Exploring Trends in the Use of Virtual Simulations in the Science Classroom

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This study explored and presented teachers' perspectives on the use of virtual simulations and how their practices reflected this. This study aimed to understand when teachers use virtual simulations, why they use them, how they use them, challenges they encounter if any and if they have alternatives to the simulations. The findings showed that when selecting simulations, teachers consider: Focus on Student type, learning levels and rigor, Accurate representation, especially the appearance and graphics relevant to the concepts and Ease of access, use and versatility especially with LMS. While factors like the type of student and the type of content taught inform the pedagogical decisions of the teachers. Finally, this study found that while most of the teachers seem to use and support the use of simulations, caution was advised especially the risk of misconception based on the illustration or graphics used in the simulations.

Computer simulations can offer students the opportunity to observe a real-world experience and interact with it (Sahin, 2006; Nilsson & Jakobsson, 2011; Widiyatmoko, 2018). Effective use of the computer simulation technology medium enhances learning in a science classroom because it can help facilitate communication, encourage inquiry, increase opportunity for collaboration between learners, and is used to make teaching/instructional materials.

While a lot has been written about the use of virtual simulations in the science classroom (Smith, & Puntambekar,2010; Merchant, 2019, Yılmaz & Hebebci, 2022), we need to know more about how teachers decide on the type or particular simulation to use. This study aims to understand when teachers use virtual simulations, why they use them, how they use them, the challenges they encounter, and if they have alternatives to the simulations. This study aims to foreground teacher perspectives on how and why they select simulations.

Previous literature has provided information about why teachers use simulations in science classrooms. In explaining the attractiveness of virtual simulations, Scalise et. al (2011) stated that "with school funding evaporating, strong educators, school districts, particularly in smaller, poorer, rural or more remote areas, view virtual labs as an attractive choice" (p.1051). The availability of virtual tools has created opportunities for teachers to better engage students using appropriate examples that may reduce misconceptions.

Methods

Since this study aimed to provide teachers a voice by presenting their perspectives, the qualitative research method was used. The following research questions were developed to better understand these parameters, with the hope that the results from this study will provide enlightenment.

This was qualitative research using the multiple case study approach and a descriptive cross-case design meant to answer the research question: What are the considerations that grades 9-12 teachers use in selecting or adopting virtual simulations in science education? The data source was the semi-structured interviews and lesson plans shared by teachers who volunteered to participate after completing the invitation.

A high school in a district in the midwestern United States was used in this study. The school district is a 1:1 device district, which means all students have school-issued devices. The target population used for this study was science teachers currently teaching in the selected high school of the district. Six participants volunteered to participate (3 males & 3 females). These participants are referred to in this study using pseudonyms for anonymity.

Table 1

Participants' Demographics and Simulation Use Information

Criteria	Elsa	Jasmine	Theo	Alvin	Daphne	Simon
Content Area	Biology Earth and Space Science	Chemistry	Environmental Science Chemistry	Biology Chemistry	Physics	Biology
Years of Teaching	Over 20 years	Over 10 years	About 20 years	About 5 years	Over 10 years	About 20 years
Gender	Female	Female	Male	Male	Female	Male
Age Range	Above 50	35-45	35-45	25-34	Above 50	35-45

Frequency of using Simulation	All the time At least 2 per unit	Not frequently About twice a semester	Frequently, about 7-8 for one course every few weeks 2 continuously throughout the year 4- 6 times for extra practice for another course	Not frequently	Frequently	Frequently Almost 1 per unit

Data Analysis

The interview responses were analyzed using thematic descriptive analysis, while content analysis was done on the lesson plans. Initial codes (predetermined code or apriori), which are descriptive codes, were used as a criterion for data collection. The data collection instruments (interview protocol questions) were derived based on the codes. Some emergent codes were derived after a review of the information from the data collected. The table below shows the specific categories of the predetermined and emergent codes, as well as their definition. The emergent codes are represented in italics in Table 2.

Table 2

Themes, Predetermined & Emergent Coding Scheme of virtual simulation use

Definition	Codes	Category	Themes
What teachers consider before selecting or adopting the simulation to use	Accessibility Cost/Subscription Student type Difficulty levels/Rigor Ease of Access & Use Curriculum Content Link to LMS Downloads or Direct Access Manipulability (Editable Variable outputs) Engaging Appearance Data Collecting Capacity Input and Output Capability Complexity of variable options Differentiation Versatility	CONS (Consideration)	1. Student type, learning levels, and rigor 2. Ease of access, use, and versatility (especially with LMS) 3. Accurate representation (especially the appearance and graphics)

Results And Discussion

After reviewing the information shared by the various participants, a cross-case analysis was required to examine the similarities and differences between the information shared. This is especially relevant so we can see how various practitioners use the same tool for instruction. The information is presented in Table 3.

Table 3

Summary of Participants' Interview Responses

Participants	Consideration	Memorable Quotes
Elsa Frequent User	high quality, ease of use by students, easy for students to manipulate and figure out	"If students are unable to figure out what, what to do on a simulation, then they're gonna be less likely to pursue and you know dive into the activity".
Jasmine Uses them once or twice a semester	directly link to the LMS, Manipulability, whether a student could see numeric values as outputs from simulations, graph these data points and see trends	"allow students to kind of see what can't be seen otherwise" "I would be looking for those quantified relationships."
Theo Frequent User Uses them every few weeks	Accessibility Cost it's effectiveness as a learning tool	" I don't do simulations just for the sake of them" "it's just not feasible to do that hands-on with everything" " it really it gives me a visual assistant to, to teaching a concept "
Alvin Rarely uses them	Appearances Is the presentation of the simulation engaging? how easy the simulation is to understand with little background knowledge? specific scenario or what sort of goal I'm looking for, but how, how easy it is to collect data	"Not because I don't like it or anything, honestly, it's just implementation time, making sure I'm utilizing it well" "And so for me, a simulation in the interface that actually matters a lot. If something looks like it's running Windows 95, chances are kids aren't gonna like that "
Daphne Frequent User	depends on the class level depends how advanced the simulation is	"if it's an entry level, like first time taking physics, I use those simulation to learn about the concepts and to be able to go deeper into the concept. If I use the simulation at higher level classes, like

	Ease of Manipulation and not too complex	advanced courses, I use it to review previous knowledge" " it can create misconceptions just because a lot of what they see is not something that they will see normal life"
Simon Frequent user	Visualization Manipulability Appropriateness for the class levels Versatility	" it's something that students have a hard time visualizing, so it gives them a visual" " students can kind of play with the variables of something or be able to toggle you know, the way that something is functioning in the system to see how the system responds"

Consideration in selecting or adopting simulations in a science classroom

Focus on Student type, learning levels, and rigor. According to one of the teachers interviewed, they preferred to use simulations for students in advanced classes rather than in lower-level classes. For instance, they would rather provide a simulation for an AP physics class on pulley systems but run a hands-on lab for a general-level physics class. They have noticed this reduces the rate of misconceptions. Daphne mentioned that " The driver always is the level of exposure that they had to physics already. So if they have no previous exposure, I try to have physical models. If they already have a little bit of knowledge or experience with those concepts, then I can have either more technology involved in the setup or maybe have a simulation".

Accurate representation, especially the appearance and graphics relevant to the concepts. A teacher shared that they select specific simulations to fit with the particular concept they want to illustrate, using the statement, "I like to use a lot of simulations when some concepts are a little bit more abstract or harder to see." Therefore, knowing their students, how they learn, and the best way to present the information to facilitate learning, can be regarded as a major consideration for the teachers before selecting a simulation.

Some of the teachers mentioned how misconceptions can occur while students are using simulations. They advised that the teacher has to be aware of this all the time so they can handle any situation that comes up. According to Daphne, " It also depends on the actual simulation because, as I said, there's some simulations that if you do not clarify certain aspects of the simulation to the student, it can create misconceptions just because a lot of what they see is not something that they will see in normal life." Accurate representation, appearance, and graphics were shared as some of the reasons simulations may be chosen, but they could also contribute to misconceptions on the part of the student.

Ease of access, use, and versatility, especially with LMS - with devices, especially mobile phones, becoming ubiquitous, it makes sense for teachers to select a simulation that students can easily use on their mobile phones. An existing tool is used for instruction, potentially reducing the incidence of unauthorized mobile phone usage during classroom instruction and contributing to effective classroom management.

The results also suggested that teachers select simulations based on how they can easily be understood and manipulated by both teachers and students. Some teachers discussed how they use certain simulations to portray very advanced and abstract concepts, which may not easily be illustrated using a hands-on lab, therefore making the concepts easily accessible to students. Having issues with accessibility of the content may introduce a stressful situation where the students are focused on getting the simulation to work properly instead of learning the concepts required. Which could cause a challenge of too much focus on the learning tool rather than on the learning the tool is supposed to provide.

In conclusion, while some teachers' use of simulation may be limited because of the factors mentioned previously, availability of resources for physical labs also negates the use of simulations by teachers. This situation creates a situation where some teachers might not use simulations because they have the resources available to run physical labs.

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