

## Response to Referee Comments

### Referee #1: Dr. A. Jonoski

This is an interesting and valuable article that presents an overview of the current status of using digital support tools (models, data, visualisation, etc.) in hydrology university education in USA. Results from surveys and workshops carried out with hydrology university educators are presented that indicate the requirements and critical steps in moving forward towards a community-based development and sharing of new hydrology education curricula with associated digital supporting tools. The use of such supporting tools is identified to be more widespread at graduate levels, but there is a lack of such support at undergraduate levels. The opinion expressed in the article is that community-based approach for developing, sharing and using adequate curricula and supporting would be beneficial, although a number of challenges still remain. The article is clearly written and should be published after addressing few, mainly general comments, provided as follows:

**Comment 1:** The material in the article is focused on the current situation regarding hydrology education and usage of supporting tools in the USA. This is understandable since the authors seem to be most familiar with this situation. Although at the end of the introduction the authors state that the content presented in the article 'bears relevance to the global hydrology community's challenges and interests', there is no discussion on this later in the article. While many development in USA (especially, for example those of CUAHSI) may be very beneficial to university hydrology educators in other parts of the world, there are also significant barriers to reusing educational components elsewhere. Putting aside the obvious language barrier, there are issues regarding the context of presenting hydrological knowledge (social, economic, even political and judiciary), which may be very different from one country to another, and especially when considering developing countries. The scientific aspects of hydrology are, of course, universal, but the differences in context may lead to differences in knowledge needs and consequently impair the desired community-based sharing of educational content. Even a simple issue of using US measuring units (rather than SI units) may deter a potential user from using some educational material developed in USA. Therefore the authors are invited to provide some discussion regarding the opportunities and challenges in developing a truly global community-based environment for developing and sharing of curricula and digital support tools for hydrology education from their USA perspective.

**Response:** The CI we propose developing would feature modularity and design criteria that would make it inherently useful for international applications. For example, there is text in the manuscript that demonstrates the modularity and the choice of "mix and match" to accommodate individual needs (e.g., section 4.2). Additional text is included in conclusions to address this comment.

"The hydrology concepts will not change, but the context within which these concepts are taught may differ with different disciplines and geographic locations. The same CI design criteria of searchability, modularity and interoperability which facilitate reuse, adaptation, and modification of curriculum materials to prevent obsolescence, are also the essential qualities that will allow these materials to transcend disciplinary, cultural, national, geographic, and linguistic barriers as

the broader global geosciences community uses the CI to “mix and match” and continually re-develop and re-publish materials.”

**Comment 2:** The above comment becomes even more relevant, when one notices that the authors recognise ‘cultural differences between the engineering and geoscience application domains of hydrology and their affiliated disciplines....’ (page 2610, lines 18-22) as one of the potential barriers to a shared hydrology community resource, even within same country. In my opinion these differences will remain, together with the ‘bifurcations’ (as the authors call them) between ‘water quantity’ and ‘water quality’ or similar branching of topics. Hydrology is and will remain a multi-disciplinary science, with many sub-specializations (hydrology as earth science, engineering hydrology, agricultural hydrology, eco-hydrology, etc.). Therefore the goal of integrating existing (and future) content within one ‘broader community curriculum’ (page 2611, lines 1-9) may be quite challenging. It is difficult to see what will be the value of such integration, beyond having a repository of hydrology education curricula and supporting tools that can be discovered and re-used. While the creation of such a repository may be beneficial, the authors are not entirely clear about the kind of ‘integration’ they expect and recommend to occur via the community resource that they are proposing.

**Response:** See #1 above.

**Comment 3:** Regarding the supporting tools (DMDGC toolsets) the situation described in the second paragraph of page 2611 (with three classes of toolsets) is in fact not surprising. The Type 1 common tools such as Excel / ArcGIS are generic in nature and they would be used in many hydrology courses (also at undergraduate level). Type 2 (toolbar extensions added to computing environment) and 3 (numerical models) are usually more specialised and are expected to be used correspondingly at graduate level and by researchers. The key question here is whether sophisticated tools (such as numerical models, for example) can become more widespread in hydrology education. Although this may be difficult for basic hydrology courses (because of lack of students’ background), such tools, when developed with suitable visualisation interfaces, can have the power of explaining physical phenomena involved in hydrological processes, potentially stronger than traditional approaches with mathematical formulations and associated textual explanations. Researchers and educators from the field of hydroinformatics have been exploring this potential for more than two decades for both classroom (face to face) and online learning (see Abbott et al. (1994), Molkentin et al. (2001) Price et al. (2006), Price et al. (2007), Jonoski and Popescu, (2012)). The authors are invited to comment on their experiences and perception of this potential in the USA.

**Response:** The results of the workshop indicate that the community is comfortable with using numerical tools in graduate education, and we have noted that one of the suggested references draws the same conclusion. As the reviewer suggests, the challenge is definitely in bringing numerical tools into the undergraduate classroom. We believe the conclusions and results adequately highlight this point. We thank the reviewer for excellent references to the efforts of UNESCO-IHE and the suggested references, along with others, have been incorporated.

**Comment 4:** The article seems to focus on community-based development and sharing of curricula and supporting tools for usage in classroom-based education. Given the growth in online education (also in hydrology), which has significantly different educational approaches (and potentially relying even more on digital support tools) the authors are invited to comment on the potential of the community-based hydrology education resources in these situations.

**Response:** We believe that the hydrology community faces the same challenges as other communities with respect to online education. The UNESCO-IHE references provide a wealth of background on this topic. We have clarified that the scope of our work is focused on specifying design criteria for a CI for modular curriculum publication and adaptation.

**Comment 5:** One issue that needs to be emphasised is the need for partnership between universities and educational institutions with agencies and commercial companies who produce hydrology-related software tools. The authors have found from their surveys and during the workshop that educators have strong preference for freely available tools. Other experiences, however, show that inclusion of software tools that will be later used in practice may be more appreciated by the students as well as more instructive for usage during the education modules (classroom or online). This software may be licenced, but through partnerships with the software producers it is frequently available for free or at nominal fee for educational purposes. The experiences in hydroinformatics education show that a mixture of free and licenced software may be most preferred option in education.

**Response:** We agree with this comment. We have added the following text in Section 4.1.1 to address this comment.

“However, the authors note that it is not always possible or desirable to utilize purely open-source and freely available materials. Proprietary tools are sometimes desirable, particularly when they are an industry standard. The difficulty in using proprietary materials, of course, is the cost, as well as the fact that the University and the corporate partner may be natural competitors in this educational context. It is worth keeping in view the possibility of partnership with corporate providers of software and training, and to allow these corporate partners to participate in community CI and curriculum dissemination activities. This suggestion is similar to the well accepted use of expensive proprietary textbooks in the lecture environment, where the instructor integrates proprietary textbook material into the course and serves as a personal guide or an interpreter of the material for the student’s specific context.”

**Comment 6:** Finally, the realization of the community-based resource as envisaged in the article critically depends on development and provision of right incentives for the members of the community. This issue is mentioned in the conclusions of the article twice (in first bullet at the end of page 2620 and again in lines 7-9, page 2623). On the other hand, this has not been mentioned earlier in the article. The authors are invited to provide explanations about this. (Was this not something that was included in the survey or in the workshop and why?.)

**Response:** Actually, this was discussed during the workshop, and some text is added in the revised manuscript after the discussion related to Fig. 1.

“Many workshop attendees expressed surprise at this last-place result for curriculum material publication and ratings, because the development of such a system provides a key incentive for faculty to receive review and acknowledgement of their community contributions in the “teaching” dimensions of scholarship. Without this recognition and assessment provided by the hydrology education community, it is less likely that significant progress will be made on the development of curriculum materials.”

**Small editorial comments:**

Line 12 - page 2604 : the word 'is' should be removed.

*This change is incorporated*

Lines 9-10 - page 2617: I don't understand the phrase 'water movement across multiple environmental gradients' - perhaps it can be modified.

*This is modified to water flux.*

I suggest some modification of the title that will reflect the 'community-based resource' proposed in the article. Perhaps 'Moving university hydrology education forward using community-based geoinformatics, data and modelling resources' (Just a suggestion).

*The title is modified as per reviewer's suggestion.*

## **Referee # 2**

This papers provides an authoritative perspective on cybereducation together with what seems to be a comprehensive review of the US community efforts in this area and particularly the results of a survey and workshop involving US hydrology educators. The discussion and conclusions are an interesting contribution to this special issue and worth publishing as is as far as I am concerned. If the authors were to do anything then just another spell check and reduce “wordiness” in places.

*Thank you for your review!*