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Discussions

Interactive comment on "Teaching hydrogeology in the field: the bottleneck in student conceptual model development" *by* Joaquin Jimenez-Martinez

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General comments

In this manuscript the author aims to assess the importance of a student's prior knowledge on his/her results in fieldwork reporting (following an "inquiry-based learning strategy"), as well as the effectiveness of combined prior knowledge and fieldwork on conceptual model expression. The topic is interesting and nicely framed within the existing literature. The results however need substantial additional work to make this study publishable in HESS, as I specify in my comments below.

Specific comments

I find the number of samples (17 students, 1 year) too low to be representative for a

statistical analysis. The author could quite easily include previous years to increase the number, and to reduce bias from including students from a single cohort. Especially when further divided in groups based on prior knowledge (PK) ranking, the regression analysis is done within groups of 11 and 6 students, which is clearly insufficient.

The way prior knowledge (PK) is assessed is also quite limited. It corresponds to the total number of followed courses out of the 14 courses selected that have a link to groundwater. In my opinion some of these courses, such as geology, hydrogeology and cartography, should have a much larger weight than for instance "forest and landscape", given their larger importance for conceptual model building. In addition, different ways of calculating this parameter and multiple ways of ranking (in two and three groups for instance, if a larger data set is used) should be tested to address uncertainty and evaluate the best approach. To give an example, in Table 1 student 8 has had only six courses and no geology, so I wonder if that student should not receive a low or intermediate PK rank. Student 15 has had more courses but also no geology. Student 10 has had five courses only, but they cover core subjects such as geology, hydrogeology, hydrology, hydraulics and GIS, which could allow that student to receive a high(er) PK rank. It is also not entirely clear if the Groundwater course (theory and modelling) corresponds to the Hydrogeology course. I assume not, as 16 out of 17 students followed hydrogeology, but only 76% followed the groundwater course. It is it not clear then why it is not part of the list of selected courses. In addition, why did only 76% follow the groundwater course? You could take this analysis a step further and integrate course marks into the analysis.

Inquiry-based learning (IBL) was quantitatively assessed from the written report on a scale of 0-6. It is not clear how/why this scale was used and if it simply corresponds to the report mark. It is not clear if all reports were assessed by the same person and what the degree of subjectivity was. More importantly, the fact that the students worked in groups (which is good practice) questions to what degree the reports were then really individual. The latter could partly explain the high average score and poor correlation with PK. This would need to be addressed and discussed.

The way conceptual model expression (CME) was assessed is even less clear. Where/how did the students deliver the conceptual model representation? Did they do that indeed individually? How was it marked? How does the marking affect the results? This requires much more information, as the author considers this to be the identified "learning bottleneck": going from the split information to the integration of it.

To be able to further evaluate the identified "learning bottleneck" we also need to look at the fieldwork itself. The 5-day fieldwork described is indeed good for the students to increase their inquiry-based learning capabilities. However, fieldwork is done at the plot scale, and nothing is mentioned about its upscaling to the aquifer scale. This is odd, as conceptual hydrogeological models need to integrate the flow system concept, and include recharge, (intermediate) flow and discharge zones, which you are unable to find at the plot scale. Therefore, additional fieldwork or field excursions would be needed to help improve the understanding of conceptual model representation, which is not taken into account in the study.

I do not fully agree with the interpretation of the results in Table 4. The low coefficients of determination (which need to be added to the table) indeed indicate weak or no correlation, but the author then suggests this could be because the correlation is non-linear. However, the groups of 11 and 6 students are just too small to be able to come to significant conclusions, even if $p < 0.05$ (not clear in the table). In any case it is important to show the correlations in graphs, as visual inspection allows to understand the role of outliers on the correlation coefficient (or coefficient of determination).

It would further be important to see/discuss if support can be found for the statement that "when approached with a conceptual model, students may extract only those elements they consider relevant and incorporate them to their mental model, resulting in a mental model that differ from the conceptual model presented". This could be done by having students draw and explain conceptual models at different stages in

their academic career, starting when they first arrive at the programme. I do believe that the more we explain and describe conceptual models, with drawings, simulations and animations, the more the students can start to correct their own mental models on groundwater flow systems.

Technical corrections

Ln 14 (and elsewhere): "we assess", but there is only one author; I recommend avoid using "we"

Ln 76: briefly explain the term "inquiry-based learning" the first time it is used

Ln 83-85: please elaborate

Ln 96-99: please rephrase

Ln 116: "into their mental model", "that differs from"

Ln 136: "course background", "knowledge among"

Ln 149-151: units for K are incorrect, or the negative sign is missing in the exponent

Ln 168: "field course"

Ln 169: "seek to"

Ln 227: "non-significant"

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