HSR London International Conference on Multidisciplinary Academic Research
(HSR-ICMAR) 2026
https://houghtonstreetreview.com/index.php/conference

CONNECTING VIRTUAL LABORATORY ACTIVITIES WITH QUANTITATIVE CHEMISTRY PROBLEM SOLVING

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https://doi.org/10.5281/zenodo.23924351

Abstract. This paper presents an instructional sequence that connects virtual laboratory observations with quantitative chemistry problems in preservice teacher education. Drawing on the methodological framework of the author's dissertation, it links prediction, numerical calculation, simulated observation and explanation. A dilution task illustrates how students can move between an experimental situation and its mathematical representation. The contribution is a teaching design rather than a new experimental effectiveness claim.

Keywords: chemistry education, virtual laboratory, problem solving, dilution, simulation, preservice teachers.

Introduction

Students may correctly substitute numbers into a chemistry formula while remaining unable to explain the process represented by that formula. This difficulty becomes visible when a familiar calculation is presented as a laboratory situation. Digital instruction therefore needs an explicit connection between numerical reasoning and the interpretation of chemical change. A simulation provides useful observations, but observing an animation alone does not establish that a student understands the relevant quantitative relationship.

The dissertation on improving chemistry problem solving in an electronic learning environment combines staged problem solving with virtual resources and modular coursework [1]. Building on this framework, the present paper asks how a virtual activity can be organised so that students must predict and justify an outcome before viewing it. The instructional objective is to connect quantities, chemical assumptions and evidence within a single task.

Instructional design

The proposed sequence has four stages: predicting the outcome, constructing a quantitative model, examining a simulated situation and explaining agreement or disagreement. The teacher selects a virtual environment only after checking that it represents the required variables and assumptions. PhET and ChemCollective are resources discussed in the dissertation; the exact activity must be checked for its suitability to the intended task [1; 2]. The sequence does not assume that the same interface or functionality is available in every simulation.

Before opening the virtual activity, students identify what changes and what remains constant. They record their prediction in the learning management system. This record makes it possible to discuss an initial misconception even if the student later reports the correct value. The numerical solution is then developed independently. After observing the simulated outcome, students compare it with their prediction and explain the relationship in words.

Worked dilution example

Consider the preparation of a solution by diluting 50.0 mL of a 0.200 mol/L stock solution to a final volume of 200.0 mL. Students first predict whether the amount of solute and its concentration increase, decrease or remain unchanged. Under the assumptions of quantitative transfer, no reaction and no solute loss, the amount of solute is conserved. It is $n = cV = 0.200 \times 0.0500 = 0.0100$ mol. The final concentration is therefore $0.0100/0.2000 = 0.0500$ mol/L.

The distinction between adding 200.0 mL of water and making the solution up to a final volume of 200.0 mL is explicitly discussed. The familiar expression $c_1V_1 = c_2V_2$ is introduced as a consequence of solute conservation under these conditions. It should not be treated as a general rule for every mixing process. If a reaction occurs or material is lost, the original reasoning requires revision.

Where the selected virtual laboratory permits solution preparation, students reproduce the specified initial and final states and record the displayed quantities. Where it does not, the teacher supplies a consistent simulated dataset for interpretation. Students then explain why the amount of solute remains 0.0100 mol while concentration falls to one quarter of its initial value. A follow-up problem changes both the stock concentration and target volume, requiring a fresh solution rather than repetition of the same numerical answer.

Assessment and discussion

Assessment includes the initial prediction, the conservation statement, the calculation with units and the final explanation. A correct numerical result with an incorrect conservation argument is treated as incomplete evidence of understanding. Conversely, a correct model followed by an arithmetic mistake receives different feedback from a conceptual error. Screenshots may document an observation, but students must interpret the observation rather than submit it as a substitute for reasoning.

Virtual activities also have limits. Their representations may simplify volume behaviour, apparatus use or chemical interactions. The teacher should identify these assumptions and connect the digital exercise with physical laboratory practice where feasible. The design presented here has not been evaluated as a separate intervention; future evaluation should use unfamiliar transfer tasks and delayed assessment rather than activity completion alone.

Conclusion

Virtual laboratories can be connected more closely with quantitative chemistry when prediction and calculation precede observation and explanation follows it. The proposed dilution sequence makes conservation of solute the link between the experimental situation and the mathematical model. Its practical value lies in making student reasoning visible at each stage, while its effectiveness requires direct evaluation.

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