Descamps *et al.*
International Journal of Educational Technology in Higher Education (2025) 22:70
https://doi.org/10.1186/s41239-025-00569-3

International Journal of Educational Technology in Higher Education

RESEARCH ARTICLE Open Access

Effects of two scenario approaches for digital sobriety education among higher education students

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Abstract
In the context of the growing impact of digital technology, this study explores the effectiveness of a gamified learning tool designed to educate higher education students about digital sobriety. The aim is to analyse the effects of two different learning scenarios on digital sobriety maturity, motivation to adopt responsible digital behaviour and the feeling of competence to act collectively. In an experimental approach, 107 students took part in a game-based learning experience (escape game) followed by the drafting of digital eco-gesture charters. One group was asked to take individual action, while the other was asked to take collective action. The results show that both scenarios improve digital maturity, with no significant difference between the two. However, the collective scenario reinforces the feeling of competence to act collectively. Finally, regardless of the scenario, the students appear to be motivated by intrinsic and identified reasons, underlining their awareness.

Keywords Digital sobriety, Teaching tools, University education, Gamification, Motivation, Green digital education

Introduction

In a context of accelerated digital transformation, higher education occupies a strategic position in the development of twenty-first century skills, in particular digital competences (Tzafilkou et al., 2022). These competences are the subject of established frameworks, especially at the European level, such as the DigComp framework, which includes among its key dimensions the ability to "*be aware of the environmental impact of digital technologies and their use*" (Carretero et al., 2017). Often overlooked, this competence is nevertheless a crucial lever for promoting responsible digital citizenship.

Amidst the climate crisis and the increasing environmental footprint of digital technologies, this dimension of digital literacy warrants particular emphasis. UNESCO (Giannini, 2024) has called for bridging the digital and environmental transitions through education, thus promoting a genuine "green digital education". In the Francophone world, education for digital sobriety, which aims to understand, question and transform digital practices in order to reduce their ecological footprint, has emerged as a

key issue in contemporary education (Descamps et al., 2022a; Mercier & Trichet, 2023). In this perspective, digital sobriety can be defined as a critical and reflective approach to technological uses, which aims to reduce their environmental impact by questioning actual needs, limiting superfluous practices, and promoting responsible and sustainable digital behaviors (Descamps et al., 2022a). As hyper-connected and high-frequency users of technology (Alcarez, 2022), digital natives must develop a deeper understanding of the environmental consequences of their digital practices. However, despite growing institutional recognition of this imperative, educational systems are still struggling to fully integrate digital sobriety into curricula, and educational research on this emerging topic remains scarce (Dufort, 2023).

This study is situated within this context. Anchored in the field of educational technology, it draws on game-based learning mechanisms, specifically escape games, to explore the conditions under which digital sobriety literacy can be developed. The study aims to address a research gap by focusing on three main objectives: (1) analysing the effects of two distinct pedagogical scenarios on students' maturity in digital sobriety; (2) examining their motivation to adopt environmentally friendly digital practices; and (3) assessing the development of their perceived collective efficacy in acting in promoting digital sobriety.

In addition, the study investigates how a hybrid system combining digital and physical elements might enhance motivation and encourage more responsible digital practices. Adopting an experimental approach that leverages game-based pedagogical devices, the study aims to make practical and theoretical contributions to the field. It aims to shed light on the effectiveness of the educational approaches tested with higher education students, while contributing to the development of pedagogical frameworks within the emerging field of education for digital sobriety.

Literature review

Digital sobriety education and green digital education

Of the digital competences outlined in the DigComp framework, "Protecting the environment" is one that is frequently overlooked in initiatives aimed at developing digital skills in education, particularly in higher education. However, education plays a vital role in raising awareness among younger generations of the environmental impacts of digital technology is essential (Mercier & Trichet, 2023). Young people are among the most intensive users of digital technologies. In 2022, the average weekly screen time for adolescents aged 13 to 19 was 36 h and 8 min, representing an increase of 5 h and 45 min over 11 years (Alcaraz, 2022). Such widespread digital practices contribute to growing environmental impacts, including increased energy consumption, greater demand for raw materials, and more electronic waste.

In response to this situation, educating people about digital sobriety has become an urgent priority (Descamps et al., 2022a). The aim is to raise awareness of the environmental impact of digital technologies and encourage environmentally responsible digital practices. The authors have proposed a digital sobriety literacy model organised around three key components:

– Analysing the environmental impact of digital lifestyles using tools such as life cycle analysis;

– Seeking out and identifying nuanced digital solutions that help protect the environment;
– Adopting digital eco-gestures and engaging in collective action to foster digital sobriety.

These three dimensions are interdependent: impact analysis is a prerequisite for identifying appropriate solutions, and it is the articulation between critical understanding, technological choices, and collective engagement that enables the development of robust digital sobriety literacy.

Although the scientific literature on this specific form of education remains limited, several educational initiatives are beginning to emerge. For example, MOOCs (Massive Open Online Courses) such as those offered by the *Institut du Numérique Responsable*[1] and *INRIA*[2] use a transmissive approach combined with quizzes to raise awareness about the environmental impact of digital technology (Lagarrigue et al., 2023). In parallel, active learning tools such as La *Fresque du Numérique*[3] have also been developed. Widely used in higher education, this tool enables participants to work in small groups to reflect on their digital lifestyles thereby fostering collective intelligence (Meyer, 2023). These workshops usually end with a group discussion about practical eco-friendly actions that can be incorporated into daily life (Collin et al., 2024; Jouzel, 2022).

Finally, some studies, such as Tilbury et al. (2024), highlight the links between digital education and learning for sustainable development by documenting various European initiatives. However, this body of work mainly considers digital technologies as an educational tool for raising environmental awareness, rather than as an object in itself requiring a sobriety-oriented approach.

To date, few studies have assessed the impact of learning programs focusing specifically on digital sobriety education, particularly in higher education. Three main limitations clearly emerge from the literature: the lack of rigorous empirical evaluations of these initiatives, the scarcity of research focusing on university students, and the limited number of studies that consider digital sobriety as an educational objective in its own right. However, as Mercier and Trichet (2023) highlight, an increasing number of universities are seeking to balance pedagogical innovation with responsible digital practices, reflecting a growing commitment to digital sobriety within this sector. These observations reinforce the relevance of undertaking experimental studies, such as the one presented here, in order to measure the effects of pedagogical interventions.

The role of green education in higher education

Digital sobriety education is closely linked to green education, drawing upon the knowledge, skills, and competencies developed in this area (Descamps et al., 2022a). The aim of sustainability education is to foster the competencies required to promote sustainable development. It encourages responsible behaviors while addressing the three interdependent pillars of sustainability: economic, environmental, and social (UNESCO, 2017).

According to UNESCO (2017), Green Education prepares individuals to make informed decisions and take action for the well-being of the planet. From this perspective, education is

[1] MOOC Numérique Responsable. https://www.academie-nr.org/. Accessed 25 May 2025.

[2] Impacts environnementaux du numérique. https://www.fun-mooc.fr/fr/cours/impacts-environnementaux-du-numerique/. Accessed 25 May 2025.

[3] Fresque du numérique. https://www.fresquedunumerique.org/. Accessed 25 May 2025.

a Sustainable Development Goal (SDG) in its own right (Goal 4 seeks to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all'), as well as a vital means of achieving the other SDGs defined by the United Nations.

To support this ambition, UNESCO (2017, 2020) has published several strategic frameworks providing guidelines for education for sustainable development. For instance, the Roadmap for Education for Sustainable Development (UNESCO, 2020) recommends "*implementing learner-centred, project-based interactive pedagogy to transform all aspects of the learning environment and enable learners to experience what they learn and to learn from experience*" (p. 8). This framework advocates an active, experiential, and learner-centered pedagogical approach, but its concrete adaptation to digital contexts remains insufficiently documented.

More recently, in 2024, UNESCO published further guidelines on integrating green education into curricula. With regard to the specific issue of the impact of digital technologies, the guidelines state that learners over the age of 18 should be able to analyse the impact of digital systems and infrastructures, and suggest ways to improve their efficiency while minimising associated pollution. This competency is aligned with the objectives of digital sobriety, linking technological responsibility to ecological transition.

Similarly, at the European level, the European Commission has developed reference frameworks to guide the integration of sustainability into education. Just as it created the *DigComp* framework for digital competencies, it has established a dedicated framework for sustainability-related competencies: *GreenComp* (Bianchi et al., 2022). This framework consists of four interconnected competence areas: embodying sustainability values, embracing sustainability complexity, envisioning sustainable futures, and acting for sustainability (Gilbert, 2022). Nevertheless, the way in which these frameworks can be translated into concrete pedagogical interventions for digital sobriety remains largely unexplored.

Universities have a big role to play in teaching people about sustainability. In his report, Jouzel (2022) says that it is important for universities to get involved in preparing young adults for the challenges of ecological transition and sustainable development. To meet this objective, it is essential to use a competency-based approach combined with active teaching methods. These teaching methods should also get students involved and let them express themselves by offering places where they can talk about and work together.

Research shows that using technology in the classroom can help teach students about sustainability. For example, Dziubaniuk et al. (2023) show how connectivist learning environments, where students work together, can support the development of sustainability skills in higher education. This shows how digital tools can get students involved in sustainable practices, especially when used in active and connected teaching situations.

The development of skills related to sustainability is based on well-known ideas in the literature, especially those related to environmental education (*éducation relative à l'environnement*, ERE) and ecocitizenship education. The environmental education wants people to understand environmental issues and to behave responsibly towards the environment (Sauvé & Brunelle, 2003).

In the context of the young adult demographic, Villemagne (2017) underscores the necessity for environmental education to encompass social, economic, cultural, political,

and ecological considerations. The process engages learners in the deconstruction of dominant ideas, beliefs, and values, as well as the power structures that underlie environmental challenges. This approach is designed to encourage participants to engage in profound reflection and critical thinking in response to the intricate issues of sustainability.

Meanwhile, ecocitizenship education moves beyond environmental awareness. It emphasises active citizenship and social justice, encouraging civic engagement and democratic participation to address environmental challenges (Naoufal, 2017; Sauvé, 2017). According to Blanchet-Cohen (2017), this form of education relies on collective learning, providing participants with the opportunity to express their environmental awareness and broaden their understanding of citizenship. Co-construction is emphasised as a learning method because it enables the development of shared solutions tailored to learners' realities.

Beyond the acquisition of knowledge and the development of sustainability competencies, these educational approaches also promote a process of both individual and collective empowerment. They encourage adults and their communities to engage in collective action to transform societal practices (Clover et al., 2013). This process reinforces the idea that sustainability education can catalyse profound and lasting change, including in the realm of technological practices.

While the literature on sustainability education provides a rich and structured framework, it has so far been only marginally applied to digital sobriety. The articulation between institutional frameworks, active pedagogies, and education for digital sobriety in higher education remains largely unexplored, which justifies the present study.

Game-based learning for educating on digital sobriety

Active learning, which underpins both green education and ecocitizenship education, can also be implemented through game-based learning (ludopédagogie) (Genevois & Leininger-Frézal, 2010; Lépinard, 2024). This approach, which uses games as a medium for learning, is rooted in a participatory, experiential, and engaging pedagogical logic. In the context of this study, it was employed to raise students' awareness of responsible digital practices and to promote more sustainable behaviors.

Game-based pedagogy has proven to be relevant in numerous educational contexts, particularly in environmental education and eco-citizenship education (Genevois & Leininger-Frézal, 2010). This approach is based on the idea that games are intrinsically engaging and motivating activities that facilitate active learning by involving participants in dynamic ways. Lavigne (2022) emphasises that game-based learning is not confined to recreational play, but rather seeks to integrate playful mechanisms into pedagogical settings to enhance learner engagement and motivation. This type of mediation combines immersion, decision-making, and critical reflection, conditions often met in escape game environments.

This approach is gradually gaining traction in university education, placing value on playful experiences that go beyond merely transmitting theoretical knowledge (Lépinard, 2024). Game-based learning creates interactive, immersive and dynamic environments in which students can develop skills by taking part in engaging activities. A meta-analysis by Zeng et al. (2024) highlights the positive impact of gamification on student performance. These findings are corroborated by Ortiz et al. (2025), who conducted a study focusing on gamification in STEM learning in higher education. Their results

confirm that gamification is effective in not only improving academic performance, but also significantly enhancing learner motivation. However, the extent to which these effects are realised varies depending on the context, student profiles, and how game elements are integrated into the pedagogical scenario (Callan et al., 2015). Some scholars caution against the superficial or instrumental use of gamification, as this can undermine deep learning if it is not grounded in clear educational objectives.

Additionally, Murillo-Zamorano et al. (2021) argue that, when embedded in active learning settings, gamification can reconcile the expectations of digital society, academia and students. Their study demonstrates that co-creative and empowering gaming experiences foster the development of essential 21st-century skills.

Tools used in game-based learning can include physical and digital games. At the European level, Tilbury et al. (2024) identified several examples of serious games designed to raise awareness of sustainability issues, including *Earth Cubs*[4] and *Questagame*.[5] Regarding digital sobriety education, a number of initiatives are beginning to emerge. For example, *Econumia*[6] is a board game that addresses responsible digital issues, while *PhoneImpact*[7] is a serious game that focuses on smartphone manufacturing. *Impact-Agency*,[8] meanwhile, is a game that promotes eco-friendly digital practices. However, the literature remains largely descriptive: while these games are presented, they are rarely subjected to rigorous scientific evaluation, and there is a clear lack of studies examining their actual impact in higher education.

Thus, despite the richness and diversity of the game-based initiatives identified, two main gaps stand out: first, the absence of rigorous assessments of their effects on digital sobriety; and second, the scarcity of research specifically focused on university students.

This theoretical and empirical gap highlights the importance of our study, which focuses on the intersection of digital education, sustainability, and game-based learning. The study examines the impact of a gamified scenario combining digital and physical components on motivation, environmental awareness, and the sense of collective efficacy. The connection between escape games, cognitive engagement, and learning has been explored in recent studies, particularly by Marfisi-Schottman et al. (2022). They demonstrate that intricate, game-based systems centred on societal issues can enhance learner engagement and foster self-determined motivation.

This motivational dynamic can be understood through the lens of Self-Determination Theory (Deci & Ryan, 1985), which categorises types of motivation according to their perceived autonomy. In educational settings, self-determined motivation (whether intrinsic or identified) has been found to be associated with sustained engagement, higher-quality learning and an enhanced sense of competence. When applied to sustainability, this theory has been used in various studies to explain the adoption of pro-environmental behaviours. Pelletier et al. (1997) demonstrated that the more autonomous the motivation to act ecologically, the more sustainable the behaviour becomes. Fiorello and Luu (2014) confirm this relationship, emphasising that eco-responsible actions are strengthened when driven by autonomous motivation rather than obligation or guilt.

[4] Earth Cubs. https://earthcubs.com/watch/. Accessed 25 May 2025.

[5] Questagame. https://questagame.com/. Accessed 25 May 2025.

[6] EcoNumia. https://gamepartners.fr/numerique-responsable-econumia/. Accessed 25 May 2025.

[7] PhoneImpact. https://learninglab.gitlabpages.inria.fr/serious-game/smartphone/. Accessed 25 May 2025.

[8] https://www.impact-agency.com/serious-game-numerique-responsable-ecogestes-numeriques/

These findings support the idea that educational environments which are playful and collaborative and which foster self-determined motivation are particularly effective in raising student awareness of digital sobriety issues in a sustainable way.

Methodology

Research questions

The field of digital sobriety education in higher education remains largely unexplored in scientific literature. This study examines the effects of two learning scenarios on higher education students, employing active and game-based pedagogical approaches. The influence of these educational interventions on three key dimensions was analysed: students' motivation to adopt environmentally responsible digital practices, their level of digital sobriety maturity, and their perceived collective efficacy to take action.

Three research questions were formulated to structure this investigation:

- RQ1: How do these scenarios influence students' *progress* in terms of *digital sobriety maturity*, particularly with regard to their sense of competence and their ability to use digital technologies responsibly?
- RQ2: What *effects* do the two learning scenarios have on students' *motivation* to adopt environmentally responsible digital practices?
- RQ3: To what extent do these learning scenarios impact students' *perceived competence to take collective action in promoting digital sobriety* within a university community?

The third question is of particular importance, as emphasised in the IPCC (2023) reports, which stress the need to foster collective agency in order to address current environmental challenges. Transitioning to more sustainable digital practices requires more than individual behavioural change; it necessitates a systemic approach rooted in cooperation, civic engagement, and the transformation of collective practices. This concept of perceived collective competence aligns with Self-Determination Theory (Deci & Ryan, 1985), which identifies competence as a key factor in self-determined motivation and the adoption of sustainable behaviours.

These three research questions enable us to organise our analysis around the motivational, cognitive, behavioural and collective dimensions of digital sobriety education in a higher education context.

Experimental design

This section outlines the learning intervention and experimental design, as illustrated in Fig. 1.

The experiment was conducted in three distinct phases:

1. First, all participants completed a pre-test to collect demographic and personal data to characterise the sample. They also completed an evaluation using the Digital Sobriety Maturity Scale (Échelle de Mesure de Maturité à la Sobriété Numérique – EMSN) (Descamps et al., 2022b). The EMSN is a psychometrically validated tool that was developed to assess two main dimensions:

   - Participants' perceived competence in three specific domains: digital skills, ecological awareness, and digital sobriety;

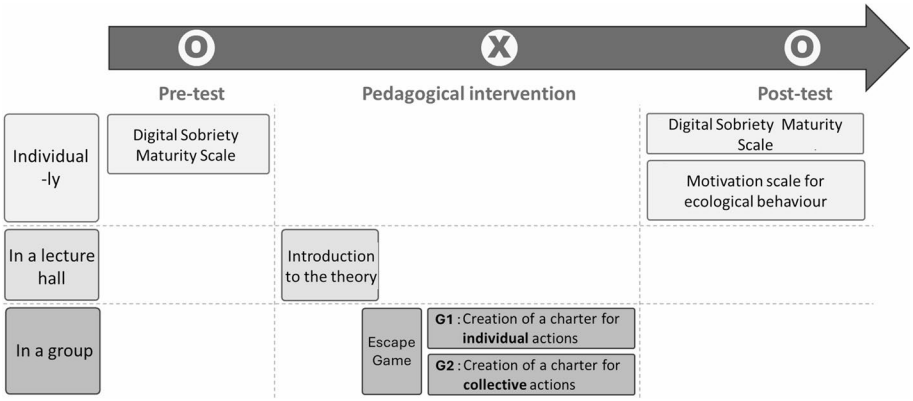

Fig. 1 Overview of the experimental procedure

– Environmentally responsible digital practices, categorized into four areas: web browsing, communication, digital environment management, and consumption.

For each item, respondents rated themselves on a Likert scale ranging from 0 to 3. This assessment provided a global digital sobriety maturity score, allowing for a standardized measurement of the participants' initial situation.

2. The pedagogical intervention consisted of the following sequential stages:

– *Theoretical introduction* A 10-min lecture was given to provide an overview of the theoretical foundations of digital sobriety literacy, based on the framework proposed by Descamps et al. (2022a).

– *Escape Game* Participants engaged in an interactive game designed to solve puzzles and answer questions related to the environmental impact of digital technologies and their responsible use. The final objective was to unlock a virtual safe. The game combined physical cards containing quizzes and QR codes with digital interactions such as web navigation, a collaborative online wall and a virtual safe. This combination of tangible and digital tools aimed to enhance immersion, collaboration and reflection, in line with the principles of experiential, game-based learning (Fig. 2).

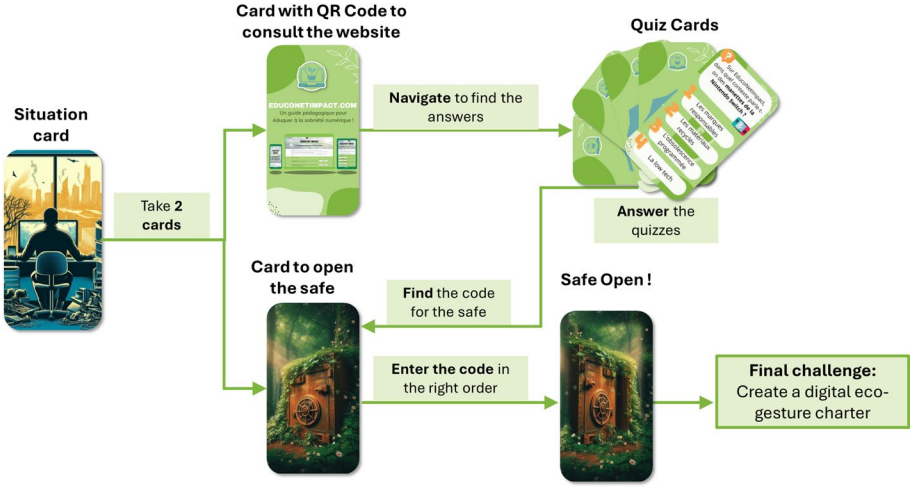

Fig. 2 Illustration of the escape game

Fig. 3 Examples of student-created digital eco-gesture charters

– *Creation of a digital eco-gesture charter* After unlocking the safe, participants were asked to design a charter of digital eco-gestures to be posted on a virtual wall (Fig. 3).

At this juncture, the students were randomly divided into two groups according to distinct teaching scenarios. The allocation was carried out during the distribution of the games: the lecture hall was divided into two nearly equivalent sections, resulting in a first group of 57 students and a second group of 50 students.

– The Group 1 members collated a charter centred on individual actions, as part of an eco-citizenship approach with a focus on personal responsibility. This approach is predicated on a pedagogical model founded on cognitive pragmatism (Naoufal, 2017). This standpoint posits that learning occurs through the medium of concrete experience and personal reflection on action. It emphasises the development of individuals' critical thinking skills, their ability to make informed choices and adopt responsible behaviour based on their own analysis of environmental issues.
– Group 2 developed a charter centred on collective actions within the university community. The present scenario is founded upon a cooperative and experiential pedagogy, integrating cognitive and affective pragmatic dimensions (Naoufal, 2017). The distinction between the two modalities is based on the typology of eco-citizenship practices described by Naoufal (2017). The theoretical framework under discussion posits that the emergence of an eco-citizen consciousness is fuelled by intellectual commitment (i.e. understanding of the challenges of digital sobriety), concrete group action, and emotional and symbolic sharing around common values. The approach is designed to enhance collaborative capabilities by fostering co-construction, solidarity, and the collective assimilation of knowledge and solutions.
– Finally, participants completed a post-test which again incorporated the EMSN in order to evaluate their progression in terms of digital sobriety maturity. The questionnaire also incorporated the Motivation Scale Toward Environmentally Responsible Behaviours (Échelle de Motivation vis-à-vis des Comportements Écologiques – EMCE), which was validated in French by Pelletier et al. (1997).

This instrument evaluates the following motivational dimensions: intrinsic motivation, integrated regulation, identified regulation, introjected regulation, external regulation and amotivation. Responses were collected using a Likert scale ranging from 1 to 7.

Sample

The experiment was conducted in a public university located in the province of Hainaut, Belgium. This territory, historically marked by deindustrialization, has a GDP per capita below the national and European average (Eurostat, 2024), as well as less favorable socio-economic indicators compared to other regions of the country. Although no individual data were available regarding the students' socio-economic status, these contextual elements help to more precisely situate the studied population and inform the interpretation of the results.

This study's sample consists of first-year undergraduate students enrolled in a Bachelor's programme in Psychological and Educational Sciences at the University of Mons in Belgium. The learning intervention was implemented as part of a course unit dedicated to developing digital competencies.

A total of 164 students participated in a learning session aimed at developing the "*protecting the environment*" competency, which is considered an integral part of digital skills. Of these, 107 completed both the pre-test and the post-test. These students constitute the final sample used for data analysis.

The sample is predominantly female, with 82.24% (88 out of 107) identifying as women. The average age of participants was 21.02 years ($\sigma = 6.83$). Additionally, participants' interest in various issues related to digital sobriety education was assessed. Specifically, their sensitivity to technology, environmental concerns and digital sobriety itself were measured using a Likert scale ranging from 0 to 3. The results, presented in Table 1, indicate that students in this sample demonstrated a particularly strong interest in environmental issues.

Results

Effects of two learning scenarios on digital sobriety maturity

To assess students' evolving digital sobriety maturity, a global score was calculated using the EMSN before and after the intervention. The calculation of relative gains and losses was conducted by applying the Hainaut (1975) formula, which is defined as follows:

$$\text{Gain}: (\text{Post} - \text{score} - \text{Pre} - \text{score}) \,/\, (\text{Maximum score} - \text{Pre} - \text{score}) \times 100$$
$$\text{Loss}: (\text{Post} - \text{score} - \text{Pre} - \text{score}) \,/\, \text{Pre} - \text{score} \times 100$$

The results for each student group are presented in Table 2. According to the literature, a relative gain is generally considered positive if it exceeds 30–35% (Gérard & Van Lint-Muguerza, 2000). However, Gérard (2003) suggests that, for social or behavioural

Table 1 Sensitivity before the pedagogical intervention

Sensitivity Likert's scale ranges from 0 to 3	Mean ($\overline{X}$)	Coefficient of variation (CV)
Technologies and the impact of digital tools on human beings	1.80	39.89
Ecology and environmental protection	2.13	39.26
Environmental impacts of digital technologies and digital sobriety	1.66	50.86

Table 2 Relative gains in digital sobriety maturity scores

Action charter type	N	Pre-test (%)		Post-test (%)		Relative gain (%)	
		$\overline{X}$	σ	$\overline{X}$	σ	$\overline{X}$	σ
Group 1: individual actions	57	40.01	9.42	60.62	12.30	27.63	11.79
Group 2: collective actions	50	40.19	8.89	59.48	9.50	25.85	10.28
Total (all participants)	107	40.09	9.13	60.09	11.04	26.80	11.09

Table 3 Learner Motivation to adopt more responsible digital behaviors

Motivation type		Group 1 (N = 57)				Group 2 (N = 50)				All (N = 107)			
		$\overline{X}$	σ	Min	Max	$\overline{X}$	σ	Min	Max	$\overline{X}$	σ	Min	Max
Adoption of eco-gestures		5.18	0.95	3.00	7.00	5.08	0.97	3.00	7.00	**5.13**	0.95	3.00	7.00
Intrinsic motivation		4.74	1.23	2.25	7.00	4.65	1.37	1.50	7.00	**4.70**	1.29	1.50	7.00
Extrinsic Motivation	Integrated	4.39	1.41	1.25	7.00	4.15	1.35	1.50	7.00	4.28	1.38	1.25	7.00
	Identified	5.33	1.02	2.50	7.00	5.23	0.98	1.50	7.00	**5.28**	1.00	1.50	7.00
	Introjected	4.31	1.56	1.00	7.00	4.44	1.57	1.00	7.00	4.37	1.56	1.00	7.00
	External	2.51	1.14	1.00	5.50	2.40	1.27	1.00	6.00	**2.46**	1.20	1.00	6.00
Amotivation		2.65	0.88	1.25	4.50	3.10	1.07	1.00	6.75	**2.86**	0.99	1.00	6.75

learning outcomes, such as those investigated in this study, a threshold of 25% is a more accurate indicator of significant progress. Based on this criterion, the pedagogical intervention appears to have had a positive effect on students' digital sobriety maturity in both groups (relative gain: 27.63% and 25.85%, respectively).

A Mann–Whitney U test was conducted to compare the two learning scenarios. This non-parametric test is suitable for comparing two independent groups when the data do not follow a normal distribution. This was confirmed in our case by the Shapiro–Wilk normality test ($p < .001$ for both groups). The results of the Mann–Whitney test indicated a p-value greater than 0.05 (see Table 3). Consequently, no statistically significant difference was observed between the two groups in terms of relative gain in digital sobriety maturity ($W = 1531$; $p = 0.051$).

Effects of two learning scenarios on motivation to adopt more responsible digital behaviors

To evaluate learners' motivation to adopt environmentally responsible digital behaviours, we employed the EMCE scale developed by Pelletier et al. (1997). An additional item was included to specifically measure students' motivation to adopt the eco-gestures identified in their learning charters. This 1–7 scale allows for the distinction between different types of motivation.

Analysis of Table 3 reveals several notable findings. Regardless of group, students demonstrated a relatively high motivation to adopt the eco-gestures they had identified ($\overline{X} = 5.13$). The highest level of motivation was observed for identified regulation ($\overline{X} = 5.28$), followed by intrinsic motivation ($\overline{X} = 4.70$). These results suggest that students perceive digital sobriety as a meaningful and conscious choice. They appear to derive personal satisfaction from adopting more responsible digital practices.

In contrast, motivation driven by external factors, such as rewards, sanctions, or social pressure, was relatively low ($\overline{X} = 2.46$). Additionally, amotivation, or the absence of motivation, remained fairly low across the sample ($\overline{X} = 2.86$), which is a positive indicator.

Table 4 Comparison of motivation to adopt more responsible digital behaviors

Motivation		W	df	*p*
Adoption of eco-gestures		1499.500		0.626
Intrinsic motivation		1442.000		0.918
Extrinsic Motivation	Integrated	1578.000		0.340
	Identified	1537.000		0.484
	Introjected	1368.500		0.726
	External	1536.500		0.486
Amotivation		1093.000		**0.038**

Table 5 Relative gains in terms of feeling competent to act collectively

		Pre-test		Post-test		Relative Gain (%)	
		$\overline{X}$	σ	$\overline{X}$	σ	$\overline{X}$	σ
Act collectively to reduce the impact of digital tech	G1	0.74	0.61	1.51	0.83	33.33	33.48
	G2	0.68	0.74	1.82	0.80	47.33	34.89
	All	**0.71**	**0.67**	**1.65**	**0.83**	**39.88**	**34.70**
Act collectively to protect the environment	G1	1.09	0.63	1.51	0.80	**20.47**	37.54
	G2	1.20	0.67	2.02	0.62	44.67	37.26
	All	**1.14**	**0.65**	**1.75**	**0.77**	**31.78**	**39.16**

Mann–Whitney U tests were conducted to compare motivational differences between the two groups. The results, shown in Table 4, indicate that there were no statistically significant differences between the groups in terms of any type of motivation, except for amotivation. The associated *p*-value for amotivation was below 0.05 ($p = 0.038$), indicating a significant difference between the groups. Therefore, we can say that group 2, having thought about a collective approach to eco-responsible digital use, has a higher level of motivation than group 1, feeling more disengaged from adopting digital eco-actions.

Effects of two learning scenarios on perceived collective efficacy

As part of this study, the EMSN included two items designed to measure students' perceived ability to act collectively. Students were asked to self-assess on a Likert scale from 0 to 3 in two areas: (1) their perceived ability to *'take collective action to reduce the environmental impact of digital technologies*', and (2) their perceived ability to *'collaborate and develop creative initiatives for environmental protection*'. To assess how these perceptions evolved over time, relative gains were calculated using Hainaut's (1975) formula.

Overall, the results in Table 5 indicate that the average relative gains, calculated across all participants, exceeded 30% for both items. These findings (39.88% and 31.78%, respectively) suggest that the learning intervention positively impacted students' perceived ability to act collectively to reduce the environmental impact of digital technologies and protect the environment more broadly.

However, a group-wise analysis reveals some differences. Students in Group 1, who developed a charter focused on individual actions, showed a relative gain of only 20.47% in their perceived collective efficacy to protect the environment, which is below the 30% threshold. The learning scheme did not lead to any significant improvement in their sense of competence to act collectively to protect the environment.

Mann–Whitney U tests were conducted to further explore this difference and compare the two groups, as shown in Table 6. The results indicate statistically significant

Table 6 Comparison of relative gains in the feeling of competence to act collectively

Mann–Whitney U				
	W	df	*p* Group 1 ≠ Group 2	*p* Group 1 < Group 2
Act collectively to reduce the impact of digital tech	1531.000		0.030	0.015
Agir collectivement pour protéger l'environnement			< 0.001	< 0.001

differences between the two groups. The associated *p*-values are below the 0.05 threshold, enabling us to conclude that students working on a collective action charter (Group 2) developed a significantly higher sense of competence in acting collectively to reduce digital environmental impact ($p = 0.015$) and protect the environment ($p < 0.001$).

These results confirm the existence of a differential effect of the learning scenario on students' perceived ability to act collectively. The scenario based on collective action appears to be more conducive to the development of this sense of competence than the scenario based on individual action. One potential explanatory hypothesis is that the nature of the collective scenario provided students with more opportunities to discuss collective ideas and to co-construct solutions. The collective scenario is characterised by the mobilisation of co-creation and co-reflection mechanisms, aligning with the principles of socio-constructivist pedagogy. This pedagogical approach emphasises learning through shared action and the construction of meaning in groups (Brini, 2024).

Discussion

Summary of results

This study aimed to analyse the impact of two learning scenarios designed to educate students about digital sobriety. The results revealed significant improvements in digital sobriety maturity in both scenarios, with no notable difference between the two groups. These results confirm the effectiveness of the learning intervention, regardless of whether it was based on cognitive pragmatism or integrated cognitive and affective pragmatism (Naoufal, 2017).

In terms of students' motivation to adopt environmentally responsible digital behaviours, both groups demonstrated high levels of motivation. This motivation is predominantly based on identified and intrinsic regulation, which supports the idea that the learning experience effectively fostered self-determined motivation, as outlined in Self-Determination Theory (Deci & Ryan, 1985). This type of motivation has been linked to sustained engagement and the adoption of environmentally friendly behaviours (Fiorello & Luu, 2014; Pelletier et al., 1997). These findings suggest an increased awareness of the need for the more responsible use of digital technologies.

However, a higher level of amotivation was observed among those engaged in collective action planning. This could be attributed to a cognitive overload linked to the complexity of the collective task (Bouzidi et al., 2006) or to a lack of individual involvement, possibly due to a perception of remoteness from concrete personal action. Alternatively, the complexity of the collective task may have induced a degree of emotional distancing or difficulty in projecting oneself into the action, which is consistent with limitations identified in certain gamified interventions (Callan et al., 2015). Conversely, students who had reflected on individual actions were more likely to engage in introspection regarding their own digital habits, which could explain the lower level of amotivation in this group.

The collective action scenario had a greater impact on students' perceived collective efficacy. This confirms the effectiveness of this approach in enhancing collective action. However, caution is warranted regarding its potential effect on amotivation. Nevertheless, the collective approach appears to be more effective in developing collective competence, which tends to remain underdeveloped in the absence of targeted educational interventions (Descamps et al., 2023a, 2023b). Facilitating student reflection on collective agency appears to have meaningfully enhanced their perceived self-efficacy. As Bader et al. (2017) have highlighted, such pedagogical practices can contribute to societal transformation. This is consistent with the work of Murillo-Zamorano et al. (2021), who emphasise that gamified, co-creative and empowering learning environments can effectively combine active learning, personal engagement and competency development. Similarly, integrating dedicated moments for collective action into learning interventions promotes learner engagement with sustainability issues, as Lange (2013) points out.

Transferability and pedagogical implications

Beyond the experimental validation of the device, it is important to consider the transferability of the results to pedagogical and curricular practices. The findings of this study confirm the relevance of hybrid and game-based approaches for integrating digital sobriety into university curricula. In line with international frameworks (UNESCO, 2020, 2024), these approaches foster active and reflective pedagogy, contributing to students' ecological awareness.

The collective scenario, by strengthening the sense of competence to act together, highlights the value of integrating co-construction activities into teaching practices (Naoufal, 2017). Similarly, the observed self-determined motivation suggests that priority should be given to approaches that stimulate voluntary engagement rather than coercive strategies (Deci & Ryan, 1985; Pelletier et al., 1997).

From a practical perspective, these results indicate that short game-based modules can be used to introduce digital sobriety within broader courses on digital skills or sustainable development. In concrete terms, activities such as the co-construction of eco-action charters represent formats that are directly transferable to classroom settings. Their logistical simplicity facilitates their integration across various higher education contexts.

Institutions could also consider including such approaches in their curricula as transversal devices, in alignment with the European *DigComp* and *GreenComp* frameworks. Finally, three recommendations emerge: (1) explicitly integrate digital sobriety into competency frameworks, (2) design accessible hybrid game-based approaches without requiring excessive technical resources, and (3) train educators in their implementation to avoid superficial gamification (Callan et al., 2015).

Limitations and future research directions

It is important to acknowledge that the findings are based on self-reported data and perceived competence, neither of which necessarily reflects learners' actual behaviours or abilities. As these data are based on self-assessments, they could be influenced by reporting bias or the Dunning-Kruger effect (Girard et al., 2024), i.e. a cognitive bias according to which the least competent individuals tend to overestimate their abilities, for lack of hindsight or sufficient knowledge to assess their skills objectively. In a context

where environmental protection is a digital competence that is still in its infancy among students (Mercier & Trichet, 2023), it is possible that some participants, lacking an objective view of their real skills in the field, may have overestimated their sense of competence due to a lack of knowledge of the complexity or real scope of the subject.

Another limitation lies in the short duration of the intervention, which does not allow for the measurement of lasting effects on actual digital behaviors. One area for future research would be to assess the long-term effects of such pedagogical interventions on real-world digital practices, for example through the use of delayed post-tests (Crinon et al., 2003). In fact, changes in behaviour, particularly those linked to practices such as eco-friendly digital use, often require prolonged support (Mercier & Trichet, 2023) and regular reminders if they are to be maintained over time.

Finally, integrating mixed methods and qualitative approaches could provide deeper insights into learners' motivations and barriers. Analysing learning artefacts, such as the eco-gesture charters developed by students in each scenario, could also provide additional information on the differential impacts of the tested learning models.

Conclusion

This study aims to evaluate the effectiveness of an engaging, hybrid learning environment in promoting digital sobriety awareness among higher education students and strengthening their collective skills in the face of environmental challenges. Leveraging a hybrid escape game combining digital and physical elements activated an active, immersive and engaging learning experience, in line with the principles of game-based pedagogy.

The results suggest that students are primarily motivated to adopt responsible digital behaviours through conscious choice (identified regulation) or personal satisfaction (intrinsic motivation), rather than coercion or disengagement. These motivational profiles are consistent with Self-Determination Theory (Deci & Ryan, 1985) and are conducive to the long-term internalisation of pro-environmental behaviours (Pelletier et al., 1997).

Our observations confirm the importance of collaborative approaches in developing eco-citizen skills and fostering a sense of collective competence, a key lever in the capacity to promote a sustainable transition. They encourage higher education institutions, the target audience for this study, to incorporate these practices into their programmes, particularly through teaching scenarios centred on collective action, co-construction and reflexivity.

Finally, this research opens up new avenues for evaluating the long-term effects of educational interventions on actual digital behaviours and for refining pedagogical strategies that support sustainable digital and ecological transitions. Situated at the intersection of educational technology, sustainability, and motivation, this study contributes to broader pedagogical reflections on educating for a more mindful, sustainable, and collaborative digital culture.

Acknowledgements

We would like to thank the Faculty Unit for Educational Support (CFPU) of the Faculty of Psychology and Educational Sciences at the University of Mons for facilitating access to the experimental field during the course "Development of Digital Competences" and for its logistical support.

Author contributions

Conceptualization, research design, methodology, manuscript writing.

Funding
Not applicable.

Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests
The authors declare that they have no competing interests.

Received: 2 June 2025 / Accepted: 3 November 2025
Published online: 24 November 2025

References

Alcaraz, M. (2022). Les plus petits passent 6 heures par semaine sur Internet, autant que sur la télévision. *Les Echos*. https://www.lesechos.fr/tech-medias/medias/les-plus-petits-passent-6-heures-par-semaine-sur-internet-autant-que-sur-la-television-1394549. Accessed 19 May 2025.

Bader, B., Therriault, G., & Morin, E. (2017). Engagement écocitoyen, engagement scolaire et rapport aux savoirs. In L. Sauvé, I. Orellana, C. Villemagne, & B. Bader (Eds.), *Éducation, environnement, écocitoyenneté : Repères contemporains* (pp. 81–100). Presses de l'Université du Québec.

Bianchi, G., Pisiotis, U., & Cabrera, M. (2022). *Greencomp: The European sustainability competence framework*. Publications Office of the European Union. https://doi.org/10.2760/13286

Blanchet-Cohen, N. (2017). Apports des pédagogies autochtones à l'apprentissage de l'écocitoyenneté. In L. Sauvé, I. Orellana, C. Villemagne, & B. Bader (Eds.), *Éducation, environnement, écocitoyenneté : Repères contemporains* (pp. 68–80). Presses de l'Université du Québec.

Bouzidi, D., Ajhoun, R., & Benkiran, A. (2006). Les annotations pour un apprentissage collaboratif. In *Premières journées communication et apprentissages instrumentés en réseau* (pp. 372–382). France: Amiens.

Brini, R. (2024). *L'innovation en pédagogie active : regards croisés sur l'apprentissage par le Design Thinking et l'affordance numérique pour un enseignement universitaire plus engageant et inclusif* [Doctoral dissertation]. University of Bordeaux. https://theses.hal.science/tel-05035429/ Accessed 19 May 2025.

Callan, R. C., Bauer, K. N., & Landers, R. N. (2015). How to avoid the dark side of gamification: Ten business scenarios and their unintended consequences. In T. Reiners & L. C. Wood (Eds.), *Gamification in Education and Business* (pp. 553–568). Springer International Publishing. https://doi.org/10.1007/978-3-319-10208-5_28.

Carretero, S., Vuorikari, R., & Punie, Y. (2017). *DigComp 2.1: The digital competence framework for citizens with eight proficiency levels and examples of use*. Luxembourg: Publications Office of the European Union. https://doi.org/10.2760/38842.

Clover, D. E., Jayme, B., Hall, B. L., & Follen, S. (2013). *The nature of transformation: Environmental adult education*. Sense Publishers.

Collin, A., Capitaine, A., Vincent, A. F., Coquerelle, M., Dejous, C., Ghiotto, A., Desainte-Catherine, M., Loubet, P., & Jégo, C. (2024). Enseignements sur les enjeux environnementaux et les impacts du numérique dans une école d'ingénieurs. *JEESES,* 10. https://doi.org/10.53480/jeeses.cea2

Crinon, J., Marin, B., & Legros, D. (2003). L'impact de la collaboration à distance sur l'apprentissage des temps du récit au cycle 3. In *Environnements informatiques pour l'apprentissage humain* (pp. 103–114). ATIEF.

D'Hainaut, L. (1975). *Concepts et méthodes de la statistique. Tome 1*. Labor.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Plenum.

Descamps, S., Temperman, G., Boumazguida, K., & De Lièvre, B. (in press). Développement et validation psychométrique d'une échelle de mesure de la maturité à la sobriété numérique.

Descamps, S., Temperman, G., Boumazguida, K., & De Lièvre, B. (2023). Sobriété numérique et acteurs de l'éducation : analyse croisée de leur sentiment de compétence et de leurs usages déclarés. *Distances et médiations des savoirs, 43*. https://doi.org/10.4000/dms.9259.

Descamps, S., Temperman, G., & De Lièvre, B. (2023). Évaluer sa maturité à la sobriété numérique : comment évaluer ce nouvel enjeu du XXIe siècle ? In *33e Colloque de l'ADMEE-Europe : Pluralité de contextes, pluralité d'évaluations en éducation*, Université des Antilles, Pointe-à-Pitre, France

Descamps, S., Temperman, G., & De Lièvre, B. (2022a). Vers une éducation à la sobriété numérique. *Humanités numériques, 5*. https://doi.org/10.4000/revuehn.2858.

Dufort, D. (2023). Sarah Descamps, Gaëtan Temperman, et Bruno De Lièvre, Vers une éducation à la sobriété numérique. *Distances et médiations des savoirs, 43*. https://doi.org/10.4000/dms.9509.

Dziubaniuk, O., Ivanova-Gongne, M., & Nyholm, M. (2023). Learning and teaching sustainable business in the digital era: A connectivism theory approach. *International Journal of Educational Technology in Higher Education, 20*(1), 22. https://doi.org/10.1186/s41239-023-00390-w

Eurostat. (2024). *Regional statistics by NUTS classification - 2024*. https://ec.europa.eu/eurostat

Fiorello, A., & Luu, P. (2014). Promouvoir des changements de comportements durables : Les apports de la théorie de l'autodétermination. Une application au comportement de tri des déchets ménagers. *Revue Française Du Marketing, 249*(4/5), 37–64.

Genevois, S., & Leininger-Frézal, C. (2010). Les "serious games" : un outil d'éducation au développement durable ? In *Colloque international Éducation au développement durable et à la biodiversité : concepts, questions vives, outils et pratiques*, Digne-les-Bains, France.

Gérard, F. M., & Van Lint-Muguerza, S. (2000). Quel équilibre entre une appréciation globale de la compétence et le recours aux critères ? In C. Bosman, F. M. Gérard, & X. Roegiers (Eds.), *Quel avenir pour les compétences ?* (pp. 135–140). De Boeck Université.

Gérard, F. M. (2003). L'évaluation de l'efficacité d'une formation. *Gestion 2000, 20*(3), 13–33.
Giannini, S. (2024). *Bridging the green and digital transitions through education*. UNESCO. https://doi.org/10.54675/ZACQ4808
Gibert, A. (2022). GreenComp : Des compétences pour un avenir durable. *Cahiers Pédagogiques, 576*(3), 7. https://doi.org/10.3917/cape.576.0007
Girard, A., Gérard, I., Colin, O., Moyon, M., & Vanhoolandt, C. (2024). Étude de l'impact d'un dispositif d'apprentissage différencié et personnalisé en sciences en première année d'université. In *L'enseignement supérieur et les communautés : des dynamiques interconnectées*, AIPU, Le Mans, France.
IPCC. (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC. https://www.ipcc.ch/report/ar6/syr/. Accessed 19 May 2025.
Jouzel, J. (2022). *Sensibiliser et former aux enjeux de la transition écologique et du développement durable dans l'enseignement supérieur*. Ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation. https://www.enseignementsup-recherche.gouv.fr/sites/default/files/2022-02/sensibiliser-et-former-aux-enjeux-de-la-transition-ecologique-dans-l-enseignement-sup-rieur-16808.pdf. Accessed 19 May 2025.
Lagarrigue, A., Ninassi, B., & Farhi, L. (2023). Impact'Num le MOOC responsable. *Collection numérique de l'AMUE*, 29(2). https://hal.science/hal-04402645. Accessed 19 May 2025.
Lange, J.-M. (2013). Curriculum possible de l'éducation au développement durable : entre actions de participation et investigations multiréférentielles d'enjeux. *Éducation relative à l'environnement,* 11. https://doi.org/10.4000/ere.691.
Lavigne, M. (2022). La ludopédagogie, acteurs et idéologie. *Educations, 6*(1). https://doi.org/10.21494/ISTE.OP.2022.0821.
Lépinard, P. (2024). La ludopédagogie au service du développement des compétences transversales des futurs managers. In *Formation* (pp. 178–184). Caen: EMS Editions.
Marfisi-Schottman, I., Longeon, T., Furnon, C., & Marne, B. (2022). 10 Commandments of the Serious Game Padawan: Lessons Learned After 4 Years of Professional Training. In T. E. Eds. (Ed.), *Lecture Notes in Computer Science: Vol. 13647. Games and Learning Alliance* (pp. 97–108). Springer. https://doi.org/10.1007/978-3-031-22124-8_7.
Mercier, C., & Trichet, F. (2023). Accompagner les formateurs et les étudiants à la sobriété numérique. *Distances et médiations des savoirs, 43*. https://doi.org/10.4000/dms.9449.
Meyer, J. (2023). Une fresque pour les jeunes. *Les Cahiers Dynamiques, 82*(1), 94–96. https://doi.org/10.3917/lcd.082.0094
Murillo-Zamorano, L. R., Sánchez, J. Á. L., Godoy-Caballero, A. L., & Muñoz, C. B. (2021). Gamification and active learning in higher education: Is it possible to match digital society, academia and students' interests? *International Journal of Educational Technology in Higher Education, 18*(1), 16. https://doi.org/10.1186/s41239-021-00249-y
Naoufal, N. (2017). Justice environnementale et écocitoyenneté. In L. Sauvé, I. Orellana, C. Villemagne, & B. Bader (Eds.), *Éducation, environnement, écocitoyenneté : Repères contemporains* (pp. 101–118). Presses de l'Université du Québec.
Ortiz-Rojas, M., Chiluiza, K., Valcke, M., & Bolanos-Mendoza, C. (2025). How gamification boosts learning in STEM higher education: A mixed methods study. *International Journal of STEM Education*. https://doi.org/10.1186/s40594-024-00521-3
Pelletier, L. G., Green-Demers, I., & Béland, A. (1997). Pourquoi adoptez-vous des comportements écologiques ? Validation en langue française de l'échelle de motivation vis-à-vis des comportements écologiques. *Revue Canadienne des Sciences Du Comportement, 29*(3), 145–156. https://doi.org/10.1037/0008-400X.29.3.145
Sauvé, L., & Brunelle, R. (2003). Éducation relative à l'environnement : regards-recherche-réflexion. *Chaire De Recherche Du Canada En Éducation Relative à L'environnement, 4*, 378. https://doi.org/10.4000/vertigo.5110
Sauvé, L. (2017). L'éducation à l'écocitoyenneté. In A. Barthes, J.-M. Lange, & C. Chauvigné (Eds.), *Dictionnaire critique des enjeux et concepts des « éducations à »* (pp. 56–65). L'Harmattan.
Tilbury, D., Auzinger, M., & Zarka, Z. (2024). Study on learning for sustainability and digital education in primary and secondary schools. *Publications Office of the European Union*. https://doi.org/10.2766/3742964
Tzafilkou, K., Perifanou, M., & Economides, A. A. (2022). Development and validation of students' digital competence scale (SDiCoS). *International Journal of Educational Technology in Higher Education*. https://doi.org/10.1186/s41239-022-00330-0
UNESCO. (2022). Berlin declaration on education for sustainable development: Learn for our planet, act for sustainability. Paris: UNESCO.
UNESCO. (2017). *Education for sustainable development goals: Learning objectives*. Paris: UNESCO.
UNESCO. (2020). *Education for sustainable development: A roadmap*. Paris: UNESCO.
UNESCO. (2024). *Greening curriculum guidance: Teaching and learning for climate action*. Paris: UNESCO.
Villemagne, C. (2017). Éducation à l'environnement des adultes. In L. Sauvé, I. Orellana, C. Villemagne, & B. Bader (Eds.), *Éducation, environnement, écocitoyenneté : repères contemporains* (pp. 157–176). Québec: Presses de l'Université du Québec.
Zeng, J., Sun, D., Looi, C., & Fan, A. C. W. (2024). Exploring the impact of gamification on students' academic performance: A comprehensive meta-analysis of studies from the year 2008 to 2023. *British Journal of Educational Technology, 55*(6), 2478–2502. https://doi.org/10.1111/bjet.13471

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