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Deliverable D3.1 Set of rewarding actions that can be used and executed as part of BPMN process

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Abstract

All parties participating in the waste management process (not only citizens) must be engaged to be successful. For this reason, it is important to establish gamified processes for both citizens and administrations. In this deliverable, we discuss the integration of a set of rewarding actions that can be used and executed as part of the BPMN processes used to describe waste disposal processes. In particular, we aim to integrate dedicated APIs within the workflows in n8n that enable both the automated analysis of submitted waste reports and the dynamic assignment of reward points to users. We propose a pilot study involving middle school students requiring careful consideration of privacy, data protection, and ethical aspects, given the involvement of minors. For this reason, for the pilot, we adopt a semi-automated approach where automation is used only to support and log the process, but the actual evaluation and rewarding remain in the hands of human operators. Further, we propose the integration of LLMs into the n8n-based BPMN process to automatically evaluate the submitted waste reports in terms of quality and usefulness. We also reported an example of prompt and answers resulting from a first small feasibility study.

Keyword list

Gamification, citizen participation, BPMN

Glossary, acronyms & abbreviations

ltem	Description			
COBOL	COmmunity-Based Organized Littering			
LLM	Large Language Model			
SDGs	Sustainable Development Goals			
KPIs	Key Performance Indicators			
BPMN	Business Process Models Notation			

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1 Introduction

To report littering is not enough. Waste has to be removed and disposed of correctly. Different agencies must manage different types of waste. For instance, expired drugs must be managed by specific operators since they can develop toxic substances, asbestos requires procedures that involve specific companies and protective measures, while other waste could be even disposed of by citizens (e.g., as in the initiative launched by the European Environment Agency in 2018 to remove plastic littering from beaches (European Environment Agency, 2024)).

To deploy a littering management solution that goes beyond the straightforward capability of citizens to report waste through apps, it must be considered that waste management works in radically different ways in big cities, towns, rural areas, and the countryside. Different administrations and organizations shall follow different processes to manage waste, making it impossible the design of a "one-fit-all" solution.

<u>Business Process Models Notation (BPMN)</u> is a modelling notation used by organizations to create data-driven visual representations of business processes. In modern organisations, which change and adapt at a high speed, dynamic and flexible handling of business processes is desirable.

All parties participating in the waste management process (not only citizens) must be engaged to be successful. For this reason, it is important to establish gamified processes for both citizens and administrations. Citizens will be rewarded for both reporting and removing waste, with the latter activity being rewarded the most. Further, citizens will be rewarded for confirming or disproving waste removal actions taken by other actors, obtaining virtual rewards that may be exchanged for tangible benefits such as free entry to public institutions, like museums.

Administrations will also compete in terms of their ability to keep areas clean, based on citizens' reports. Further, the indexes derived from the collected data could be used by administrations to demonstrate the impact of actions on littering management in terms of KPIs, also in the context of the SDGs.

In the context of our waste reporting platform, the implementation of a robust rewarding mechanism is a critical factor for ensuring user engagement and data quality. However, when dealing with reports that include pictures, privacy and ethical concerns impose important limitations on the use of automated image analysis systems.

In this deliverable, we discuss the integration of a set of rewarding actions that can be used and executed as part of the processes used to describe waste disposal processes. In particular, since we are implementing these processes using the <u>n8n</u> workflow automation tool, we aim to integrate dedicated APIs within the workflows that enable both the automated analysis of submitted waste reports and the dynamic assignment of reward points to users. This approach allows us to treat reward attribution as a formal part of the overall process logic, making it traceable, modular, and adaptable to different pilot configurations. By embedding these rewarding actions directly into the BPMN execution layer, we can enrich the gamification component of the application while maintaining consistency, accountability, and the possibility of hybrid (manual and automated) decision flows.

The rest of the deliverable is organized as follows:

- Section 2 presents the integration of the set of rewarding actions into the implementation of our approach;
- Section 3 describes our proposal for rewarding automation using LLMs;

• Section 4 concludes the document with some remarks and future directions.

2 Synchronizing Gamification Processes into BPMN

The gamification processor, which assigns points to users based on the quality and impact of their reports, can be tightly integrated into the broader waste reporting workflow using BPMN. In our project, we implement these processes using the open-source workflow automation platform n8n, which provides a flexible and modular environment to coordinate tasks, handle user input, and interact with external services through APIs.

The rewarding actions are modeled as specific tasks or sub-processes within the workflows that govern the full reporting lifecycle from report submission to validation and visualization on the dashboard. Once a report is submitted via the app, n8n triggers a series of nodes that store the report in a Notion database and notify the team. At this point, the workflow follows an automated evaluation path, where APIs (or LLMs) are invoked to analyze the report (e.g., using image analysis or text evaluation) and compute a corresponding score.

This setup allows the rewarding logic to be embedded as part of reusable and auditable processes, making it easier to replicate and customize the system in other contexts or municipalities.

While our technical framework supports the automation of reward assignment, the pilot study conducted in a middle school requires careful consideration of privacy, data protection, and ethical aspects. Given the involvement of minors and the use of user-submitted photographs, we have opted not to enable automatic analysis of the reports during the experimental phase.

The concerns that led us to this decision are related to privacy, since the image content may unintentionally include personal data (e.g., identifiable people or private property). Furthermore, using automatic tools such as LLMs may envisage ethical bias since they might unfairly penalize or reward users based on unclear criteria or biased training data.

As a result, for the pilot, we adopt a semi-automated approach where automation is used only to support and log the process (e.g., notify the reviewer, collect responses, visualize rankings), but the actual evaluation and rewarding remain in the hands of human operators.

Despite the limitations on automation, we have defined a clear set of actions that are recognized and rewarded within the process. These actions are embedded as reward conditions and processed at different stages of the workflow. In the table below, the rewarding actions are listed.

Action	Reward Type	Details
Submission of a valid waste report	Base points	Points vary based on the type and size of waste
Attaching multiple pictures from different angles	Bonus points	+2 points for at least 2 different perspectives
Providing high-quality, recent pictures	Bonus points	+1 point if the image is sharp, clear, and recently taken
Collaborative report submission (teamwork)	Group average reward	Team scores are computed as the average of individual rewards
Submitting duplicate or irrelevant reports	Penalty or no reward	-2 points or report flagged for review
Including useful context in the picture (scale, signs)	Bonus points	+1 point if the image helps localize the dump site more effectively

3 Towards Automatic Reward Assignment Using LLMs

To explore the feasibility of automated reward assignment, we experimented with integrating an LLM (e.g., via <u>OpenAI</u> or <u>Hugging Face</u> APIs) into the n8n-based process. The goal is to evaluate the photos attached to submitted waste reports by prompting the LLM to assess the quality and usefulness of the images and assign a reward accordingly.

This integration is designed as an optional sub-process in the waste reporting pipeline. When a report is submitted, a specific n8n node sends a structured prompt that guides the LLM to perform a photo evaluation, including the attached image.

The LLM then returns a structured JSON response indicating whether the picture meets certain rewarding criteria (e.g., clarity, no people detected, multiple angles). This response is parsed by the workflow to assign points or to notify a human operator for borderline cases.

We designed the following prompt template to provide the LLM with enough context to evaluate the photo reliably, while also encouraging a structured and deterministic output.

You are a waste reporting assistant. A user has submitted a report including a photo of a potentially illegal waste dump. Your task is to evaluate the photo and assign a reward score (0 to 5) based on the following criteria: 1. Clarity and quality of the image (is the waste clearly visible and in focus?) 2. Usefulness of the photo for identifying the dump site (e.g., visible landmarks or scale elements) 3. Angle and coverage (does it show the waste from a good angle? is it too close, too far?) 4. Novelty (does it seem like a new picture or a reused one?) 5. Privacy violations (are people shown in the picture or car number plates?) Please analyze the photo and return a JSON object with this structure: ł "score": number (0 to 5), "clarity": short comment, "usefulness": short comment, "novelty": short comment, "privacy violations": short comment, "final verdict": short summary string }

This prompt can be customized for different languages or contexts and reused in *n*8*n* using dynamic variables that adapt to the current report's content.

In the following, we report two real examples of answers to the described prompt for two photos that we submitted to ChatGPT.



"score": 3,

"clarity": "The image is reasonably clear, and the dumped waste is visible.", "usefulness": "The location is identifiable thanks to the road and vehicle position.",

"novelty": "It appears to be a new photo, not previously submitted.",

"privacy violations": "Partial visibility of a car license plate and a person.",

"final_verdict": "Good report image, but privacy issues slightly reduce its usability."



"score": 4, "clarity": "The photo is sharp and well lit.", "usefulness": "Context is a bit limited, but the dump is clearly visible.", "novelty": "Appears to be a unique picture.", "privacy violations": "No visible faces or license plates.", "final_verdict": "Effective and clean report with no privacy issues." }

In these examples, the first photo is penalised by the fact that both a man and a car are visible. In the other photo, there is a man too, but since his face is not visible, it got a higher score.

We report an example of a workflow first retrieving the submitted picture, and the waste types reported in the system. Then in the second block, using Mistral LLM Rest API, the picture is analyzed to associate the existing types, e.g., plastic, paper, etc. A second prompt is then chained with the scheme reported before to classify the picture w.r.t. the quality.



The last node will update the submitted report with the extra rewards calculated by the LLM. In the following pictures, we show the second report that gained +5 extra reward after the automated elaboration of the LLM in the workflow definition.



This reward management, combining LLM in the workflow definition, allows for the customization and refinement of the rewarding process. Indeed, if the manager wants to update the rewarding system can change the LLM prompts to weigh the various rewards or even define new rewarding actions based on the automated analysis. Moreover, the process definition can be interleaved with workflow tasks impacting the reward or extra reward of the submitted reward. For instance, the process can decide when to supply the reward based on the status of the submission. This can be simply done by filtering the transitions between the tasks based on the status of the submission. When the operator changes the status of the submissio, n the reward will be provided.

4 Conclusions and remarks

In this deliverable, we propose the integration of gamification principles, low-code automation tools like n8n, and LLMs to foster active citizen participation in environmental monitoring, specifically in the context of illegal waste dumping.

By aligning incentive mechanisms with clear reporting workflows and ethical constraints, we have designed a process that is, at the same time, transparent thanks to visual workflows that make each automation step verifiable, and scalable allowing for easy integration of new components, such as LLMs for evaluating user submissions.

While the pilot study revealed important limitations, especially regarding the automatic verification of reports due to ethical and legal concerns, we were still able to implement a meaningful reward logic for validated contributions.

Finally, the experimental use of LLMs for reward assignment opens a promising direction for future development, in which intelligent agents can support, rather than replace, human decision-making. Our next steps will involve refining the reward scoring process, extending gamified actions, and assessing the long-term impact of this approach on user engagement and waste management outcomes.

As future direction, we plan a fine-tuning LLM evaluation to refine the LLM prompt and explore the use of vision-language models specifically trained for environmental or civic monitoring to improve photo evaluations. Another objective is to expand the reward logic by introducing new gamified elements such as levels, badges, or streaks to reinforce long-term engagement and reward diverse forms of participation (e.g., verification, moderation, education). Lastly, from the ethical point of view, we plan to establish an advisory board or protocol to periodically review the system in light of ethical, legal, and social considerations, particularly as AI takes on more decision-making roles.

5 References

European Environment Agency: Citizens collect plastic and data to protect europe's marine environment. https://bit.ly/2MdhZQX, accessed: January 2024.

Blair, G.S., Bencomo, N., France, R.B.: Models@ run.time. Computer 42(10), 22-27 (2009).

Sabatucci, L., Lodato, C., Lopes, S., Cossentino, M.: Towards self-adaptation and evolution in business process. In: Proceedings of the Workshop AI Meets Business Processes (AIBP) (2013).