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Promoting Science Self-Concept with Inquiry-based Curricula

Mike Stieff, Stephanie M. Werner
mstieff@uic.edu, swerne3@uic.edu
University of Illinois, Chicago

Abstract: Science self-concept is a strong predictor of engagement in science learning and career choice. Students who report higher science self-concept display more self-efficacy and greater achievement in their science courses, which positions the construct as a potential target of curriculum interventions. Here, we report our interim findings regarding the potential of a technology-infused guided-inquiry curriculum, The Connected Chemistry Curriculum, for improving students' chemistry self-concept. Using data from a longitudinal study of the curriculum's efficacy, we analyzed improvements in 1048 students' chemistry self-concept after using Connected Chemistry for an academic year. The results show that CCC significantly improves students' chemistry self-concept compared to business-as-usual practices.

Keywords: Self-concept, Inquiry, Science Education

Introduction

The Connected Chemistry Curriculum (CCC, Stieff, Nighelli, Yip, Ryan, & Berry, 2012), a technology-infused guided inquiry curriculum, is a self-contained chemistry curriculum that makes central use of visualization software to facilitate learning in secondary chemistry. Like other science curricula that emphasize the use of educational technologies (e.g., SimCalc, PhET), CCC aspires to serve the dual purpose of supporting learning while providing youth with an opportunity to increase their experience and proficiency with digital mediums. The curriculum has been under iterative development for 18 years, and studies of CCC have focused mainly on its efficacy for improving conceptual change and representational competence in the discipline. Here, we report our initial efforts to examine the potential of the curriculum to impact socio-affective factors, such as self-concept.

Present study

We present here our preliminary analysis of the long-term impact of a 9-month implementation of CCC on self-concept. We conducted an implementation study that compared changes in students' self-concept in chemistry, math, and general academics in classes taught by the same group of teachers with or without implementing CCC. Specifically, we tested whether students in CCC classes reported higher levels of chemistry self-concept.

Study context

The data reported on here were collected during 2017-2019 in the context of an ongoing efficacy study of CCC. Participating schools were located in one of three urban/urban-fringe school districts in the U.S. Great Lakes region. 31 participating teachers taught chemistry with business-as-usual (BAU) methods for one year before implementing CCC in the consecutive year. An implementation of CCC consisted of implementing a minimum of one lesson from each of CCC's 9 curriculum modules throughout the year. In both years, research personnel made visits to the participating classrooms approximately once per month to collect field observations, collect data on fidelity of implementation, and administer pre- and post- measures to students.

Instrument

Self-concept was assessed with The Chemistry Self-Concept Inventory (Bauer, 2005), a measure for assessing self-concept related to chemistry, mathematics, and academics. The 40-item Likert survey assesses students' self-concept of themselves as learners and includes 5 subscales: chemistry learning, mathematics learning, academics in general, academic enjoyment, and creativity.

Participants

2366 students taught by 31 teachers completed the self-concept inventory at the beginning and end of each school year. The survey was administered in class within the first two weeks and last two weeks of each school year.

Results

Before analyzing the effect of the CCC implementation, we tested the validity and reliability of the survey in this study. 1301 completed surveys administered during the first two weeks of the BAU data were sequestered for this analysis. Four of the five subscales had good reliability (Chronbach's $\alpha > .72$). Via Confirmatory Factor Analysis, we found that a four-factor model with the Creativity subscale ($\alpha = .44$) removed best fit the data, ($X^2(521) = 3568.528$, $p < .001$, CFI = .81, RMSEA = .067).

We constructed a multilevel model (MLM) to determine the effect of CCC implementation (BAU vs. implementation) on student self-concept (gain scores). For this analysis, only students who completed 100% of all pre- and post-test survey items were included, which resulted in 1048 students. Individual students were nested within their teacher for this analysis. All subscales were normally distributed based on visual inspection of the histograms. For most of the subscale pairs, there was a general linear trend as shown by a scatterplot matrix. There was no multicollinearity between the dependent variables, with all Pearson correlations below $r = .41$, $p < .05$. Levene's test for homogeneity showed that one subscale, chemistry, did not meet this assumption, $F(1,1046) = 6.284$, $p = .012$. A MLM was run for each of the four dependent variables (subscales) with students nested within teacher. Only one model had significant fit: chemistry self-concept ($F(1,1039.813) = 35.275$, $p < .001$). All other models were nonsignificant (Table 1). For the significant model, a statistically significant difference was found between BAU and CCC Implementation Years (B = -.2642, SE = .0445, $p = .001$). Upon implementing CCC, students within the same teacher improved their chemistry self-concept by a factor of .26.

Table 1: MLM fit statistics for each model.

Self-concept subscale	Model fit	B	SE	p
Chemistry	$F(1,1039.813) = 35.275$, $p < .001$	-.2642	.0445	.001
Math	$F(1,1042.718) = .200$, $p = .654$	-.016585	.0370	.654
Academic	$F(1,1043.552) = .058$, $p = .810$	-.008963	.0374	.810
Academic Enjoyment	$F(1,1046) = .260$, $p = .610$	-.0196	.0385	.610

Conclusions

Our results suggest that implementations of CCC can yield improvements in students' self-concept and that this improvement is specific to chemistry. We observed a significant improvement in chemistry self-concept in CCC classrooms relative to business-as-usual practices, but no concurrent improvements in other attitudinal factors. The specificity of this effect is consistent with other reports (e.g., Scherer, 2013) that have identified domain-specific aspects of science self-concept. Importantly, the specificity of the finding suggests that CCC works to improve students' science self-concept in classrooms where it is implemented but does not lead to general improvements in academic self-concept or enjoyment. Our interim findings lend empirical support to earlier predictions (Jansen, Scherer, & Schroeders, 2015) that inquiry curriculum can better develop students' science self-concept relative to other designs and suggest that self-concept may be an important target for future design-based research studies.

References

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