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Design for Sustainable Behaviour: An Exploratory Study in Schools' Washrooms

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Abstract: Recent research suggests that built environments can influence user behavior. Concurrently, Design for Sustainable Behaviour (DfSB) has emerged in design and manufacturing disciplines. This paper explores the application of DfSB in built environment design by devising and implementing a toolkit to prompt children to behave more sustainably in schools' washrooms. The resource consumption before and after the toolkit installation in two primary schools was measured and compared. Afterward, interviews and a workshop were carried out to gather the perceptions of children and staff. Results show a preference for stickers that are playful and portray natural motifs. Also, the toolkit design concepts were not perceived by most users, suggesting it can be simplified and serve mainly as a reminder to perform a particular behavior. Yet, the interview participants suggested that the toolkit could indirectly contribute to more sustainable behaviors by creating a pleasant environment and prompting children to not play/waste resources. Additionally, the research reviews and classifies existing DfSB strategies into three categories, providing valuable insights for designers on tailoring interventions based on user control, attitudes, and targeted behaviors.

Keywords: design for sustainable behavior; behavior change; school building; built environment; user behavior

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1. Introduction

The building sector is receiving growing attention in worldwide policies for sustainable development since it is responsible for a large portion of resource consumption (e.g., 36% of global energy use) [1]. Many technologies were proposed in order to make the built environment more sustainable, such as the use of renewable energies and the optimization of heating, ventilation, and air conditioning (HVAC) systems [2]. Yet, user behavior and actions (e.g., to turn on the heating, to open the window, to switch on the light) also play an important role in building resource consumption [3,4]. For example, one case study carried out in the UK in a residential context found that 37% of the energy consumption variation was due to user behavior [5]. Eon et al. [4] analyzed the impact of user behavior on energy and water use and found that rigid routines and habits are harder to change. User behavior is complex as it is influenced by external (culture, economy, and climate) and internal factors (individual comfort preference, physiology, and psychology), requiring an interdisciplinary approach to be fully understood [6].

Design for Sustainable Behaviour (DfSB) assumes that a product design can shape or create sustainable behavior [7–10] which is defined as the use of products with minimal

impact [11]. While user behavior can also play a role in product sustainability during the purchase and end-of-life phases [12,13], the use phase is considered a key success factor in sustainable design [14]. Unsustainable behaviors identified during the use phase include product misuse, overuse, and insufficient exploitation [12]. As a result, it is crucial to implement strategies that promote sustainability during this phase [14].

DfSB comprises a number of strategies to shape the interaction between users and products, thus reducing social and environmental impacts [7]. These strategies differ in their rationale to influence user's behavior, for example, by motivating or forcing users to behave more sustainably. Indeed, a number of taxonomies containing distinct strategies have been developed [9,11,15–24]. For instance, Scurati et al. [25] proposed a three-step framework to characterize gameful and playful products for behavior change: (i) capture user attention, (ii) trigger the desired behavior, and (iii) provide rewards through feedback. Montecchi and Becattini [13] presented the Human Behaviour Inefficiency Model, a framework with six steps to assist designers in modeling user behaviors during the product's use phase. Medeiros, Rocha, and Ribeiro [26] introduced a decision support diagram to promote sustainable behavior, which synthesizes existing DfSB frameworks into four steps: (i) user analysis, (ii) level of user or product control, (iii) strategy definition, and (iv) methods for integrating strategies into the product. However, there is little research examining the effectiveness of such strategies in product design and the extent they are able to change behavior and/or reduce environmental impacts [27].

Built environments can influence user behaviour as suggested by Cleland et al. [28] and Niedderer et al. [29]. Cleland et al. [28] investigate the correlation between the built environment and physical activity or sedentary behavior in older adults based on a number of studies. Results show that walkability and land use mix (density and pattern) were positively associated with physical activity [28]. Niedderer et al. [29] examined the development of accessible and inclusive built environments for the elderly, and those with a disability and proposed that the design of built environments influences the behavior of people with dementia, autism, learning difficulties, and brain injury [29]. Following such reasoning, it becomes relevant to study DfSB (which has been mainly used for manufacturing products) in this context, particularly as it can support the design of built environments that prompt users to behave more sustainably.

DfSB has been mainly investigated in the residential and office contexts focused on the design of woodstoves [30], televisions [31,32], radiators [27], washing machines [33], refrigerators, coffee machines [34], and mobile phones [35], but it can also be explored in educational contexts. Children spend a large proportion of their time at school, but the role of the indoor school-built environment is poorly investigated [36]. Also, children often share sustainable behaviors with their parents and other adults in the community [37] by replicating what they learned at school in the household routine. For example, a study in Norway showed that children had a significant influence on the recycling behavior of other family members by exercising social pressure after studying such themes in school [38]. Childhood experiences are known to influence lifelong habits and attitudes [39]. Thus, it is suggested here that DfSB can provide means to improve children's behavior.

In order to explore the application of DfSB strategies in built environment design and to improve children's behavior, this study presents a toolkit based on DfSB strategies to support more sustainable behaviors in school washrooms. It is comprised of a set of stickers applied to light switches and soap, toilet paper, and paper towel dispensers. The toolkit was installed in two schools (a public and a private one) in the southern region of Brazil. The consumption of resources before and after its implementation was measured and compared. Afterward, interviews and a workshop were carried out to gather users' perceptions of the toolkit.

2. Materials and Methods

The research method was based on a case study and supported by field research. The research object consisted of a set of washrooms in two school buildings (a private and a public one) located in the southern region of Brazil. This study followed the Design Intervention Process (Figure 1) [10]. First, an intervention plan was defined (Phase 1) followed by an understanding of users and context (Phase 2). Design opportunities, target actions, and design strategies were identified (Phase 3). An intervention design was then developed (Phase 4) and evaluated with real users (Phase 5). This can lead to loops to redefine users, context, and design opportunities or to improve the intervention. This interactive process ends with an evaluation of the intervention (Phase 6).

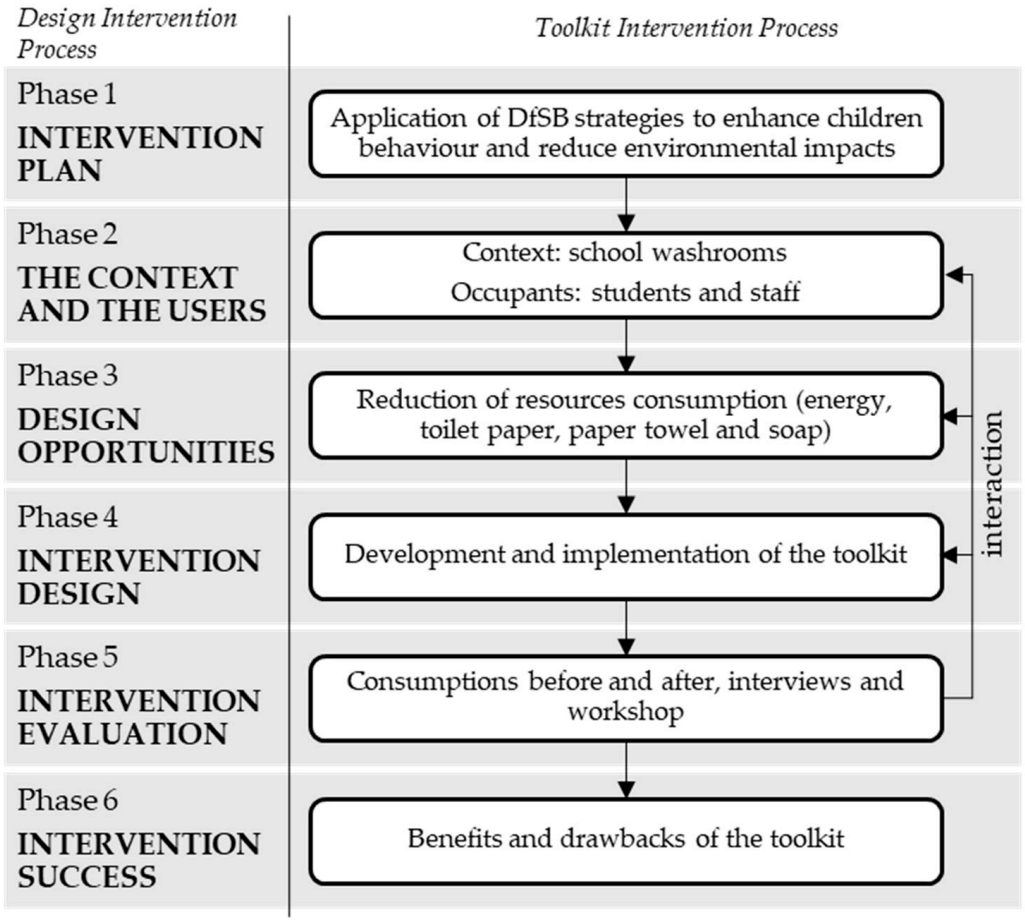

Figure 1. Design Intervention Process adapted to this study.

In Phase 1, DfSB strategies proposed in the literature were reviewed and synthesized in three fundamental groups in order to select the strategies to design the toolkit: (i) product–user distribution of control; (ii) product–user control and more dimensions; and (iii) behavioral dimension.

The selected school washrooms are presented in Figures 2 and 3 and Table 1. All stickers of the proposed toolkit were applied in School A (private). Yet, only the light switch and toilet paper stickers were installed in School B since soap and paper towels were unavailable in this public school. School B (public) had posters on water consumption and good manners (e.g., "use water and paper without wasting", "close the tap tightly", and "throw the paper in the bin") in the washrooms. The users' actions and desired behavior in washrooms were listed to help in the solution development (Table 2).

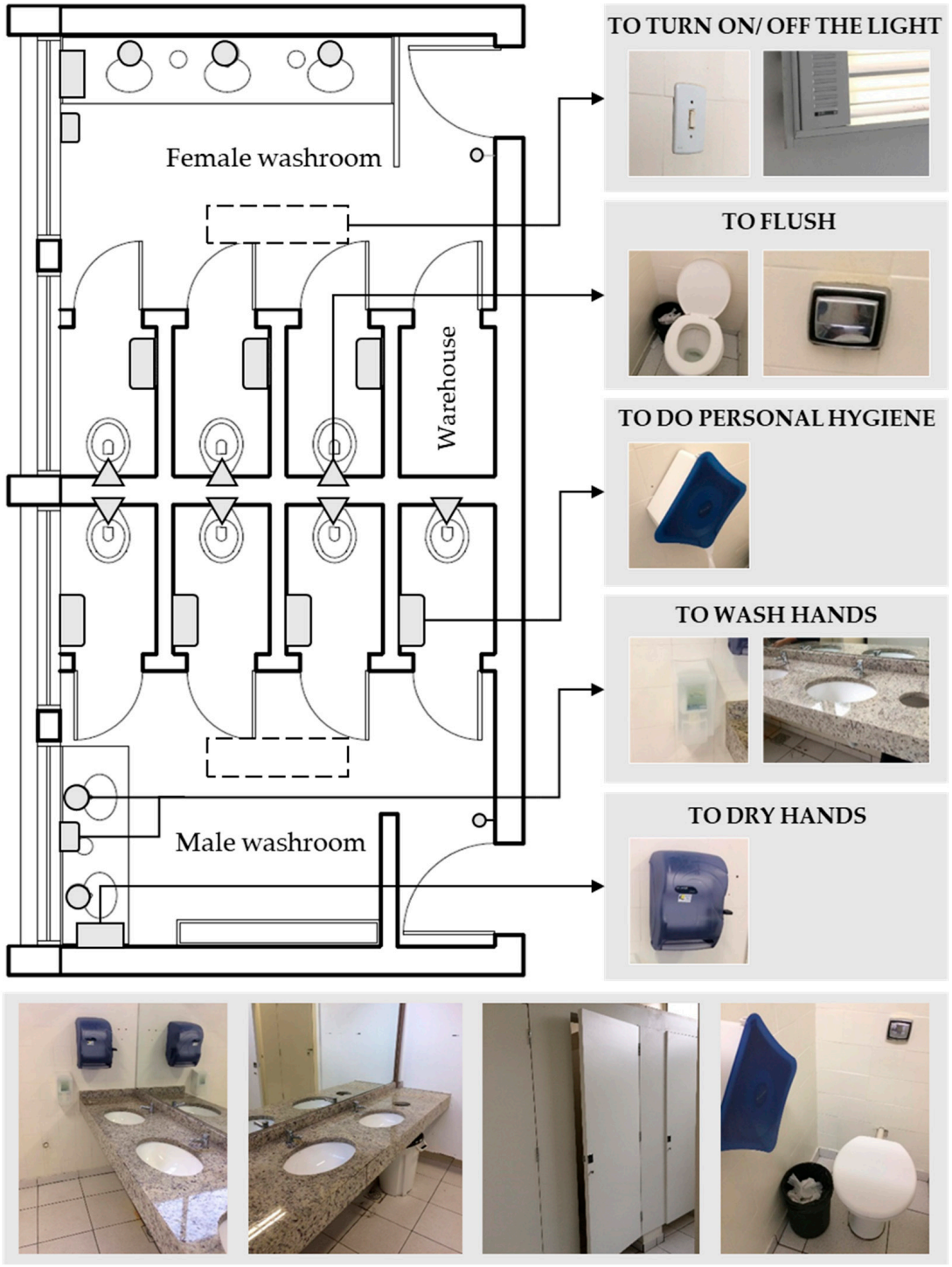

Figure 2. Floor plan and washroom perspectives (School A—private school).

Table 1. Overview of Schools A and B.

	School A (Private School)	School B (Public School)
Number of students	770	645
Age of students	2–17	6–17+ adults
Number of teachers	105	119
Number of staff	80	35
Washroom selected	Two washrooms used by approximately 110 persons, including students (1st to 3rd year of Elementary School), teachers and staff (Figure 2)	Three washrooms used by approximately 160 persons, including students (1st to 5th year of Elementary School), teachers and staff (Figure 3)

Figure 3. Floor plan and washroom perspectives (School B—public school).

Table 2. User's actions and desired behaviors in washrooms.

Action	Resource	Device	Desired Behaviour
To turn on/off the light	Energy	Switch/lamp	To turn off the light when leaving the room
To do personal hygiene	Toilet paper	Dispenser	To use just the necessary amount of toilet paper
To wash hands	Soap and water	Dispenser/tap	To use just the necessary amount of soap and water
To dry hands	Paper towel	Dispenser	To use just the necessary amount of paper towel
To flush	Water	Flush/toilet	To choose the right flush (toilet with double flushing)

The intervention evaluation consisted of three parts (Phase 5 in Figure 1). First, the consumption of resources was measured eight weeks before and seven weeks after the toolkit implementation—the monitoring period spanned from August to December, with the toolkit being implemented in October. Single-phase energy meters (model DDS238-1) installed in the schools' switchboard measured washrooms' energy consumption. Rolls of 300 m (toilet paper), refill packages of 900 milliliters (soap), and paper towel packages were used to measure, respectively, toilet paper, paper towel, and soap consumption. Second, interviews (structured in six questions) were carried out with students and staff who use the selected washrooms (Table 3 and Figure 4). Third, co-creation workshops [40] were conducted with third-year students (21 students from School A and 19 students from School B, average nine years old).

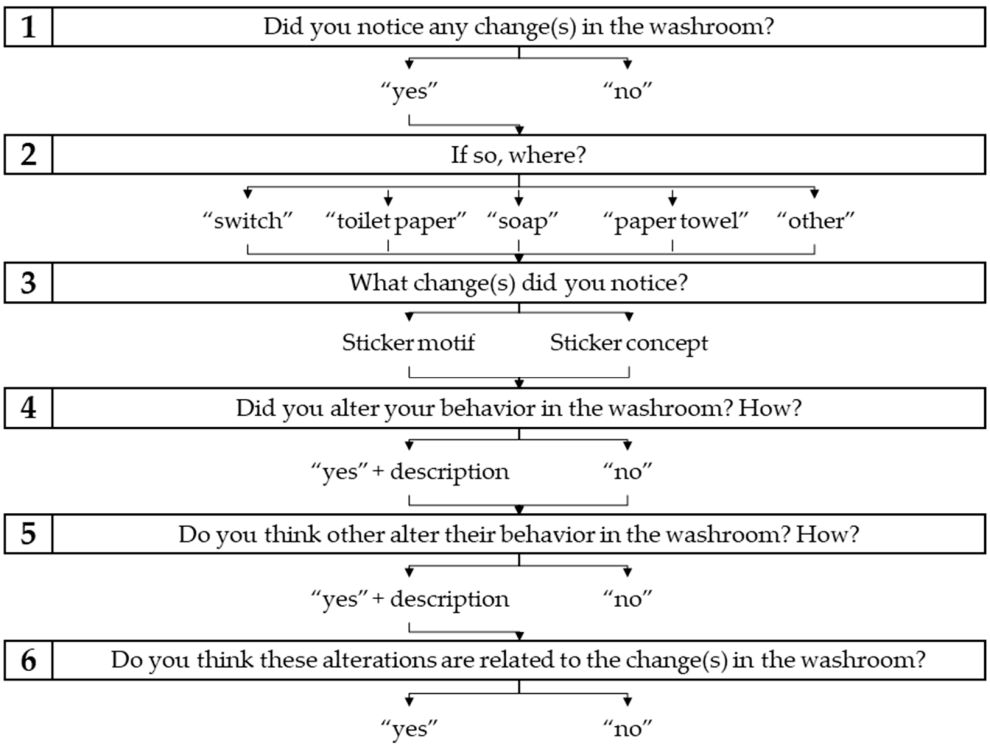

Figure 4. Interview structure.

Table 3. Profile of users interviewed.

		Average Age	Number of Participants	Male	Female	School A (Private School)	School B (Public School)
Students	1st year	7	8	3	5	3	5
	2nd year	8	4	1	3	3	1
	3rd year	9	10	4	6	5	5
	4th year	10	2	1	1	0	2
	5th year	11	2	1	1	0	2
Staff		38	10	0	10	5	5
Total			36 100%	10 28%	26 72%	16 44%	20 56%

The workshop was structured in four steps (Table 4) according to Kumar [41], Sanders and William [42], and Visser et al. [43]. First, in order to introduce the theme of the workshop, students had to guess what was in the five boxes (water, paper towel, toilet paper, soap, or a lamp—representing energy) by putting their hands inside. The "Storyboard" required students to create the user journey by selecting and ordering cards containing common actions developed in washrooms: (i) turn the light on, (ii) turn the light off, (iii) use the toilet, (iv) flush the toilet, (v) wash hands, (vi) dry hands, (vii) wash the face, (viii) brush the teeth, and (ix) blow the nose. For the "Scale Model" (Figure 5), students (organized into three groups) had to connect the resources (water, paper towel, toilet paper, soap, and energy) with devices (toilet, tap, dispensers, and light switch). Lastly, students devised new ideas for the stickers (using drawings), which were then presented and discussed.

Table 4. Workshop structure.

Part	Duration	Objective	Tools
1. Introduction	10 min	Introduce the subject, build engagement, and align expectations	The mysterious boxes
2. Immersion	30–40 min	Create a shared understanding about the workshop subject (resource consumption in toilets)	Storyboard and Scale model
3. Generation	30–40 min	Create and explore new ideas (co-creation)	Drawing
4. Reflection	10 min	Present new ideas (drawings) for the stickers	Discussion

Figure 5. Example of scale model.

3. The Proposed Toolkit

3.1. Description

The light switch sticker has an animal motif that is complete when the light is off (Figure 6a) and slashed by a red band when the light is on (Figure 6b). It relies on users' sense of order or motivation to have the complete animal as a means to reduce energy consumption (Table 5). The paper towel sticker has a natural landscape motif (rainforest or palm trees). The trees are seen when the refill is full (Figure 7a) and start to disappear as paper is used (Figure 7b) until completely vanishing (Figure 7c). The sticker seeks to reduce consumption by eliciting the link between resources (paper) and the environment (trees). The toilet paper sticker has a flower motif and follows the same rationale (Figure 8). Lastly, the soap sticker contains an animal and encourages users to keep the motif complete (Figure 9), thus using only the necessary amount of soap.

Table 5. Sticker motif and concept.

Sticker	Motif	Concept
Light switch (Figure 6)	Animals (dinosaur, giraffe and octopus)	The animal is complete when the light is off (Figure 6a) and slashed by a red band when the light is on (Figure 6b)
Paper towel (Figure 7)	Trees	The trees are complete when the dispenser is full (Figure 7a) and start to vanish as the paper towel is used (Figure 7b,c)
Toilet paper (Figure 8)	Flower	The flower is complete when the dispenser is full (Figure 8a) and start to vanish as the toilet paper is used (Figure 8b,c)
Soap (Figure 9)	Animals (butterflies and geckos)	The animals are seen when the dispenser is full (Figure 9a) and start to vanish as the soap is used (Figure 9b)

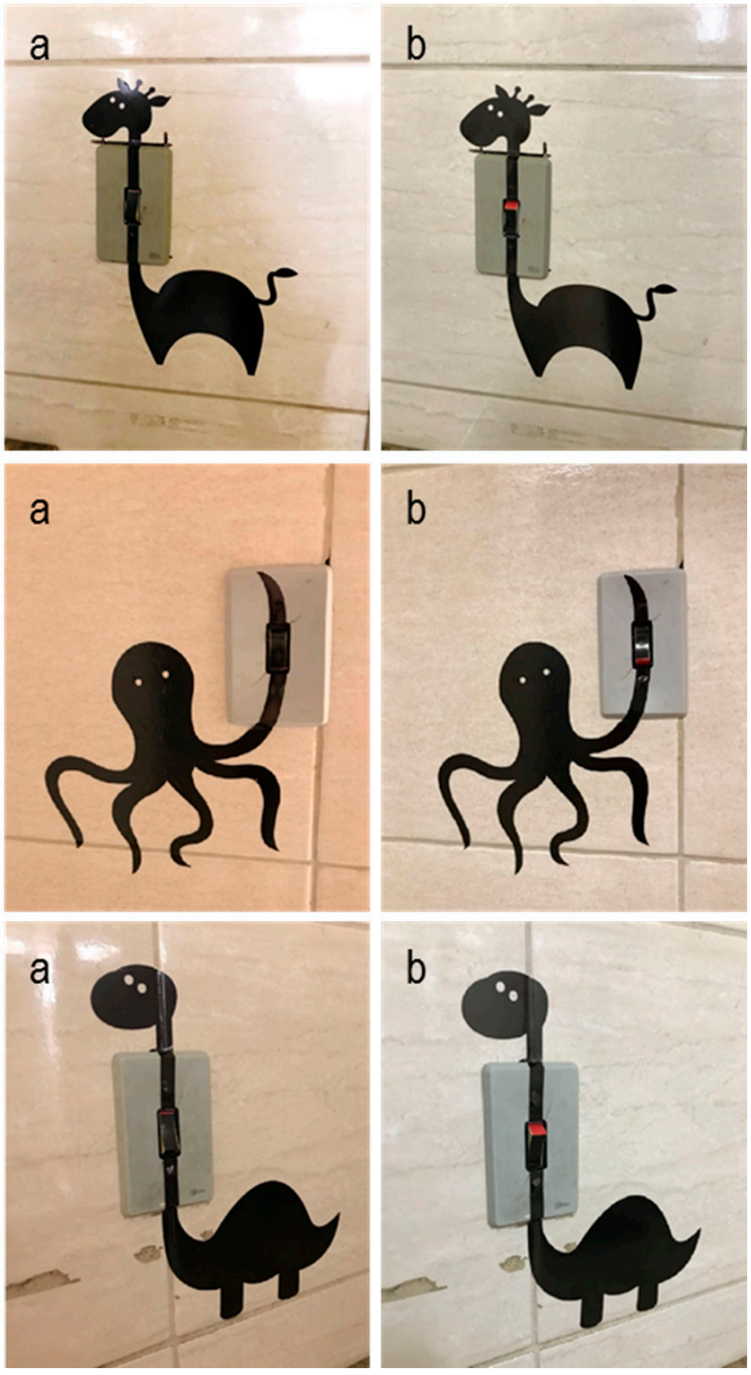

Figure 6. Light switch sticker when the light is off (**a**) and on (**b**).

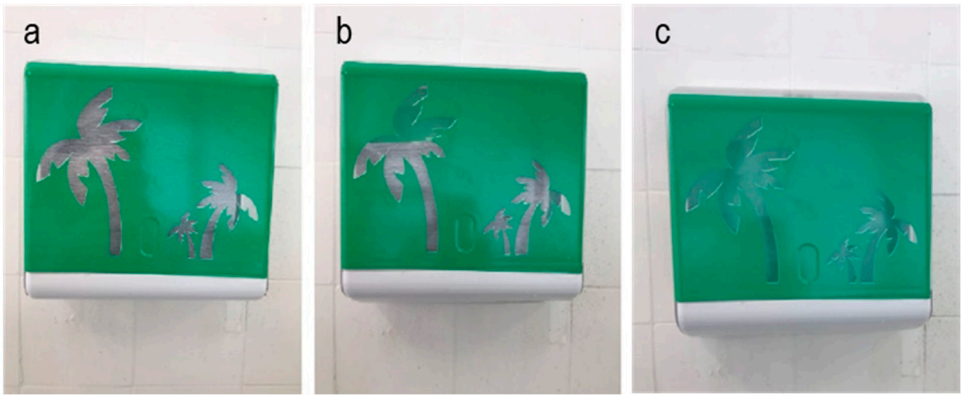

Figure 7. Paper towel sticker when the dispenser is full (**a**) half-full (**b**) and empty (**c**).

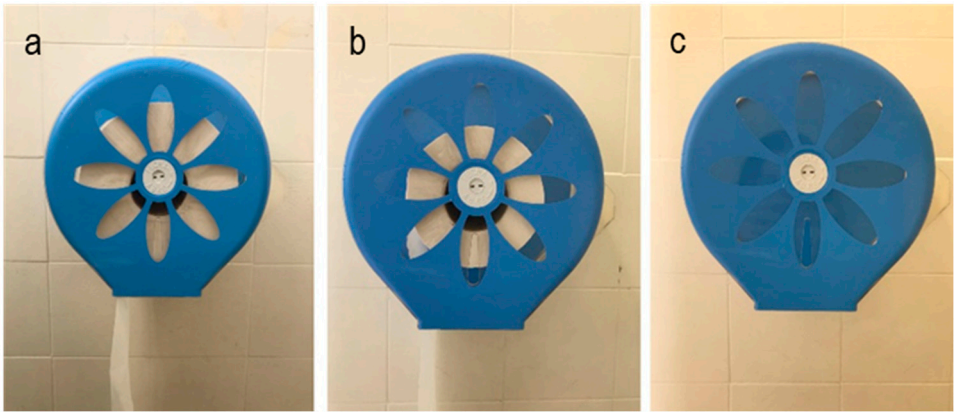

Figure 8. Toilet paper sticker when the dispenser is full (**a**) half-full (**b**) and empty (**c**).

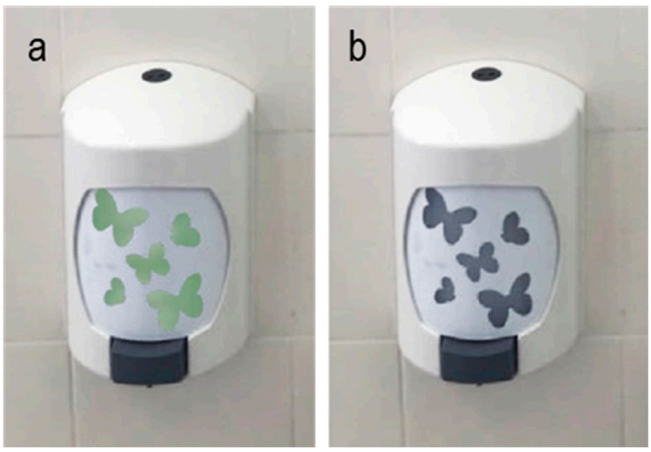

Figure 9. Soap dispenser sticker when the dispenser is full (**a**) and empty (**b**).

3.2. DfSB Strategies and the Proposed Toolkit

3.2.1. Product–User Distribution of Control

As for strategies organized in terms of product–user distribution of control (Figure 10), the toolkit can be classified as "persuading", more specifically as "encouraging" according to Zachrisson and Boks [20]. This is because it involves a voluntary behavior change by making the desired behavior more intuitive. For example, the light switch sticker prompts users to turn the light off in order to keep the animal motif complete.

	USER			CONTROL								PRODUCT	
Jelsma and Knot (2002)				Scripts									
Verbeek (2006)	Persuade			Seduce								Force	
Wever et al. (2008)	Eco-feedback			Scripting								Forced Functionality	
Lilley et al. (2009)	Eco-feedback			Behaviour Steering								Persuasive Technology	
Steg and Vlek (2009)	Informational Strategies			Structural Strategies									
Lidman and Renström (2011)	Enlighten			Spur				Steer				Force	Match
Selvefors et al. (2011)	Increase Knowledge	Create attention		Engage	Steer and Spur								
Tang and Bhamra (2012)	Eco-information	Eco-choice	Eco-feedback	Eco-spur				Eco-steer				Eco-technology	Clever-design
Zachrisson and Boks (2012)	Informing			Persuading								Forcing	
	Information		Feedback	Enabling	Encouraging			Guiding		Steering		Forcing	Automatic
Daae (2014)	Information		Feedback	Enable	Remind	Motivate	Threaten	Create goals	Reward	Persuade	Make it easy	Guide	Punish	Make it difficult	Disable	Force	Automatic
Coskun (2015)	Inform			Enable/ Disable							Support				Automate		

Figure 10. Product–user distribution of control model [8,11,15,16,19–24,44] with the classification of the toolkit highlighted in red.

3.2.2. Product–User Control and More Dimensions

As for strategies organized in terms of user–product control and user awareness (high or low), the proposed toolkit can be classified, respectively, as "persuasive influence" and "make aware persuasion" as shown in Figure 11a [45] and Figure 11b [46]. This is because the toolkit calls user's attention to resources consumption while keeping them in control of usage. As for strategies organized in terms of user–product control and attitude [20], the toolkit can be classified mainly as "positive behavior" but also as "neutral behavior" depending on user attitude (Figure 11c). This is because the control is shared between the user and the product, as the users decide the behavior, while the product persuades them to realize the desired behavior. If the user has a negative attitude toward the desired behavior, the behavior change might be neutral.

As for strategies organized in terms of the three-dimensional model of DfSB proposed by Shin and Bull [9], the toolkit can be classified as user 'autonomous' control (user–product control dimension), since the user can choose how to behave, feedforward approach (information dimension), as it provides an individual's selection of action that is based on future scenarios (e.g., the trees disappearing on the paper towel dispenser), and extrinsic motivation because it shows implication in external factors (e.g., paper towel consumption).

As for strategies organized in terms of the model proposed by Daae [44], the toolkit can be classified as "shared control" (user–product control dimension) (Figure 11e). It provides "medium obstructiveness" since it can be ignored. It is classified as "promote" (encouragement dimension) as it motivates users to perform the desired behavior (by keeping the motif complete). It is defined as "emotional" (meaning dimension) since it relies on plants (trees and flowers) and animals' motives to alter the user's behavior. The behavior change is "in line" with the user's beliefs and values (direction dimension) as users learn about sustainability in school and probably want to reduce resource consumption. The toolkit is in the middle spectrum for the empathy dimension since users do not rely just on concerns about themselves or others—it is a mixture of both. Finally, the toolkit is "unimportant" (importance dimension) since users might not care about it. The user is also targeted "during the behavior" (timing dimension) and is "frequently" exposed to it (exposure dimension).

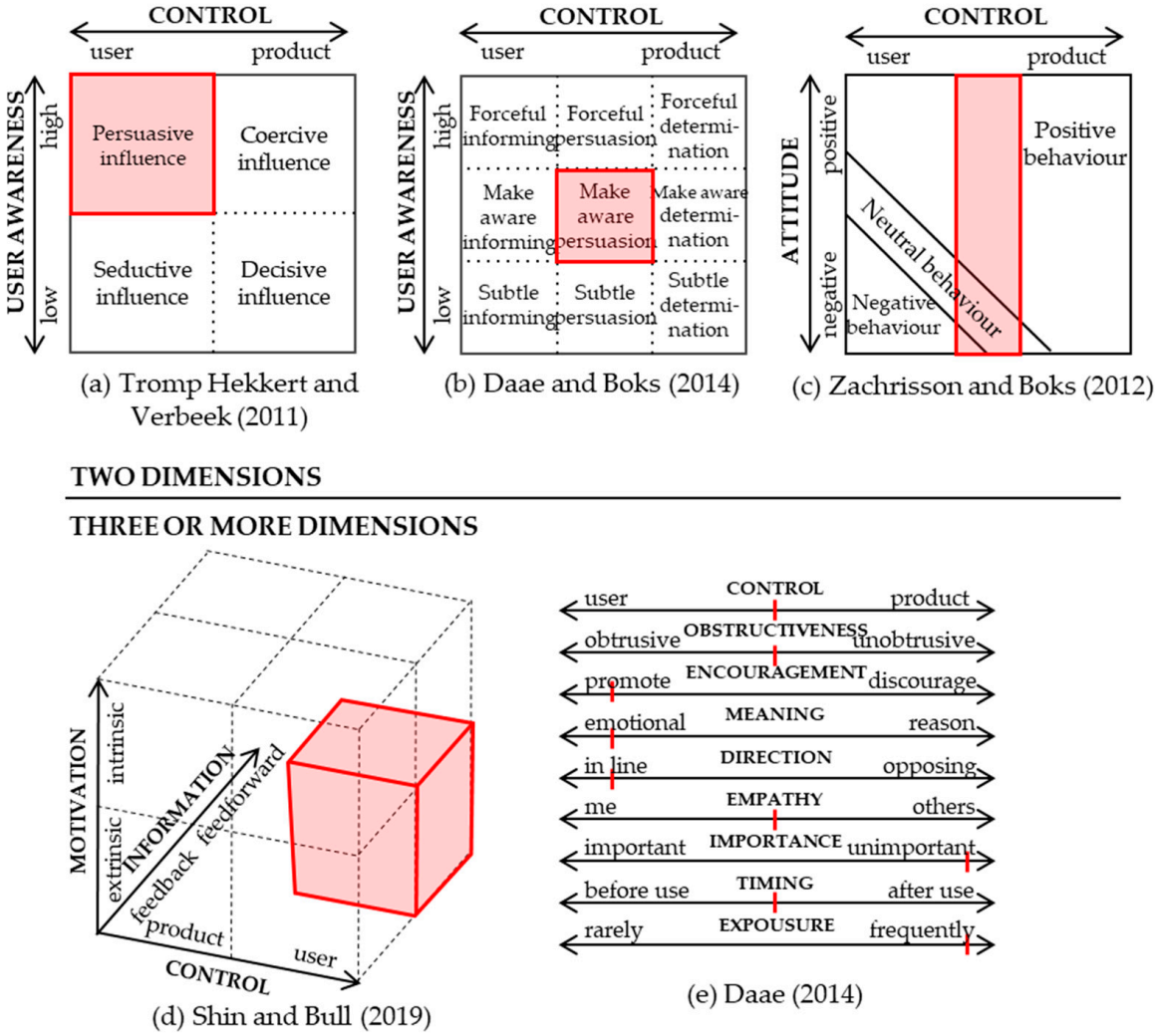

Figure 11. Product user control and user awareness models [9,20,44–46] with the classification of the toolkit highlighted in red.

3.2.3. Behavioural Dimension

As for strategies organized in terms of behavior type (old and new) and behavior duration (one-time, during a specific period, or from now on) [47], the toolkit aims to "do/increase or stop/decrease an old behavior from now on" (Figure 12a). For example, to turn off the light (an old behavior) when leaving the washroom (from now on) or to use just the necessary amount of paper or soap (decrease an old behavior from now on).

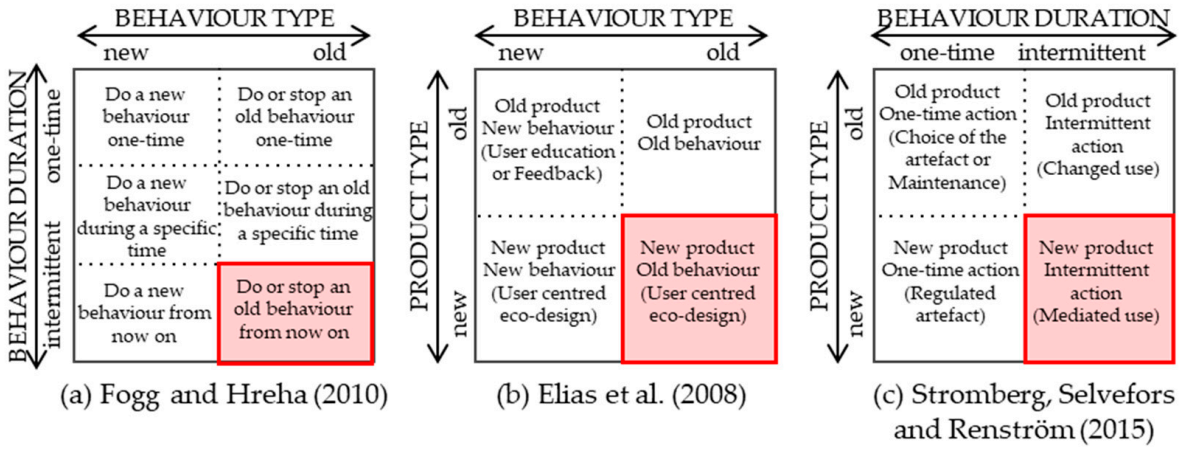

Figure 12. Behavior models [17,47,48] with the classification of the toolkit highlighted in red.

As for strategies organized in terms of behavior type (old and new) and product type (old and new), the toolkit follows a "user-centered eco-design" (Figure 12b) [17]. This is because it involves a new product (a set of stickers) to improve old/existing behaviors. In terms of product type (old and new) and behavior duration (one-time and intermittent), the toolkit can be classified as "Mediated use" (Figure 12c) [48]. This is because a new product (the toolkit) is obtained in order to guide more resource-efficient use of old products (devices).

4. Intervention Evaluation

4.1. Interviews

Most users (29 of 36) answered that they noticed changes in the school washroom ("yes" to the first question in Figure 13). In School A, only students from the 1st year answered "no" (13%) probably because they might use another washroom that is closer to their classroom. In School B five students (25%) answered that they did not perceive any change. All staff (from both schools) observed the changes and three teachers also commented that their students talked about the changes in the first week of the intervention. All users who answered "yes" to the first question listed the light switch sticker as a change in the washroom (Question 2 in Figure 13). The soap, the paper towel, and the toilet paper stickers received less attention: only 50% perceived the soap sticker (School A), 71% spotted the paper towel sticker (School A) and 78% and 40% noticed the toilet paper sticker (Schools A and B, respectively). In School B, 27% of the students listed other changes such as using less toilet paper to play and keeping the washroom clean. This indicates that while some interventions were effective in catching users' attention, others were less impactful or not as easily noticed.

In School A, 85% of users remembered the light switch sticker had an animal motif compared to 47% in School B (Question 3 in Figure 13). However, just 28% of the users in School A and 47% in School B presented a concept for the sticker such as "to draw attention to turn the light off" (two users in School A and three in School B) and "to decorate" (three users in School B). Only one teacher (School B) stated that the animal (light switch) is slashed by a red band when the light is on and thus accurately grasped the intended concept (Table 5). As for the toilet paper sticker, 43% and 7% of users (Schools A and B, respectively) remembered the flower motif. 21% of the users in School A associated it with nature, whereas 7% in School B considered it to be only an embellishment. In School A, 43% of the users remembered the tree motif for the paper towel sticker, and 28% related it to nature as "the paper comes from the tree". However, no users elicited the intended concept for paper towels and toilet paper (Table 5). Finally, in School A, 36% of the users

remembered animals (butterflies or geckos) were the motif for the soap sticker and 7% related it to soap bubbles. The small percentage of users in both schools that understood the intended purpose behind the motifs, highlights a gap between design intent and user understanding, suggesting that the visual cues were not fully effective in communicating the desired behavior change.

Figure 13. Interview answers.

Only 7% and 27% of users (Schools A and B, respectively) answered that they changed their behavior in the washroom (Question 4 in Figure 13). On the other hand, more than 40% of users from both schools believed that other users had changed their behavior (Question 5 in Figure 13) by using less paper and soap and turning the lights off. All users who answered "yes" to Question 5 also associated the changes to the toolkit implementation (Question 6 in Figure 13). Some noticed the stickers create a pleasant environment, making students more respectful of such spaces and also playing less with resources, particularly toilet paper. This could indicate that the interventions had a social or observational influence, even if they did not directly prompt individual behavior change.

4.2. Workshop

The "storyboard" activities were organized into two groups (Table 6): (i) energy consumption (turn on and turn off the light) and (ii) toilet paper, soap, and paper towel consumption (use the toilet, wash hands, and dry hands). As for energy consumption, almost half of users (48%) neither turn the light on or off in School A. 24% only turn the light on and 4% only turn the light off when leaving, whereas 24% perform both activities. In School B, more than half of users (63%) turn the light on and off. 21% only turn the light on and 11% only turn the light off, whereas 11% do not perform any of these activities. All users from School A included the three activities related to toilet paper, soap, and paper towel consumption in their journey (namely, use the toilet, wash hands, and dry hands). In School B, 85% mentioned all these activities, 5% included only washing hands, 5% did not include drying hands and 5% did not include using the toilet.

Table 6. User's journey.

Resources	Activities	School A (21 Users)	School B (19 Users)
Energy	Only turn on the light	24%	21%
	Only turn off the light	4%	11%
	Turn on the light + Turn off the light	24%	63%
	Neither turn on or turn off the light	48%	11%
Toilet paper, soap and paper towel	Only use the toilet	0%	0%
	Only wash hands	0%	5%
	Use the toilet + Wash hands (without dry hands)	0%	5%
	Wash hands + Dry hands (without use the toilet)	0%	5%
	Use the toilet + Wash hands + Dry hands	100%	85%

As for the "scale model" activity, all expected relationships between resources and devices (dark grey cells in Figure 14) were identified by most participants in Schools A and B (66% to 100%). Some participants connected (i) "soap dispenser" with "water" and (ii) "tap" with "soap" (light grey cells in Figure 14), suggesting that water and soap are often jointly used. Some participants also connected toilet paper to the toilet device.

Resources / Devices	*Water*		*Energy*		*Paper towel*		*Toilet paper*		*Soap*	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Toilet	100%	66%					33%			
Light switch			100%	66%						
Tap	100%	66%							33%	66%
Paper towel dispenser					100%	66%				
Toilet paper dispenser							66%	100%		
Soap dispenser	33%	33%							100%	66%

Figure 14. Devices and resources relationship.

In the drawing activity, some students (57%) proposed concepts similar to the toolkit such as a butterfly with the body being the switch button, which would indicate whether the light was turned on or off. Other students (36%) proposed stickers with textual recommendations such as "do not think only about yourself", "the planet belongs to everyone", "please do not use much paper at once" and "you are killing many of us" with an image of a tree (Figure 15b). One group of students (7%) proposed a sticker (Figure 15a) showing the life cycle of paper (from production to usage). Lastly, stickers with sad and happy faces (relating to bad or good consumption) (13%) were also presented.

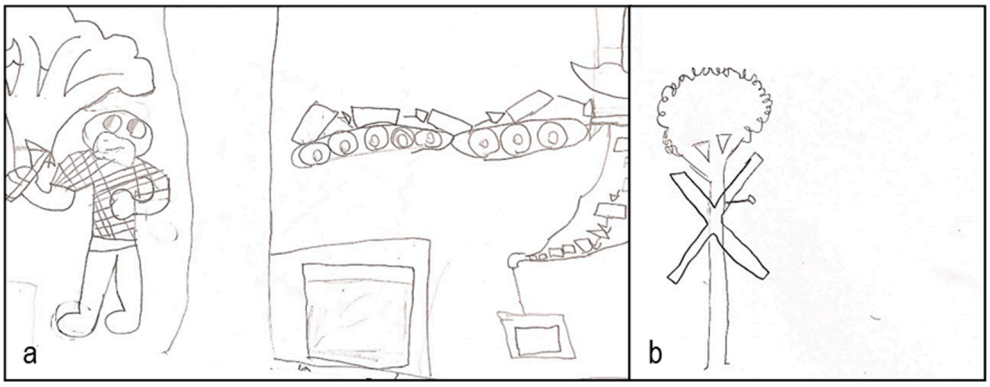

Figure 15. Examples of drawings of Schools A (**a**) and B (**b**).

4.3. Consumption Before and After the Toolkit Implementation

The resource consumption (except for energy) was registered weekly by the cleaning staff and was divided by school days (excluding holidays) to produce daily averages (Figures 16–18). The energy had a major reduction particularly in School A, as the daily average dropped from a minimum of 1.03 kWh before the toolkit to a maximum of 0.82 kWh after it (Figure 16). This reduction was consistent over time, highlighting the robustness of the findings despite potential external influences. While the decrease in energy consumption at School B was more subtle, it was still evident, further supporting the effectiveness of the toolkit. The consumption of toilet paper showed little change in both schools (Figure 17). Yet, it did not reach the peak registered before the toolkit implementation (two rolls/day).

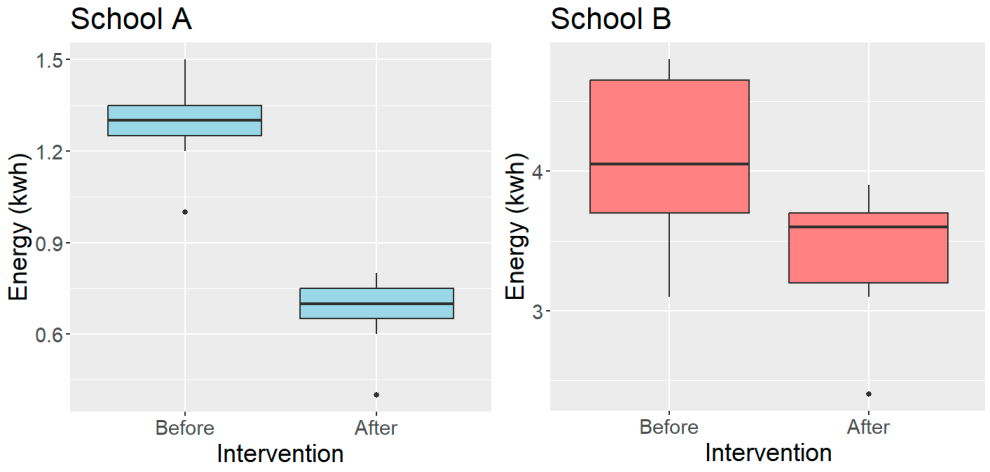

Figure 16. Energy consumption before and after intervention (daily average).

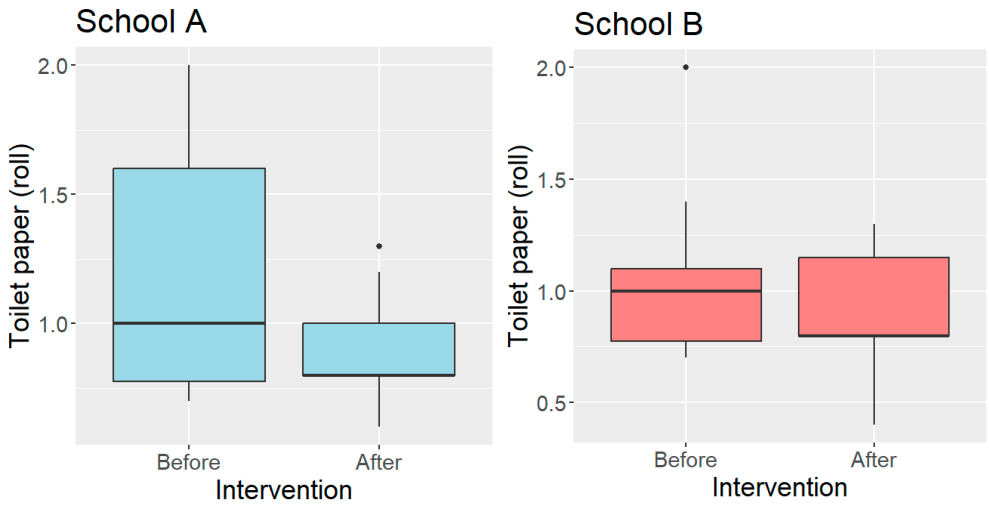

Figure 17. Toilet paper consumption before and after intervention (daily average).

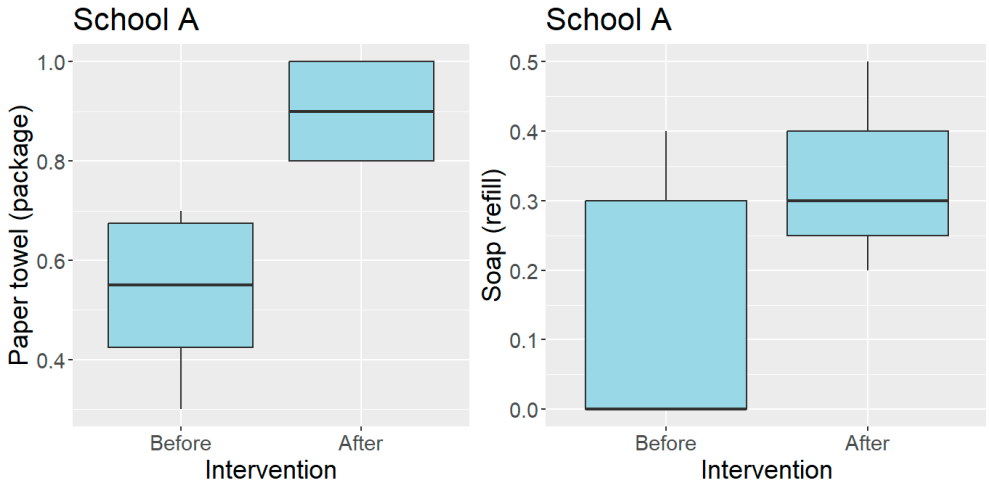

Figure 18. Paper towel and soap consumption before and after intervention (daily average).

In School A, the consumptions of paper towel and soap were also registered. The paper towel consumption increased after the toolkit implementation (Figure 18): it raised from daily averages of 0.33 to 0.67 package to 0.80 to 1 package per day. The soap consumption also increased from a daily average of 0 to 0.4 and 0.2 to 0.5 (Figure 18). While these changes were observed, further exploration of external factors, such as seasonal influences or variations in school activities, could provide additional context to the results.

5. Discussion

5.1. Light Switch Sticker

In School A, the washrooms are used during the daytime as the classes occur only in the morning and afternoon. This is confirmed by the results of the users' journey: 48% of users did not include "to turn on" or "to turn off the light" (Table 6). The reduction in energy consumption can be associated with the toolkit implementation (Figure 16) since all users perceived the sticker. Yet, just 28% mentioned the intended concept (Table 5) and most mainly stated that the sticker reminded them to turn the light off (Questions 2 and 3 in Figure 13). Also, users' awareness of energy usage (based on the scale model results shown in Figure 14) may have contributed to the reduction in consumption. However, external factors, such as daylight variation throughout the day, could also have influenced energy consumption patterns, as washrooms used primarily during daylight hours may not require

as much artificial lighting. Future studies could further investigate how environmental variables, like sunlight availability, may interact with the toolkit's design to affect overall energy consumption.

In School B, the washrooms are used especially during the morning and the evening, requiring artificial lighting (energy) most of the time. This is shown in the user's journey results, where 63% of participants included the activities "turn the light on" and "turn the light off" 21% included just "to turn on the light" and 11% just "to turn off the light" (Table 6). Energy consumption showed little change in this school (Figure 16) but all users perceived the light switch sticker (Question 2 in Figure 13). Differently from School A, only 13% of the users perceived the sticker as a reminder to turn off the light: 20% considered it only a decoration (Question 3 in Figure 13). Such difference in addition to the fact that 1/3 of users did not associate the switch with energy (scale model activity as shown in Figure 14) may be why energy consumption reduction was more subtle in School B. The design of the toolkit, specifically the use of subtle concepts, may not have resonated strongly with the users, suggesting that a more direct and engaging approach could enhance its effectiveness in this context.

5.2. Toilet Paper Sticker

Little changes in toilet paper consumption were registered in School A (Figure 17). Yet, 78% of users perceived the toilet paper sticker (Question 2 in Figure 13) and 21% associated it with nature (Question 3 in Figure 13). Since toilet paper is required for personal hygiene, it is difficult to identify the actual opportunity to reduce its consumption—for example, if there is unnecessary consumption. All users included the activity "to use the toilet" in their journey (Table 6), indicating that all use toilet paper at some point.

Only 40% of users perceived the sticker in School B (Question 2 in Figure 13), and 7% associated it with decoration (Question 3 in Figure 13). 13% pointed out that colleagues were being more respectful in the washroom and not wasting resources (e.g., playing with toilet paper). This shows the indirect role of stickers towards resource consumption: by creating a pleasing environment and thus prompting children to behave sustainably. Paper towels are not available in School B. Thus, the "dry hands" activity, which was included by 84% of the users in their journeys, is also associated with toilet paper consumption.

5.3. Paper Towel Sticker

In School A, 71% of the users perceived the paper towel sticker and 28% associated it with nature (Questions 2 and 3 in Figure 13). Some answered that "the paper comes from the tree" (Question 3 in Figure 13) which shows that the tree motif is directly associated with paper production. In the workshop, students suggested sad and happy faces as motifs for the stickers and also the paper lifecycle/production (Figure 15a). Yet, the paper towel consumption increased after the toolkit implementation (Figure 18). This suggests that the sticker might need to be more ludic and literal, differently from the subtle concept explored (Table 5) which was understood only by a few users. Also, the sticker may have attracted users' attention to the paper towel dispenser, leading them to use more paper towels than before and potentially causing a rebound effect. To avoid such unintended consequences, the sticker's design could be revised to provide clearer, more engaging prompts to reduce consumption. For example, incorporating more literal representations or explicit messages about resource conservation could make the intended behavioral change more apparent and effective.

5.4. Soap Sticker

All users included "to wash hands" in the user journey (Table 6), which is related to soap consumption. In addition, five of six groups (both schools) made the association

between the soap and the respective dispenser and three groups associated it with the tap (Figure 14). This indicates that users are aware of the soap usage while washing their hands. However, soap consumption increased in School A (Figure 18). Half of the interview participants perceived the sticker in the soap dispenser and 36% remembered the sticker motif (Table 5) but no one associated it with nature (Questions 2 and 3 in Figure 13). Similar to the paper towel sticker, the increase in soap consumption suggests a possible rebound effect. To mitigate this, the design of the sticker could be made more direct and explicitly focused on encouraging users to use less soap without compromising hygiene.

5.5. Limitations

This study has some limitations, primarily related to the data collection process, which may affect the generalizability and interpretation of the findings. First, the relatively small number of participants in the interviews limits the diversity of perspectives, which may reduce the robustness of the conclusions drawn. Second, the absence of historical data on resource consumption from both schools prevents a clear comparison to assess the impact of the interventions or behaviors under investigation. Third, the reduced monitoring period for resource consumption may not provide a comprehensive picture of the long-term effects of the interventions. Finally, the study does not account for other potential influences on resource consumption, such as environmental factors like sunlight, which could affect the use of artificial lighting. Given the defined scope of this study, additional analysis addressing other potential factors was not possible within the parameters of this research. Despite these limitations, the study offers valuable insights and a foundation for future research in the field of design for behavior change and its impact on the built environment.

6. Conclusions

This study has explored the application of DfSB strategies in the built environment by proposing a kit of stickers to improve children's behavior in school washrooms. It was implemented in two school buildings located in the southern region of Brazil and the consumption of resources (energy, toilet paper, paper towels, and soap) was measured. To complement the quantitative data, interviews, and a workshop were also carried out to gather users' perceptions and understanding of the toolkit.

The results suggest that children can and should be involved in the design of the school environment according to the DfSB rationale, as indicated by the numerous ideas generated in the co-creation workshop. Also, the sticker design can be simple and straightforward serving mainly as a reminder to perform a particular behavior. It is also important to replicate the data collection of resources consumed before and after the implementation of products based on DfSB strategies.

While the interview responses suggested that the toolkit helped create a pleasant environment and could potentially encourage more sustainable behavior by prompting children to avoid wasting resources, the resource consumption data, especially related to paper towels and soap consumption, indicate that its overall effectiveness may not align with the initial expectations. Although reductions in energy consumption were observed in both schools, the increase in paper towel and soap consumption in School A suggests the potential for unintended consequences, such as a rebound effect. This phenomenon, where savings in one area (e.g., energy) might be offset by increased use in another (e.g., paper towels), highlights the complexity of behavior change and the need for more nuanced interventions. The toolkit's design may need refinement, such as using more explicit or engaging motifs, to better target reductions in all resource categories. Moreover, while the numbers presented here suggest some trends, further research, and continued monitoring are necessary to confirm the long-term impact of DfSB-based interventions. Monitoring

over a longer period and expanding the study to include a more diverse sample would provide a deeper understanding of the toolkit's sustainability impact.

This study also reviewed and classified DfSB strategies/models proposed in the literature in three groups. The first group (Figure 10) contains strategies organized only in terms of product–user distribution of control. On one end, the user has control over the behavior whereas on the other end, the product determines the user's behavior. These strategies help designers define how the product will support a more sustainable behavior—by informing, encouraging, forcing, etc. The second group (Figure 11) organizes strategies in terms of product–user distribution of control and one or more dimensions, such as user awareness or user attitude. Adding another dimension helps designers to further explore how the product will work (for example, depending on the user's attitude towards the desired behavior). The third group (Figure 12) examines the targeted behavior (for example, to stop an old behavior permanently or to perform a new behavior) and thus can be used prior to the product design. By classifying DfSB strategies into these three groups, this study offers valuable insights for designers, enabling them to develop solutions tailored to specific user behaviors, attitudes, and goals.

Ultimately, this study highlights the potential of DfSB principles to foster sustainability and behavioral change. The findings offer a promising direction for future design practices, particularly in educational settings. However, they also highlight the complexity of promoting sustainable behavior, which could be influenced by factors such as the intervention's duration, contextual variables, and how the toolkit was received by participants. To gain a deeper understanding of these dynamics, future research could explore the impact of longer interventions, a more diverse sample, and refined toolkit designs. Additionally, investigating external factors, such as environmental conditions and seasonal variations, could further inform the design of behavior change interventions to ensure their long-term success.

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