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ORIGINAL PAPER

Enhancing Teacher Education with Simulations

David Kaufman[1] · **Alice Ireland**[1]

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Abstract As calls for accountability in our schools increase, teaching quality faces scrutiny and, often, criticism. These realities challenge teacher education programs to find new ways to ensure that their graduates will be effective in highly demanding work settings. In this article the authors draw on literature and practice examples to highlight ways that simulations can strengthen critical aspects of teacher preparation as teacher education programs look for ways to better equip their graduates for future challenges. Experience shows that simulations can support screening for program admission, practice for improving teaching and classroom management skills and development of teaching dispositions. Their potential is increasing as technological advances provide greater realism, distributed access and simulation applications for mobile devices.

Keywords Classroom practice · Dispositions · Practicum · Simulations · Teacher education · Teaching quality

As calls increase for school accountability, teaching quality faces scrutiny and, often, criticism. Teachers need an ever-broader range of knowledge, skills, attitudes, and behaviors to guide and motivate students to achieve measurable learning goals. This challenges teacher education programs to find new ways to ensure that their graduates will be effective in highly demanding work settings.

✉ David Kaufman
dkaufman@sfu.ca

[1] Faculty of Education, Simon Fraser University, Burnaby, BC, Canada V5A 1S6

Simulations are well-established learning tools in many disciplines. Although their use is relatively uncommon in teacher education, research and experience in other fields, particularly medical and health education, point to their potential for developing effective teachers. Drawing on these other disciplines, this article highlights ways that simulations can strengthen critical aspects of teacher preparation as programs look for ways to better equip their graduates for future challenges.

Teaching Quality and Teacher Education

A teacher's competence is widely identified as the most influential factor on student learning, compared to demographic and social factors (Goldhaber 2002; Hanushek 2014). Although there is little consensus on the specifics of quality teaching (Levine 2006), teachers are expected to have a wide range of knowledge, dispositions and skills, including subject matter knowledge, pedagogical knowledge and skills, supportive and caring attitudes, professionalism and skills in planning and in managing diverse groups of students. As a result of policy initiatives and the movement to data analytics, however, teaching effectiveness is increasingly defined and evaluated in terms of outcomes-based models (Darling-Hammond et al. 2012). Teacher education programs are under increasing pressure to ensure that their graduates can produce measurable learning gains in their students in the face of growing criticism that these programs are not prepared to graduate teachers for today's conditions (Allen et al. 2014; Knight et al. 2015; Levine 2006; Liston 2012).

Attempting to understand how individual teachers promote student achievement, researchers have identified distinct dimensions of effective teaching practice (Stronge et al. 2011). Stronge et al.'s review identified evidence for four broad

practice categories: instructional delivery; student assessment and feedback; the learning environment including classroom management; and personal qualities including caring positive relationships, fairness, enthusiasm and encouragement to take responsibility (2011). Their study found measurable differences in classroom management and personal qualities between top- and bottom-performing teachers, as measured by student achievement. The Gates Foundation Measures of Effective Teaching (MET) study (Kane et al. 2014) found similar relationships. Classroom behaviors associated with *press* (keeping student busy, on task, thinking rigorously and persisting through difficulty) and *support* (caring, communicative, helping behavior and interesting lessons) were positively associated with learning outcome improvement in their large-scale study. Kane et al. and other researchers argue for a stronger focus on effective classroom and support practices in teacher education programs.

Classroom practices have historically been developed through the practicum, where student teachers practice applying knowledge and skills, receive feedback and gain experience in working with students and managing the classroom environment. Practicum experiences allow teacher candidates to learn and grow in protected settings and are often viewed as the most important aspect of teacher education programs (Arnett and Freeburg 2008; Darling-Hammond 2006; Girod and Girod 2008). However, the practicum often suffers from problems including a lack of appropriate or diverse field placements, host teacher shortages, host teachers' poor teaching practices, lack of opportunities to work with special-needs students, limited opportunities for repeated practice and poor integration with the university curriculum (Billingsley and Scheuermann 2014; McPherson et al. 2011; Putnam and Borko 2000; Wilson et al. 2001).

Recently, some have argued for increasing the prominence of practice in teacher preparation, moving to a focused emphasis on core practices that contribute to teaching effectiveness (Ball and Forzani 2009; Forzani 2014; Grossman et al. 2009). Fundamental to this approach are *pedagogies of enactment*, in which discrete parts of complex practices are role-played, evaluated and refined based on feedback (Grossman et al. 2009). These make classroom practice an integral part of teacher training rather than a separate stage near its conclusion.

Teachers' personal qualities and supportive behaviors, long acknowledged as important, have been the focus of recent research on dispositions for teaching. Various definitions of dispositions are used (DeMuth 2012), but they express a broad constellation of values and behavior patterns that affect classroom practice. Helm (2006b) lists as examples kindness, caring, initiative, fairness, decency, service, pro-social behavior, honesty, humility, trust, empathy, healing, a sense of community, having high expectations for students and themselves, teaching students to think critically, having a strong work ethic and having an appreciation of cultural diversity. Helm (2006a) explored assessing candidates' dispositions before they are admitted to teacher training, concluding that some candidates are better suited than others to be good teachers and that dispositions need to be developed through modeling, assessment and feedback during teacher preparation. Harrison et al. (2006) described a comprehensive process for assessing candidates' dispositions before admission, as well as at various stages during the program, that focused on observable behaviors related to effective teaching. Assessments were used to screen program candidates and for formative feedback at the start and end of the practicum.

Improved initial assessment, together with increased practice, observation and feedback during teacher training, are thus likely to enhance new teachers' classroom skills and teaching dispositions, improving their future student learning outcomes. Several types of simulations provide opportunities to extend and enhance this practice and feedback. In the following discussion we outline their characteristics, give examples of their use and suggest ways in which they can enhance aspects of teacher education related to student achievement.

Simulations for Learning Professional Practice

A simulation is a simplified but accurate, valid and dynamic model of reality implemented as a system (Sauvé et al. 2007). Simulations are distinguished from games in that they do not involve competition. A simulation allows users to encounter problem situations, try decisions and actions, experience the results and modify their behavior without risking harm. Simulations have been widely used for many years in settings such as aviation and medicine, where real-world skills practice is logistically challenging, dangerous, or costly (e.g., see Drews and Backdash 2013; Lu et al. 2014). Simulations may or may not be implemented using digital technologies, but increasingly take advantage of them to provide more realism, flexibility, access, and detailed feedback.

Simulations have many advantages for learning and practice, including the ability to repeat scenarios with specific learning objectives, practice for longer periods than are available in real life, use trial and error, experience rare or risky situations, and clearly measure outcomes with validated scoring systems. For skills development, a simulation's outcome measures, combined with debriefing and reflection (Crookall 2010), serve as feedback for a formative assessment cycle of repeated performance practice and improvement (Ferry et al. 2005; Girod and Girod 2008).

Simulations are becoming more common in pre-service teacher education, allowing practice and feedback for skills such as lesson planning and implementation, classroom management and teaching students with varying learning needs and challenges (e.g., see Bradley and Kendall 2014; Girod

and Girod 2008). Pre-service teachers can move from theory into action, with more practice time and variety than would be available in limited live practicum sessions, without negatively affecting vulnerable students (Carrington et al. 2011; Hixon and So 2009). As in other domains, learning from simulations in teaching depends on reflection and repeated practice (Girod and Girod 2006). Teacher assessment with simulations appears less common, but examples from other domains point to this potential.

Situational Simulations

Simulations have been categorized in many ways, based on their situations, tasks, disciplines and supporting technologies (e.g., Alessi and Trollip 2001; Bradley and Kendall 2014; Maier and Grössler 2000). Alessi and Trollip identify *situational simulations* as those that model aspects of working environments and interpersonal interactions, making them particularly applicable to teacher training and assessment. As described by Lyons (2012):

> [A situational simulation] … could be a clinical scenario, a conflict situation or an emergency situation where the student makes decisions to respond to the situation and develops strategies to rectify the situation as they would do in real life contexts. The provision of a real life situation gives learners a sense of immediacy and involvement where time and the chosen response matter to the successful outcomes. (p. 4)

Medical and health educators use situational simulations for practice and evaluation in scenarios such as patient interviews, crisis response and emergency departments. In management and other fields they are also used to support hiring decisions. In medical and health education, in particular, they are supported by extensive research and validation as training and assessment tools. Three broad types of situational simulations, discussed below, are likely to be especially useful as teacher education tools.

Scenario/Role-Play Simulations

In a scenario/role-play simulation, the student assumes a role and performs tasks such as diagnosing an illness (as a physician), coordinating an emergency response or teaching a lesson. When the scenario is presented, the student may have to do research to complete the tasks. The scenario might progress following a branching tree logic based on the user's decisions or a linear scenario requiring actions in sequence. The "in-basket" exercise (Stearns et al. 2003) is a variation in which the role involves handling multiple tasks based on a collection of memos, documents and requests. These often require effective priority-setting and communication with others under time pressure and are used in management, public-sector and educational recruiting to test the skills of potential managers and school leaders (e.g., Schroffel 2012). Team-based scenario/role-play simulations, with students performing multiple roles, are used for team training in health care (Eppich et al. 2011).

Problem-based learning (PBL) is a scenario/role-play simulation approach that is particularly important in medical and health care education (Barrows and Tamblyn 1980). (Case-based learning is sometimes regarded as a separate approach [Srinivasan et al. 2007] but is included with PBL for the purposes of this discussion.) There are many styles of problem-based learning, ranging from short single-paragraph cases used in residency and continuing medical education, to long cases requiring several pages that are used in the first and second year of medical school. Depending on the instructional goals and the student's prior knowledge, the case may demand anywhere from quick judgments to in-depth, multi-stage reasoning and research. Cases that simulate actual patient problems are used for training in diagnosis and clinical reasoning, as well as for assessment by many professional bodies, e.g., in Step 3 of the United States Medical Licensing Examination (www.usmle.org). PBL was originally developed using paper-based delivery, but it is now supported by a range of learning technologies (Jin and Bridges 2014; Tambouris et al. 2012); for example, McLean et al. (2014) describe a mobile PBL application in which virtual patients are introduced via video, patient data is released online in intervals, and students work in virtual clinical teams to manage patients.

Scenario/role-play simulations are not new in teacher education, but they are gaining prominence as the need for practice in authentic situations is emphasized. Choi and Lee (2009) described CBL-CMPS, a web-based learning environment using a structured approach to help student teachers develop skills and dispositions needed for solving real-world ill-structured classroom dilemmas. Ball and Forzani (2009) discuss short role-plays focusing on specific classroom tasks (e.g., teaching fractions to a fourth-grader) as a vehicle to reflect on and improve specific cognitive and relational practices that contribute to learning. Butvilofsky et al. (2012) describe a simulation which second-language teachers role-played their students and were taught in a language that they did not know well. Reflecting on their experience of discomfort and confusion led them to better understand effective teaching techniques and to empathize with their students' learning challenges. Hume (2012) described a similar simulation in which pre-service science teachers role-played their students and were able to better see how specific teaching practices could address their students' needs.

Following the example of business recruiting, in-basket and role-play simulations are also used (more commonly in alternate-route teaching programs) to screen potential teacher candidates. Stanford University uses an office-hour simulation to screen potential second-language teaching assistants for their language fluency and communication skills (Stanford

2014). The not-for-profit group Teach for America requires candidates to teach simulated classes as part of their final interviews before hiring (Teach for America 2015). Uplift Education, a Texas charter school network, is developing a "predictive analytics" framework to screen teacher candidates based in part on performance on role-play exercises involving emailing an upset parent, teaching a model lesson, and analyzing student performance (Pappano 2011). Citizen Schools uses "job simulation activities," in-basket exercises that include lesson planning and email correspondence based on hypothetical student profiles, as part of a multi-stage tutor hiring process (Citizen Schools 2015).

Simulations with Standardized Patients and Students

A standardized patient is a healthy person (a professional or amateur actor) who is trained to realistically and accurately reproduce a medical scenario (McMaster 2015). Standardized patients are used in the Objective Structured Clinical Examination (OSCE), a type of situational simulation used extensively in medical and health care education for both practice and final assessment of clinical and interpersonal skills. At an OSCE "station," students are given a task to perform in a specific time period, such as taking a history, performing a physical examination or giving bad news. An expert assessor uses a predetermined checklist to assess the student either at the station or later using a video recording of the interaction. Shorter OSCEs (e.g., five stations) are used for training and feedback, while longer ones (12 or more stations) are typically used to increase validity and reliability in high-stakes examinations (Kahn et al. 2013; Pell et al. 2010). OSCEs have also been used at admissions to assess candidates' interpersonal skills (Eva et al. 2004). More complex simulations using multiple standardized patients have been used to develop skills in leadership, teamwork, and patient care management (Horsley et al. 2014).

A similar approach, the Objective Structured Teaching Exercise (OSTE), has been used for teacher training in medicine (Sturpe and Schaivone 2014; Trowbridge et al. 2011). Using a trained standardized student, the OSTE requires a learner, playing the teacher role, to manage the situation, responding to a standardized student's individual behaviors, learning characteristics and possibly special needs. Immediate feedback is based on a pre-determined behaviorally-based scale or checklist. Trowbridge et al. (2011) noted that based on qualitative evidence, the OSTE improves teaching performance, and has potential for developing and evaluating specific teaching competencies. OSTE implementation is costly and resource-intensive, however, and so far has been limited to simulations with single standardized learners rather than full classes.

eduSIMS (http://edusims.syr.edu) uses standardized patients, students and community members to train pre-service teachers and school leaders in communication and management skills (Dotger 2009; Dotger and Alger 2012). These simulations focus on issues that teachers and leaders commonly encounter, such as struggling or disabled students, concerned parents, ethical dilemmas and school bullying (eduSIMS 2015). Each simulated conference is captured on video for feedback and debriefing.

Computer-Based Clinical Simulations

Situational simulations that use technology to model people and/or learning environments often provide a more realistic user experience of practice in clinical settings. Boundaries are fluid between this group and those discussed above, but these examples illustrate how simulations are taking advantage of growing technological capabilities.

Computer-based clinical simulations are widely used in medical and health education for practice at many levels, from isolated clinical skills through comprehensive protocols (Gaba 2007; Issenberg et al. 2005). A patient simulator, for example, presents an interactive patient and clinical work environment through a physical model, computer displays, or virtual reality. It allows a user to work through steps in a simulated medical case including history-taking, physical examination, laboratory tests, diagnosis and, in some cases, management of the patient's condition (Gaba 2007). The simulation may provide detailed feedback on the user's performance, such as whether they were efficient, systematic and cost-effective (Melnick 1990). Computer-based simulated patients are used in a number of medical certification exams (Boulet 2008). Multi-user physical and virtual training environments are increasingly being used for team training, for example in emergency medicine, disaster preparedness and cardiac life support (Heinrichs et al. 2008; Khanal et al. 2014).

In teacher education, computer-based classroom simulations are being used with growing success. Using simulated students based on real people, The Cook School District simulation, (http://cook.wou.edu), is designed to support pre-service teachers in their practice of connecting teaching and learning (Girod et al. 2007). The simulation animates the Teacher Work Sample Methodology (TWMS) (Girod 2002), which dates from the 1970s and models in detail connections between teacher actions and student learning. Originally used in the context of a real field experience with real students, TWMS requires a teacher to define and defend learning goals, pedagogical approaches and lesson plans, supported by pre- and post-tests, analysis of results and student learning gains, and reflections on connections among teaching, student learning, and personal professional growth (Girod and Girod 2006). The simulation provides a practice setting with simulated students that are based on real students (taken from the experience of former classroom teachers). In the simulated environment, users are able to repeat and modify their

teaching strategies and plans in a variety of grade levels and content areas. Interaction is in the form of choices, with feedback provided through documents and reports. Cues, prompts and personal notes encourage reflection during and following the simulation, and feedback is provided through impact of user decisions and actions on student learning. The TWS methodology is used for assessing teacher performance at about 30 US institutions that are part of the Renaissance TWS Group (http://www.wku.edu/rtwsc/), although the simulation itself is used only for practice of TWS skills.

ClassSim, an online simulation, focuses on training teachers for special needs students. (Ferry et al. 2004, 2005). The simulation uses virtual episodes in a kindergarten class setting with decision points for the teacher about lesson structure, classroom management, and interactions with students. Learning is supported with materials, online links and a reflection space. There is evidence that ClassSim contributes to the development of pre-service teachers' professional identities and to their skills in connecting theory to real-life practice (Carrington et al. 2011).

In one of few commercially available simulations for teacher training, the company Aten Inc. offers a stand-alone or web-based "Classroom Teacher Training 3D simulation" that contains branching scenarios in which student teachers make classroom management decisions, receive expert advice and view outcomes from their decisions. Learning modules cover various classroom situations (Aten Intelligent Educational Systems Inc. 2015).

Other simulations attempt to more accurately reproduce the experience of working in a classroom setting. SimSchool offers web-based practice experiences for pre-service teachers (Badiee and Kaufman 2014; Christensen et al. 2011; Gibson 2007). It uses screen shots of a classroom of up to 18 randomly generated, cartoon-character students seen from the teacher's position at the front of the room. Students have a range of cognitive abilities and personalities, including ESL and autism. The simulation dynamically generates learner behaviors in response to teacher actions, chosen from lists of possibilities that are based on a model of cognition, personality and communication theory. Recent studies have evaluated simSchool's effectiveness for general teaching practice (Badiee and Kaufman 2014; Deale and Pastore 2014), developing student teachers' self-efficacy (Christensen et al. 2011), pre-service teacher assessment (Gibson and Halverson 2004), and learning to work with diverse and special-needs student populations (McPherson et al. 2011; Rayner and Fluck 2014). These have indicated a range of positive learning outcomes for pre-service teachers after simSchool use, although users have questioned its realism.

TeachLivE [TLE] (http://teachlive.org) attempts to fully reproduce a classroom using a "mixed reality environment" that blends real and artificial content. Because suspension of disbelief (i.e., belief that the simulated environment is in some sense "real") is important for learner engagement in a simulation (Dede 2009), users teach in a physical classroom environment (or with a TV-cart display) with simulated student avatars operated as puppets by a trained human (Dieker et al. 2014). Classroom scenarios can be set up to teach specific skills and behaviors, and the system enables repeated practice. It is now used at 48 US universities. In addition to teaching general classroom management skills, it has been successfully used to train teachers of special-needs learners including severely autistic ones (Dieker et al. 2014). The puppetry approach allows a wider range of learner behaviors to be modeled without the need for full psychometric computational models.

Implementation Issues

Adopting simulations for teacher education is challenging. Ideally, simulation use should be based on a strong theoretical foundation, clear understanding of the behaviors to be practiced or assessed, a valid simulation model, enough realism to engage users and mechanisms for evaluation, feedback and debriefing. Cost and time constraints, as well as educators' reluctance to change teaching approaches, can be barriers, although these vary with simulation type and complexity. In universities, the choice to use simpler simulations such as role-plays is typically made by individual educators, at the cost of the professor's time to develop or source scenarios and to integrate them into classroom-based practice. Using standardized students involves additional costs for actors playing classroom roles. Finally, implementing computer-based simulation requires new investment in software and possibly hardware, instructor training and ongoing costs for technology support. One possibility for managing some of these costs has recently been introduced by simSchool, whose pricing options include per-user licensing fees that can be charged back to students.

Conclusions: Looking to the Future

While simulations are widely accepted in medical and health education, the examples we have cited in teacher education are often research prototypes used in experimental settings. Although role-plays are available for various specific training situations, only simSchool, TeachLive and Aten Inc.'s simulations appear to be widely distributed. However, these and the research examples show that simulations can serve as candidate assessment tools, provide opportunities to practice specific skills and interpersonal behaviors and help to develop dispositions to support effective teaching. In particular, they can be tools to augment practicum experience with a cycle of practice, feedback, reflection and repeated practice.

In addition to the possibilities identified here, simulations show promise as assessment tools for final certification and for teacher hiring (Kaufman and Ireland 2015) and as practice vehicles for professional development. While these are beyond the scope of this article, they complement the uses we have discussed. Also, technology advances promise greater realism, distributed access, and applications on mobile devices (e.g., Gibson 2013). Teacher education is likely to gain significantly as technology-supported teaching simulations become more sophisticated, more easily implemented, and more widely used.

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