monitoring initiatives can generate meaningful capacity-building and governance benefits, but evaluation should clearly distinguish participation outputs from causal effectiveness claims (Capdevila et al., 2020; Dominguez-Rendón et al., 2024).

The application component is consistent with contemporary approaches to community water-quality monitoring. Malthus et al. (2020) found that smartphone applications can support inland water-quality assessment while also highlighting variability in data type, usability, and scientific reliability across platforms. Carrion et al. (2020) similarly described a lake-monitoring application that integrates citizen observations with broader environmental-monitoring systems. These studies support the rationale for a Telaga Ngipik application that simplifies biological information into visual categories. The reported SUS score of 84.2 further suggests favorable perceived usability. Lewis (2018) identifies SUS as a robust standardized usability measure, although interpretation is strongest when sampling, administration, and scoring procedures are fully documented.

The reported 42.5% increase in technical competence and 65% increase in self-initiated monitoring activity are directionally consistent with literature indicating that citizen-monitoring programs can strengthen community knowledge and engagement. Capdevila et al. (2020) identified participant knowledge, motivation, institutional support, communication, and feedback as key success factors in water-quality citizen science, while Njue et al. (2019) emphasized that citizens can contribute useful hydrological information when appropriate protocols and support are provided. A more recent synthesis by Dominguez-Rendón et al. (2024) suggests that community monitoring can contribute to organizational strengthening and local decision-making when participants are connected to institutions and collaborative

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arrangements. In this program, however, raw denominators and comparison-group values for the 42.5% and 65% indicators were unavailable; these figures should therefore be interpreted as program-monitoring summaries rather than statistically verified effect estimates.

The environmental-stewardship indicator warrants similar caution. Environmental education can improve knowledge, attitudes, intentions, and behavior, but these outcomes are conceptually distinct and should not be treated as interchangeable. Ardoin et al. (2020) found that successful conservation education often depends on local relevance, partnership, and opportunities for action, while van de Wetering et al. (2022) reported positive average effects of environmental education on knowledge, attitudes, intentions, and predominantly self-reported behavior. Grilli and Curtis (2021) and Rau et al. (2022) likewise show substantial variation in the magnitude and sustainability of behavioral effects. The reported 88% stewardship-intention indicator therefore suggests strong immediate motivational engagement but does not establish sustained conservation behavior without follow-up observation.

The socio-psychological findings provide useful preliminary insight into how participants perceived the lake environment, although they are more appropriately interpreted as measurement-development findings than as intervention outcomes. Being Away and Compatibility had the highest reported mean scores. This pattern is conceptually consistent with restorative-environment research, in which natural settings may provide psychological distance from routine demands and support activities that fit individual goals and preferences (Menardo et al., 2021; Jang & Son, 2020). Panno et al. (2020) further linked the Being Away dimension with eco-friendly behavior through cognitive reappraisal, while Ríos-Rodríguez et al. (2021) showed that perceived environmental quality can influence perceived restorativeness in public spaces. Nevertheless, because a full local validation process was not documented, these constructs should not yet be described as locally validated scales.

The inter-item findings also identify specific priorities for instrument refinement. Within Compatibility, the correlation of .90 between PRS14 and PRS15 may indicate redundancy or substantial content overlap. Fascination included very weak relationships for several item pairs, suggesting that some items may capture distinct aspects of attention or may not function uniformly in this community. Reviews of restorative-environment scales emphasize the importance of psychometric testing, contextual adaptation, and construct clarity before scores are used to support strong substantive conclusions (Pasanen et al., 2018). Future evaluations should report complete item wording, adaptation procedures, content-validity indices, internal-consistency coefficients such as alpha or omega, and factor-analytic evidence when sample size permits.

The Health item set requires additional caution because it was analyzed in the program data but was not defined as one of the PRS dimensions. Treating it as a separate construct resolves this conceptual inconsistency without discarding the available correlation information. Its correlation range of .19-.91 suggests heterogeneous item relationships, potentially reflecting multiple health-related components, redundancy, or both. The inconsistency in the

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previously reported percentage further illustrates the need for explicit scale definitions and scoring formulas. In this version, the reported mean of 0.528 and stated maximum of 5 are retained, while the percentage of maximum is reported transparently as 10.56%.

All five summary variables departed significantly from normality in the n=42 complete-case dataset. Non-normality does not necessarily indicate poor data quality, particularly for bounded Likert-type measures that may display skewness or ceiling effects. It does, however, influence analytical choice. Rank-based methods such as Spearman correlation or non-parametric group comparisons may be appropriate when consistent with the research question, whereas regression-based models require assessment of model residuals rather than simple normality tests of each observed variable. Because complete comparison-group data were unavailable, no additional inferential model was introduced.

The principal methodological limitation is the incomplete alignment between the planned two-group design and the outcome data available for analysis. Although 100 participants were enrolled, program summaries were available for 50 intervention participants and psychometric analyses for 42 complete cases. Reporting denominators separately resolves the apparent inconsistency but cannot recover missing comparison-group outcomes or explain the eight incomplete psychometric records. Consequently, the study cannot determine whether the intervention produced greater improvement than routine community activity. Future evaluations should document allocation, baseline comparability, attrition, pretest and posttest values by group, change scores, confidence intervals, effect sizes, and the statistical software used.

Despite these limitations, the community-empowerment structure represents an important practical strength of the program. The involvement of Pokmaswas, village-community representatives, student facilitators, and a locally embedded monitoring cadre creates a multi-actor governance structure that may support continuity beyond the formal intervention period. Rather than positioning community members merely as recipients of environmental information, this arrangement provides opportunities for them to participate in data collection, interpretation, communication, and potentially local environmental decision-making. Such participation is particularly important in citizen-science initiatives, where long-term sustainability depends not only on technical competence but also on continued communication, feedback, institutional recognition, perceived relevance, and opportunities for participants to see how the information they generate contributes to tangible environmental-management processes (Capdevila et al., 2020; Hadjichambis et al., 2021; Dominguez-Rendón et al., 2024). From a community-development perspective, this shift from passive participation toward shared responsibility may strengthen local ownership, environmental stewardship, and collective capacity for lake governance. However, these potential benefits should not be assumed solely from the existence of a participatory structure. Their sustainability will depend on whether monitoring activities are institutionalized, responsibilities are clearly distributed, community-generated data are periodically reviewed, and feedback mechanisms connect local observations with village authorities and relevant environmental agencies. For Telaga Ngipik,

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the next stage should therefore move beyond maintaining the digital application as a technical product and toward establishing an integrated community-monitoring system. This would involve routine monitoring schedules, standardized data-collection protocols, periodic refresher training, transparent data validation, and formal mechanisms for communicating findings to local decision-makers. Strengthening these institutional linkages would increase the likelihood that the application becomes not merely an educational tool, but a locally owned platform for evidence-informed environmental stewardship and adaptive lake management..

CONCLUSION

The Telaga Ngipik program established a feasible community-based model integrating saprobic water-quality communication, digital application use, environmental education, and socio-psychological reflection. The available records indicate a SUS score of 84.2, a 42.5% increase in technical competence, an environmental-stewardship intention indicator of 88%, and a 65% increase in self-initiated monitoring activity, while complete-case psychometric analyses included 42 respondents. These findings support the practical feasibility of the model and indicate substantial participant engagement. However, complete comparison-group outcome estimates were unavailable; therefore, causal effectiveness cannot be established. Future implementation should retain complete participant-flow data, validate the socio-psychological measures, document raw pretest and posttest outcomes by group, and examine whether monitoring practices and pro-environmental behaviors are sustained over time.

RECOMMENDATIONS

Pokmaswas and the local monitoring cadre should conduct and document periodic water-quality and phytoplankton monitoring, with findings shared with village authorities and relevant environmental agencies. The service team should maintain the application, provide refresher training, and conduct structured follow-up at 3-6-month intervals. Future evaluations should use clearly documented instruments, complete intervention and comparison datasets, standardized participant-flow reporting, and repeated behavioral indicators so that program impact can be assessed beyond immediate self-report outcomes.

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