Promoting Students' Writing Skills in Science through an Educational Simulation: The GlobalEd 2 Project

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Abstract. Using a problem-based learning (PBL) approach, GlobalEd 2 (GE2) utilizes an interdisciplinary approach to learning writing, science, and social studies. Leveraging technologies commonly available in most middle grade classrooms (computers with Internet connections), GE2 engages classrooms of students as teams in simulated negotiations of international agreements on issues of global concern such as water resources and climate change. The impact of student interactions within the simulation on the writing self-efficacy and the ability to author evidenced-based arguments in science of 420 7th and 8th grade students across two states is presented. Results indicate that after participation in a GE2 simulation, students not only increased their writing self-efficacy, but also significantly increased the quality of their written scientific arguments.

Keywords: Writing, Problem-based Learning (PBL), Simulation, Self-Efficacy.

1 Introduction

It has been argued, that to develop a scientifically literate citizenry, science education needs to be grounded in meaningful socio-scientific contexts related to the world in which students live [1; 2]. Socio-scientific issues are complex in nature and often do not have a single clear-cut solution. Such issues confront students with situations in which they have to engage in formulating their own opinions based on data, their own experiences and values, and collaborative decision-making. They are regarded as real-world problems that afford students the opportunity to participate in the negotiation and development of meaning through scientific argumentation [3; 4; 5]. Argumentation includes any dialog that addresses "the coordination of evidence and theory to support or refute an explanatory conclusion, model, or prediction" [4, p. 995]. Research has shown that when students engage in scientific argumentation, they not only learn to develop valid arguments but also learn science concepts while they are arguing [e.g., 5; 6; 7; 8].

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Unfortunately, inquiry-based approaches to teaching and learning science that involve socio-scientific issues are not often employed within typical science classrooms [3; 9; 10; 11]. The lack of socio-scientific inquiry tasks in science classrooms likely results from fact that the shift in the science standards towards scientific literacy and related pedagogical reform was set forth without commensurate alteration of the curricular space devoted to the teaching of science in the schools [12]. Inquiry-based curricula, especially programs that immerse learners in active investigations of contemporary issues, can consume significant chunks of classroom time. Given the standardized test-driven culture of today's educational system, the allocation of scarce instructional time and resources is a major concern for both teachers and administrators [13]. Further, research on science teachers has found that they feel under prepared and often lack the confidence necessary to implement and manage socio-scientific inquiry within the science classroom context [14; 15 16; 17]. So while it appears that we know what to do develop a scientifically literate citizenry and address dwindling science interest and participation among our students in STEM, we are simply not doing it as much as we should or could.

Rather than compete for the already overburdened curricular space devoted to science instruction, GE2 expands the curricular space afforded to the teaching of science by building upon the interdisciplinary nature of social studies. PBL researchers have illustrated that leveraging interdisciplinary contexts, like social studies, as a venue to engage in real world problem solving can deepen students' understanding, flexibility in application and transfer of knowledge [18 19; 20; 21]. Because problem-based learning (PBL) consists of a presentation of authentic problems as a starting point for learning, it increases student motivation and integration of knowledge [22] and when working cooperatively in groups within a PBL environment, students learn how to plan and determine what they need to solve problems, pose questions, and decide where they can get these answers as they make sense of the world around them [23].

There can be no doubt that recent USA policy initiatives across local, state and national levels have placed increased pressure on schools to improve student performance in the domains of literacy, mathematics and science. Problem-based learning (PBL) researchers have illustrated for decades that leveraging interdisciplinary contexts as a venue to engage in real world problem solving can deepen students' understanding, flexibility in application and transfer of knowledge [24; 25; 18; 19]. Recognizing this, the GlobalEd 2 Project (GE2) is an educational multi-team game that uses educational technologies currently available in most middle schools to build upon the interdisciplinary nature of social studies as an expanded curricular application aimed at increasing instructional time devoted to science and persuasive writing in a virtual environment [25].

The GE2 game operates within a middle school social studies class, focusing on an international science crisis. GE2 capitalizes on the interdisciplinary nature of social studies in order to expand the curricular space for additional opportunities to learn science and the use of educational technology, without sacrificing the curricular goals of the social studies curriculum. It works as a simulation environment in which classrooms of students work to reach an agreement on a critical global science issue, while representing a specific country over a period of 14 weeks.

The core of GE2 is the problem-based scenario. Interactions occur through a web-based system enabling email and real-time conferencing in a secure environment. Classrooms of students are assigned their country 4-6 weeks before the simulation, and are given analytical tasks to broad topical issue areas (i.e., human rights, economics, environment, health) presented in the scenario. Students are told that their country has to "stay in character" (e.g., remain consistent in policy positions and value systems of their country), while attempting to develop responses to problems within the issue areas. The scenario developed for the current simulation focused on Global Water Resources.

Students are instructed to learn about the values and customs of their respective countries prior to the simulation, so that they are prepared to make appropriate "in character" responses. Students did not know the name, race, sex or location of the students on other teams, only the name of the country, issue area and student's initials; there are generally 14-18 countries in a simulation.

There are three phases of the GlobalEd 2 Project: Research, Interactive and Debriefing (see Appendix A). The Research phase lasts six weeks, the Interactive phase lasts six weeks and the Debriefing phase lasts two weeks. The goal presented to the students is to negotiate an agreement on the science topic with at least one other country-team in the game.

2 Statement of the Research Problem

GE2's extensive use of written communications creates an invaluable venue for students to learn and practice written scientific argumentation in a real world context and to an authentic audience. Research illustrates that both instruction and authentic opportunities to write have been shown in the literature to improve writing skill [26; 27]. In addition, with more opportunities to experience success in writing there is a greater chance to positively impact their writing self-efficacy. Writing self-efficacy has been shown to mediate academic performance in writing [28]. As such, GE2 has the potential to impact not only the quality of students' written work within the simulation, but also has the opportunity impact longer-term performance.

The three research questions addressed are: 1) Is there a significant increase in middle grade students writing self-efficacy after participating a GE2 simulation?; 2) Is there a significant increase in the quality of students' written scientific argumentation after participating in a GE2 simulation?; and 3) Are there differences on the impact of GE2 with respect to the quality of written scientific argumentation across gender and socioeconomic status?

3 Methodology

A total of 420 student participated in a GE2 simulation; 312 of these students were from suburban schools located in New England, the remaining 118 students were from a large Midwestern city. All schools participating were public schools, with students drawn from both the 7th and 8th grades. Suburban schools were markedly

higher with respect to socioeconomic status with fewer than 15% of participants receiving free/reduced lunches. Students from urban schools were significantly lower socio-economically, with over 80% of student receiving subsidies for lunches. IRBs were obtained for all students whose data was collected. Those students who did not have parental consent participated in the educational program but did not participate in the research component of GE2.

Prior to implementing the GE2 simulation in their classrooms, teachers from both sites were trained for the implementation of GE2, including writing and teaching scientific argumentation. Students complete a battery of pre-test instruments prior to being introduced to GE2 (see Appendix A for a breakdown of the three GE2 phases and timeline of assessment administration). Within this battery was a 5-item measure of writing self-efficacy (Likert scale format, 1 representing low efficacy and 5 representing high efficacy) and an open ended writing prompt patterned after prompts students receive as part of state mandated standardized tests. This writing prompt asked students to write a persuasive argument either for against the claim that the Earth is in danger of running out of fresh water. They were asked to clearly provide a claim, provide evidence for their claim as well as the reasoning they used to link that evidence to their claim. All assessments were administered using paper and pencil format. Students then began participation in the GE2 simulation that lasted for approximately 14 weeks. After completing the 14-week simulation portion of GE2, student were re-administered the same battery of assessments as post measures of performance. See Appendix B for a figure detailing the GE2 learning environment.

Writing self-efficacy items were summed to create one composite score pre and post for each student (possible range: 5-25). Student essays were scored by two trained independent raters - blinded to student identity and time of administration. An adapted version of the argumentation rubric developed by Midgette, Haria and MacAuthur [29] was used to rate essays for quality of argumentation. The basic structure of this rubric examines the presence of claims, evidence and reasoning, the completeness of these argumentation chains as well as whether they addressed the opposition in their arguments (possible range 0-5). Inter-rater agreement exceeded 85%. Where ratings differed, scores from each rater were averaged to yield a single argument score for each student's essay.

4 Results

To address the first research question, regarding writing self-efficacy of the overall sample, pre and post scores were analyzed using a dependent t-test. Results indicated a significant difference between pre and post scores ($t(415)=2.27$, $p<.05$), with students indicating significantly greater writing self-efficacy after participation in GE2.This analysis was repeated for research question 2, examining the argumentation quality score derived from the open-ended essay responses provided by students. Results of this t-test also indicated a significant increase in scores from pre to post.

To further examine the impact of gender and socioeconomic status on student writing self-efficacy and argumentation quality over time, a series of ANCOVAs were

conducted where pretest scores served as the covariates, post-tests as the dependent variables and gender and socioeconomic status as the independent factors. Results indicated significant differences between both gender and socioeconomic status with respect to writing self-efficacy at the time of the post-test after controlling for pre-test differences on this construct ($F(1,410) = 5.9$, $p < .05$; $F(1,416) = 3.97$, $p < .05$, respectively). The results show while that students representing each strata changed positively over time, females and students from the urban setting were significantly more self-efficacious with respect to writing than their counterparts at the time of the post-test, after controlling for pre-test differences. Regarding argument quality as measured by the open-ended essays, no differences in the amount of change by gender or socio economic status were noted, indicating that all groups improved their writing quality relatively equally (ps>05).

5 Conclusions

There is much still to learn about GE2 and its impacts on student learning. However, we believe that the increased opportunities that GE2 affords students to construct written arguments in a real world context, the application of knowledge to solve problems rather than recall information and the authenticity of the audience to which students are writing are particularly salient affordances promoting positive change in academic performance. While this study does not provide a control group against which we can assess the changes in GE2 participants' performance compared to standard educational practice, the results presented here speak to the potential of GE2 as a meaningful context within which students can learn and practice their ability to construct written scientific argumentation. Students who participated in the simulation increased both their writing self-efficacy and their writing performance scores over the course of the curricular intervention, across gender and socioeconomic status. Further, the results of this study suggest very positive curricular implications of writing intensive, interdisciplinary, problem-based learning (PBL) approaches like GE2, while also suggesting future directions for PBL research.

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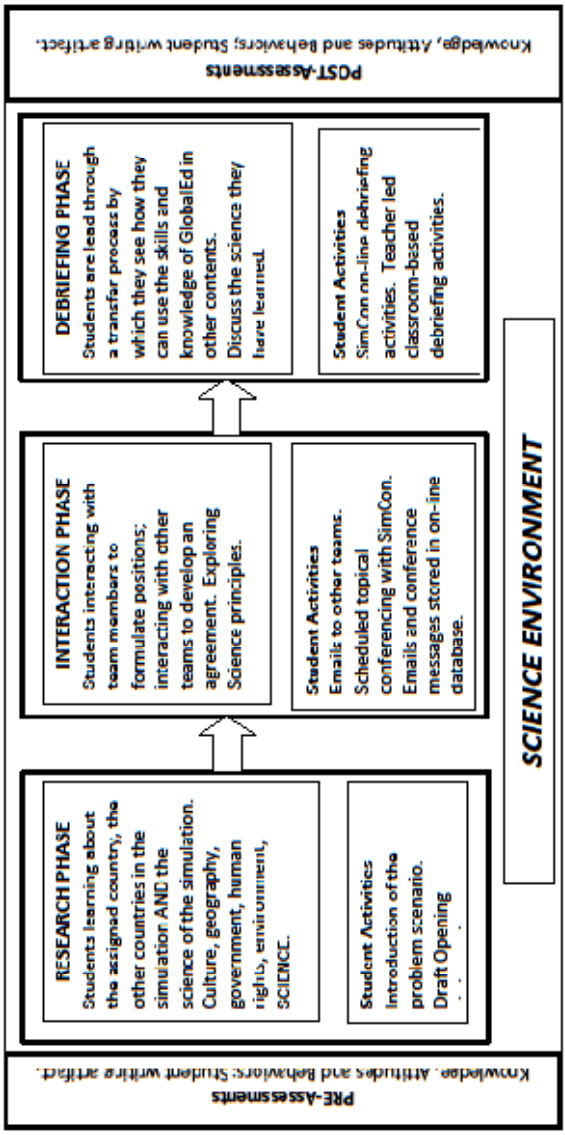
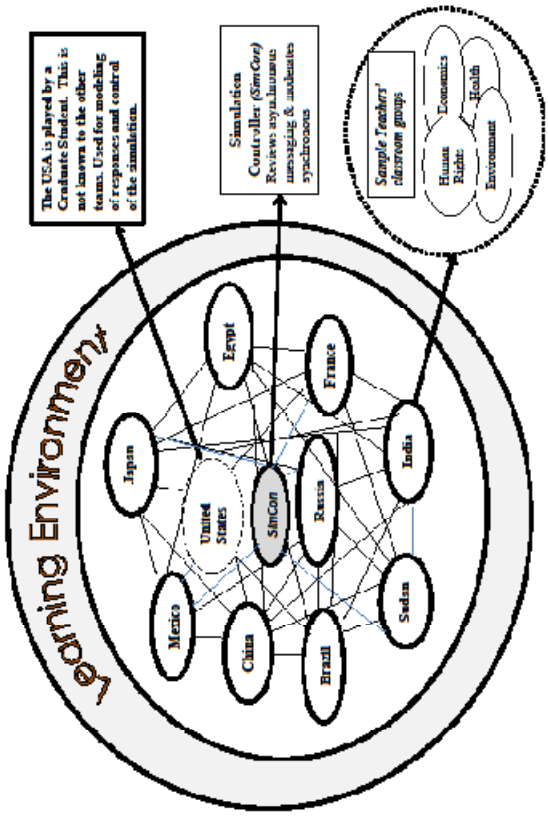
Appendix A. The Three Phases of GlobalEd 2





Appendix B. GlobalEd 2 Learning Environment