An exploration of nudging towards transformative environmental behaviour changes prior to a values-crystallization event

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ABSTRACT

Reduction of environmental problems needs durable transformative changes in behaviour, and developments in Transformative Learning are increasingly called for, to achieve them. Only recently has a method been demonstrated to routinely produce transformations in behaviour - a significant step forward - but they are not focused in specific thematic directions, and rarely environmental, which leaves the research need still unanswered. Here, we present an exploration of the use of that method (which involved values-crystallization of groups) with prior Nudging, with the aim of increasing the environmentally-themed transformed behaviours. The Nudging used was one open question about the environment in participants' current roles, plus a short questionnaire about current environmental behaviours, which also provided baseline data. Comparison with 3–4-days post-event interviews revealed most of the reported transformative behaviours *were indeed environmental*, such as waste sorting, water and electricity conservation, found retained via further 14-56-days post-event interviews. These results, from two separate groups of participants, suggest that the Nudging_Plus_Values-crystallization approach may be useful for pro-environmental practitioners in sustainability. Furthermore, the process involved of influencing choice spaces via Nudging, in values-crystallization events, deserves further studies to confirm causation and understand linkages between Nudging, reflection, values-crystallization, and Transformative Learning because it is likely that the process can be easily transferred to many different types of behaviour change programs, which will be of interest to a wide range of researchers and practitioners.

1. Introduction

1.1. Overview

The existential crisis level of human-created environmental issues has now widely been accepted [1,2]. These include major environmental issues such as climate change, widespread pollution, harmful waste management practices, and water shortages [3,4] which pose severe challenges to the world [5]. The need for behavioral modifications has been robustly evidenced and reported [1,6] and this requires a type of learning which has the capacity to lead to transformations in perspectives and then behaviours. The concept of Transformative learning (TL) has now been established as a critical element to solving these environmental sustainability problems

[7], to the extent of it being sought for in most studies which advance social and behavioral solutions to achieve sustainable transformations [8]. Transformative Learning focuses on changing mindsets and behavioral practices by first changing deep perspectives, which can lead to durable behaviour changes e.g., towards more-sustainable life styles [9], which makes if of great interest to sustainability studies. However, approaches using Transformative Learning which can routinely produce behaviour changes are still rare, and they only include few, if any, which are environmental in nature.

Pro-environmental behaviours in specific practices like recycling, upgrading to energy-efficient domestic appliances, conserving water, using public transport, and turning off lights [10,11] have been given much attention by both educators and governments. While seemingly small in effect, if persistently practiced by many people over time, they will aggregate to larger effect [12,13] and educational institutions can have a general impact by training individuals to think critically about such specific behaviours, and thus understand their impacts on the planet [14,15]. Although direct education about specific environmental behaviour can sometimes influence students to change, a different approach highly sought by researchers in sustainability is the concept of Transformative Learning (TL) to instead challenge and change underlying frames of references and worldviews of individuals, because this approach has the potential for deep impact on multiple sustained behaviour changes - transformative behaviour changes [16,17].

A vital component for learning towards transformational behaviour change, is critical reflection. This is needed for grounding the learning with real-life experiences [18]; processing of information to assist embedding it [19,20]; and to help participants make connections between their personal life and their environmental consequences [21,22]. Recent approaches have explored ways to increase this personal processing of information, such as through the visualization of futures [17], or intersubjective dialogue.

Another prerequisite which has been identified is values clarification, because by its nature it incorporates disruptive learning comprising disruption, deep learning and change agency [23,24], which allow access to deeper learning and reflection processes while the individual simultaneously assesses the need for changing their perspectives and behaviours.

In this work, we bring in an approach used in another field of study which incidentally produces Transformative Learning and involves the above elements of values clarification and critical reflection, and thus has potential for making significant contributions to the research gap -approaches for effective Transformative Learning. Research studies on a values-crystallization approach in the form of a 2-4-h workshop named WeValue InSitu (WVIS) has demonstrated the possibility to trigger groups to have a heightened clarity and awareness of their shared values, and to review the priorities of a wide range of their current actions [24–26]. The WVIS approach has recently been shown to routinely lead to Transformational Learning Outcomes (TLOs), including transformative changes, as formally defined by Ref. [27], in both thinking and behaviours [25,28]. This is a significant contribution to the call for approaches for TL, but not for pro-environmental targets because very few of the changed behaviours are environmentally relevant. It is not yet understood what determines which types of behaviours are changed, but they seem to be related to the topics which the participants dwell on during their explorations of their aspirations and shared values. It is also not yet clear which of the several stages of the WVIS (discussed in more detail in 1.2), or their contexts, influences those themes, as the underpinning theory is still in development. But empirical results from tens of previous events show that themes have been typically found to concern social equality, personal development, children's futures, career progression – and only rarely, the environment.

Therefore, in this work we bring in yet another approach from another field to help target *environmentally themed* behaviour changes. In the field of behavioral economics there are research studies on modifications in the choice-environment of people which can significantly influence their choices made, e.g. to act more environmentally friendly [20,29]. These can include placing target goods near the cash register in shops, or providing cues through visuals, words, or sensations [30] which can unconsciously drive decisions [31]. This approach is called Nudging. The choice-environment changes are ambient and thus not considered direct or restrictive manipulation of the individuals. Nudging is known to be more effective if it targets a very specific behaviour and if the ambient environmental influences are made very near the point of choice or decision-making [32].

In this study, we explore a novel approach to produce transformative pro-environmental behaviours, in response to the calls for new approaches. Our innovation is bringing together the two concepts mentioned above from different fields: to use *Nudging* to try to influence the nature of the *values-crystallization* which takes place, and thus the thematic nature of the TLOs produced in WVIS, for environmental themes. We will check for indications that the TLOs have any environmental themes through follow-up interviews documenting reported behaviour changes with respect to baseline reports, transcripts of those as well as critical reflections of the WVIS facilitator for any indications of where, within the WVIS stages, the Nudging may have had an influence. The findings will be used to inform future designs of more-specific studies.

1.2. Theoretical background

1.2.1. Theory of Transformative Learning

Mezirow's Theory of Transformative Learning (TL) specifies TL as, "*the process by which we transform our taken-for-*granted *frames of reference … to make them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action. Transformative learning involves participation in constructive discourse to use the experience of others to assess reasons justifying these assumptions, and making an action decision based on the resulting insight.*" [27].

Mezirow's Theory of TL defines two major types of TL outcomes (which we term TLOs): Transformation in Meaning Schemes (a.k.a. Points of View), pertaining to more narrow and specific aspects of life [33], and Transformation of Perspective (a.k.a. Habit of Mind), entailing a shift in wider beliefs and assumptions after becoming critically reflective of the source, nature, context and consequences of taken-for-granted beliefs [27]. The indication of strong TL is when it leads to a TLO involves a resulting change in behaviour – termed transformative behaviour change - and much research in TL focuses on learning configurations which might produce that. TL is thus frequently proposed as a crucial route out of the socio-ecological system challenges caused by human actions [7], and is now a

mainstream approach in environmental sustainability and environmental education, where transformative changes at both the individual and societal levels are considered acutely necessary [1,34].

Learning configurations which can produce desirable TL outcomes in applied sustainability settings are thus increasingly called for [9,20]. Some examples are [35]: highlighted that dealing with the issues of climate change and its attributed consequences, required TL to transform routines and behaviour, and [36] identified TL as best practice for sustainable management of natural resources for Cambodian farmers and called for more reliable approaches to foster it. A study of local farmers' sustainable behaviour compliance [34] discovered major positive environmental impacts occurred because of the nature of TL taking place, and called for more robust approaches that could predictably foster these. A recent review of TL [9] concluded that "there is a need for better methods and tools that can provide insights into the processes and outcomes of transformative sustainability learning".

1.2.2. Values crystallization (WeValue InSitu)

To address the above-mentioned research need in TL, a series of investigations using a values-crystallization approach known as WeValue InSitu (WVIS) was extended to include a strand focused on TL. WeValue was originally co-designed using research-through-
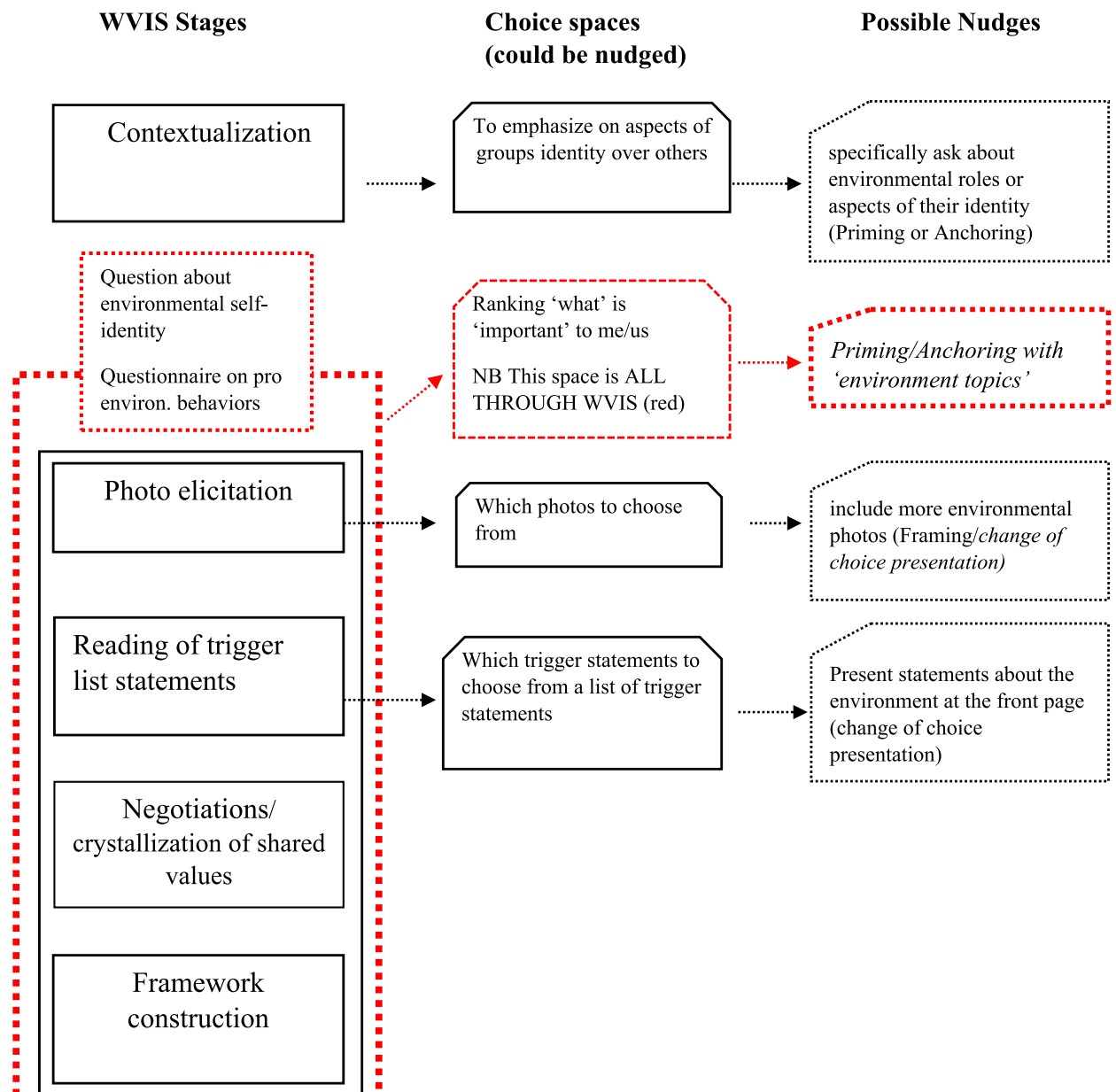

Fig. 1. Choice spaces and nudge opportunities occurring at specific WVIS stages as well as one which runs through all of them.

design methods [37,38] with civil society groups to crystallize their tacit shared values (for example to provide performance indicators which held high face-validity [39]. It was then found to incidentally produce some types of Transformative Learning [40] especially when used with participants who had a background with common in-situ experiences [41] in which case it was named WeValue InSitu (WVIS) to indicate the boundary within which the process proceeded. One strand of later studies [25,28], focused on detailed examinations of the TL outcomes of the standard WVIS approach, and confirmed that it routinely led to durable transformations of behaviours with respect to formal definitions of [27,42]. WVIS has thus been proposed as an important useful tool that for systematic studies on the links between TL outcomes (changes of behaviour and also of mind) and the TL subprocesses which create them (within WVIS) [43].

Because of the importance to so many sustainability studies of an approach which is capable of routinely producing TL, there have been several studies to understand the WVIS mechanisms in action, and to develop a theory for them. A series of studies have shown they can be related, plurally, to several theories including: critical reflection [44], meaning-making [45], Polanyi's Personal Knowledge Theory ([45] and further papers in preparation). In this investigation we only wish to explore broad indications of potential Nudging influences on the WVIS process: we thus focus here on describing WVIS and its stages in terms of its choice spaces: how Nudges might conceivably influence them, and what data would be useful to explore potential influences. These ideas are summarized in Fig. 1 and presented in more detail below after some background information on Nudging.

1.2.3. Nudging

The concept of Nudging comes from behavioral economics literature, where the objective is to lead individuals to act in a certain direction without intentionally limiting their freedom of choice [46], and it includes different types of techniques such as providing tangential cues through visuals, words, or sensations [30]. It relies on the premise that people's judgments are generally pre-constrained, limited, and biased, which can cause individuals to regularly make choices that counteracts their interest, values, or decisions [29,47].

Because individual human behaviours are at the heart of many complex environmental issues [48], Nudging has increasingly been used by policy makers to impact on many pressing environmental challenges such as lowering electricity cost and usage [20,49,50]. Nudges may be applied in different forms such as cues, reminders, ambient displays, and easy-to-access information [20,51,52] and usually very specific behaviours and very close to the point of decision: Nudge interventions do not require critical reflection, and usually result only in small and short-term behaviour changes or choices [53]. Successes have been reported such as significant increases in environmental identity reported when individuals were charged for using single-use carrier bags [54], and pedagogical nudging has been used to transform student attitudes towards entrepreneurship education [55]. Initial nudges may potentially trigger individuals to start a longer process of changing their self-concepts [56], possibly leading to embedding related behaviour, but generally speaking, such changes towards sustainable behaviour does not involve the conscious consent of individuals. There have been calls for studies where reflection is used to purposely embed a Nudge, where individuals reflect and thus learn from such experiences [57].

In applying Nudging to WVIS, we need to consider WVIS in terms of its 'choice spaces' (denoted in Fig. 1 which shows the various choice spaces with the WVIS and the various Nudge techniques that can be introduced). Using this lens, the most pervasive choice space concerns "what the participants think is valuable, meaningful and worthwhile (VMW) to them" about the experiences/activities they have in common. This is the central focus of WVIS: every one of the different WVIS stages centers on facilitating the participants to critically reflect on this question, through different techniques which are carefully designed and linked [45]. It can thus be seen as an overarching choice space, concerning the choice of ranking or prioritizing aspects as "the most VMW" (aka 'important') to participants.

Additionally, each individual WVIS stage has further choice spaces: in the photo-elicitation stage participants are asked to first consider, without discussions, what they think is VMW about what their common experiences, and to choose 2 photos from a choice of 30–40 photos provided, to use as props to explain their ideas to the others. There is thus a choice space regarding which type of photos are provided, and in principle that could be Nudged by including more environmentally themed ones. Participants must listen to each other present these individual ideas, and so it is possible that any Nudge influence manifesting here might have cascade effect on further stages e.g. on discussions.

The next WVIS stage involves participants choosing from 139 'trigger statements', individually and without discussion, and marking those which resonate with them in any way concerning what is VMW about their common experiences. There is thus a choice space here regarding the trigger statements: in principle they could have extra ones added which emphasize environmental themes. The facilitator then invites participants to nominate the strongest-resonating ones for in-depth reflections and discussions, and so it is possible that any Nudge influence manifesting here might have cascade influences on further stages e.g., decisions of final agreed statements of shared values, and the way they are articulated.

After the total WVIS process it is known that participants often continue to reflect on it, and one study has documented how those reflections can continue to influence changes in mind and behaviour over several weeks [25]. Therefore, there is a possible window for a choice space at the very end of the WVIS process where a focus group for participants to give feedback on their experience of WVIS could be Nudged to emphasize environmental themes to influence later reflection processes (Fig. 1).

1.3. Objective

In this study we will explore the possibility of creating a process which can routinely produce Transformative Learning Outcomes – but which are specifically environmentally-themed. We will do this by applying environmentally-themed Nudge interventions prior to a standard WVIS process, with the intention of enhancing the environmentally-themed nature of related transformative behaviours of

participants, by influencing the choice spaces. Possible pathways for the Nudge to potentially influence the outcomes will be explored through considerations of the nature of the outcomes, and post-event Reflection Notes of the facilitator on the WVIS event, and of data from separate WVIS stages as indicated in Fig. 1.

2. Methods

This study aims to develop a novel method which can routinely produce transformative learning and pro-environmental behaviour changes in participants. It is a preliminary qualitative exploration of the use of a Nudging technique intended to influence the environmental vs. non-environmental nature of the ultimate transformative learning and behaviour outcomes of an otherwise-standard values-crystallization (WVIS) process. Guidance on WVIS structure, sub-processes, materials and facilitation techniques of the WVIS process are available elsewhere [45,58].

This study's innovation was to apply Nudging to WVIS, with an expectation that there were relevant choice-spaces within the WVIS which could be influenced. The Nudge was deliberately chosen as one suitable to be placed as early on as possible (see Fig. 2) so that a) it had the potential for a cascade influence on any of the stages of WVIS; and b) so that any Nudge influences would be easier to explore in the context of previous, standard, WVIS events. If effective, further studies could be planned with Nudges placed between different WVIS stages to investigate more precisely any differing potential influences, and the interacting processes involved.
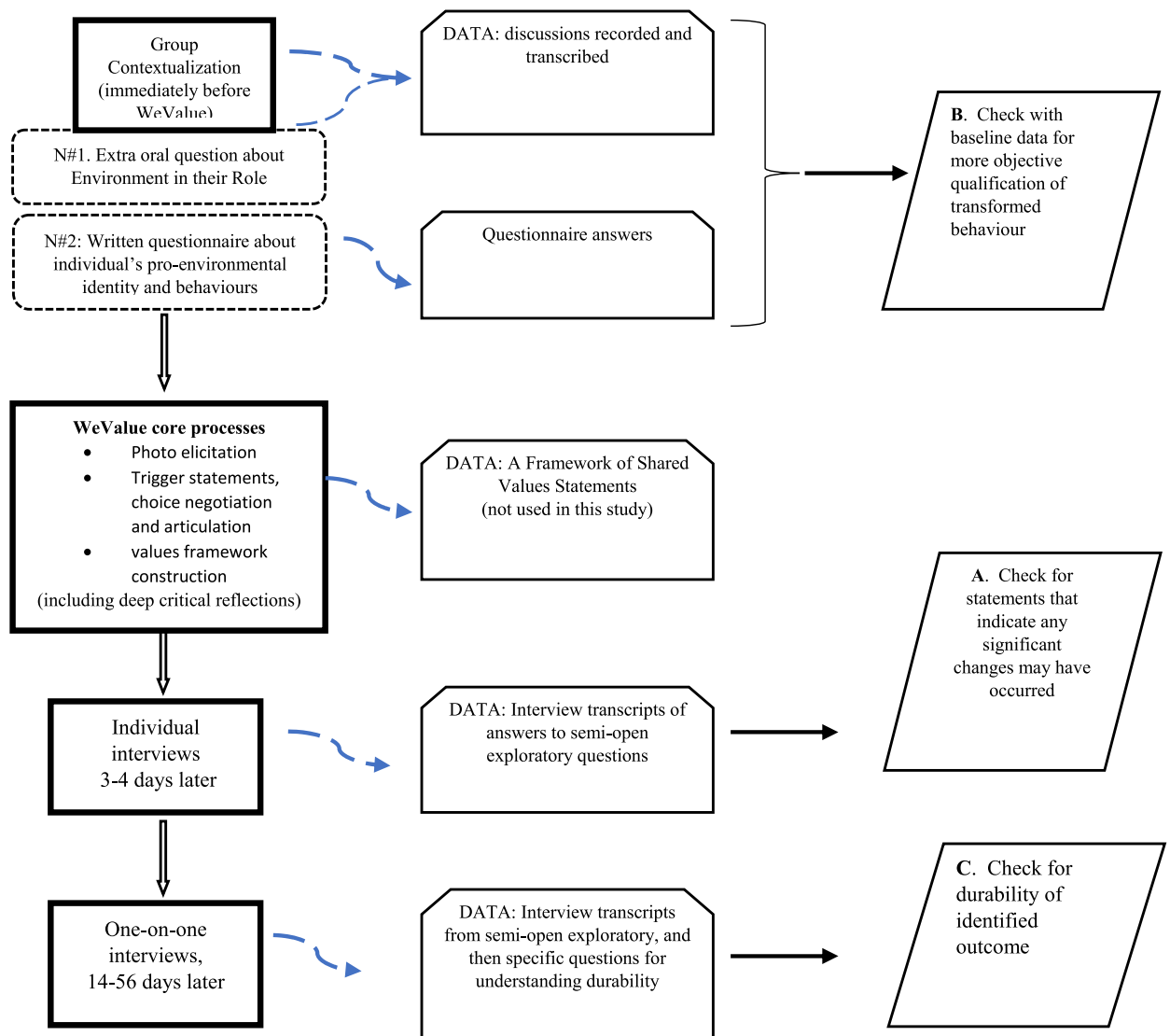

Fig. 2. The standard WVIS processes (bold boxes) and chosen Nudges (dashed); data collection design; and data analysis pathway, for considering the nature of transformative learning outcomes.

2.1. Nudge design

The chosen Nudge was applied immediately after the group self-contextualization activity, where participants introduce themselves (and confirm to themselves what work/activities/experiences they have in common), but before the start of the core WVIS subprocesses (Fig. 2). The Nudge was designed to have two elements, which occurred consecutively. The first Nudge element added a question to the very end of the group self-contextualization, which would be the first time the participants heard the mention of any environmental theme, and thus their answers here could be used as a baseline to identify changes mentioned in the post-event interviews:

Normal contextualization question: *"Please tell me who you are and what you are studying, as international students at this university."* (Each participant answered in turn.)

Extra contextualization question: *"Did you have any program related to the environment or any experience related to environmental sustainability?"* (Each participant answered in turn.)

The second Nudge element was to ask participants to complete a short-written questionnaire (individually, without sharing), which had four questions relating to behaviour and identity: three with ratings in a Likert scale, and one semi-open question about how they viewed themselves:

Please indicate to what extent you agree with the following sentences:

Strongly disagree (-3) -2 -1 0 1 2 (3) Strongly agree.

a) I act environmentally friendly e.g. saving water, waste sorting, turning off lights and air conditioners
b) Acting environmentally friendly is an important part of who I am
c) *I see myself as an environmentally friendly person*
1. How would you describe yourself with regards to being environmentally friendly and environmental sustainability practices: would you say you are environmentally friendly?

The intention of this Nudge design was to influence choices about topics chosen in the immediately subsequent WVIS reflection, discussion and negotiation activities, towards environmental topics, by first having participants here explicitly relate them to their own lives while answering. It was not understood in detail the manner in which this might happen, or how any such influences might ultimately lead to enhancement of the TL outcomes to make them more environmentally-related: the purpose of this study.

2.2. Participant selection

The participants selected for this study were international students who had studied in the same university in an international city in China for two years or more, had overlap interest and activities and knew each other in the dorms and at mealtimes. This study is exploratory in nature, with no intention to produce statistically representational results, but it was decided to run two groups to give a general, broad, indication of the variability of results, and to allow the exploratory findings to be formed across two groups. Both groups had age ranges 25-30 y: the first came from Nigeria, Congo and Cameroon; the second group from Tanzania and Congo. Both sets of participants were studying a variety subjects (electronics, software engineering, public relations, economics, political science) but none were environmental.

The WVIS approach works well with group sizes of 3–12 participants, requiring 2–5 h depending on the group size, to allow in-depth dialogue and reflection for all participants, which is a condition known to encourage transformative learning in WVIS [24], and also more generally [59]. In this case a group size of 4 participants was used to reduce the total time burden on participants to 2 h. WVIS is a complex process requiring a trained and experienced facilitator who is aware of how to guide the group to self-contextualize itself, to keep personal contributions out of the process as much as possible (i.e. no personal examples, insights, comments but to focus on reflecting back participant ideas): the facilitator in this case was both, and herself an international PhD student from Africa studying at a university in China and a co-author of this study.

2.3. Data collection and ethics

Fig. 2 shows the flows of data collection and analysis. All students participated voluntarily and gave their informed consent for the study after being given oral and written information. The ethical considerations for this work were pre-approved by the HSSE Research Ethics and Governance Committee of the University of Brighton, reference REGC-15-022.

Other than during the Nudge, the WVIS facilitator ensured minimal input of external content into the discussions and crystallizations of group values, but rather focused on orchestrations (detailed in Ref. [45]) such as reflecting back statements; challenging choices of words; and pointing out compound ideas that might need de-coupling. This is standard practice in WVIS to maximize the authenticity and face-validity of the outcomes. After each of the two WVIS events the facilitator wrote down Reflection Notes on her impressions of the sessions.

After the Nudging_Plus_Values-crystallization event, about 3–4 days later, the participants were contacted for post-event semi-structured interviews which were presented as space for general feedback on the event, using purposely broad and open questions about participants' feelings and thoughts about their experience with the WVIS process. This was to ensure that initial comments about

any changes in thinking or behaviour could be mentioned without participants being led by the interviewer to environmental or other topics. This approach allowed respondents to say what was important to them about the workshop event in their own words, which might include descriptions of any types of transformations they may have experienced and put into action. Only if they mentioned some impacts, were those probed further to try to understand whether they had changed their minds or ways of thinking about anything. If any of the topics mentioned were related to the environment, then they were specifically asked whether they experienced any kind of change in specifically pro-environmental behaviours as a result of taking part in the workshop.

All interviews were collected in person. The researcher first consulted with the participants for a convenient time and preferred location. The first interviews were collected between 3 and 4 days post-event: long enough for a potential effect to embed, but not so long as to reduce the possibility for external influences. Between 14 and 56 days later, the participants were contacted for a second post-event interview which could provide data on the durability of the identified changes, and possibly reveal new ones: long enough to count as 'durable' but extending over several weeks to accommodate the availability of the interviewee.

Our analysis of shifts in thinking or behaviour would include consideration of the comments in-situ in the interview text, and thus take note of any signs of desirability bias when drawing out insights.

2.4. Data analysis

All the post-event interviews were recorded and transcribed. These were then deeply read through separately by two researchers who used manifest content coding [60] to identify and then extract any candidate statements that indicated evidence of any specific changes in worldviews or ways of thinking or behaviours – in any theme. Those statements were then crosschecked against statements made earlier, in response to the pre-WVIS group contextualization question, which had been designed to provide baseline statements prior to the event which touched on environmental issues (the data analysis schematic is shown in Fig. 2). The two researchers compared analyses and findings and after rounds of checking, they came to an agreement, including the qualification of some TLOs as transformative behaviours.

3. Results and discussion

The WeValue InSitu (WVIS) approach has elsewhere been established as capable of routinely producing Transformative Learning Outcomes (TLO) [25], but not directed to any given theme - environment or other. The main desired result in this investigation is the production of environmentally-themed transformative learning outcomes and behavioral changes, supported with pre-post evidence. Such results would signal this area of research as a potential new contributor towards sustainability.

3.1. Themes of TLOs reported

For the two separate groups of participants taken through the WVIS process, 15 (13) TLOs of various types were identified in the first (second) group, of which 9 (7) respectively were identified as *behavioral* transformations and with an *environmental* theme. The full relevant quotes extracted from the post-interview data are given in the Supplementary Materials, and some examples are discussed in more detail below.

The headline result is that desired outcome - the *presence and dominance of environmentally-themed TLOs* - was seen in the results. This is a remarkable and significant result for both TL and sustainability studies which are calling for approaches that can deliver these outcomes and immediately suggests further investigation to understand how it occurred, because it is highly unusual with respect to all past WVIS studies (which did not involve Nudging). WVIS events each typically produce 5–12 TLOs, of which only 0–2 would have any environmental dimension, per group of 4 people. For example, a recent study [25] which followed the same data collection and analysis methods as this current study (but without any Nudges) reported 16 TLOs, but *none* of them were environmental.

On the basis of the results of this exploratory study, it is thus recommended to carry out an experimental design using comparable groups in the same wider cultural context: one with the Nudge and one without. (Although a third group would ideally be set up to test the Nudge without WVIS, i.e. a stand-alone questionnaire about current environmental behaviours, the resource requirements would have to be weighed up against the fact that there are already studies showing it does not generally cause behaviour change, much less durable behaviour change beyond several weeks [61,62].

3.2. The specific behavioral nature of the TLOs

In Section 3.1 we stated that the dominance of TLOs with an environmental dimension in the results was exceptional. Here we wish to highlight another unusual feature which is very relevant to their usefulness in sustainability: the fact that they were predominantly behavioral, and predominantly concerning specific behaviors.

As stated in the Introduction, the core purpose for Transformative Learning is to produce reassessment of prior beliefs and assumptions, and to make, *"… an action decision based on the resulting insight"*. However, TL researchers commonly only identify Transformative Learning which results in shifts *in thinking,* partly because it is so much more difficult and resource-intensive to identify and measure behaviours than perspectives. And partly because psychology-based models suggest that if attitudes have changed then behaviours will likely follow. The most prized outcome is durable behaviour changes, and they are the most challenging to identify and measure and even then, are very difficult to link to the TL event [8]. The WVIS values crystallization approach is unusual in routinely producing not only perspective changes, but also some behavioral changes, and durable results have been found in long-term studies.

However, the very narrowly specified behaviour changes reported in this study are unusual: they include waste sorting, electricity reduction, and water conservation. Examples are discussed below, and detailed extracts of paired statements made by participants pre- and then post-event are given in Table 1.

3.2.1. Waste sorting behaviour changes

Waste sorting practices are highly encouraged in Shanghai, with different bin colors allocated for food waste, recyclables, and hazardous waste, and each one having clear poster pictures indicating what waste is appropriate to deposit there. During our post-WVIS interviews, more than one participant attested previously not paying attention to this, but now meticulously paid attention to the labels and correct waste disposal. One mentioned that she had previously known about environmental issues, but they never meant anything important to her personally, and she never took any measures – until after the Nudging_Plus_Values-crystallization workshop.

Another participant mentioned that, while responding to the questionnaire question with Likert scales (which was a Nudge), she realized precisely how badly her environmental actions were rated. By checking her responses pre- and post-event, we can see clearly see evidence of the shift:

Pre-event question (in writing): *would you say you are environmentally friendly?*

Response (in writing): *I think I am somewhere in the middle. I care about the environment sometimes and act accordingly but I cannot really take a position (Ppt Da)*

3.2.2. Post-event interview comments

… before, I know that there is this problem you know the environment the ocean and all that the ecosystem everything is getting so bad, the ice is melting and all that but it was like yeah that's what's happening I never thought there was nothing I could do about it but it's not that I really didn't care but I was like whatever before we stated the workshop there was this questionnaire we had to respond to and my answers were really bad like there was nothing I could do to help, I just kept ticking like 0, 1 so that's how bad I was and I'll say I pay more attention to the environment now and I don't know maybe if I was careless before I'm not anymore and maybe if I talk to people every time we mention anything related to the environment I'll tell them you know … (talk about the environment) I think it's more in the way that I am thinking and acting now. It's kind of change …. I also put my trash in the right bin now. (Ppt Da)

These comments indicate that the Nudge not only triggered the participant to intrinsically reflect and transform her general

Table 1
Examples of excerpts indicating participant behaviour transformations in waste sorting, electricity usage and water usage behaviours.

Group#	Pre-event response to question: *"Did you have any program related to the environment or any experience related to environmental sustainability?"*	Post-event comments (1-2-1 Post-Event Interview)
WASTE SORTING		
1	*I was taking That course last semester … but we don't talk about that (environment) lot in …. (Ppt Da)*	*… I felt like we should all be concerned, we should be actively doing something like everything we can do to protect the environment and all that but I didn't really do that like since that experience (WV) I now pay more attention to where I put my trash, I actually read the labels (Ppt. Da)*
2	*like biology when I was in high school (Ppt Sa)*	*… it makes me aware of the environment like before I was trying to be conscious now since after the workshop I am more conscious about that and I try to do my best to take care of the environment* *…. I know there the house trash and the residual trash so I am trying my best not to put everything in a hurry and to separate them before I used to put them randomly but now I am taking more time to look in which bin my trash will go (Ppt Sa)*
ELETRICITY USAGE		
1	*(none on this topic)*	*…. If you notice now my lights are off as I used to leave it on sometimes even when I'm not using it (ppt Nj)*
2	*Not at all (Ppt Cr)*	*…. You know before you can switch **off your AC** not because of the value but because of the money. But now I do them **because they are part of my values**. So, for now I'll say I am more conscious about sustainability issues and reusable items and plastics (Ppt. Cr)*
WATER USAGE		
1	*what I'm doing right now has nothing much to do with the environment, I don't really work with materials. I think it's the material that really affects the environment because I think they don't degrade easily. So, what I am doing now is data processing there is no direct linkage with the environment.*	*… wasting water, I now take caution in how I use water especially tap water because normally we just open and just leave it running. So, I started watching how I use that kind of water .Before the workshop I never imagine you people consider those kinds of things very important as something to look at but after that workshop I started thinking that I have to watch how I use water and other things. (ppt Us)*
2	*Not at all (Ppt Cr)*	*… even in the kitchen …. When using water to wash I no longer let it running through out …. (Ppt cr)*

Ppt = participant.

perspective and action about a specific pro-environmental behaviours, but also ultimately contributed to her advocating others. This particular data only linked the Nudge to the behaviour – not the WVIS processes – and this is the kind of delicate information that future studies will need to untangle for a more robust understanding.

3.2.3. Electricity-saving behaviour changes

The topic of electricity conservation is not common in WVIS discussions generally, but it came up in the critical reflective negotiation discussions in one event, probably 'nudged' by the earlier use of the Nudge PEB (pro-environmental behaviours) questionnaire. In post-interviews one participants mentioned paying more attention to switching off lights and appliances that consume more electricity, such as air conditioning. One participant who pre-WVIS stated that she had no connection with environmental practices, explained how she had not only changed her behaviour to switching off lights, but how these actions were now embedded as part of her values:

> …. . during these periods of the Corona virus, you will not want to touch things with your hands but I knew I had to do them separate the waste, switch off lights etc. because they became part of my values. Now even with the Corona I can switch off the lights when leaving places because they have become part of my values …. (ppt Cr)

3.2.4. Water-saving behaviour changes

Even though the post-interviews used semi-open questions without mentioning any specific behaviours, participant reports seem to center on the same practices written about in the Nudge questionnaire (which had been answered individually, in writing, using Likert scales). One participant mentioned how, pre-WVIS, he never imagined that behaviours such as water usage should be curtailed, and he believed that all his actions were already environmentally friendly, generally speaking. But post-WVIS he said he realized that these actions do affect the environment and he now pays more attention to the amount of water he uses daily:

Pre-event question (in writing): … would you say you are environmentally friendly?

> **Response (inwriting):** *I don't use materials that harm bring harm to the environment. All materials harmful to the environment are well taken care of in a good manner (Ppt Us)*

Post-event (interview) comment: … I started watching how I use water. Before the workshop I never imagine … people consider those kinds of things very important as something to look at but after that workshop I started thinking that I have to watch how I use water and other things. (Ppt Us).

These comments indicate that the WVIS session played a key role in the participant's change of thinking and behaviour. However, this exploratory study design does not tell us which part of the WVIS influenced them. When the Nudge questions were administered to the participants before the WVIS, they were not told why it was administered, and therefore there was no obvious logic that the content should influence subsequent discussion topics, but the Facilitator noted in her (own) reflection Notes that over half of the topics were environment related, for both groups. Similarly, during the photo-elicitation stage of WVIS, participants were asked to choose some photos to use as props to explain what was important to them as students, and they were not asked at any point to pick any particular kind of photo. But the Facilitator's reflection Notes mentioned that the participants mostly picked pictures related to the environment. These points suggest that the Nudges had already potentially influenced the group's reflective environment in that Photo Elicitation Stage, and then fed into the critical reviews of their values, potentially influencing them.

In sum, the data provides evidence that behaviour changes were reported by participants as an outcome of the Nudging_Plus_Values-crystallization event, for two separate events, and that many of those reported were pro-environmental behaviours. These outcomes suggest that this approach has potential to answer the calls outlined in the introduction for methods and approaches to be developed which can produce transformative pro-environmental behaviour changes. The novel concept used – to use themed Nudges to influence the choice spaces of a values-crystallization process to produce themed behaviour changes – could be transferred to classroom situations in educational institutions, or in businesses within personal development events, or to informal education and civil society activities where discussions and values-crystallization events of various types are used. Because of this large potential range of application and contribution to sustainability, this approach is worthy of further study to confirm the causality, and demonstrate scaling-up and transferability capabilities.

3.3. Durability of behaviour change

The durability of any Transformative Learning outcome, including changes in behaviour, is always of interest to researchers, but empirical evidence for it is repeatedly noted as lacking – to the extent that the very existence of TL has been called into question [63, 64]. Separately, several Nudge intervention researchers have called for durability studies of behaviour changes associated with Nudging, to better understand the scope of its possible impact [48,65]. The data collection design in this study included interviewing participants a second time after a relatively long period – 14–56 days (depending on availability) - to check the durability of any candidate behaviour changes. Several examples were found:

> I no longer use takeaway bags every time I go to the canteen: I simply take my own containers. (Ppt Cr (14 days later)

> I prioritize the way I dispose of my waste nowadays, even the way I use water: like these are the things that I didn't pay much attention to (before). (Ppt Nj 56 days later)

Even though these are self-reported and not third-party reported, they provide rarely-reported evidence of durable behaviour changes from transformative learning, and also potentially Nudging. It suggests that the combined use of themed Nudges directly before deep and critical reflections might have potential to answer calls for effective themed transformative learning outcomes which are also durable [63], and deserves further study. If confirmed, the Nudging_Plus_Values-crystallization approach will be very useful to practitioners in environmental education, and researchers in fields of learning and of education, and would be worthy of further specifically designed studies.

This exploratory finding is also worth further investigation towards contributions to research conversation in the Nudging literature, as some authors have advocated Nudging techniques to be applied for changes of context or learning environments, or to create mindful reflections, to thus lead to more-durable changed behaviours e. g Ref. [30].

3.4. Findings concerning potential nudge influences on WVIS processes

As shown in Fig. 1, there are various ways that Nudges might potentially influence the choice spaces around different specific WVIS stages, and here we discuss insights around those. To obtain data on these, the Facilitator was asked, after the event, to write down her reflections in Notes, concerning the environmental content in each stage.

During the photo elicitation stage of a standard WVIS event it is typical for participants to select perhaps 10–20% of the photos to be environmentally-themed, but in both of the Nudge_WVIS events in this study, over half of the photos chosen were environmentally-themed. Thus, this gives the impression of a much higher-than-usual number.

During the trigger list statements stage where the participants were asked to choose statements that resonate with them, a bit over half (circa 60–70%) of the statements chosen were environmentally-themed. In standard WVIS events the percentage would normally be much lower, at perhaps 10–20%. Thus, this gives the impression of a much higher-than-usual number.

In the final negotiated Statements of Shared Values, approximately half, or just less, of the statements were environmentally-themed for both groups, whereas in standard WVIS events percentages of 10–20% are more typical. Thus, this gives the impression of a much higher-than-usual number.

3.5. Prior values alignment

The data from this study also revealed an unexpected feature, in that some participants clearly expressed that they did not initially hold values aligned with pro-environmental behaviours initially (prior to the Nudging_Plus_Values-crystallization event) and yet later said otherwise (see for example Table 1, under Electricity Usage). They even explicitly stated that they thought these changes came about during the WVIS process. This is of interest because some areas of research have suggested that interventions towards more pro-environmental behaviours may only work for individuals whose values already align to such behaviors e.g.; [32]. It is possible that during the critical reflections of WVIS - which are always related to shared values_in_action, - that the meaning-making and meaning-checking cycles involved [45] provided space for individuals to re-label some of their values with labels being used by other group members, and recognized them afterwards as 'environmental'. If so, then this aspect of the process deserves more study, since this is an important goal in environmental education: to shift an individual who initially expresses no environmental values, to pro-environmental behaviour.

4. Conclusions

The findings from this preliminary study are noteworthy because there is a clear and widespread reported lack of approaches/ methods for prescriptively producing transformative pro-environmental behaviours towards sustainability, and this study demonstrates one that has done this, and is worthy of further studies to test and confirm it.

Although the standard WeValue InSitu approach has already been established to routinely produce transformative learning outcomes, they have not historically contained many pro-environmental behaviour changes, limiting usefulness for behaviour change in sustainability. Here, the findings from this exploratory study suggest that prior Nudging may enhance environmentally-themed behaviour changes, including some which are durable and specific.

The novelty demonstrated in this study is that Nudging prior to the standard WeValue InSitu approach may enhance the production of environmentally-themed transformational behaviour changes in individuals. The post-interview data suggests the mechanisms: that the Nudges influenced subsequent choice of topics within the WeValue InSitu stages where critical reflection and meaning-making are facilitated. This is novel for values crystallization studies because those stages were not previously considered choice spaces. It is novel for Nudging studies because the behaviour changes seen can continue for long periods, and are influenced in groups, not single behaviours.

These exploratory results suggest that further, specifically designed studies would be worthwhile to investigate related research questions: a) was the environmental Nudging_Plus_Values-crystallization process *the cause* for the environmental Transformative Learning Outcomes reported? b) Which characteristics of the Nudges used were critical, and why; c) which WeValue InSitu processes, stages and choice spaces are most sensitive to this potential effect from Nudging, and why; d) is the potential effect seen generalizable? e) does the finding raise new ethical question: should those working in sustainability feel they can ethically 'Nudge' individuals without informing them in advance?

5. Limitations

These study presents outcomes from only two groups undergoing the Nudging_Plus_Values-crystallization process, and both were of university students: for generalisability further groups should be tested. This study was only exploratory in nature and thus any insights would need to be investigated with more specific research designs to be confirmed or ruled out, including the use of control groups and specific data collection. The work here has minimised possible differences in facilitation and event context and environment between the two groups, but these should be controlled for the comparison groups in future studies. Transformative Learning (TL) was assumed to take place in the WVIS workshop due to the *de facto* production of TL outcomes, but in order to directly confirm the TL a more detailed study would need to include transcribing the entire process and fully analysing the sub- or micro-processes (e.g., in the style of [27] or Polanyi [45] within it to identify steps in the TL process. This would be expected to also reveal specific links to the TLOs. Lastly, the analysis methods used here were non-standard: future studies could consider the advantages of using standardized methods, and the possible effects of social desirability bias in the interviews should be carefully noted.

Ethics statement

This work was approved by the HSSE Research Ethics and Governance Committee of the University of Brighton, reference REGC-15-022.

Author contribution statement

Marie Harder: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Rahel N. Tening: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Additional information

Supplementary content related to this article has been published online at [URL].

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e18689.

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