

Review of: "Implementing Simulation Software to Develop Virtual Experiments in Undergraduate Chemical Engineering Education"

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Potential competing interests: No potential competing interests to declare.

I was asked to review the manuscript titled "Implementing Simulation Software to Develop Virtual Experiments in Undergraduate Chemical Engineering Education". Open peer review is a rather unusual concept (ordinarily, the anonymity of peer review is an essential tool in academia to ensure honest feedback and to prevent reviewers from being intimidated out of rejecting manuscripts that should rightly be rejected), but I will treat this review as I would a review for any peer-reviewed scientific journal. Having read the manuscript, I find that it is nearly devoid of meritorious scientific content that would contribute meaningfully to the peer-reviewed scientific literature; additionally, I have ethics concerns that I believe should prevent publication. Consequently, I recommend that this manuscript be rejected. My top reasons are explained in greater detail below.

First, this manuscript lacks focus: it is not clear what the authors are studying. The title would imply that this is intended to be a methods paper about the authors' implementation of a software package for teaching chemical engineering students, yet the authors show no code, no software flowcharts, and nothing of the user interface; they also mention nothing about testing or distribution of their software, or how another teaching lab might obtain and use these tools or reproduce the results (the educational experience). The first sections of the body, in contrast, would suggest that this is a study about a pedagogical tool's efficacy, yet the authors do not systematically evaluate the tool's efficacy for teaching. (See the next paragraph for more discussion about this.) Midway through the manuscript, the focus abruptly switches yet again: sections 2.3.1, 2.3.2, 2.3.3, and 2.3.4 resemble an undergraduate's ordinary differential equations homework, inserted into a manuscript about pedagogy in chemistry without any explanation of the meaning of the ODEs, their parameters, or their relationship to anything to do with chemistry. It reads as though this section were written by a different author who thought that the subject of study was ordinary differential equations themselves rather than pedagogical tools, though the next section switches back to the focus of classroom education. By the end, the reader is left rather baffled as to why he or she was being told this story, and what the central message was supposed to be.

Insofar as the most frequently recurring focus of the manuscript was the efficacy of a set of pedagogical tools for teaching chemical engineering, no objective evaluation is made of the relative merits of these particular virtual laboratory software tools (or virtual laboratories in general) compared to more traditional physical laboratories. While there are many statements of the apparent superiority of virtual labs, they are not backed up by evidence, making much of the body of the

manuscript read like an advertisement full of hyperbolic sales-pitch phrases rather than an objective study. The authors completely overlook, or dismiss as disadvantages, many of the *advantages* of in-person teaching laboratories, such as gaining familiarity with complicated equipment, learning how to deal safely with hazardous reagents (like the sodium hydroxide that is reduced to a line in figures 2 and 3), learning how to process *real-world* data complete with noise and possible systematic error, and learning how to troubleshoot when things go wrong (as things inevitably do in the real world). The only data presented that could possibly serve as evidence for or against virtual labs is the grade distribution from a class in which they were introduced and a histogram of survey results. The former compares years before and after the introduction of virtual labs, but it is not clear why an increase in grades should be considered an improvement in education when the grading criteria necessarily changed with the change in methods (and with the COVID-19 pandemic), and there is next to no discussion of what grades tell someone about the merits or detriments of a pedagogical method (or how the immense impact of the pandemic can be corrected for). The latter, the survey, is presented on its own, with no point of comparison (e.g., for a course that used in-person labs) and with no further analysis or discussion, meaning that it too is not evidence of the merits *or* detriments of this pedagogical approach. (Additionally, the survey results are completely opaque: I am not at all clear what a reader is supposed to get out of 50% of the class answering “agree” to “knowledge”, “skill”, or “attitude”: the question asked is not presented.) For this to be a study of a pedagogical tool, it would have to present a comparison to other pedagogical methods involving some sort of objective and independent metrics (grades being both subjective and highly dependent on the evaluation method, which is what is being studied) and numerical analysis.

Finally, the authors assert that no ethical approval is required for this study. However, the manuscript contains much qualitative discussion about students’ response to virtual labs, and figures 14 and 15 show statistics about students’ grades and responses to a questionnaire. This makes this a study involving human subjects, which certainly does require the oversight and approval of an ethics body, usually from before the commencement of the study. In particular, the publication of students’ grades, information that is not normally publicly available, requires someone in a position of authority to certify compliance with university and governmental rules about proper handling and anonymization of such data, and with any requirements that may exist about seeking student consent. Publishing a study involving human subjects without proper ethics body oversight would be a serious breach of a publisher’s obligations. This alone warrants rejecting the manuscript.

There are also many minor problems with the presentation (figures with unclear captions, statements that don’t make sense, overly broad statements, missing or unclear definitions, *etc.*), but given the fundamental flaws in the manuscript, I have not enumerated those here.

To summarize: due to its lack of focus, its failure to systematically and objectively study any of the things that it apparently might be trying to study, and its missing ethics committee approval for the use of human subjects, I can only recommend that this manuscript be rejected.