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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Understanding groundwater – students' pre-conceptions and conceptual change by a theory-guided multimedia learning program" *by* U. Unterbruner et al.

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Response to Reviewer's Comments on our manuscript "Understanding groundwater – students' pre-conceptions and conceptual change by a theory-guided multimedia learning program"

First of all, we want to thank the reviewer for her/his valuable comments on our manuscript. The suggestions are helpful for improving the quality of our paper. Please find below our replies on the reviewer's comments.

REVIEWER'S COMMENT: This paper presents an interesting study on the impor-

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tant subject of groundwater education. The paper discusses students' misconceptions about the subjects, describes the development of a multimedia learning program, and conducts pre- and post-tests to evaluate impact of the intervention. The paper is based on adopting the Model of Educational Reconstruction (MER) as a research design. The paper is interesting, important and follows a valid scientific approach. However, the paper needs improvements in several key areas, such as: 1. Methodology: The manuscript needs to do a better job in explaining the MER model. For example, last paragraph, page 11692, states that: "A balance between science-related issues and educationally oriented issues is considered a necessity in effective teaching and learning." But what are theses issues specifically? (science-related "issues" and educational oriented "issues").

AUTHORS' RESPONSE: In the MER, the iteration between science contents and students' pre-conceptions is in the center of attention. A science-related teaching (as is usual at universities) may primarily follow the scientific nature of a certain topic. That means e.g. that a chapter about groundwater in a hydrogeological book or a university lecture may start with a definition of groundwater, with Darcy's Law to quantify hydraulic conductivity of a porous medium, etc.

The MER on the other hand, has to follow another approach taking students′ pre-conceptions into account. MER focusses on the notions of the underground rivers and lakes and therefore comes to the point of view that the teaching process must not automatically follow the scientific systematics and routines, but has first of all to make clear for the students what the ground does look like. E.g. that there are sediment layers, that rain water runs through gravel and sand and is gathered above clay, that groundwater flow takes place within pores between distinct grains of sand and gravel, etc. "Educational oriented issues" means another focus on the issue and/or additional topics owed to the learners' pre-conceptions. The opposite proceeding is (as it was practiced in earlier times) only to "reduce" the scientific content to the anticipated level of the learners.

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Please read in chapter 3.1 and 3.3. (11698 – 11704) how we realized the MER approach when designing our multimedia learning program. If considered as appropriate we can add more details.

REVIEWER'S COMMENT: 2. Design of tests and interpretation of results: The new learning program includes aspects related to introducing new and correct scientific contents on groundwater, and introducing such concepts using multi-media means. Can we isolate the effects of these two different aspects, i.e., new content on the one hand, and multi-media elements on the other hand? Can the evaluation research questions and tests isolate the individual effetcs of these different aspects of the intervention? In other words, did the improvement result from introducing new and correct scientific content, or was mainly attributed to the use of multi-media techniques?

AUTHORS' RESPONSE: Our aim was to investigate the multimedia program's learning efficacy. Indeed, the effects of the new content on the one hand and the multimedia effects on the other hand cannot be seen isolated. We directly combined the content with the potential of multimedia and used many multimedia tools like animations, dynamic presentation of contents, an efficient balance between pictures and texts, a so called pedagogical agent and several more. Therefore you cannot take off the content from the multimedia program and implement it into a paper-pencil or "teacher only" version.

REVIEWER'S COMMENT: 3. Manuscript length: the manuscript is a little too long and can benefit from a more concise presentation of background, methodology, and results.

AUTHORS' RESPONSE: We already focused our manuscript on the main points and tried avoid details. However, we will scan the revised version for potential abbreviations and we will be grateful to reviewer #2 to give us some ideas which part should be abbreviated to his/her opinion.

REVIEWER'S COMMENT: 4. Writing style: while the manuscript is fairly well-written, it needs a significant revision to improve its readability. For example, there are several

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places where the language style is a little awkward, sentences are fragmented and repetitive, and there are many problems with punctuations (commas, periods, capital and small letters), etc. There is also an excessive use of numbering/bullets throughout the manuscript. I included below some examples of these, but the authors need to check the entire manuscript.

Examples of minor corrections (please check the entire manuscript for more of these): -Line 10 page 11692: “In a first step, we developed the multimedia learning program theory-guided”; this sentence needs to be re-phrased. Problems with use of punctuations (periods; commas, etc.), sentence lengths and structure (e.g., lines 10-15 on page 11700). Excessive use of numbering makes reading the manuscript rather difficult to follow (e.g., see pages 11700, 11701, 11706, 11707).

AUTHORS’ RESPONSE: We were supported by a native speaker and a translation agency checked our manuscript. But of course we will check the manuscript again with special attention to the above mentioned points.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 11689, 2015.