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Using Simulations to Foster Pre-Service Teachers' Diagnostic Competences: What Aspect of Authenticity Matters?

Amadeus J. Pickal, Institute of Education, University of Hildesheim, pickal@uni-hildesheim.de
Katharina Engelmann, Institute of Education, University of Hildesheim, katharina.engelmann@uni-hildesheim.de
Raimund Girwidz, Chair of Physics Education, LMU Munich, girwidz@lmu.de
Birgit J. Neuhaus, Biology Education, Faculty of Biology, LMU Munich, birgit.neuhaus@lrz.uni-muenchen.de
Christof Wecker, Institute of Education, University of Hildesheim, christof.wecker@uni-hildesheim.de

Abstract: Prior research is somehow divided about the importance of authenticity in simulation-based learning, but in simulations designed for fostering diagnostic competences, there seems to be no general relationship between authenticity and diagnostic competences. In the present study, we investigated perceived authenticity and its role for learners' diagnostic accuracy in a simulation that was designed to foster pre-service teachers' diagnostic competences. Pre-service teachers completed the video-based simulation and composed a written diagnosis of a student's scientific reasoning skills before rating the authenticity of the simulation on three dimensions (realness, involvement and spatial presence). The results showed that the simulation was perceived as authentic – except for spatial presence – and that only the relation of involvement to diagnostic accuracy was statistically significant. This is partly in conflict with previous findings and suggests that the design of simulations for fostering pre-service teachers' diagnostic competences should focus more on involvement rather than on realness.

Introduction

During a regular school day, there are many occasions on which teachers employ diagnostic competences. These diagnostic competences play an essential role in successful teaching (Helmke & Schrader, 1987) and especially as a prerequisite for the specific support of individual students (Schrader, 2009). Diagnostic competences can be defined as the ability to collect and interpret information for the purpose of making high-quality decisions or assessments (see Heitzmann et al., 2019), for example regarding students' knowledge, skills and so forth. Even though previous research pointed out that teachers' diagnostic competences are on average rather high, there is still room and a need for improvement (Südkamp et al., 2012). This is especially true for pre-service teacher education, as diagnostic competences often do not play a central role in university-based teacher training programs. Consequently, (pre-service) teachers need a sufficient amount of opportunities to improve their diagnostic competences. Since practicing with actual students may often not be an option due to organizational obstacles and ethical requirements, practicing with simulations can offer a convenient alternative.

Using authentic simulations to foster diagnostic competences

Simulations represent certain segments of reality and offer learners the opportunity to interact with these segments and thereby develop specific skills and competences (Heitzmann et al., 2019). Therefore, simulations are considered highly useful for fostering a variety of different competences, including diagnostic competences. This appears to be true in the field of medical education, where simulation-based learning already plays a significant role (see Peeraer et al., 2007). Meanwhile, it has also been gaining more and more popularity in teacher education (see Chernikova et al., 2020). This increasing interest in using simulations for learning in teacher education is also associated with an increasing interest in design guidelines for creating simulations and the question: What is an effective simulation?

The relationship between realness, involvement and spatial presence of simulations and diagnostic competences

Because of fast technical progress and increasing opportunities (like e.g. "virtual reality"), there often is a specific focus on the authenticity of simulations and on whether or not an effective simulation needs to be as authentic as possible. Prior research regarding the importance of authenticity of simulations is somehow divided. Henninger and Mandl (2000) emphasized that more authenticity is not always better, because it is sometimes advisable to simplify certain facets of a learning environment and therefore reduce the authenticity in order to avoid excessive cognitive load resulting from too many different sources of information (see e.g. Ayres & Sweller, 2014). However, a recent meta-analysis found higher learning effects with more authentic simulations than with less

authentic simulations (Chernikova et al., 2020). Nonetheless, empirical research investigating the effects of authenticity in learning environments covers a variety of aspects of authenticity that range from evaluations of more objective criteria, such as whether a simulation contains all critical elements of the corresponding real life situation (see e.g. Norman et al., 2012), to learners' individual perceptions (see e.g. Frank, 2014; Schubert et al., 2001). Thus, in answering the question of effectiveness, a more differentiated analysis is needed, comparing different aspects of authenticity in order to understand which aspect of authenticity matters most in simulations. In line with a factor analysis conducted by Schubert et al. (2001), the most important facets of learners' individual perceptions of authentic learning environments might be perceived realness, involvement and spatial presence. Perceived realness is the realistic feel of a simulation. Perceived involvement is the feeling of being fully involved in an experience. Spatial presence is the feeling of really "being in the situation" (see Schubert et al., 2001; Vorderer et al., 2004). Research in the field of medical education suggests rather low correlations between perceived realness, involvement as well as spatial presence and diagnostic competences (Fink et al., 2021), but there are no findings yet on whether similar correlations can be found in the field of teacher education.

Aims and research questions

The purpose of the present study was to measure the perceived authenticity of a simulation that was designed and developed for the purpose of fostering pre-service teachers' diagnostic competences. We assume high perceived authenticity to be indicated by high ratings for perceived *realness*, *involvement* and *special presence*. Further, we aim to examine the relationship between the perceived authenticity of the simulation and pre-service teachers' *diagnostic accuracy* within the simulation.

RQ1: How do pre-service teachers rate the video-based simulation regarding the perceived *realness, involvement* and *spatial presence* of the simulation?

RQ2: Is there a meaningful relationship between the perceived *realness, involvement* or *spatial presence* and pre-service teachers' *diagnostic accuracy*?

Method

Participants

Participants were recruited at three different German universities. All 160 participants were enrolled in university-based teacher programs (53.8 % female, 43.8 % male; age: $M = 22.91$, $SD = 2.90$; semester: $M = 4.99$, $SD = 1.77$).

Simulation environment

To mimic a specific classroom situation that involves the process of diagnosing students, we created a video-based simulation focused on diagnosing students' scientific reasoning skills. This simulation contained staged videos showing pairs of students conducting inquiry tasks in class. Based on the respective school subject (physics or biology) the students' task was to find out whether or not certain independent variables influence the focused depiction of an object through optical lenses (physics) or the growth of plants (biology). Those tasks were limited to four independent variables (e.g. the distance between object and lens in physics or the amount of water in biology) in each of the two subjects. The videos were staged because we wanted to make sure that both versions (physics and biology) were fully parallel in structure. While working with the simulation, the participating pre-service teachers' task was to collect information about one specific student's scientific reasoning skills and to later compose a written diagnosis about his or her skills. In addition to the videos (displayed on the upper left hand side of the screen), the simulation featured a table containing information about the experiments conducted by the students in the videos as well as their observations (displayed on the upper right hand side of the screen), a note pad, offering participants the opportunity to write down individual notes (displayed on the lower right hand side of the screen) and a navigation area (displayed on the lower left hand side of the screen). In the navigation area, certain pre-formulated questions appeared and disappeared throughout the video. This was designed to give participants the possibility to interact with the students featured in the videos and collect additional relevant information. If a participant decided to ask a certain question (e.g. "What do you want to find out now?"), he or she had to click on the respective link and received the answer of the student via an additional video that was inserted in the main video. A limited overall amount of time was available for asking questions to ensure that participants would only ask deliberately selected questions.

Measurement of variables

After working with the simulation, participants rated their perception of the simulation on three different scales. All statements were rated on a 5-point Likert scale ranging from (1) disagree to (5) agree. *Realness* was measured by three items (e.g. "I think the learning environment is authentic") from an adapted scale (Schubert et al., 2001;

see also Seidel et al., 2010) with satisfactory reliability (Cronbach's $\alpha = .77$). *Involvement* was measured by four items (e.g. "I have immersed myself in the situation") from an adapted scale (Vorderer et al., 2004; see also Frank, 2014; Seidel et al., 2010) with acceptable reliability (Cronbach's $\alpha = .61$). *Spatial presence* was measured by three items (e.g. "I felt like I was actually there in the simulated situation") from an adapted scale (Vorderer et al., 2004) with satisfactory reliability (Cronbach's $\alpha = .79$).

For the purpose of quantifying participants' *diagnostic accuracy*, the written diagnoses were coded on the basis of the different sub-skills of scientific reasoning. Two independent raters coded for each of 11 specific scientific reasoning sub-skills (e.g. the skill to formulate specific hypotheses or the skill to manipulate the examined variable – while keeping all other independent variables constant) whether the sub-skill was mentioned in the written diagnosis and – if it was mentioned – if the sub-skill was diagnosed correctly. An additional coding variable captured whether the diagnosis noticeably indicated awareness of the difference between actual behavior and underlying latent sub-skill. The score for *diagnostic accuracy* was the percentage of the variables coded as "present" or "correct", respectively. Overall the two raters achieved a high agreement; $ICC_{absolute}$ (159,159) = .82. Averaged scores of both raters were used in the statistical analyses.

Results

The descriptive results indicated that on average participants perceived the *realness* and the *involvement* of the simulation as relatively high (see Table 1). The differences between these average ratings and the midpoints of the corresponding scale were statistically significant and amounted to a small effect in the case of *realness*; $t(159) = 4.04$; $p < .001$ (two-sided); $d = 0.32$ and a large effect in the case of *involvement* $t(159) = 10.32$; $p < .001$ (two-sided); $d = 0.81$. The ratings for perceived *spatial presence* were lower and below the midpoint of the rating scale (see Table 1). This difference was also statistically significant and amounted to a moderate effect; $t(159) = -6.75$; $p < .001$ (two-sided); $d = 0.54$.

Table 1
Descriptive statistics for perceived authenticity

	M	*SD*
Realness	3.29	0.92
Involvement	3.56	0.69
Spatial presence	2.47	0.99

In a multiple regression analysis with *diagnostic accuracy* as the criterion variable, *involvement* was found to be a statistically significant positive predictor ($\beta = .36$, $p < .001$), whereas *realness* ($\beta = -.08$, $p = .32$) and *spatial presence* ($\beta = -.12$, $p = .19$) were not statistically significant predictors.

Discussion

Pre-service teachers rated the authenticity of our simulation as rather high, as they stated that they felt involved during participation (*involvement)* and perceived the learning environment as a realistic depiction of a classroom situation (*realness*). Only the feeling of "being in the actual situation" was rated rather low (*spatial presence*). The results of the regression analysis only partially agreed with findings from previous research, as we found a statistically significant relationship between *involvement* and *diagnostic accuracy*. In line with the results of Fink et al. (2021), the relations between *realness* and *spatial presence* on the one hand and pre-service teachers' *diagnostic accuracy* on the other hand were not statistically significant. As the *involvement* ratings for the simulation were the highest among the three aspects of authenticity, these results further strengthen the validity of the developed simulation.

In summary, our findings suggest that it may be useful to take a more differentiated look at the role of authenticity, as our results point in the direction Henninger and Mandl (2000) suggested: It may not be sufficient to only increase the *realness* of simulations and therefore this aspect of authenticity perhaps should not be the sole focus of interest. Instead, it might be more important to get learners cognitively involved. Obviously, this does not mean that creating a realistic experience is not important as both facets are interconnected to a great extent; yet it may be useful to consider how increasing the degree of realness of a simulation can lead to more learner involvement.

Nevertheless, these findings stand in need of replication using more elaborated methods. In line with the idea of Norman et al. (2012), it may also be advisable to include additional measures of authenticity that also consider whether a simulation contains all critical elements of the corresponding real life situation. This may also require assessments by experts, since learners may not be able to evaluate respective critical elements themselves.

In conclusion, we still suggest that the statistically significant relationship between *involvement* and *diagnostic accuracy* provides some indication of what really matters when developing simulations for fostering diagnostic competences in pre-service teachers and that developers of simulations should focus more on inducing learner involvement than on maximally realistic simulations.

References

Ayres, P., & Sweller, J. (2014). The split-attention principle in multimedia learning. In R. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 206–226). Cambridge University Press.

Chernikova, O., Heitzmann, N., Stadler, M., Holzberger, D., Seidel, T., & Fischer, F. (2020). Simulation-based learning in higher education: A meta-analysis. *Review of Educational Research, 90*(4), 499–541.

Fink, M. C., Reitmeier, V., Stadler, M., Siebeck, M., Fischer, F., & Fischer, M. R. (2021). Assessment of diagnostic competences with standardized patients versus virtual patients: Experimental study in the context of history taking. *Journal of Medical Internet Research, 23*(3), e21196.

Frank, B. (2014). *Presence messen in laborbasierter Forschung mit Mikrowelten: Entwicklung und erste Validierung eines Fragebogens zur Messung von Presence [Measuring presence in laboratory-based research using microworlds: Development and initial validation of a questionnaire for the measurement of presence]*. Springer.

Heitzmann, N., Seidel, T., Hetmanek, A., Wecker, C., Fischer, M. R., Ufer, S., Schmidmaier, R., Neuhaus, B., Siebeck, M., Stürmer, K., Obersteiner, A., Reiss, K., Girwidz, R., Fischer, F., & Opitz, A. (2019). Facilitating diagnostic competences in simulations in higher education a framework and a research agenda. *Frontline Learning Research*, *7*(4), 1–24.

Helmke, A., & Schrader, F.-W. (1987). Interactional effects of instructional quality and teacher judgement accuracy on achievement. *Teaching and Teacher Education, 3*, 91–98.

Henninger, M., & Mandl, H. (2000). Vom Wissen zum Handeln - ein Ansatz zur Förderung kommunikativen Handelns [From knowledge to action - an approach for fostering communicative behaviour]. In H. Mandl & J. Gerstenmaier (Eds.), *Die Kluft zwischen Wissen und Handeln* (pp. 197–219). Hogrefe.

Norman, G., Dore, K., & Grierson, L. (2012). The minimal relationship between simulation fidelity and transfer of learning. *Medical Education, 46*(7), 636–647.

Peeraer, G., Scherpbier, A. J., Remmen, R., Winder, B. Y. de, Hendrickx, K., van Petegem, P., Weyler, J., & Bossaert, L. (2007). Clinical skills training in a skills lab compared with skills training in internships: Comparison of skills development curricula. *Education for Health, 20*(3), 125.

Schrader, F.-W. (2009). Anmerkungen zum Themenschwerpunkt Diagnostische Kompetenz von Lehrkräften [The diagnostic competency of teachers]. *Zeitschrift für Pädagogische Psychologie, 23*(34), 237–245.

Schubert, T., Friedmann, F., & Regenbrecht, H. (2001). The experience of presence: Factor analytic insights. *Presence: Teleoperators & Virtual Environments, 10*, 266–281.

Seidel, T., Blomberg, G., & Stürmer, K. (2010). Observer: Validierung eines videobasierten Instruments zur Erfassung der professionellen Wahrnehmung von Unterricht [Observer: Validation of a video-based instrument for investigating the professional perception of lessons]. *Zeitschrift für Pädagogik, 56*, 296–306.

Südkamp, A., Kaiser, J., & Möller, J. (2012). Accuracy of teachers' judgments of students' academic achievement: A meta-analysis. *Journal of Educational Psychology, 104*(3), 743–762.

Vorderer, P., Wirth, W., Ribeiro Gouveia, F., Biocca, F., Saari, T., Jäncke, L., Böcking, S., Schramm, H., Gysbers, A., Hartmann, T., Klimmt, C., Laarni, J., Ravaja, N., Sacau, A., Baumgartner, T., & Jäncke, P. (2004). *MEC spatial presence questionnaire (MEC-SPQ): Short documentation and instructions for application*. http://academic.csuohio.edu/kneuendorf/frames/MECFull.pdf

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