Enhancing Student Affect From Multi-Classroom Simulation Games via Teacher Professional Development:

Supporting Game Implementation With the ROPD Model

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ABSTRACT

Educational simulations often require players to maintain a high degree of engagement for play in the simulation to continue. Student motivation and engagement is tied to affective factors, such as interest and self-efficacy. As such, game designs and teachers who implement them should promote student interest and self-efficacy in play. In this study, a responsive online professional development (ROPD) program was provided to teachers as they implemented a multi-classroom socio-scientific simulation game for middle school social studies classrooms called GlobalEd 2. A series of ANOVAs revealed that student affect toward the game and its content, including student interest and self-efficacy, was highest when their teachers likewise had a high degree of participation in the ROPD program. This evidence demonstrates the importance that ongoing implementation supports can have in classroom-based simulations and serious games and the benefits of ROPD in furthering the impact of simulation games.

KEYWORDS

Distance Learning, Engagement, Interest, Learning Analytics, Motivation, PBL, Problem-Based Learning, ROPD, Self-Efficacy, Serious Games, Simulation Games, Teacher Professional Development

INTRODUCTION

Simulations and serious games have been repeatedly demonstrated as useful and highly engaging learning activities when used in a classroom setting (Boyle et al., 2016; Connoly et al., 2012; Young et al., 2012; Vlachopoulos & Makri, 2017). With the advent of ubiquitous digital technologies and communications services, simulation games and other learning environments that are modeled to realistically mirror real-world interactions and complex systems are experiencing a renaissance as a viable student-centered approach to learning (Bednar et al., 1992; Jonassen, 2009; Strobel & van

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Barneveld, 2009). Because highly interactive simulations and serious games can be increasingly supported with digital technologies to connect players across time and geography, the possibilities of simulations to impact students in an engaging way today is quite promising (Chinn & Malhotra, 2002; Mergendoller et al., 2000; Taber, 2008; Zhonggen, 2019).

However, when implemented in a classroom setting, how teachers implement simulation games can influence the outcomes of the game. Educational simulations are often designed based on theories of learning with which certain outcomes are expected based on how students interact within the activity. As teachers are ultimately the facilitators of simulations with students, it is important from a design standpoint that teachers implement simulations in ways that adhere to the intentions of the designers and align with the underlying learning principles upon which the simulation has been designed. This is not to say that teachers should not flexibly implement or adapt simulations to meet the specific needs of their classrooms. Instead, teachers should be supported in their implementation of simulations with robust professional development programs, in part to understand how and why certain elements were designed in the game, as well as whether the expected outcomes of each activity are implemented to ensure that the simulation provides its intended educational benefits (Fishman et al., 2003; Hochberg & Desimone, 2010; Riel, 2020).

This study investigates student affective outcomes from playing a classroom-based simulation game called GlobalEd 2 in relation to their teacher's participation in a responsive ongoing professional development program (ROPD) to support their implementation of GlobalEd 2. Teachers participated in the ROPD in real time as they implemented GlobalEd 2, with the ROPD intended to support teachers with any challenges that emerged as students were playing the simulation. The primary benefit of an ROPD program is to maximize the benefit of any kind of curricular intervention by providing regular information, support, and coaching to teachers. As a result, it is expected that teachers would have a higher degree of implementation and engagement with the simulation, which would extend to students.

The study hypothesized that teachers' higher levels of participation in ROPD to support their implementation of the GlobalEd simulation game would be positively related to higher levels of student affect related to simulation play. By increasing teachers' engagement with and implementation of the simulation game in their classroom, the authors expected that the regular ROPD participation would subsequently (but indirectly) promote higher levels of interest, self-efficacy, and motivation among students as a result of their teacher's engagement with the ROPD.

BACKGROUND

The Importance of Student Affect in Student-Centered Learning and Simulations

Simulations and serious games are not newcomers to the classroom as a result of the networked age. Since the 1960s, computer-based simulations have been used extensively in medical fields and other high-skilled professions where tasks and activities can be realistically modeled according to real-life rules, physics, and structure (Gorbanev et al., 2017; Issenberg et al., 2005; Rutten, Van Joolingen, & Van Der Veen, 2012; Heitzman et al., 2019). Social processes have also commonly been modeled within simulations for educational purposes, such as political processes, governance and policy making, elections, and international relations (Asal & Blake, 2006; DiCamillo & Gradwell, 2013; Lean et al., 2006; Vlachopoulos & Makri, 2017). With the advent of networked web technologies, the number of educational possibilities of digitally mediated simulations have dramatically increased via large numbers of players, immediate feedback, and real-time analytics about learner behaviors (Lawless & Riel, 2020).

Simulation games are a subset of a larger group of classroom interventions that can be classified as "student centered." Student-centered activities are those in which students primarily determine their own activities and outcomes and the flow of activities occurs only in response to students' interests, interactions, and ongoing play (Driver, Leach, Millar, & Scott, 1996; Osborne, Erduran, & Simon, 2004; Turner, 2008). Meeting students' affective needs while playing a student-centered game or simulation is a critical challenge for any teacher implementing such activities, as students who are not engaged with a simulation or student-centered environment, it will likely have little to no effect (Ertmer & Simons, 2006; Jonassen, 2009; Lamb, Anetta, Firestone, & Etopio, 2018; Strobel & van Barneveld, 2009).

One such affective factor that is known to influence student engagement is *interest*. A student's perceived level of interest about a subject, as well as interest in the activities they are asked to perform play a substantial role in whether the student will be motivated to participate (den Brok, Brecklemans, & Wubbles, 2004; Skinner et al., 2008; Speering & Rennie, 1996). Interest is an essential affective trait that students must have for any given learning task, including simulation games. Simulations and serious games have repeatedly observed higher levels of student interest because of several reasons, including the unique nature of the game-like interface in comparison to more rote-and-drill type learning activities, a low risk of failure, and an emphasis on open play and role taking (Jonassen, 2009; Singh, Granville, & Dika, 2002; Strobel & van Barneveld, 2009). However, students are always at risk of waning levels of interest as games become stale and interactions become less exciting, or if the game simply fails to stay fun (Imlig-Iten, & Petko, 2018; Younis, 2017).

Similar to interest, a student's level of *self-efficacy* is likewise a critical affective factor that plays a role in student participation and benefit in simulations and serious games. Within any learning activity (including simulation games), a student has to perform a variety of tasks to complete any given objectives. A student's level of self-efficacy, or the level of confidence a student has in performing a given task, has a strong bearing on whether a student will be motivated to perform the task (Gilbert, Voelkel, & Johnson, 2018; Ketelhut, 2007; Martin & Rimm-Kaufman, 2015). In other words, students who do not think they can do it will be less likely or less motivated to even try.

The concept of self-efficacy is particularly important for simulation games in the classroom, as a simulation attempts to model the real-life thinking, skills, and processes that a student is attempting to learn (Fredricks, Blumenfeld, & Paris, 2004; Lamb, Anetta, Firestone, & Etopio, 2018; Tuckman & Sexton, 1991; Siegle & McCoach, 2007). A high degree of self-efficacy not only increases their motivation for continued play through perceived impact, confidence, and effectiveness at playing the game well, but also improves their confidence and perceived ability to perform the same modeled actions in the simulation in other contexts, which is what the simulation game is attempting to achieve (den Brok, Brecklemans, & Wubbles, 2004; Falloon, 2020; Kuipers et al., 2017; Zapko, Ferranto, Blasiman, & Shelestak, 2018). Therefore, it is imperative that a student develop their sense of self-efficacy while playing a simulation game for learning purposes. The affect, attitude, and emotion held by students about any educational activity are important for teachers to monitor and continually develop for the activity to succeed (Dunlap, 2005; Skinner et al., 2008).

Supporting Teachers' Implementation of Classroom Simulations and Games

Student-centered pedagogies have been repeatedly demonstrated to positively develop student affect, problem-solving skills, critical thinking, inquiry, and ability to synthesize information across domains with far greater impact than conventional approaches like lecture and rote memorization (Jonassen, 2009; Koschmann et al., 1996; Mergendoller et al., 2000). However, by giving control and agency to students to take control of their own learning, the educational environment becomes more open-ended by design (Ertmer & Simons, 2006). As a result, many teachers have expressed a degree of unpreparedness of implementing student-driven curricula for the first time, and likewise express a strong desire for long-term support while they learn how to implement new pedagogical strategies and teaching roles in the classroom (Fischer & Dershimer, 2020; Oliver & Stallings, 2014; Riel, Lawless, & Brown, 2016; Theelen, Van den Beemt, & den Brok, 2019).

The implementation of interactive classroom simulations requires a special subset of pedagogical skills on part of teachers to facilitate high-energy, sustained play (Oliver & Stallings, 2014). These pedagogical approaches differ from conventional lecture or drill work, which include facilitating student inquiry, guiding student information gathering and synthesis skills, and coaching students to stay on task and meet expected milestones (Ertmer & Simons, 2006). Within simulations and classroom games, there is a critical importance on keeping students engaged and participating in the activities of the game, as the students are those who primarily determine their own learning paths. Because of this, engagement and participation have been repeatedly demonstrated to be related to students' affective states in many ways (den Brok, Brecklemans, & Wubbles, 2004).

Simulations, games, and other interactive curricula must also account for and seek to maintain a high level of student affect while they participate via the design of the learning activities that are within the game's design (Lamb et al., 2018). Such design elements that can foster positive student affect include the simulation rules, interaction expectations between players, scheduled events, expected behaviors and tasks of players, and the objectives or conditions for victory with which students use to plan their actions. Students must have a strong sense that playing the simulation will be fruitful and that their actions will have an impact. As with any game, this reasoning is intuitive from a design perspective, as a player will likely quit a game when they are not winning, or if it seems hopeless to keep playing without much perceived ability to impact the game.

It can then be reasonably hypothesized that a teacher who implements a simulation with high levels of enthusiasm and confidence will likely foster higher levels of interest and engagement among their students (Lamb et al., 2018; Skinner et al., 2008; Wubbels & Brecklemans, 2008). Conversely, low levels of interest and engagement on part of the teacher could be expected to promote low levels of student affect toward the simulation and its subject content (den Brok, Brecklemans, & Wubbles, 2004; Oliver & Stallings, 2014).

Teacher professional development programs are frequently used to prepare teachers to facilitate interactive, student-driven classroom activities (Guskey, 2000; Hochberg & Desimone, 2010; Marrongelle, Sztajn, & Smith, 2013). One form of teacher professional development that has been specifically designed for supporting teachers who are implementing novel curricular designs is *responsive ongoing professional development,* or ROPD (Flint, Zisook, & Fisher, 2011; Riel, Lawless, & Brown, 2017). In ROPD, a dedicated support team typically consisting of the designers of the curriculum or game, as well as disciplinary and pedagogical experts, support teachers' real-time implementation of new activities simultaneously with the teachers' participation in ROPD. Thus, ongoing supports and reflective opportunities like ROPD can provide guidance to teachers to ensure than any adaptations made during implementation align with the underlying expected outcomes as designed by the game designers (Gikandi, 2013; Hoban & Hastings, 2006; Riel, Lawless, & Brown, 2017; Riel, 2020).

Gaps in the Literature: Identifying Links between ROPD and Student Affect

There is a growing body of literature that highlights the benefits of simulation games and serious games toward promoting student knowledge and inquiry skills that are transferrable to other contexts (Baptista & Oliveira, 2019; Boyle et al., 2016; Connoly et al., 2012; Young et al., 2012; Zhonggen, 2019). However, the literature currently lacks investigations into the effects of how student-centered interventions, such as simulations, are implemented in the classroom in various ways, as well as how novel interventions can be supported with professional development programs (Barker, Nugent, & Grandgenett, 2014; Dane & Schneider, 1998; Fischer & Dershimer, 2020; O'Donnell, 2008). As teachers are the ultimate implementers of any classroom-based simulation game, it is important to understand the influence that teacher practice, teacher professional development support, and local classroom play has on the intended student outcomes from the game designers (Fischer & Dershimer, 2020; Fishman et al., 2003; Theelen, Van den Beemt, & den Brok, 2019; Vartulli & Rohs, 2009; Wayne et al., 2008).

The goal of this study was to examine whether teacher participation in an ROPD program intended to increase teachers' implementation of a simulation game had any benefit toward student affect toward science and social studies by using simulation games. To investigate this, the present study examined teacher implementation of GlobalEd, a classroom-based simulation game for middle-school social studies students. The simulation hosts multiple simultaneous participants using a web-based communications platform to facilitate dialogue among participants and to model problem-solving approaches to real-world challenges.

Specifically, the authors investigated whether a teacher who is more invested in the implementation of a classroom-based simulation, as evidenced via participation in a voluntary ROPD program, had any observable links to higher levels of affect in their students regarding the simulation game being played. This study benefits the field by identifying processes that can positively influence student interest, self-efficacy, and engagement during the classroom play of a student-centered simulation. Such positive student experiences as a result of play can improve the benefits of simulations to increase student knowledge, skills, and later interest in STEM subjects and careers.

The goals discussed above informed the following research questions:

RQ1: Was there any variation in the frequency and patterns of teachers' use of the ROPD program designed to support classroom implementation of and teacher engagement with the GlobalEd simulation game?

RQ2: Do higher levels of teacher ROPD participation over a 14-week period during simultaneous implementation of the GlobalEd simulation game have a positive effect on the levels of student affective factors of self-efficacy and interest in science and social studies content after the simulation?

METHODS

The GlobalEd 2 Simulation Game: The Context of The Study

The context of this study is GlobalEd 2 (GE2, www.globaled2.com), a multi-classroom social studies simulation game that centers on student-developed solutions to real-world socioscientific problems (Lawless et al., 2018). The simulation promotes socio-scientific literacy by developing student skills in research, information literacy and scientific argumentation as students apply social studies and science knowledge to develop solutions to a given *problem scenario* in the simulation (Anderson, 2002; NRC, 1996; Sadler, 2009). Previous problem scenarios for students have included global crises such as severe regional fresh-water scarcity, global food security, large-scale oceanic oil spills, and disastrous effects related to climate change.

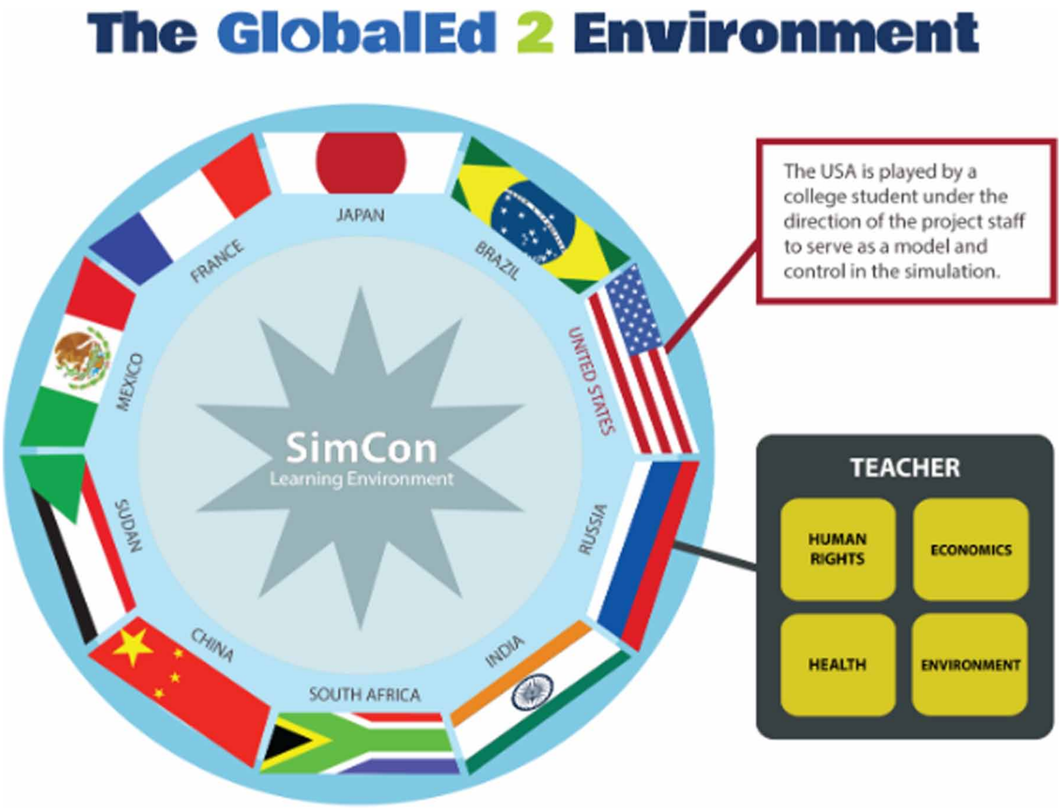
Students within each classroom play the role scientific advisors for an assigned country. They are then tasked with representing their country's interests at a simulated international summit that is convened to solve the given simulation problem scenario. Between 14 and 20 countries and their student delegates "attend" each simulation, representing classrooms that are spread out geographically, but meet regularly in a digital space to discuss the problem scenario and develop solutions. All students are expected to maintain realistic roleplay of their country throughout the simulation, including use of diplomatic language, consideration of geopolitical and economic realities, history, and alliances with other countries. Figure 1 provides a graphic illustration of a GE2 simulation.

The GE2 simulation is conducted over three phases. Figure 2 provides a graphical summary of each of the three GE2 phases.

In the first phase, the *research phase,* students conduct a collaborative deep investigation within their classroom about their assigned country, including its history, economy, policies, neighbors in the region, and likely positions held by the country related to the problem scenario. Students use web-based resources and search engines to find and synthesize information about their assigned country in relation to the given problem scenario.

After initial research, the second *interactive phase* begins. This phase typically lasts four to six weeks as country delegates interact with one another using an online simulation communications

Figure 1. The GlobalEd 2 Simulation Environment



platform. Students debate with other participant "countries" in the interactive phase both asynchronously via an email-like messaging system, and synchronously during scheduled live conferences in which all participants attend to discuss issues related to the simulation.

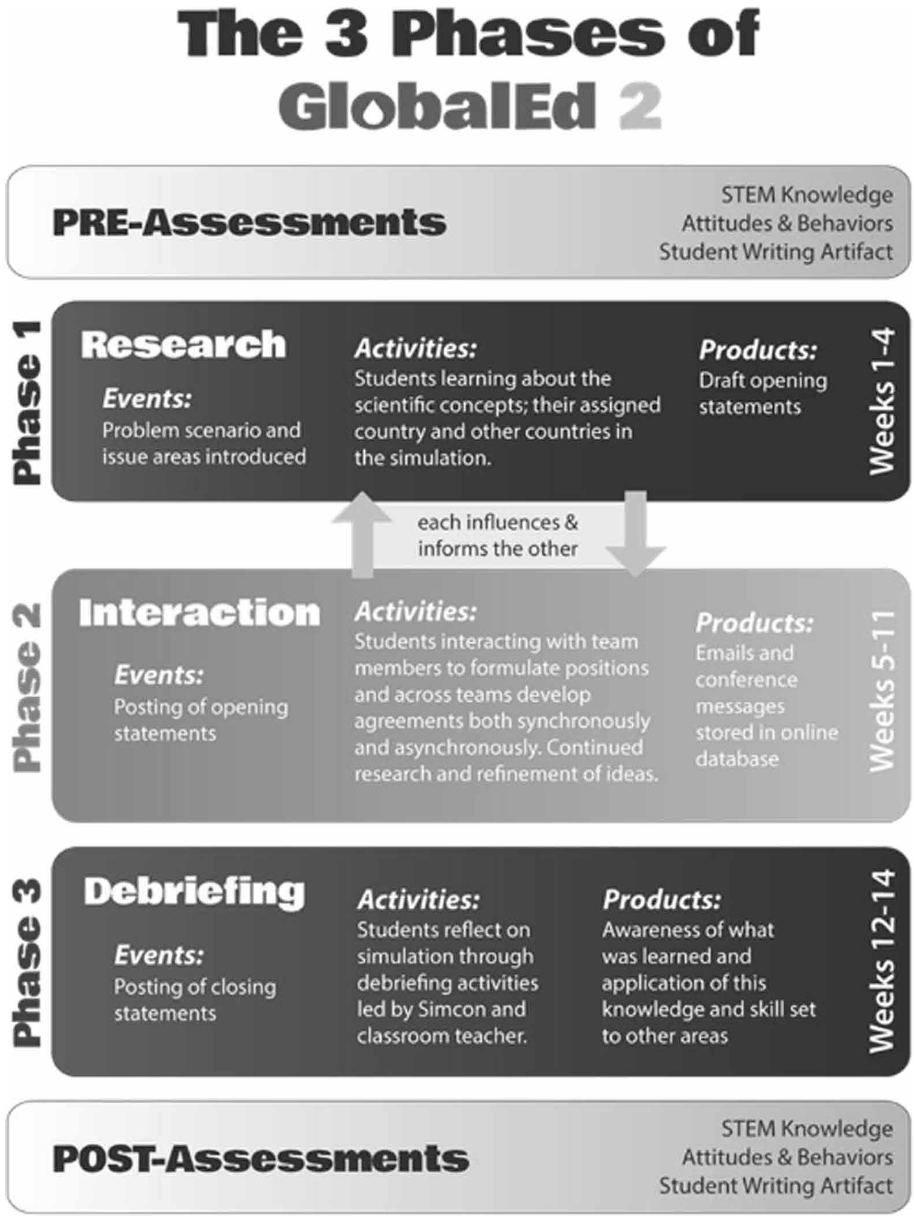
Finally, the simulation concludes with the *debriefing phase*. Each student group prepares a final proposal and submits it to all participants. Students vote on proposals and the proposals that receive the most votes win the game. During this debriefing phase, students also reflect on their experience in the simulation and consider how the skills that they developed during the game can be used in other contexts.

Digital and Face-to-Face Interactions in the Simulation

Multiple levels of social interactions occur both offline and via the web-based simulation software. This multi-modal approach affords students with contexts to explore, debate, and apply science and social studies concepts to authentic problems with varying opinions and solutions. First, students within a classroom work face-to-face within small groups to research their country and develop and refine the positions of their country as the simulation progresses.

Second, each student has an individual login account to interact in the simulation's online communications platform to share, discuss, propose, and vote on ideas to solve the given problem scenario while playing the role of their assigned country. For most of the simulation, students submit messages asynchronously to other countries within this communications platform as they debate and cooperatively investigate the feasibility of solutions to the problem scenario. However, scheduled *live conferences* are also an opportunity for students to meet together and collaboratively discuss issues

Figure 2. The three phases of GlobalEd 2 simulations



related to the problem scenario. All messages are moderated by a simulation staff member called *simcon*, who maintains decorum with the students and provides coaching to students on their use of diplomatic language and argumentation skills.

GE2 ROPD Program

A long-term ROPD program (Riel, Lawless, & Brown, 2017) was provided to teachers in real time as they implemented the GE2 simulation. The ROPD operated as weekly cycles of feedback and support between teachers and project staff, with each week beginning with an email bulletin that contained curricular and teaching resources and scheduled milestone reminders for teachers to prepare for each week.

Each week, teachers were sent an email news bulletin about upcoming activities and milestones in the simulation, as well as resources to support implementation. Emails were developed in HTML and delivered with Mailchimp (mailchimp.com). Weekly emails were the primary tool for responding to teachers' expressed needs as they were actively implementing the simulation, including materials such as (1) important notices about upcoming milestones, (2) updates on student activity from within the simulation, and (3) resources, podcasts, worksheets, and curricular materials to help teachers with each week's implementation of the simulation. The Mailchimp system includes a robust digital usage analytics package, allowing the researchers to identify how each teacher used the weekly emails. Figure 3 provides a screenshot of an example teacher email bulletin.

After each week, teachers also completed a weekly journal. The journal served as an opportunity for teachers to (1) reflect on their previous week and evaluate whether their goals were met, (2) plan their next week, and (3) communicate with simulation staff on any challenges that they had experienced and subsequently ask for supportive resources. Simulation staff then conducted a needs analysis by reviewing each journal entry each week to identify opportunities for supporting teachers' implementation of the simulation. New supportive resources for teachers would be then included in

Figure 3. Screenshot of sample email bulletin

the next email bulletin for teachers to use in their classroom. In Figure 4, a screenshot of the teacher journaling system is provided.

The cyclical nature of ROPD consisted of an email bulletin with supportive resources and information for the upcoming week, then teachers completed the journal entry to provide an opportunity for reflection and communicating needs.

Participants

16 middle school social studies teachers from the United States volunteered to teach using the GE2 simulation for one semester. Each teacher also simultaneously participated in the GE2 ROPD to support their implementation over the 14-week simulation period. Eight of the teachers were from a large urban school district in the U.S. Midwest, while the other eight teachers were from multiple suburban school districts from the U.S. Northeast. This purposive sampling allowed for a more accurate snapshot of the U.S. public schools system and the implementation of simulations in schools representing varying population densities. Teachers were recruited over the Internet using social media outreach and direct communications to eligible schools. Teachers were provided with a small stipend for participating in the GE2 ROPD program.

The 16 teacher each taught one social studies classroom using the GE2 simulation for one 14-week semester. Within all classrooms, a total of 315 middle school students (i.e., 7th-8th grade) played the GE2 simulation for the semester. Students in all classrooms using GE2 had access to four iPad tablets that were provided by the GE2 game staff, in addition to any classroom technology already present in each class.

Data and Procedures

Measuring Teacher ROPD Participation/Engagement

In this study, the level of participation with the GE2 ROPD activities were conceptually defined as the level of effort demonstrated by completing increasingly complicated tasks within each activity.

For each week over the 14-week period, teachers' participation with the email bulletins and teacher journals were scored on a scale of 0 to 3 based on increasing levels of effort on part of the teacher with activities for each week. The rubrics used for calculating teacher ROPD participation for each week are presented in Table 1. A score of 0 indicated no participation/effort with the activity and a score of 3 indicated the maximum level of effort as recorded on the scale. Each successive level on the scale represented more effort than the previous levels. The rubrics were developed prior to scoring.

For teacher participation in the weekly email bulletins, increasing levels of effort were observed via higher levels of interaction with elements within each week's email. Each email contained a selection of resources for implementing the simulation, lesson plans and curricular resources, time-sensitive URLs, and references to the project calendar about upcoming scheduled milestones and activities in

Table 1. Teacher ROPD weekly email bulletin and weekly journaling participation score rubrics

Score	Email Criteria	Teacher Journal Criteria
0	Did not open at all	Did not complete journal at all
1	Only opened the email, no additional interaction	Completed journal late
2	Opened multiple times (denotes multiple user sessions) OR clicked on 1-2 unique links (links tracked via unique URLS)	Completed journal on time, but was incomplete
3	Clicked on more than 2 unique links	Completed journal on time, and fully completed all fields

Note: *Scores at higher levels require more effort and build upon previous levels.*

the simulation. The frequency of email clicks and identifying whether the email bulletin each week was opened were analyzed, with an increasing number of click interactions representing more effort.

For participation with the weekly teacher journals, each participant was asked to submit on-time entries to their journal every Friday on a weekly basis. As such, progressive levels of effort were represented by (a) whether or not entries were completed, as some participants never completed journals for some weeks; (b) on the timeliness of the entry, with an on-time entry each week having priority over a late-submitted journal; and (c) if teachers submitted more than one journal at a time for past weeks to make up for previous journal entries that were not submitted. Each week, teachers were reminded about missing journal entries during the week following a missing entry, so it was reasonable and desirable for teachers to "catch up" on entries to increase their engagement with implementing the simulation in their classroom.

It was not the goal of the researchers to evaluate the email bulletin and weekly journal interactions in ways that determined whether the interactions and entries were correct or "good." Instead, a stance was taken to identify the ways of simply *how* teachers interacted with the email bulletins and journal entries at varying levels of frequency, and which actions with these activities required more effort than others.

Overall ROPD Participation Composite Score

The primary teacher variable in this study examined teachers' level of ROPD participation with both email bulletins and teacher journals. A composite score combining the participation scores from each ROPD activity for each week was calculated. Both the weekly email bulletin and weekly journaling participation scores were combined for this measure.

The composite participation score was generated in three steps. First, a *weekly score* was calculated consisting of the sum of each teacher's email bulletin and weekly journaling participation scores for a given week. This yielded 14 email weekly scores and 14 journaling weekly scores for each participant. Second, a *14-week activity score* was generated representing the entire 14-week period for each activity. This yields two variables, one for each of the email bulletin and the weekly journaling activities. For email, this was computed as the mean of the combined 14 weeks of each activity (i.e., 14-week email score and 14-week journaling score). Using mean scores allowed for teachers to have a "bad week" or two on occasion in which a highly participating teacher might have a low scoring week. Using the mean would provide a more accurate level of participation over time instead of using raw scores.

The third step was to generate a single *composite score* for each teacher. This indicated the teachers' overall ROPD participation as they implemented the GlobalEd simulation. This was computed by combining the two 14-week combined activity scores (i.e., email and journals). Summing the scores yielded a scale with a minimum of 0 and maximum of 6.

For additional ease of interpretation, teacher composite scores were subsequently recoded to create categories based on quartile. Teachers scoring 0 to 4 (i.e., the bottom 0-25th percentiles) were considered as a "low" participating teacher, those scoring a 5 (i.e., the 26-75th percentiles and the median score) were considered as a "moderate/average" participating teacher, and those scoring a 6 were considered (i.e., top 76-100th percentiles) were considered as "high" participating teachers. As such, the highest and lowest participation scores represented the top and bottom quartiles of the distribution, respectively.

Measuring Student Affect: Interest and Self-Efficacy

Two of the desired affective outcomes of the GE2 simulation was to instill a deep sense of student interest and self-efficacy in social studies and science topics. As the problems that students solve in GE2 are based on real-world socio-scientific issues, it was the hope of the designers that students would simultaneously develop an interest in and perceived ability to perform tasks within these domains.

In addition, students were also supported in their development of the special skills associated with playing the simulation itself, such as the problem-based learning skills upon which interactions in the simulation were based. These skills include critical thinking, problem solving, information research and synthesis, web searching skills, and argumentative dialogue by using appropriately linked claims, evidence, and reasoning.

At both the beginning and the conclusion of the 14-week simulation implementation period, students who played the GE2 simulation were given assessments that captured aspects of students' affective traits. Identical assessments were administered to all students at both the beginning and end of the simulation (i.e., pre-post design). These assessments used five-point Likert-type scales to ask students to rate their perceived levels of interest and self-efficacy on six separate items related to science, social studies, and the types of skills they used in the simulation game. Items within each of the six categories were combined into a summative scale, with high internal reliability (i.e., Cronbach's Alpha > .9 for each category). Table 2 provides a description of each of the six scales used to measure student affect.

RESULTS

Teacher ROPD Participation and Simulation Implementation Engagement

To answer Research Question 1 regarding the teachers' frequency and patterns of participation in the ROPD, time series were plotted of the mean scores for each category of teachers' ROPD over the 14-week simulation implementation period. As participation in the ROPD program simultaneously with implementation of the GlobalEd 2 simulation is likely indicative of an increased level of engagement on part of the teacher, an examination of the sustained level of ROPD participation is useful toward understanding how teachers can stay engaged when implementing a long-term simulation game. This is especially the case for the GlobalEd simulation, which facilitates interactions between multiple classrooms via the online simulation software and can be overwhelming to teachers who are new to implementing such media.

Figure 5 illustrates the time series of the mean weekly email bulletin scores for teachers, as grouped by their 14-week activity score. For the email bulletin, there were 6 participants who were in the "high" participation category (i.e., top quartile), 9 participants who were in the "moderate" participation category (i.e., middle two quartiles), and 1 teacher who was in the "low" participation category. Although the figure shows only 12 weeks, it represents a 14-week period due to no email bulletin being sent during the weeks during and after the U.S. Thanksgiving holiday (i.e., weeks 12 and 13). For the purposes of time series continuity, week 14 was labeled as week 12 for the time series in Figure 3.

The trend lines along the email time series illustrate that teachers who were implementing the GlobalEd simulation game varied in their mean weekly ROPD participation, including those in the "high" category of participation. In other words, membership in the "high" participation category did not necessarily indicate that participation in the ROPD was *consistently* high throughout the entire

Table 2. Student affect scales: Interest and self-efficacy

Name
Social studies topics and skills self-efficacy
Social studies topics interest
Science topics and skills self-efficacy
Science topics interest
Science career interest
Problem-based learning skills self-efficacy (i.e., the skills used within the simulation

14-week simulation game. Teachers participated in the ROPD at varying levels, and likely reflected spikes and falls in teachers' level of engagement with the simulation in their classroom.

Similar to the time series of teacher email bulletin use, Figure 6 illustrates the time series for the weekly reflective teacher journaling participation scores. This uses the same group assignment of high-moderate-low participation categories as the email bulletin, representing membership in quartiles. 6 teachers were in the "high" participation category, 7 teachers were assigned to the "moderate" category (representing those closest to the middle two quartiles), and 3 teachers were in the "low" participation category.

It is important that in comparison to the email bulletins, for the teacher journaling activity there are two additional weeks in the analysis. This is due to no bulletins being sent to teachers for two holiday weeks, but the journaling activity was still active during this time and teachers were still asked to complete their journaling for every week. Thus, the time series in Figure 4 spans the entire 14-week period of the GlobalEd simulation implementation.

Of additional interest, Figure 6 also illustrates a "holiday dropoff," with downward trends around week 12 for all groups. This is an important trend to be aware of for any classroom-based simulation game or serious game, especially if any milestones or objectives are to be completed around scheduled holidays.

Compared to the email bulletin, teachers' level of participation trend lines in the teacher journaling activity were more closely mirrored between the participation level groups (i.e., low-moderate-high).

Figure 4. Screenshot of teacher journaling interface

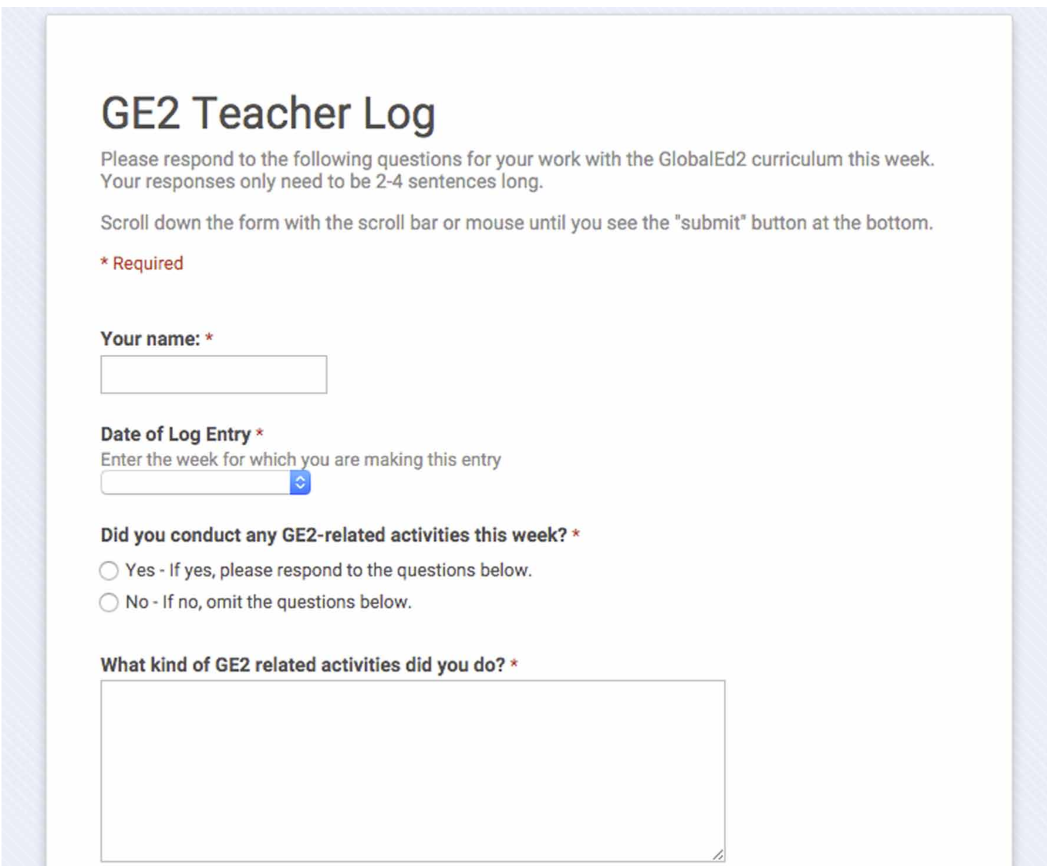
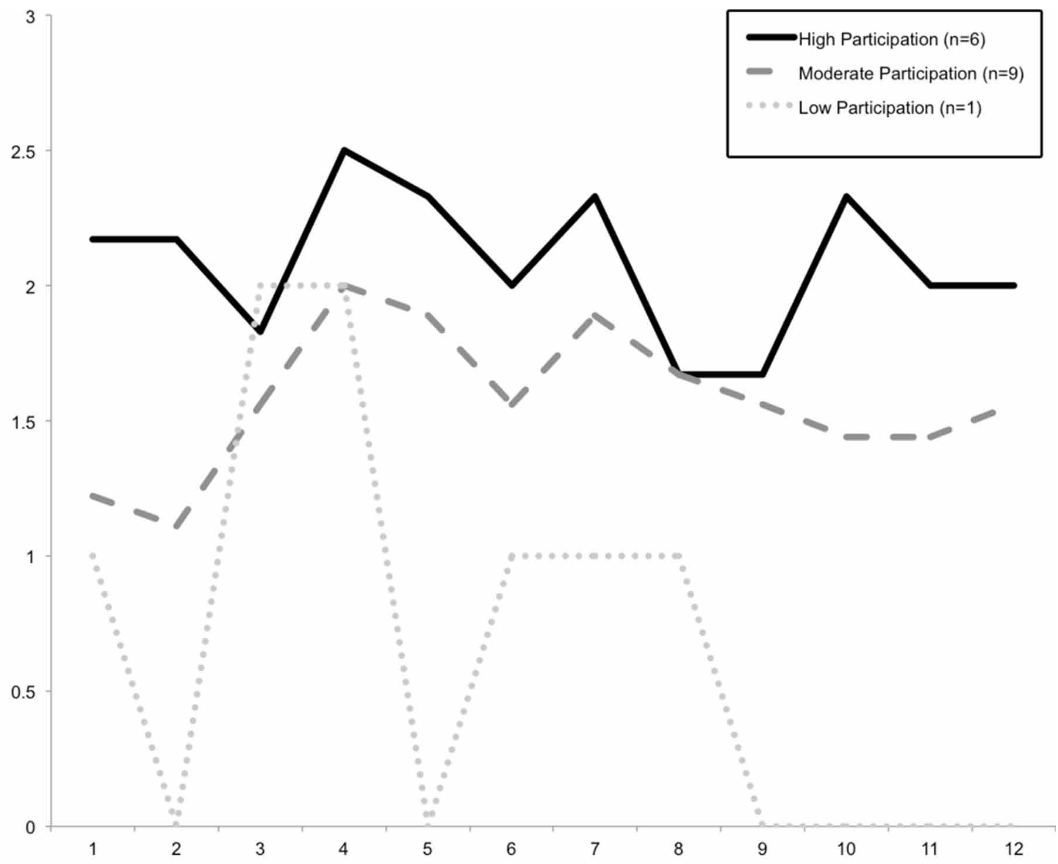


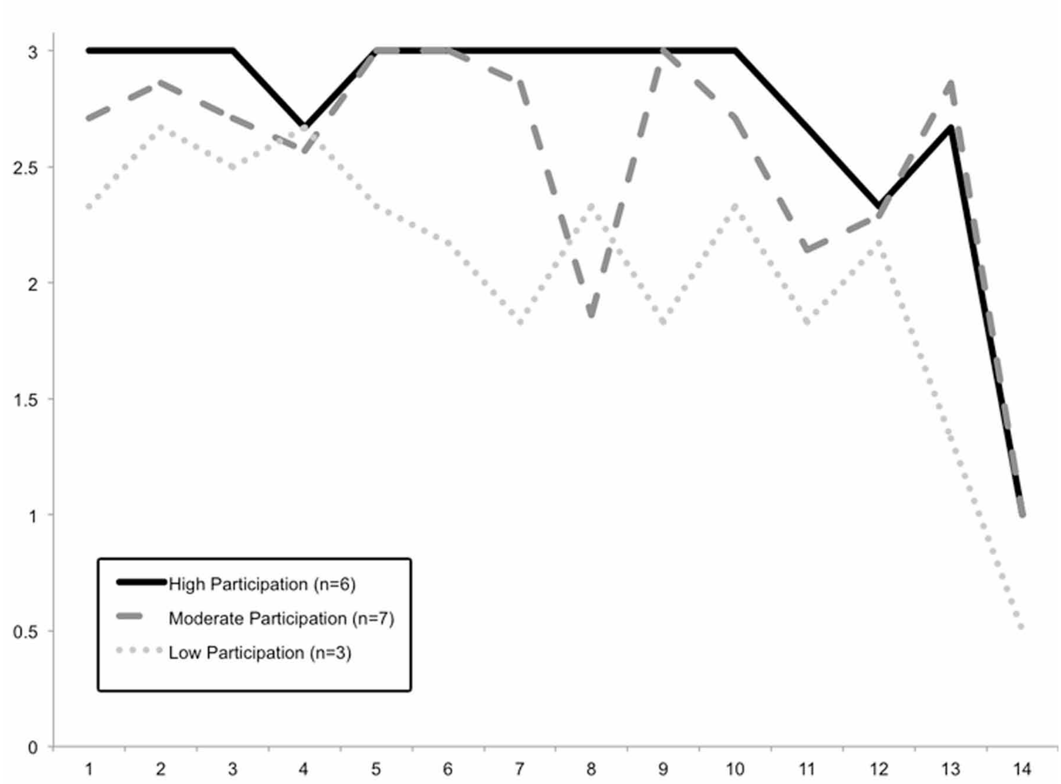
Figure 5. Time series of mean weekly participation scores for email bulletins, grouped by 14-week activity score



For the highest level of participation, the mean weekly scores were consistently at their highest possible outcome during most of the simulation implementation timeframe. The mostly flat solid black line in Figure 6 for the high participating group illustrates this well. This contrasts with the highest performers with the email bulletin in Figure 5, where the "high" participating group exhibited a much higher degree of variation in their mean scores across weeks. In the case of GlobalEd, the support staff regularly reminded participating teachers to complete their teacher journals if they were not yet completed for a given week and thus repeatedly encouraged teacher engagement throughout the simulation using multiple points of contact: teachers received reminders to complete logs, email bulletins with information about upcoming events and resources, and teachers navigated the regularly scheduled simulation milestones, multi-classroom conferences, and activities that all student participants were expected to complete.

There are some additional features worth mentioning that additionally provide evidence for linking teachers' ROPD participation with their level of engagement in implementing the GlobalEd simulation in their classroom. First, around week 4, there is an increase in participation among all teacher groups (low-moderate-high) with both email bulletins and teacher journals. This is attributed to requirements in the simulation to shift activities and for students to become more active in the online simulation software. As students began to increase the frequency of their interactions in the online simulation environment, teachers shifted their role from being facilitators of student research to supporting students' interaction with others in the online environment. This included helping students to craft written messages, support student inquiry and questioning, conducting further research

Figure 6. Time series of mean weekly participation scores for teacher logs, grouped by 14-week activity score



as topics were discussed in the simulation, preparing for synchronous conferences, and preparing proposals to the simulation problem scenario.

New simulation activities could have triggered a renewed interest among teachers in the ROPD program to learn more about the new types of activities and how to complete them satisfactorily. These observed spikes in participation within the ROPD might be signals that teachers renewed their attention, as the required pedagogical strategies for implementing the simulation had shifted and that additional resources were sought by teachers.

Similar to the spikes in ROPD participation as a result of a shift in the simulation activities, the effects of longer, more drawn out timespans can also be seen. The "middle time" of a simulation game between the simulation's rapid and high-energy opening and its sometimes-frenetic conclusion can be one of the toughest points to keep people energized as the novelty of activities wear off. In both the email bulletins and teacher journaling between weeks 4 and 10, this period represented six weeks of general interactions between students in the simulation. Although there were some scheduled events within the simulation to keep up interest, a drop off can be observed as activities become repetitive.

Teacher ROPD Participation and Student Affect in Simulation Games

After reviewing the fluctuations of the levels of teacher participation in an ROPD designed to support implementation of a classroom-based simulation game, the second stage of this analysis focused on identifying connections between ROPD participation and student interest and self-efficacy related to the game and its content. As seen in the descriptive time series in Figures 5 and 6 above, for all three participation levels (low-moderate-high), teachers all experienced similar patterns of spikes and drops, albeit at different mean levels. This is noteworthy, as it shows that the design of the simulation likely drives participation in an ROPD to support teachers, and ROPD might also help to drive continued high-impact implementation of the simulation.

An analysis of the level of ROPD participation on student affect provides evidence on the effect that an ROPD program has on teachers' implementation of and engagement with a simulation game in their classroom. ROPD intended to improve teachers' engagement with a simulation game in their classroom can then have an indirect impact on students' level of affect regarding the game and its content.

To investigate these relationships from Research Question 2, a series of ANOVA analyses were performed. Student affective growth was measured as the gain observed on identical affective assessments given to students (posttest - pretest).

Table 3 describes the series of individual ANOVA tests on the six student affective outcomes with mean comparisons using Tukey post-hoc tests with Bonferroni corrections. Students were divided into three groups for ANOVA comparison based on their teacher's overall level of participation in the ROPD program (i.e., the *composite* participation score for their teacher). Three ANOVA models had significant mean differences: science self-efficacy ($F(2,283)=5.482$, $p < .005$), science career interest ($F(2,283)=6.352$, $p < .002$), and self-efficacy in the simulation's required problem-based learning skills ($F(2,283)=3.481$, $p < .032$).

Post-hoc comparisons between the high, moderate, and low participation groups for each affective measure were also examined. As illustrated in Table 3, significant (i.e., $p < .05$) post-hoc differences are indicated in parentheses if there was a significant difference observed between categories within an affective item based on teachers' level of ROPD participation. Each parenthesis set indicates the category number(s) for which there was a significant difference. For example, in *science self-efficacy* for the high participation teachers (group 3), there was a significant mean difference observed between the high participation teachers group and group 2, indicated by parentheses group number (2).

The post-hoc comparisons between ROPD participation level of students' teachers revealed positive effect trends of ROPD participation on student affect on all of the science-related affective items, as well as the simulation's problem-based learning skills self-efficacy, which represented the types of problem solving, inquiry, and self-regulation skills that students needed to perform to play the GlobalEd simulation game. For the *science self-efficacy, science interest, science career interest,* and *problem-based learning skills self-efficacy* items, a positive trend is observed with the lowest mean student gain scores appearing within the "low" ROPD participation teacher category. In other words, for students whose teachers participated in the ROPD at higher levels, they had demonstrated

Table 3. ANOVA series of mean gain scores (pretest - posttest) of GE2 students on affective scales. Grouped by teacher composite participation score

Teacher Composite Participation Score	Social Studies Self-Efficacy	Social Studies Interest	Science Self-Efficacy*	Science Interest	Science Career Interest*	PBL Skills Self-Efficacy*
Group 1. Low ROPD Participation Teacher (score = 1)	-0.0325	0.0274	-0.2760 (2, 3)	-0.2193	-0.1730 (3)	-0.1542 (3)
Group 2. Moderate ROPD Participation Teacher (score = 2)	-0.1195	-0.2877	-0.0094 (2)	-0.0356	0.0506 (3)	-0.0666
Group 3. High ROPD Participation Teacher (score = 3)	0.1400	0.1500	0.1450 (1)	0.719	0.3451 (1, 2)	0.1425 (1)

*p < .05 for ANOVA model. Significant post-hoc participation group comparisons at p < .05 indicated in brackets. Example: [2] in a cell indicates a significant post-hoc difference between the given group and group 2 within the column.

higher affective gains on these items. In addition, negative mean scores indicated a lower response on the post-test compared to the pre-test (or a loss of interest/affect).

CONCLUSION

In this study, the authors assumed that students' affective states are ultimately influenced by the level of effort that a teacher dedicates to the classroom implementation of simulation games, as well as the design of the simulation activities. ROPD programs like that of the GE2 ROPD are intended to support teachers' implementation of simulations in real time, as well as to help teachers maintain a high level of engagement with the simulation.

In light of these assumptions, the authors hypothesized that a high level of teacher engagement with implementing a simulation game can model high levels of energy and excitement with simulations for students, which in turn can lead to higher excitement, interest, and self-efficacy levels for students during the simulation. In other words, a teacher's high level of enthusiasm and dedication toward a simulation is expected to be a positive influence for students as they play the simulation. A high degree of enthusiasm can thus pass to the students as they play the game, improving their affective states related to the game's content and skills to a higher degree than students whose teachers choose to completely ignore or provide low-level implementation of the simulation.

To investigate this end (although indirect) effect of an ROPD program on student affective states, the authors assigned participation scores to teachers based on their level of observed effort in the GE2 ROPD program. A series of ANOVAs were used to identify the growth of student affect as a result of playing GE2 and having a teacher participate at a high level in the GE2PD. The authors found that higher levels of teacher participation in an ROPD program to support the classroom implementation of a simulation game had a positive effect on the growth of student interest and self-efficacy in science related topics and the problem-based learning skills that students used within the simulation game.

The present study supports the hypothesis that teachers who continually stay engaged with student-centered curricula, like a simulation game, will have positive effects on their students' affective states. This aligns with past findings on teachers influence on student affect as a result of positive affective disposition toward classroom activities (Skinner et al., 2008; Wubbels & Brecklemans, 2008).

Future studies should investigate the effects that ROPD programs have on actual classroom practice – that is, how ROPD influences teacher implementation of simulation games and the ways they facilitate activities with their students. This, however, requires a significantly more robust endeavor to observe everyday teacher practices, such as in-class observations or self-reported teaching behaviors. Additionally, similar to the methods used with the email bulletins in this study, online server logs can capture teacher activities, if such activities occur within a digital environment where logfiles can be used.

A research benefit of ROPD that is performed online is the automatic and unobtrusive capture of participation data within server-side logs. As the participatory data from ROPD represent the behaviors of authentic teacher practice, an additional line of research would be to analyze the relationships between ROPD participation intended to support teachers' implementation of simulations and serious games, and the actual pedagogical and teaching tasks that are performed within these games.

As games and simulations employ digital tools to assist with facilitating interactions, server logs can be likewise employed to investigate how teachers and students alike interact

ithin simulations. The interaction data from digital game environments can thus provide evidence for linking the effects between teacher preparation and training programs (such as ROPD) with teacher practice, and then subsequently between teacher practice and student outcomes. Connecting this complete "chain of logic" between teacher professional development and student outcomes is an increasingly important and much-needed aspect of educational technology and classroom intervention research to know what educational interventions work (Hochberg & Desimone, 2010; Wayne et al., 2008).

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