COmmunity-Based Organized Littering: Effectiveness and Obstacles for Adoption

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I. Introduction

In recent decades, urbanization, rising consumption, and disposable products have increased municipal solid waste worldwide, placing growing pressure on local authorities responsible for collection, disposal, recycling, and timely intervention [1]. In particular, littering and improper waste disposal in public spaces remain major environmental problems with ecological, social, and economic impacts [2], [3].

Crowdsourcing and community-based approaches offer a promising way to support traditional monitoring by involving citizens in reporting environmental issues [4], [5]. Existing platforms already allow users to report litter and illegal dumping [6], [7]. However, they still require significant manual work by public administrations and waste operators to validate reports, classify waste type and severity, and prioritize interventions, especially when data are heterogeneous or incomplete.

The COmmunity-Based Organized Littering (COBOL) project [8] addresses these issues through workflow-based and data-driven solutions for collecting and managing crowdsourced waste reports. Within the project, a mobile application was developed to support the detection, documentation, and georeferencing of abandoned waste.

We run a pilot study involving 28 students from the *Istituto Comprensivo "G. Di Girolamo" Magliano dei Marsi*, L'Aquila (Italy). They were engaged in a supervised activity using the application to detect and report abandoned waste in their local environment. The pilot was designed with a dual purpose: on the one hand, to act as a real-world test of the COBOL reporting workflow and data collection approach; on the other hand, to function as an educational and civic engagement activity, aimed at raising awareness and fostering active participation among young citizens.

II. Planned Pilot Study

Within the COBOL project, a dedicated mobile application was developed to support the systematic detection, documentation, and analysis of abandoned waste in public spaces. The application allows users to photograph littering sites and enrich each report with predefined attributes, such as waste type, estimated size, and contextual information when relevant.

Each report is automatically georeferenced through the device's GPS and stored together with structured metadata, enabling both validation and quantitative analysis. The application was designed with a user-centered approach, focusing on ease of use and suitability for non-expert users, including citizens involved in community-based monitoring activities. As such, it represents a key component of the COBOL methodology, transforming individual observations into structured data for monitoring, awareness raising, and evidence-based decision-making.

The pilot involved 28 students aged approximately 11 to 14 in collaboration with teachers and parents for a period of 20 days (15/05/2025–03/06/2025).

A. Training Phase and Challenge Design

Before the experimentation, a training phase was organized to prepare students for the activity and ensure the safe, responsible, and consistent use of the application. Students were introduced to the operational rules and to the challenge-based incentive system designed to increase engagement and improve data quality.

a) General Rules of Conduct: Participants were instructed to avoid unsafe behavior, including approaching hazardous materials or entering dangerous or restricted areas. They were also required not to include people or identifiable personal elements in the submitted photographs, in compliance with privacy and ethical standards. Finally, students were informed that metadata would be automatically checked to ensure data consistency and validity. These rules aimed to protect participants, improve data reliability, and comply with legal and ethical requirements, particularly given the involvement of minors.

b) Individual Scoring Mechanism: To encourage participation and careful reporting, a points-based system was introduced. Each submitted report initially received a Started status and was later reviewed by the project team. After validation, reports were classified as Received or Confirmed, and points were assigned only when quality criteria were met.

The base score was calculated according to the type of waste reported and the estimated size of the littering site, with the final score obtained by multiplying these two factors. To be valid, each report had to include a clear picture, identifiable waste, and no people in the image.

Bonuses and penalties were applied to promote accuracy and completeness.This mechanism encouraged careful classification, and high-quality documentation.

c) Group Scoring and Rewards: Participants were also organized into groups, whose score was calculated as the average of the individual scores of all members, encouraging collaboration and shared responsibility. Two award categories were defined: the Best Reporters Group, assigned to the two groups with the highest average score, and the Best Reporter, assigned to the student with the highest individual score. These rewards were presented during the training phase to motivate participation while maintaining a focus on learning outcomes and data quality.

III. Results

The results of the pilot experimentation were analyzed in terms of both data quality and participation dynamics. The validation process showed that, out of 306 submitted reports, 116 reports (38%) were rejected during the review phase, while the remaining reports were accepted and confirmed. This result highlights the challenges of ensuring reliable data in citizen-based monitoring activities, especially when involving young participants, and confirms the importance of both validation procedures and preliminary training.

The daily submission trend shows strong initial engagement, with a peak of 106 reports recorded on 17 May 2025. After this peak, participation gradually decreased and stabilized at around 10 reports per day during the later phase of the pilot. This pattern is consistent with challenge-based and citizen science initiatives, where initial enthusiasm tends to decline over time, suggesting the need for continuous support, feedback mechanisms, and periodic re-engagement actions.

Overall, the pilot proved effective in generating a substantial number of reports in a short time, but also revealed that participation does not automatically translate into actionable data. The 38% rejection rate suggests that data quality was a central issue, mainly related to incomplete or inaccurate submissions. The submission trend further indicates that the challenge-based format mainly stimulated initial enthusiasm, with engagement rapidly decreasing after the early peak. This suggests that future deployments should combine gamification with continuous feedback and re-engagement mechanisms. The predominance of plastic waste was expected, while the high proportion of unidentified waste points to difficulties in classification by non-expert users and suggests the need for clearer guidance.

IV. Limitations and Lesson learned

The pilot experimentation provided valuable insights into the adoption of a community-based litter reporting approach in an educational context, highlighting both positive outcomes and relevant limitations for future implementations.

a) What Worked Well: A major strength of the pilot was the intuitive design of the mobile application, which allowed students to quickly understand and use its main functionalities with limited technical support. This confirmed the effectiveness of the user-centered approach adopted during development. Moreover, a subset of students showed strong engagement, actively participating throughout the pilot and regularly submitting reports, demonstrating the potential of students to contribute to community-based environmental monitoring when properly motivated.

b) Limitations and Challenges: Despite the positive results, several challenges emerged. A significant number of reports did not meet the validation criteria, mainly due to inaccurate waste classification, insufficient descriptions, or poor photo quality. More importantly, the pilot revealed a tension between engagement and data quality: while the competitive setting encouraged participation, in some cases it also led students to prioritize the number of reports over their accuracy and relevance. This was an unforeseen effect of the incentive mechanism and highlights the difficulty of designing gamified citizen-reporting activities that promote both motivation and reliable data collection, particularly with young participants.

c) Lessons Learned and Future Recommendations: The pilot highlighted the importance of providing more detailed initial training on what constitutes a "good report", including examples of correct and incorrect submissions. Future activities should also carefully design reward mechanisms, avoiding excessive emphasis on competition from the beginning. Finally, the reporting activity should be integrated into a broader educational pathway, such as civic education, science, or geography, to strengthen students' sense of responsibility and connect the activity to clear learning objectives.

Overall, the pilot showed that technology alone is not sufficient to ensure high-quality participation. Effective adoption requires intuitive tools, educational framing, and well-balanced incentive mechanisms.

V. Conclusions and remarks

The pilot involving lower secondary school students demonstrated the potential of combining digital tools, educational activities, and community engagement to address littering through a structured, community-based approach.

From an educational and civic perspective, the experience showed that young participants can actively contribute to environmental monitoring. Extending the initiative to other schools and communities could help create a network of young "environmental observers", promoting awareness, civic responsibility, and engagement with local environmental issues. The feedback collected from students also represents a useful resource for improving the application and preparing it for broader deployment.

From a technological perspective, the pilot produced a structured dataset of geolocated and annotated photographs of abandoned waste. This dataset could support the development of computer vision models for automatic litter recognition and classification, enabling future semi-automated or automated monitoring solutions. Making the dataset publicly available could also benefit education, research, and innovation, supporting open science and reuse by schools, researchers, and developers.

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