Response to R2, Maurits Ertsen

With apologies for being late with my comments, I was (and still am) very happy to see that a paper combining education, societal issues and water is being shared with the scientific community. Indeed, I agree with the authors that education is useful. What I am a little concerned about – or put differently: what I would like the authors to elaborate on in a next version of the text – are three issues. I will discuss these below, after which I provide a few remarks on specific elements in the text.

Thank you very much for your constructive feedback! Please find below a point-by-point reply to your comments and our intended changes to the manuscript.

Issue 1: methodological strength

Interesting as the paper is, I do not think that the material that is available allows for any assessment of the Water and Us design and method now. It is very difficult to see which data are actually being mobilized to support any of the claims about why Water and Us delivers on its promises. I'll discuss the potential challenge that WaU promises quite a few things in the other two Issues. For the methodological issue, most claims are supported by observations (which are occasionally labelled as "qualitative" I have to assume (eg 266 and 268)). I could not detect any clear description on how data to evaluate the effects of WaU are (to be) collected. The breakdown into impacts might work, but it would be needed to specify for each (rather different) category how data are to be found and applied in any analysis. Discussing the EC framework does not much more than mentioning what expectations the authors have (eg note the "potential" on line 251). The methods and underpinning evidence are quite anecdotal. Some numbers are merely descriptive, but how to understand them? As a small remark: the figures are not very informative, as they show only very small bits and pieces. As a side note on method: the claim that the didactic approach is sound is not too strange, but is also relatively thinly supported.

Thanks for your feedback. We agree that the current state of Water and Us is a first step, rather than an already established methodology. Thus, we will address your concern in two ways:

1. We will elaborate on an array of objective indicators to be discussed in Section 3 and applied in future steps of Water and Us to measure impact and validate our educational hypotheses. We will comment on how our first experiences informed the definition of such objective indicators;
2. Following this and other comments of yours, we will edit our language to clarify that we are documenting our first step, which others can co-develop and further expand.

Issue 2: role of education

As already mentioned above, claiming that education is useful is not that weird. It is also perfectly ok to suggest that education is something beyond learning how to do calculus or the like. I am also not surprised that current education is not using the "latest knowledge" as such. That is to be expected in systems that are slow, and that use material with a certain slowness in production adaptation. As such, using the type of workshop (laboratory) that the

text presents is actually a pretty good answer, as it would allow bringing in recent ideas in a flexible way into existing programs. However, in order to discuss whether the workshop WaU is effective, we would need to know how it links to school programs and approaches (which are expected to be different). One workshop in a sea of otherness might not change too much? My other concern is the rather automatic assumption that educating people results in better actions. I refer to Issue 3 for some remarks on "better actions" as such, and would like to suggest under Issue 2 that the relation between "education" and "action" is not straightforward at all. Knowing things does not mean that actions follow, either because there is no agreement or because one cannot take action. Furthermore, I do think that we have seen quite a few well-educated people doing rather undesirable things in history. Knowledge is political, action is (perhaps even more clearly) a political choice.

We totally agree with you on this.

Regarding the link between Water and Us and current school programs, we will add one paragraph discussing how this initiative is closely linked to civics (in Italian, Educazione Civica, see https://www.istruzione.it/educazione_civica/) and to science programs in high school. Civics programs in Italy specifically include educational targets on sustainability and environment, while science programs cover topics related to Earth science, the water cycle, and climate. In this regard, please note that our workshops are closely designed with teachers, who actively take part in preparing the class and gathering feedback in the immediate aftermath.

Regarding your very interesting reflection on the link between education and action, we will add a discussion and some references in our revised manuscript on this. We will make sure no automatic link between education and action emerges from the text, and we will discuss best practices on how to connect these two aspects. We will also mention and elaborate on several EU projects geared towards behavioural change that are currently underway and supporting Water and Us (e.g., https://ichange-project.eu/).

Issue 3: the complexity of the issue

This observation on knowledge and actions as political brings me to my final concern. I am quite sure that the designers of WaU are not aiming for a positivistic approach to climate, water and society. Having said that, the text does suggest quite clearly that there are good and bad explanations on topics, or that knowledge leads to defining solutions or avoiding conflicts. As soon as one allows stakeholders in (which WaU does, great!), I would suggest that one has to allow for different representations of "climate, water and society", or at least different claims on what is at stake and what needs to be done. And: whose story is told? Whereas the California drought – and the recent drought in Italy – are excellent entries into the complexity of the issue of "drought", the two examples provided in the text to show the importance of socio-hydrological focus (Dust Bowl and Maya) are simply not as straightforward as the text suggests. It is actually quite unclear how Maya society responded to drought – assuming that a society is a useful unit of analysis to discuss responses – if only because the evidence one uses matters quite a bit. This issue refers also to the cases and type of materials that are used in WaU: new evidence is coming in regularly, which can shift interpretations, but it could also be a case of different interpretations on the same evidence. The suggested relation between climate change, water cycle and conflict is actually not that straightforward.

Thank you for these additional, valuable comments. We will both amend the example of storytelling (what is currently the prologue to our manuscript) to remove the Maya events, and

generally revise the text to avoid any positivistic or unidirectional approach to the topic of water and climate.

Summary

In summary, I think the paper claims too much on methods and evidence on the Water and Us project, on the role of education in creating change, and on the topic of water, climate and society itself. What I could imagine, and would welcome very much, is that the paper invites others to try out the Water and Us approach. As such, publishing the experience so far would be a very good thing. It would mean for me, however, that the paper should quite drastically be changed in tone – with much less claiming and much more information on the process the module does in class. Such an invitation would also benefit from a much clearer designed methodology to evaluate the impact of the approach.

We agree with this general overview. We will amend the text as outlined above and further elaborate on our methodology to be more precise on how Water and Us plays out in the classroom, as requested.

Some remarks on text elements

Line 2: One would expect that high-school students miss certain knowledge, right, especially when it comes to larger, real-life issues?

We agree and will clarify this.

Line 11: Why use the term "fictious"? That does suggest there is also a "real" cycle?

Yes, our experience is that the current understanding of the water cycle by students is based on a natural representation with no human interference. This is fictitious in essence, as the "real" water cycle does include human actions (as recently acknowledged by, e.g., the USGS: https://www.usgs.gov/special-topics/water-science-school/science/water-cycle-diagrams)

Lines 13-14: This claim on education leading to less conflicts is too simple.

We agree and will clarify this (see response to your general comments above).

Lines 35-37: In many other countries issues on rights and access would arise too. Why use the term "endemic"?

We agree that similar issues may arise elsewhere, and indeed this is the main idea behind Module 3 of Water and Us (see the reference to the Turkana Lake). However, we generally address an Italian audience (or, at least, this is our experience so far). As such, we think it is appropriate to keep a reference to Italy here. Throughout the text, we invite readers to elaborate on "local" examples that would be more relevant in other areas of the world.

The term "endemic" was metaphoric and meant that conflicts around the use of water have always existed in this country and are part of our everyday life.

Line 50: The word “could” is very interesting here, as it could open up the whole question on what counts as knowledge, including evidence, uncertainties and representations.

The word “could” was used here to merely denote the fact that climate change scenarios are still uncertain to some extent. We will clarify this.

Line 53: Elephants in rooms tend to be invisible or at least made invisible. Is that an appropriate metaphor for climate change? There may be disagreement, especially on how to act, but I would not think climate change is invisible as an issue.

We thank you for this comment. Our confusion might partially be because we are not native speakers. We meant that climate change is a topic that everyone knows about, but is often avoided in public discourse. Reviewer 1 appreciated this metaphor, which seems appropriate based on several online sources, so we would keep it in the text.

Line 58: Why only mention one initiative?

Thanks for this. If you refer to “Fridays for Future”, this is by far the most well-known bottom-up initiative related to climate change based on our experience with Italian high-school students, which is why we used it here. We will add more initiatives in the revised manuscript.

Lines 80-84: The many different remarks made show that a diversity of issues can be related to education. Which effect one accepts as more important (or more true…) might influence how one design educational formats. If complexity is the main reason for climate change being absent in teaching, one might come up with a different course compared to when issues are mixed up.

Thanks for this. We will specify in the manuscript that Water and Us does start from the assumption that climate change is complex and contemporary, both aspects that make it difficult for teachers to fully cover it.

Lines 85-92: Paragraph where many of the issues I refer to can be seen.

We agree and will address them as outlined above.

Lines 118-120: Does bringing in the ambiguity of policy and governance also refer back to the possible ambiguity of/in the (natural) sciences?

Line 120: Is “existing literature” one paper?

Our narrative does include a constant reference to the uncertainty of climate change scenarios, and how decision makers take this uncertainty into account. At the same time, we are clear on what is currently known and understood, and how this knowledge is used to inform international agreements.

Regarding line 120, that was one example of the existing literature. We will add more.

Paragraph 2.3: In Line 155, the claim is made that there is a clear vocabulary, whereas the remaining paragraph text suggest quite strongly that differences in definitions are real – which I think is actually very cool to show and to use in class. But how does this relate to the remark in Line 155? Does it mean that the authors argue that there is one set of correct definitions?

We start from the assumption that a clear and precise vocabulary does exist (e.g., on what the Paris Agreement or greenhouse gases are – we largely rely on IPCC materials on this). At the same time, we also want students to understand that information that they might gather online or among themselves can be inaccurate, or simply partial. The second module of Water and Us aims at going from such incomplete definitions to precise ones. We also ask students to mention the source of information they used to come up with their proposed definition, so that we can comment on the reliability and accuracy of these sources.

Line 175: Can one use the term "mismanagement"? Is the story that clear?

We think that mismanagement is part of the problem, as we clarify with students (https://www.tandfonline.com/doi/abs/10.1080/14634980903578308?journalCode=uaem20). However, we also clarify that climate variability plays a role. This will be clarified.

Lines 197-198: I do not agree that these three core messages can be directly associated with the three modules. These core messages at least use words/terms that were not too central in the descriptions of the modules.

Of course, the link between an elementary-school version of Water and Us and its high-school counterpart is mediated by the need of changing lexicon and target. We will specify that the elementary-school version captures the component of Water and Us that are pertinent, relevant, and helpful to elementary school students.

Line 208: The 70% is quite often used in discussions suggesting that water is important. I find it rather a cliché, but my more serious concern is that the body-water actually shows how complex the metaphor is: water is not visible at all in one's body, right? The body-type H20 is perhaps not the river-type H20?

We agree this is a simplified concept, but we found it very effective with elementary-school children. Our experience is that they do understand this concept and it helps them familiarizing themselves with the importance of water.

Line 220: Why is this framework useful or applicable?

In this passage, we are shifting from methods to results. So we found it important to introduce how we moved from theory to practice. We will clarify this.

Line 236: Is the 100% explained because it is a self-selected group? If so, the statistics is not terribly meaningful.

The group of involved teachers was a mix between self-selected teachers and teachers who were involved on a later stage because Water and Us was already active in their school. In any case, we agree that this statistic should we interpreted with care. We will clarify this.

Line 242: Using the term "diffusion" when it comes to knowledge goes quite against the idea of active learning, which would apply terms like "constructing knowledge".

We will amend as suggested.

Line 245-246: I see the link between what WaU does and the field of socio-hydrology, but I am not ready yet to accept the suggestion that a focus on education contributes to the scientific field of socio-hydrology as such. Perhaps this needs to be explained?

We agree with this and will rephrase the passage accordingly.

Line 266: What does "qualitatively high" mean here? I think we were informed that 90% had heard about the topic, but that would be "quantitatively high", right?

We meant that our assessment was preliminary, and partially based on qualitative information. In this sense, the 90% awareness score is important, but should be subject to more extensive research in the future. We will clarify this.

Lines 267-273: I would stay away from claims like this when one does not have more than some observations to back it up.

This section will undergo major revisions according to comment from you and reviewer #1. In this sense, this section will likely be removed and heavily summarised in the Impact section.

Line 273-275: We know that you argue such education is needed, and I would agree with that argument, but repeating this in a section on "lessons learned" or "future directions" seems a little strange to me.

This section will undergo major revisions according to comment from you and reviewer #1. In this sense, this section will likely be removed and heavily summarised in the Impact section.

Line 276: I find it quite shocking that finding out that different groups may need different approaches is presented as a result. I do appreciate mentioning it for sure, and do hope that the observation can be used as a design principle for education.

This section will undergo major revisions according to comment from you and reviewer #1. In this sense, this section will likely be removed and heavily summarised in the Impact section.

Lines 290-298: I find the issues of "local" and "global" fascinating, and have no real solution to overcome the divide – which may partially be artificial and is certainly political. I would be

interested to know more about the remark that the categories need different goals. Why would that be?

This section will undergo major revisions according to comment from you and reviewer #1. In this sense, this section will likely be removed and heavily summarised in the Impact section.

Line 293: Is “action” the same as “behavioural change”?

In our view, action is a precondition for behavioural change. In any case, this section will undergo major revisions according to comment from you and reviewer #1. In this sense, this section will likely be removed and heavily summarised in the Impact section.

Line 304: The idea that teaching Module 4 will “educate students to democracy and free speech” may be a little huge and optimistic? It does link to my earlier issues. I agree that education is linked to larger societal issues, but that does not mean that education can easily solve problems or bring improvements that easily. I think the idea that teaching the complexity of climate, water and society is already a challenge, and worthwhile in itself.

We will revise wording as recommended and specify that the focus of Water and Us as it stands now is teaching the complexity of climate, water and society.