EmoRainbow: How Can Phygital Artefacts Support Emotional Regulation in Disaster Preparedness?

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Abstract

This paper presents two design-oriented educational units within a broader programme aimed at supporting emotional awareness, regulation, and preparedness in hydrogeological disaster scenarios in children and adolescents. The units introduce purposefully designed phygital artefacts—physical objects augmented with digital technologies—as tangible supports to externalise emotional processes and prompt reflection on coping in risk-related contexts. Through guided interaction and reflection, participants explore how emotions can be sensed, represented, and transformed through interaction, and articulate design ideas for their own emotionally expressive phygital artefacts grounded in disaster preparedness situations. The units were implemented as a pilot with university students to assess the clarity, feasibility, and coherence of the artefacts and activities prior to deployment in school contexts. The paper describes the phygital artefacts' structure and interaction logic, and how they support reflection on emotion regulation and the articulation of design concepts for disaster preparedness.

CCS Concepts

• **Human-centered computing** → *Interaction design.*

Keywords

disaster preparedness, phygital artefacts, emotion regulation, socio-emotional training

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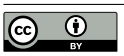

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1 Introduction

Hydrogeological disasters, such as floods and landslides, can have a profound emotional impact on children, influencing how they may cope with emergencies and prepare for future risks. Psychological and disaster research has documented increased anxiety, depressive symptoms, and post-traumatic stress following natural disasters, highlighting the importance of prevention-oriented interventions that support emotional preparedness before emergencies occur [5, 6, 17, 18]. Prior work has shown that socio-emotional training can effectively strengthen emotional competence in children and adolescents, including emotional awareness, coping, and emotion regulation strategies [3, 4, 20, 21].

In the domain of disaster education, such approaches have been successfully applied to earthquake and pandemic preparedness, demonstrating that targeted psycho-educational interventions can support young people's ability to manage fear, uncertainty, and disaster-related emotions [16, 22, 23, 26]. However, reviews indicate that many existing initiatives still rely primarily on cognitive or behavioural components and on screen-based or informational tools, while experiential, tangible, and embodied approaches to emotional preparedness remain underrepresented [15, 24, 25].

In Human–Computer Interaction (HCI), an expanding body of research has explored tangible, embodied, and phygital artefacts—physical objects augmented with digital sensing, processing, and feedback—as resources for reflection, learning, and design in educational contexts [2, 7, 8]. Prior studies show that ideating, programming, and prototyping smart or phygital artefacts can foster reflection, awareness, and agency by making abstract processes tangible and discussable [1, 11, 12]. Work in school settings further demonstrates how such artefacts support imaginative engagement and collaborative exploration, mediating meaning-making and reflection beyond screen-based interaction [9, 10, 19, 27].

Within this broader landscape of embodied and tangible interaction, a related line of work has focused specifically on affective

and emotionally expressive artefacts. These designs aim to convey, elicit, or make emotions visible through embodied interaction, supporting emotional awareness, shared understanding, and reflective engagement [13, 14, 28].

However, while affective and phygital artefacts have been explored in educational contexts[27, 29], their use for supporting emotion regulation in disaster preparedness remains limited, with existing work mainly focusing on educational programmes and digital or informational tools [23, 24].

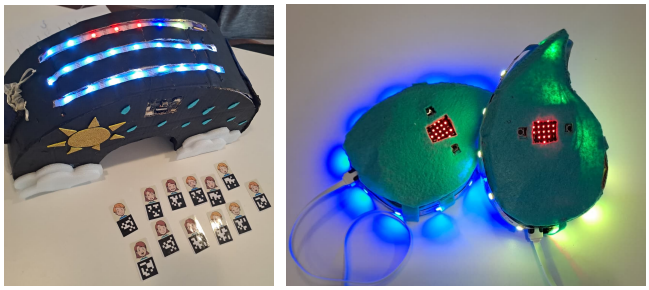
This paper reports two design-oriented educational units in which participants (i) explore emotionally expressive phygital artefacts and (ii) articulate design concepts for their own emotion-supporting phygital artefacts in flood-related scenarios. We discuss how the units make emotion regulation tangible and support the articulation of interaction design concepts grounded in regulation strategies, contributing reusable design knowledge for emotionally expressive phygital artefacts in preparedness contexts.

2 Project Overview

The work presented in this paper is part of a broader interdisciplinary research project aimed at strengthening emotional awareness, emotion regulation strategies, and preparedness for hydrogeological risks through a psycho-educational training. The programme comprises nine one-hour weekly workshops (Table 1), combining short guided activities on hydrogeological risk and emotion regulation with hands-on interaction with phygital artefacts. Within the overall programme, Units 7 and 8 are particularly relevant for this paper because they explicitly foreground interaction with phygital artefacts and the articulation of emotion regulation strategies through design activities.

The training is designed to progressively support the development of emotional competence in disaster-related contexts, from basic emotion recognition and emotional lexicon to the exploration of regulation strategies and their application to preparedness scenarios. While the programme primarily targets children in school contexts, university students enrolled in a second-year course in Developmental and Educational Psychology were involved as a pilot group and completed all units of the training. The pilot involved 161 university students across 9 class sessions, mainly working in groups. This pilot implementation aimed to inform the design and refinement of the training and to assess the clarity, feasibility, and coherence of the materials prior to deployment in school contexts.

The broader project includes pre- and post-training questionnaires and unit-level questionnaires assessing emotional competence, emotion regulation, engagement, collaboration, and agency. In the present paper, however, a design-oriented perspective was adopted, focusing on the design of the emotionally expressive phygital artefacts and on the structure of Units 7–8, using the classroom activities as contextual grounding for the design choices presented. The materials considered include group design frameworks, artefact-based outputs, observation notes, and photographic documentation, qualitatively examined to characterise how participants interpreted the artefacts and translated emotion regulation concepts into design elements.



(a) EmoRainbow supports emotional awareness through colour and light. **(b) EmoDrops support social co-regulation through proximity and messaging.**

Figure 1: Emotionally expressive phygital artefacts used in Unit 7.

3 Emotionally Expressive Phygital Artefacts

The artefacts were conceived and iteratively refined within the interdisciplinary project team, drawing on expertise in HCI, education, and psychology, as well as on concepts introduced in the preceding training units.

3.1 EmoRainbow

EmoRainbow is a phygital artefact designed to support *emotional awareness and the representation of emotional states* through colour and light (Figure 1a). The artefact builds on concepts introduced in earlier units of the training, where emotions are framed as dynamic and changeable experiences that can be recognised, expressed, and regulated over time. EmoRainbow translates these concepts into a tangible and visually expressive artefact, enabling users to externalise otherwise internal emotional processes.

The interaction logic of EmoRainbow relies on recognising, through a dedicated camera, emotion cards depicting basic emotional facial expressions—already familiar to participants from previous units—and mapping each emotion to a corresponding colour rendered through an RGB LED strip. When a participant shows a card, the artefact illuminates with the associated colour (e.g., joy in yellow, anger in red, calm in light blue), providing a simple and shared visual representation of the current emotional state. Over repeated interactions, colours can change or combine, conveying the variability and evolution of emotional states rather than a fixed condition.

From a design perspective, EmoRainbow makes emotional states visible without prescribing specific behaviours or outcomes. It functions as a reflective support that invites open discussion, supporting both individual and collective reflection on emotional regulation processes. In this way, the artefact foregrounds emotional awareness and agency, emphasising meaning-making rather than behavioural instruction.

3.2 EmoDrops

EmoDrops are phygital artefacts designed to support *social emotion regulation* by making emotional exchange and transformation visible through light and proximity-based interaction (Figure 1b). Unlike EmoRainbow, which focuses on individual and collective emotional awareness, EmoDrops explicitly address the *relational*

Table 1: Overview of the educational units, grouped by learning focus.

Phase	Units	Focus
Risk and context	U1	Hydrogeological risks and safety behaviours, introduced by a geologist.
Emotional awareness	U2–U4	Emotion recognition, emotional lexicon, and emotions related to flood scenarios.
Intensity and regulation	U5–U6	Emotional intensity and emotion regulation strategies in disaster-related situations.
Phygital artefacts	**U7–U8**	**Exploration and ideation of emotionally expressive phygital artefacts.**
Final reflection	U9	Recap and reflection on key concepts.

dimension of emotions, foregrounding how emotions can be shared, influenced, and regulated together.

Each EmoDrop represents an emotional state selected by the user through a simple button interaction and rendered through coloured light on an RGB LED strip. When two artefacts are brought close to one another, their interaction visually represents *emotional contagion and co-regulation*. When the same positive emotion is shared, the corresponding light gradually intensifies, reinforcing emotional alignment. When different emotions interact, repeated shaking of the EmoDrops triggers a progressive visual transition in which negative emotional states (e.g., red for anger) gradually shift towards the positive emotion (e.g., light blue for calm), represented by a smooth change of colour over time. Through this dynamic behaviour, EmoDrops convey emotion regulation as a gradual and relational process In addition to proximity-based interaction, EmoDrops can communicate at a distance by exchanging simple visual messages via radio, represented as icons on the LED matrix. These messages function as explicit yet non-verbal *regulation strategies*, such as offering support, encouraging calm, or signalling the need for help.

Through guided exploration and subsequent design activities, participants reflect on how emotional exchange, contagion, and intentional communication can be translated into design choices, fostering awareness of social co-regulation, creative agency, and reflection on emotionally responsive technologies.

3.3 The BigDrop

The *BigDrop* lantern is a phygital artefact designed to support calm awareness and emotional regulation in flood-related situations through ambient light and sound. While EmoRainbow focuses on recognising and externalising individual emotional states and EmoDrops on emotional exchange between people, BigDrop foregrounds how an artefact can respond to environmental and contextual cues to provide a non-intrusive, reassuring presence.

The interaction logic of BigDrop combines environmental or contextual inputs (e.g., rain- or water-related signals) with gentle outputs such as coloured light patterns and soft sounds. Instead of alarm-like feedback, the lantern responds with slow, calming light dynamics and subtle audio cues, inviting interpretation and discussion of how different responses may support emotional regulation during uncertainty.

Within the activities, BigDrop is used as an exploratory artefact to reason about alternative inputs and outputs. Participants are invited to imagine how its behaviour could change if it sensed different signals or produced different responses, exploring how input–output choices shape interaction behaviour and emotional meaning. In this way, BigDrop also serves as a scaffold for the subsequent design framework in Unit 8, helping participants articulate and narrate their own intelligent phygital artefact by reasoning about context, inputs, behaviours, outputs, and intended emotional effects, using the provided design cards.

4 Design Units

The design units described in this section were implemented with 161 university students as part of a pilot implementation of the training programme. Participants completed all educational units, allowing the research team to assess the clarity, feasibility, and coherence of the materials prior to their use in school contexts. In this setting, university students acted as a pilot group and were positioned as reflective users and emerging designers, rather than as representatives of the target population. The pilot focused on evaluating the interpretability of the artefacts and how the activities supported participants in articulating emotion regulation strategies through design.

4.1 Unit 7 – Understanding Emotional Phygital Artefacts

Goal. Unit 7 aims to support understanding of how emotions can be represented, communicated, and transformed through interaction with phygital artefacts, establishing a shared conceptual ground for reasoning about emotion regulation.

Protocol. The unit begins with an introduction to phygital artefacts and to the basic input–processing–output logic underlying their behaviour, explicitly drawing parallels with emotional processes (perceiving, interpreting, reacting). Participants are then introduced to *EmoRainbow*, which they interact with individually to explore how emotional states can be recognised and represented through colour and light. In this phase, the artefact records and visualises participants' self-reported emotions via the emotion cards, supporting reflection on emotional awareness and change over time.

The activity then shifts to a social dimension through *EmoDrops*, which are presented as artefacts that model emotional contagion and co-regulation. Participants explore how emotions can spread, blend, or be modulated through proximity-based interaction and through simple non-verbal messages representing regulation strategies. Building on this experience, participants engage in a hands-on activity using a simple LED matrix (named EmoMatrix),

configuring light patterns to create icons that symbolically represent behavioural ("doing") and cognitive ("thinking") regulation strategies.

Outputs. The unit results in shared reflections on emotional awareness, emotional contagion, and regulation strategies, as well as in the externalisation of regulation strategies through symbolic representations (EmoMatrix). These outputs prepare participants to move from experiential understanding of emotional processes to intentional design in Unit 8.

4.2 Unit 8 – Ideating Emotional Phygital Artefacts

Goal. Unit 8 shifts the focus from exploration to intentional design. Its goal is to support the articulation of design concepts for emotionally expressive phygital artefacts in disaster-related contexts, building on the experiential understanding developed in Unit 7.

Protocol. The unit begins with the introduction of *BigDrop* as a new phygital artefact. BigDrop is presented as an artefact designed to support emotional regulation in flood-related situations. Participants are first invited to observe and discuss its behaviour, and are then shown how changes in inputs, processing logic, and outputs can modify the artefact's interaction and responses. Building on this example, the design framework is introduced and explained using BigDrop as a concrete reference of a completed framework, illustrating how emotion regulation strategies can be translated into interaction design choices. Participants then work in groups to fill in the framework using a set of design cards that scaffold reasoning about the intended person and situation, the emotional challenges involved, and how selected inputs, behaviours, and outputs can support emotion regulation and co-regulation.

Outputs. The unit results in framework-based design concepts for emotionally expressive phygital artefacts, documented through completed frameworks and discussed collectively.

Figure 2 shows an illustrative example of the design articulation supported by the framework. In this case, a group designed a soft toy to support a child staying indoors during a flood: the artefact senses emotional cues (e.g., physiological signals or facial expression when the toy is held) and responds with calming outputs such as gentle vibration, soothing music, or a recorded parental voice. The framework makes explicit how emotional states, regulation strategies, inputs, and outputs are connected, illustrating how concepts explored in Unit 7 are re-articulated as interaction design choices in Unit 8.

5 Discussion and Conclusions

This paper contributes a design-oriented account of how phygital artefacts support reflection on emotion regulation and preparedness in hydrogeological-risk contexts, focusing on how interaction with these artefacts scaffolds a transition from experiential understanding of emotions to the articulation of design concepts for emotion-supporting technologies.

Across the two units, the phygital artefacts functioned not only as interactive smart objects, but as material prompts that helped participants externalise emotional dynamics and reason about how these

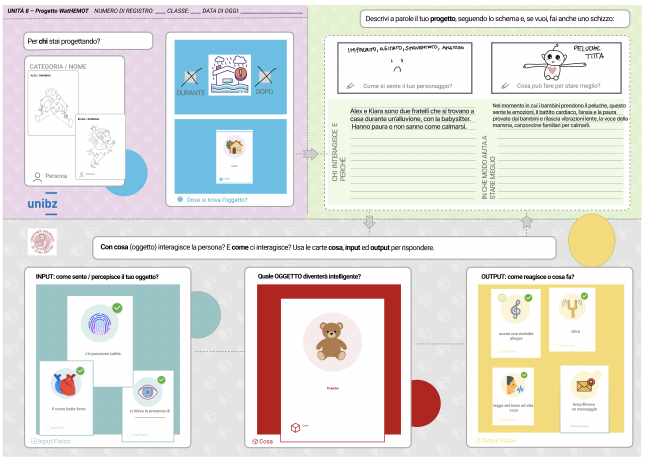


Figure 2: Illustrative example of a framework filled in by a group during Unit 8.

could be intentionally shaped through interaction design. Building on this experience, participants translated observed emotional processes into structured design ideas using a shared framework.

Three design considerations emerge. First, *making emotions tangible without prescribing behaviour* supported agency: participants interpreted light, colour, and icon-based cues as open representations rather than instructions, aligning with prior work on open-ended and interpretable tangible interaction. Second, *designing for co-regulation* became salient when interaction was distributed across multiple artefacts, foregrounding emotions as relational and socially influenced, in line with research on social and relational interaction design. Third, the activities supported the *translation of emotional experiences into intentional design concepts*, enabling participants to re-articulate emotion regulation strategies explored through interaction into the design of their own phygital artefacts using the framework.

These considerations are grounded in a pilot implementation with university students and will be further examined in future school-based implementations. Overall, this work suggests that emotionally expressive phygital artefacts can act as effective design probes within educational settings. The units support a transition from experiencing emotionally expressive artefacts to authoring new phygital artefacts, enabling participants to internalise emotion regulation concepts and re-express them through intentional interaction design.

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